Contents

National Risk Assessment: MODERATE

RISK ASSESSMENT FOR AUSTRALIA: **Seven 'Amazonian' Conure species (*Pyrrhura* Sp.)**

Class - Aves**, Order -** Psittaciformes**, Family -** Psittacidae**, Genus -** *Pyrrhura*.

SPECIES:	**Species description:**
Pyrrhura egregia (Sclater, 1881) *Pyrrhura lepida* (Wagler, 1832) *Pyrrhura melanura* (Spix, 1824) *Pyrrhura perlata* (Spix, 1824) *Pyrrhura picta* (Muller, 1776) *Pyrrhura roseifrons* (Gray 1859) *Pyrrhura rupicola* (Tschudi, 1844) **Synonyms:** ***Pyrrhura egregia*** *Conurus egregius* (Sclater, 1881) ***Pyrrhura lepida*** *Sittace lepida* (Wagler, 1832) ***Pyrrhura melanura*** *Aratinga melanurus* (Spix, 1824) ***Pyrrhura perlata*** *Pyrrhura rhodogaster* (Sclater, 1864) ***Pyrrhura picta*** *Psittacus pictus* (Muller, 1776) ***Pyrrhura roseifrons*** *Pyrrhura picta*, *P. snethlageae*, *P. parvifrons*, *P. amazonum*, *P. lucianii*, *P. roseifrons*, *P. peruviana*, *P. subandina*, *P. caeruleiceps* and *P. eisenmanni* (del Hoyo and Collar 2014) were previously lumped	The seven *Pyrrhura* Conure species assessed here range from 22 to 26 centimetres in total length. All have long, pointed tails, a mainly green plumage, and a relatively narrow, dark greyish to white eye-ring. *Pyrrhuras* are usually less noisy than *Aratinga* Conures (Beauty of Birds, 2023). ***1. Pyrrhura egregia* (Fiery-shouldered Conure):** 26 centimetres, ~ 75 grams. In the nominate subspecies (*P. e. egregia*), the head is grey, and the neck and upper parts of the body and wings are green. Front edge of the wing and the underwing coverts are yellow with orange markings. The breast is green barred with brown and yellowish white. The central part of the abdomen is reddish-brown, as is the upper side of the tail while the underside of the tail is grey. The eye is brown and surrounded by bare white skin, and the beak is horn-coloured. In the other subspecies, *P. e. obscura*, the upper parts are a deeper shade of green and there is little or no bright colour on the abdomen. ***2. Pyrrhura lepida* (Pearly Conure):** 24-25 centimetres, 70 to 80 grams. Adults of the nominate subspecies have a dark brown crown and buff ear coverts. The rest of their face is dull blue green with whitish bare skin around the eye. Upperparts are green with a bluish tinge; upper breast and sides of neck brown with buff scaling; the breast has a blue tinge. Remainder of underparts green with a blue wash. Wings are mostly green, with black and cobalt blue primaries and red underwing coverts. The tail's top surface is reddish brown, and the lower surface is blackish brown. ***3. Pyrrhura melanura* (Maroon-tailed Conure):** 24-25 centimetres; 83 grams. Generally green, frontal band dark reddish brown. The crown and nape are brown edged green with a bare orbital ring white. Throat, sides of neck and breast dark green edged buffy whitish, giving scaled effect. Primary-coverts red, tipped yellowish orange, outer primaries blue, with narrow green fringe on outer web. Tail, deep maroon above, green at base and dusky greyish below. Immature birds are similar to adults but have less red on primary coverts. *P. m. souancei* has a more strongly scaled throat, all-red primary coverts, sometimes red on carpals, brownish-red belly and blacker undertail. *P. m. berlepschi* still stronger throat scaling, carpal and belly markings invariably present (Collar *et al*., 2019).

as *P. picta* following Sibley and Monroe (1990, 1993). ***Pyrrhura rupicola*** *Conurus rupicola* (Tschudi, 1844) **Subspecies:** ***Pyrrhura egregia*** *P. e. egregia* (Sclater, 1881) *P. e. obscura* (Zimmer & Phelps, 1946) ***Pyrrhura lepida*** *Pyrrhura l. anerythra* (Neumann, 1927) *Pyrrhura l. coerulescens* (Neumann, 1927) *Pyrrhura l. lepida* (Wagler, 1832) ***Pyrrhura melanura*** *P. m. berlepschi* (Salvadori, 1891) *P. m. chapmani* (Bond & Meyer de Schauensee, 1940) *P. m. melanura* (Spix, 1824) *P. m. pacifica* (Chapman, 1915) *P. m. souancei* (Verreaux, 1858) ***Pyrrhura perlata*** *P. p. perlata* (Spix, 1824) ***Pyrrhura picta*** *P. p. amazonum* (Hellmayr, 1906) *P. p. lucianii* (Deville, 1851) *P. p. picta* (Muller, 1776) *P. p. roseifrons* (Gray, 1859) *P. p. eisenmanni* (Delgado, 1985) *P. p. subandina* (Todd, 1917) *P. p. pantchenkoi* (Phelps, 1977) *P. p. caeruleiceps* (Todd, 1947)	***4. Pyrrhura perlata* (Crimson-bellied Conure):** 24 centimetres. Colourful conure with a pale bill and base. The head is dark brown with buff flecking. Upper cheek is green, shading down to blue. Bare orbital-ring coloured whitish, and ear-coverts are flecked buff. Sides of neck and upper breast are scaled buff on grey. Red lower breast and belly. Blue flanks, thighs, and vent. Green back, with red shoulders, and green wings, with blue in the wing-coverts and violet blue in the flight feathers. Tail is brownish red and grey below, with a blue tip. **5. *Pyrrhura picta* (Painted Conure):** 23 centimetres. Medium-sized colourful conure with long, green-based red tail and bright blue primaries. The maroon face contrasts with white auriculars and a blue forecrown, which shades to deep brown. The breast is heavily scalloped gold on a deep brown background, becoming green on the lower breast and flanks and there is a large red belly patch. **6. *Pyrrhura roseifrons* (Rose-fronted Conure):** 22 centimetres. One of the medium-sized, long-tailed, largely green conures formerly included within *P. picta*. Extensive red and pink on head variable but extends at least to the rear of the eye. **7. *Pyrrhura rupicola* (Black-capped Conure):** 25 centimetres. Small, green conure, with brown-and-buff scalloped throat, rusty green belly, yellow breast, red primary wing-coverts and blue-tinged primary feathers. **General information:** The seven *Pyrrhura* species assessed here all have ranges within the upper "Amazon Basin" region of South America. Not a single species of the genus *Pyrrhura* occurs naturally in the colder zones (del Hoya, 1997). Habitat: **Fiery-shouldered Conure:** inhabits subtropical and tropical moist montane forest at altitudes between 700-1,800 metres (Birdlife International, 2023). **Pearly Conure:** occurs in lowland terra firme (with no flooding) humid forest. Even though it is sometimes reported from forest edge, clearings and second growth, it appears to prefer the canopy and interior of dense, extensive forests (D. M. Lima *in litt*., 2022; Juniper and Parr, 1998; Parker *et al.,* 1996, Portes *et al*., 2011,). Its ecology is largely unknown (Collar *et al*., 2020). Usually seen in groups of up to 25 individuals. **Maroon-tailed Conure:** Typically occurs in cloud forest, lowland wet forest in premontane zones, seasonally flooded forest, borders and partially cleared areas. Generally, only found below 500 metres although higher individuals have been witnessed, with subspecies. *P. m. soucancei* recorded to 3,200 metres and *P. m. berlepschi* to 1,500 metres (Collar *et al*., 2019). **Crimson-bellied Conure:** a species of terra firme lowland rainforest. It appears to prefer dense vegetation at the forest edge and in secondary growth. The species is often observed in small groups. Its

P. p. microtera (Todd, 1947) ***Pyrrhura rupicola*** *P. r. rupicola* (Tschudi, 1844) *P. r. sandiae* (Bond & Meyer de Schauensee, 1944) **Common Names:** ***Pyrrhura egregia*** Fiery-shouldered Conure Fiery-shouldered Parakeet ***Pyrrhura lepida*** Pearly Conure Pearly Parakeet ***Pyrrhura melanura*** Maroon-tailed Conure Maroon-tailed Parakeet ***Pyrrhura perlata*** Crimson-bellied Conure Crimson-bellied Parakeet ***Pyrrhura picta*** Painted Conure ***Pyrrhura roseifrons*** Rose-fronted Conure Rose-fronted Parakeet ***Pyrrhura rupicola*** Black-capped Conure Black-capped Parakeet	diet consists mainly of fruit, of *Trema micrantha* and various palms, as well as *Cecropia* catkins and flowers of *Bertholletia excelsa* and *Dioclea glabra*. It is known to breed from July to November in the south of its range (Carter, 2020; del Hoyo *et al.,* 1997). **Painted Conure:** occurs inside humid terra firme and várzea (seasonally flooded) forest, and in tepuis on slopes, feeding largely on fruit, flowers and seeds (del Hoyo *et al*. 1997). It travels in tight, rapidly flying flocks. The breeding season lasts from December to February, when it nests in a hole in a tree. **Rose-fronted Conure:** found in subtropical and tropical, moist lowland and montane forests, and tropical swamps at altitudes between 100-2,000 metres (Birdlife International, 2023). **Black-capped Conure:** found in humid lowland terra firme and várzea forest as well as forest edge, ranging into the Andean foothills (Collar *et al*., 2020; del Hoyo *et al.,* 1997). All seven *Pyrrhura* species are thought to feed on fruits, seeds, nuts, berries, and flowers (del Hoyo *et al*., 1997; Ragusa-Netto, 2007; Thompson, 1994). *Pyrrhura* species are also known to eat insects and their larvae (del Hoyo *et al*., 1997; Kolar, 1990). The natural diet consists mainly of tree-fruits, seeds, flowers, and berries (Beauty of Birds, 2023). *Pyrrhura* species nest in tree hollows (ADW; del Hoyo *et al*., 1997; Kolar 1990). *P. rupicola* are also known to breed in rock crevices (Kolar, 1990). **Longevity:** Pyrrhura conures typically live around 20 or 25 years (del Hoyo *et al*., 1997). *Pyrrhura perlata* 14.3 years (AnAge). **Conservation status:** **IUCN:** *P. egregia, P. melanura, P. perlata, P. picta, P. roseifrons, P. rupicola* = Least Concern *P. lepida* = Vulnerable **CITES:** *P. roseifrons* = Not listed *P. egregia, P. lepida*, *P. melanura, P. perlata, P. picta, P. rupicola* = Appendix II
DATE OF ASSESSMENT: August 2023 (Jodi Buchecker) **EIC ENDORSEMENT:**	**The risk assessment model:** Models for assessing the risk that exotic vertebrates could establish in Australia have been developed for mammals, birds (Bomford 2003, 2006, 2008), reptiles and amphibians (Bomford et al 2005, Bomford 2008). Developed by Dr Mary Bomford for the Bureau of Rural Sciences (BRS), the model uses criteria that have been demonstrated to have significant correlation between a risk factor and the establishment of populations of exotic species and the pest potential of those species that do establish. For example, a risk factor for establishment is similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia. For pest potential, the species' overseas pest status is a risk factor.

Risk assessment model used for the assessment: Bomford 2008, Bird and Mammal Model	The model is published as 'Risk assessment models for the establishment of exotic vertebrates in Australia and New Zealand' (Bomford 2008) and is available online on the PestSmart website https://pestsmart.org.au/wp-content/uploads/sites/3/2020/06/Risk_Assess_Models_2008_FINAL.pdf **CLIMATE**: In 2021 a new version of the Climatch program used to assess similarity in climate was released by the Australian Bureau of Agricultural Resource Economics and Sciences (ABARES): CLIMATCH v2.0. The increase in resolution in this new version (from 50 km to 20 km) required recalibration of Climate Match Scores. See Table 1. Sixteen climate parameters (variables) of temperature and rainfall are used to estimate the extent of similarity between data from meteorological stations located within the species' world distribution and stations in Australia. Worldwide, data from approximately 19000 locations are available for analysis. The number of locations used in an analysis will vary according to the size of the species' distribution and the number of meteorological stations located within that distribution. To represent the climate match visually, the map of Australia is divided into 19236 grid squares, each measured in 0.2 degrees in both longitude and latitude. CLIMATCH v2.0 calculates a match for each Australian grid by comparing data from all meteorological stations within the species' distribution (excluding any populations in Australia) and allocating a score ranging from ten for the highest level match to zero for the poorest match. Levels of climate match are used in the risk assessment for questions B1 (scores are summed to give a cumulative score), C6, and C8. Climatch v2.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/.

Bird and Mammal Model:

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
A1. Risk to people from individual escapees (0–2) *Assess the risk that individuals of the species could harm people. (NB, this question only relates to aggressive behaviour shown by escaped or released individual animals. Question C11 addresses the risk of harm from aggressive behaviour if the species establishes a wild population).* *Aggressive behaviour, size, plus the possession of organs capable of inflicting harm, such as sharp teeth, claws, spines, a sharp bill, or toxin-delivering apparatus may enable individual animals to harm people. Any known history of the species*	0	*All other animals posing a lower risk of harm to people (ie animals that will not make unprovoked attacks causing injury requiring medical attention, and which, even if cornered or handled, are unlikely to cause injury requiring hospitalisation).* Low risk of harm to people. Conures are small parakeets with small beaks (World Parrot Trust, 2018) making them unable to inflict much harm.

attacking, injuring or killing people should also be taken into account. Assume the individual is not protecting nest or young.		
A2. Risk to public safety from individual captive animals (0–2) *Assess the risk that irresponsible use of products obtained from captive individuals of the species (such as toxins) pose a public safety risk (excluding the safety of anyone entering the animals' cage/enclosure or otherwise coming within reach of the captive animals)*	0	*Nil or low risk (highly unlikely or not possible).*
STAGE A PUBLIC SAFETY RISK SCORE **SUM A1 - A2 (0-4)**	0	**Not dangerous**
STAGE B: PROBABILITY ESCAPED OR RELEASED INDIVIDUALS WILL ESTABLISH FREE-LIVING POPULATIONS		
Model 1: FOUR-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)		
B1. Degree of climate match between species overseas range and Australia (1–6) *Map the selected mammal or bird species' overseas range, including its entire native and exotic (excluding Australia) ranges over the past 1000 years.* *Use CLIMATCH v2.0, Value X = sum of classes 6 – 10, see Table 1.*	1 1 1 1 1 1	**1. Fiery-shouldered Conure:** *Very Low climate match to Australia* Value X = 0 CMS = 1 **2. Pearly Conure:** *Very Low climate match to Australia* Value X = 223 CMS = 1 **3. Maroon-tailed Conure:** *Very Low climate match to Australia* Value X = 61 CMS = 1 **4. Crimson-bellied Conure:** *Very Low climate match to Australia* Value X = 266 CMS = 1 **5. Painted Conure:** *Very Low climate match to Australia* Value X = 5 CMS = 1 **6. Rose-fronted Conure:** *Very Low climate match to Australia*

	1	Value X = 78 CMS = 1 **7. Black-capped Conure:** *Very Low climate match to Australia* Value X = 110 CMS = 1
B2. Exotic population established overseas (0–4) *An established exotic population means the introduced species must have bred outside of captivity and must currently maintain a viable free-living population where the animals are not being intentionally fed or sheltered, even though they may be living in a highly disturbed environment with access to non-natural food supplies or shelter.*	0	*No exotic populations have been established.*
B3. Overseas range size score (0–2) < 1 = 0; 1– 70 = 1; >70 = 2 *Estimate the species overseas range size* including currently and the past 1000 years; natural and introduced range in millions of square kilometres*		*Overseas range between 1-70 million km^2*
	0	**1. Fiery-shouldered Conure:** Overseas range estimated in Climatch: ~400,000 km^2. Extant (resident): Brazil and Guyana (Birdlife International, 2016). Extant (breeding): Venezuela (Birdlife International, 2016).
	1	**2. Pearly Conure:** Overseas range estimated in Climatch: ~1.7 million km2. Extant (resident): Brazil (Birdlife International, 2016).
	1	**3. Maroon-tailed Conure:** Overseas range estimated in Climatch: ~2.4 million km^2. Extant (resident): Brazil; Colombia; Ecuador; Peru; Venezuela and Bolivia (Birdlife International, 2016).
	1	**4. Crimson-bellied Conure:** Overseas range estimated in Climatch: ~1.7 million km^2. Extant (resident): Bolivia; Brazil (Birdlife International, 2016).
	1	**5. Painted Conure:** Overseas range estimated in Climatch: ~1.7 million km^2. Extant (resident): Brazil; French Guiana; Guyana; Suriname; Venezuela and Bolivia (Birdlife International, 2016).
	1	**6. Rose-fronted Conure:** Overseas range estimated in Climatch: ~1.13 million km^2. Extant (resident): Brazil; Peru and Bolivia (Birdlife International, 2016).
	1	**7. Black-capped Conure:** Overseas range estimated in Climatch: ~1 million km^2. Extant (resident): Brazil; Peru and Bolivia (Birdlife International, 2016).

B4. Taxonomic Class (0–1) *Bird = 0; mammal = 1*	0	*Bird*
B. ESTABLISHMENT RISK SCORE **SUM OF B1- B4 (1–13)**	1 2 2 2 2 2 2	**1. Fiery-shouldered Conure: Low establishment risk** **2. Pearly Conure: Low establishment risk** **3. Maroon-tailed Conure: Low establishment risk** **4. Crimson-bellied Conure: Low establishment risk** **5. Painted Conure: Low establishment risk** **6. Rose-fronted Conure: Low establishment risk** **7. Black-capped Conure: Low establishment risk**
Model 2: Seven-Factor Model For Birds And Mammals (Bomford 2008)		
B5. Diet score (0–1) *Specialist = 0; generalist = 1*	1	*Generalists with a broad diet of many food types.* Diverse diet consisting of a fruits, seeds, nuts, berries, and flowers (del Hoyo et al., 1997; Ragusa-Netto, 2007; Thompson, 1994;). Also known to eat insects and their larvae (del Hoyo et al., 1997; Kolar, 1990;).
B6. Habitat score (0–1) *Undisturbed or disturbed habitat*	0	*Requires access to undisturbed (natural) habitats to survive and breed.* Prefer undisturbed habitat (del Hoyo et al., 1997).
B7. Migratory score (0–1) *Always migratory = 0; non-migratory = 1*	1	*Non-migratory* (Birdlife International, 2023)
B. ESTABLISHMENT RISK SCORE **SUM OF B1- B7 (1–16)**	3 4 4 4 4 4 4	**1. Fiery-shouldered Conure: Low establishment risk** **2. Pearly Conure: Low establishment risk** **3. Maroon-tailed Conure: Low establishment risk** **4. Crimson-bellied Conure: Low establishment risk** **5. Painted Conure: Low establishment risk** **6. Rose-fronted Conure: Low establishment risk** **7. Black-capped Conure: Low establishment risk**
STAGE C: PROBABILITY AN ESTABLISHED SPECIES WILL BECOME A PEST		
C1. Taxonomic group (0–4)	3	*Bird in one of the taxa that are particularly prone to cause agricultural damage (Psittaciformes) = 2.*

		Bird in one of the families likely to hybridise with native species (Psittacidae) = 1.
C2. Overseas range size including current and past 1000 years, natural and introduced range (0–2) *Estimate the species overseas range size (including current and past 1000 years, natural and introduced range) in millions of square kilometres*	0	*Overseas geographic range less than 10 million square kilometres.* **1. Fiery-shouldered Conure:** ~400,000 km^2 (see B3). **2. Pearly Conure:** ~1.7 million km^2(see B3). **3. Maroon-tailed Conure:** ~2.4 million km^2 (see B3). **4. Crimson-bellied Conure:** ~1.7 million km^2(see B3). **5. Painted Conure:** ~1.7 million km^2(see B3). **6. Rose-fronted Conure:** ~1.13 million km^2(see B3). **7. Black-capped Conure:** ~1 million km^2(see B3).
C3. Diet and feeding (0–3)	0	*Not a mammal*
C4. Competition with native fauna for tree hollows (0–2)	2	*Can nest or shelter in tree hollows.* *Pyrrhura* species nest and shelter in tree hollows (Kolar 1990; ADW; del Hoyo et al. 1997). *P. rupicola* are also known to breed in rock crevices (Kolar 1990).
C5. Overseas environmental pest status (0–3) *Has the species been reported to cause declines in abundance of any native species of plant or animal or cause degradation to any natural communities in any country or region of the world?*	0	*Never reported as an environmental pest in any country or region.* No reports found for any of the *Pyrrhura* species assessed here.
C6. Climate match to areas with susceptible native species or communities (0–5) *Identify any native Australian animal or plant species or communities that could be susceptible to harm by the exotic species if it were to establish a wild population here.*	1 2	**1. Fiery-shouldered Conure:** *no grid squares within the highest four climate match classes that overlap the distribution of any susceptible native species or ecological communities, and has 1–346 grid squares within the highest six climate match classes that overlap the distribution of any susceptible native species or ecological communities = 1* **2. Pearly Conure:** *no grid squares within the highest two climate match classes that overlap the distribution of any susceptible native species or ecological communities, and has 1–62 grid squares within the highest four climate match classes that overlap the distribution of any susceptible native species or ecological communities = 2*

	2 2 1 2 2	**3. Maroon-tailed Conure:** *no grid squares within the highest two climate match classes that overlap the distribution of any susceptible native species or ecological communities, and has 1–62 grid squares within the highest four climate match classes that overlap the distribution of any susceptible native species or ecological communities = 2* **4. Crimson-bellied Conure:** *no grid squares within the highest two climate match classes that overlap the distribution of any susceptible native species or ecological communities, and has 1–62 grid squares within the highest four climate match classes that overlap the distribution of any susceptible native species or ecological communities = 2* **5. Painted Conure:** *no grid squares within the highest four climate match classes that overlap the distribution of any susceptible native species or ecological communities, and has 1– 46 grid squares within the highest six climate match classes that overlap the distribution of any susceptible native species or ecological communities = 1* **6. Rose-fronted Conure:** *no grid squares within the highest two climate match classes that overlap the distribution of any susceptible native species or ecological communities, and has 1–62 grid squares within the highest four climate match classes that overlap the distribution of any susceptible native species or ecological communities = 2* **7. Black-capped Conure:** *no grid squares within the highest two climate match classes that overlap the distribution of any susceptible native species or ecological communities, and has 1–62 grid squares within the highest four climate match classes that overlap the distribution of any susceptible native species or ecological communities = 2* **Example of susceptible species:** Parrot species such as Coxen's Fig Parrot (*Cyclopsitta diophthalma coxeni*, Critically Endangered) and Golden-shouldered Parrot (*Psephotus chrysopterygius*, Endangered) possibly impacted.
C7. Overseas primary production pest status (0–3) *Has the species been reported to damage crops or other primary production in any country or region of the world?*	0	*No reports of damage to crops or other primary production in any country or region.* No reports found for any of the *Pyrrhua* species assessed here.

C8. Climate match to susceptible primary production (0–5) *Assess Potential Commodity Impact Scores for each primary production commodity listed in Table 9, based on species' attributes (diet, behaviour, ecology), excluding risk of spreading disease which is addressed in Question C9.* *0 = 0; 1-19 = 1; 20-49 = 2; 50-99 = 3; 100-149 = 4; ≥150 = 5*	2	Total Commodity Damage Score = 25 (see Table 2) These species have attributes making them capable of damaging fruit, flower and other horticultural crops.
C9. Spread disease (1–2) *Assess the risk that the species could play a role in the spread of disease or parasites to other animals*	2	*All birds (likely or unknown effect on native species and on livestock and other domestic animals).*
C10. Harm to property (0–3) *Assess the risk that the species could inflict damage on buildings, vehicles, fences, roads, equipment or ornamental gardens by chewing or burrowing or polluting with droppings or nesting material.*	0	*$0.* No reports of *Pyrrhura* species damaging property.
C11. Harm to people (0–5) *Assess the risk that, if a wild population established, the species could cause harm to or annoy people. Aggressive behaviour, plus the possession of organs capable of inflicting harm, such as sharp teeth, tusks, claws, spines, a sharp bill, horns, antlers or toxin delivering organs may enable animals to harm people. Any known history of the species attacking, injuring or killing people should also be taken into account (see Stage A, Score A1).*	0	*Nil risk.*
C. PEST RISK SCORE **SUM C 1 TO C 11 (1–37)**	10 11 11 11 10 11 11	**1. Fiery-shouldered Conure: Moderate pest risk** **2. Pearly Conure: Moderate pest risk** **3. Maroon-tailed Conure: Moderate pest risk** **4. Crimson-bellied Conure: Moderate pest risk** **5. Painted Conure: Moderate pest risk** **6. Rose-fronted Conure: Moderate pest risk** **7. Black-capped Conure: Moderate pest risk**

STAGE A. PUBLIC SAFETY RISK RANK – RISK TO PUBLIC SAFETY POSED BY CAPTIVE OR RELEASED INDIVIDUALS *0 = Not dangerous; 1 = Moderately dangerous; ≥ 2 = Highly dangerous*	0	Not dangerous
STAGE B. ESTABLISHMENT RISK RANK – RISK OF ESTABLISHING A WILD POPULATION **MODEL 1: FOUR-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)** *≤ 5 = low establishment risk; 6-8 = moderate establishment risk; 9-10 = serious establishment risk; ≥ 11-13 = extreme establishment risk*	1 2 2 2 2 2 2	**1. Fiery-shouldered Conure:** Low establishment risk **2. Pearly Conure:** Low establishment risk **3. Maroon-tailed Conure:** Low establishment risk **4. Crimson-bellied Conure:** Low establishment risk **5. Painted Conure:** Low establishment risk **6. Rose-fronted Conure:** Low establishment risk **7. Black-capped Conure:** Low establishment risk
STAGE B. ESTABLISHMENT RISK RANK – RISK OF ESTABLISHING A WILD POPULATION **MODEL 2: SEVEN-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)** *≤ 6 = low establishment risk; 7-11 = moderate establishment risk; 12-13 = serious establishment risk; ≥14 = extreme establishment risk*	3 4 4 4 4 4 4	**1. Fiery-shouldered Conure:** Low establishment risk **2. Pearly Conure:** Low establishment risk **3. Maroon-tailed Conure:** Low establishment risk **4. Crimson-bellied Conure:** Low establishment risk **5. Painted Conure:** Low establishment risk **6. Rose-fronted Conure:** Low establishment risk **7. Black-capped Conure:** Low establishment risk
STAGE C. PEST RISK RANK - RISK OF BECOMING A PEST FOLLOWING ESTABLISHMENT *< 9 = low pest risk; 9-14 = moderate pest risk; 15-19 = serious pest risk; > 19 = extreme pest risk*	10 11 11 11 10 11 11	**1. Fiery-shouldered Conure:** Moderate pest risk **2. Pearly Conure:** Moderate pest risk **3. Maroon-tailed Conure:** Moderate pest risk **4. Crimson-bellied Conure:** Moderate pest risk **5. Painted Conure:** Moderate pest risk **6. Rose-fronted Conure:** Moderate pest risk **7. Black-capped Conure:** Moderate pest risk
ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY		**MODERATE**

World distribution map for seven 'Amazon Basin' Conure species (*Pyrrhura sp.*) (IUCN Red List) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis:

Figure 1 - IUCN Red List map – Pyrrhura egregia

Figure 2 - IUCN Red List map – Pyrrhura lepida

Figure 3 - IUCN Red List map – Pyrrhura melanura

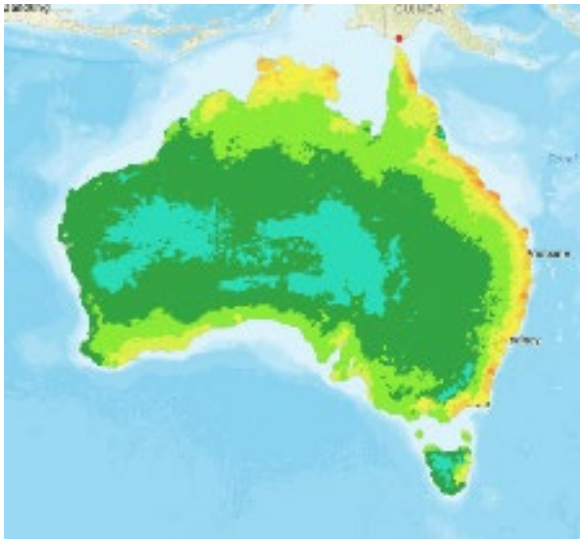
Figure 4 - IUCN Red List map – Pyrrhura perlata

Figure 5 - IUCN Red List map – Pyrrhura picta

Figure 6 - IUCN Red List map – Pyrrhura roseifrons

Figure 7- IUCN Red List map – Pyrrhura rupicola

Figure 8 – World Distribution map – Climatch



Score	Color	Count
0		0
1		3068
2		9637
3		4363
4		1208
5		655
6		267
7		37
8		1
9		0
10		0

Species: Pyrrhura sp ('Amazon Bason' Conures)
Algorithm: Closest Standard Score
588 source features selected
19236 target features selected
Approximate selected area: 7,080,024 km^2

Value X = 305 = 1 (Very Low)

1a. World distribution map for Fiery-shouldered Conure (*Pyrrhura egregia*) (IUCN Red List) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

Figure 1 - World Distribution Map - IUCN Red List

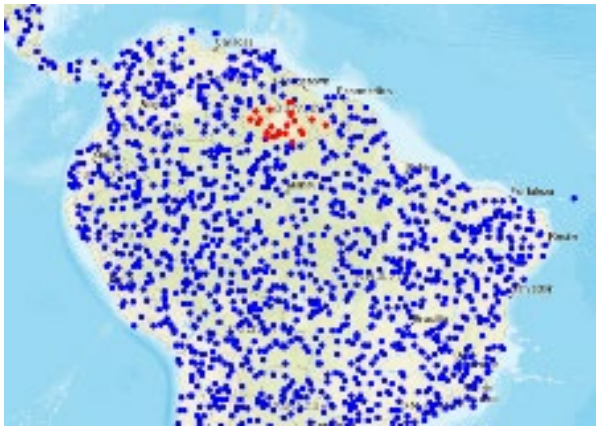


Figure 2 – World Distribution map – Climatch

1b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura egregia*

Value X = 0

Score	Color	Count
0		2
1		16670
2		2362
3		179
4		22
5		1
6		0
7		0
8		0
9		0
10		0

Species: Fiery-shouldered Conure (Pyrrhura egregia)
Algorithm: Closest Standard Score
24 source features selected
19236 target features selected
Approximate selected area: 395,538 km^2

2a. World distribution map for Pearly Conure (*Pyrrhura lepida*) (IUCN Red List) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

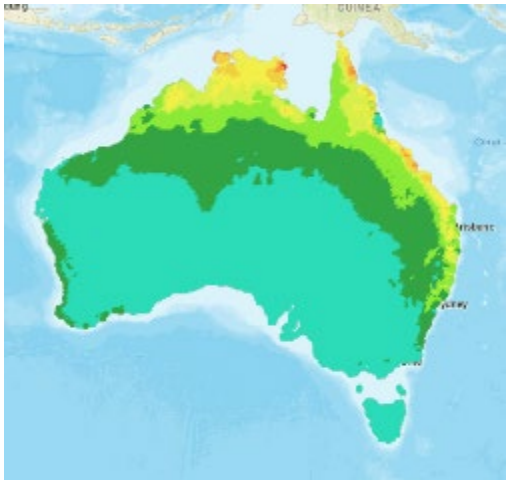
Figure 1 - World Distribution Map - IUCN Red List

Figure 2 – World Distribution map – Climatch

2b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura lepida*

Value X = 223



Score	Color	Count
0		0
1		10403
2		4925
3		2069
4		949
5		667
6		193
7		29
8		1
9		0
10		0

Species: Pearly Conure (Pyrrhura lepida)
Algorithm: Closest Standard Score
114 source features selected
19236 target features selected
Approximate selected area: 1,668,262 km^2

3a. World distribution map for Maroon-tailed Conure (*Pyrrhura melanura*) (IUCN Red List) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

Figure 1 - World Distribution Map - IUCN Red List

Figure 2 – World Distribution map – Climatch

3b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura melanura*

Value X = 61

Score	Color	Count
0		0
1		11488
2		5097
3		1755
4		610
5		225
6		57
7		4
8		0
9		0
10		0

Species: Maroon-tailed Conure (Pyrrhura melanura)
Algorithm: Closest Standard Score
178 source features selected
19236 target features selected
Approximate selected area: 2,422,662 km^2

4a. World distribution map for Crimson-bellied Conure (*Pyrrhura perlata*) (IUCN Red List) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

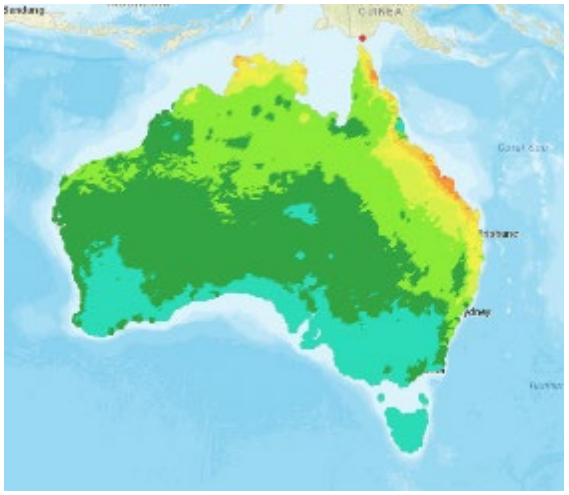
Figure 1 - World Distribution Map - IUCN Red List

Figure 2 – World Distribution map – Climatch

4b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura perlata*

Value X = 266



Score	Color	Count
0		0
1		2931
2		8765
3		5744
4		1000
5		530
6		208
7		56
8		2
9		0
10		0

Species: Crimson-bellied Conure (Pyrrhura perlata)
Algorithm: Closest Standard Score
106 source features selected
19236 target features selected
Approximate selected area: 1,699,264 km^2

5a. World distribution map for Painted Conure (*Pyrrhura picta*) (IUCN Red List) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

Figure 1 - World Distribution Map - IUCN Red List

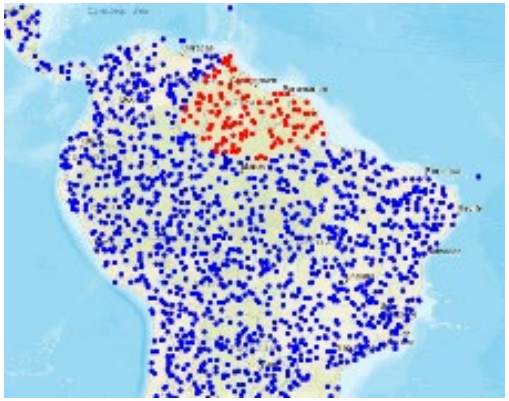


Figure 2 – World Distribution map – Climatch

5b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura picta*

Value X = 5

Score	Color	Count
0		0
1		12551
2		4273
3		2081
4		266
5		60
6		5
7		0
8		0
9		0
10		0

Species: Painted Conure (Pyrrhura picta)
Algorithm: Closest Standard Score
125 source features selected
19236 target features selected
Approximate selected area: 1,708,613 km^2

6a. World distribution map for Rose-fronted Conure (*Pyrrhura roseifrons*) (IUCN Red List) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

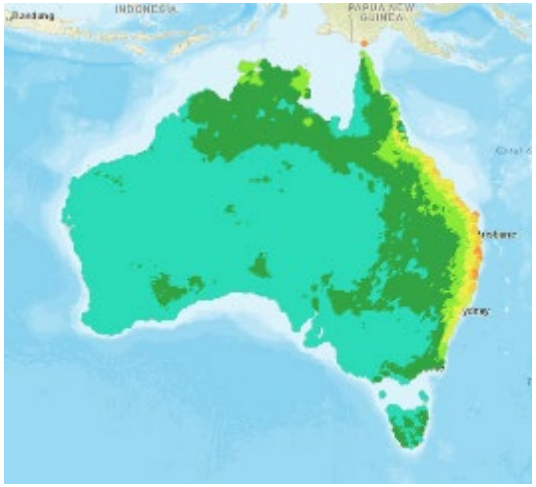
Figure 1 - World Distribution Map - IUCN Red List

Figure 2 – World Distribution map – Climatch

6b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura roseifrons*

Value X = 78



Score	Color	Count
0		0
1		12173
2		5734
3		879
4		224
5		148
6		67
7		11
8		0
9		0
10		0

Species: Rose-fronted Conure (Pyrrhura roseifrons)
Algorithm: Closest Standard Score
88 source features selected
19236 target features selected
Approximate selected area: 1,124,426 km^2

7a. World distribution map for Black-capped Conure (*Pyrrhura rupicola*) (IUCN Red List) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

Figure 1 - World Distribution Map - IUCN Red List

Figure 2 – World Distribution map – Climatch

7b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura rupicola*

Value X = 110

Score	Color	Count
0		0
1		6275
2		9781
3		2459
4		354
5		257
6		98
7		11
8		1
9		0
10		0

Species: Black-capped Conure (Pyrrhura rupicola)
Algorithm: Closest Standard Score
78 source features selected
19236 target features selected
Approximate selected area: 972,264 km^2

Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Climatch (50 km) Closest Standard Match Sum Level 6 (Value X)	2021 Recalibrated Climatch v2.0 (20 km) Closest Standard Match Sum Level 6 (Value X)
1 (Very low)	< 100	< 691
2 (Low)	100-599	691-4137
3 (Moderate)	600-899	4138-6209
4 (High)	900-1699	6210-11735
5 (Very high)	1700-2699	11736-18642
6 (Extreme)	≥ 2700	≥ 18643

Table 2: Susceptible Australian Primary Production – Calculating Total Commodity Damage Score

The commodity value index scores in this table are derived from Australian Bureau of Statistics 1999 – 2000 data. The values will require updating if significant change has occurred in the value of the commodity (Bomford 2008).

Industry	**Commodity Value Index 1 (CVI based on best available date)**	**Potential Commodity Impact Score (PCIS 0-3)**	**Climate Match to Commodity Score (CMCS 0–5)**	**Commodity Damage Score (CDS columns 2 X 3 X 4)**
Sheep (includes wool and sheep meat)	10			
Cattle (includes dairy and beef)	10			
Timber (includes native and plantation forests)	10			
Cereal grain (includes wheat, barley sorghum etc)	10	1	1	10
Pigs	2			
Poultry and eggs	2			
Aquaculture (includes coastal mariculture)	2			
Cotton	2			
Oilseeds (includes canola, sunflower etc)	2			
Grain legumes (includes soybeans)	2			
Sugarcane	2			
Grapes	2	1	1	2
Other Fruit	2	2	3	12
Vegetables	2			
Nuts	1			
Other livestock (includes goats, deer, camels, rabbits)	1			
Honey and beeswax	1			
Other horticulture (includes flowers etc)	1	1	1	1
Total Commodity Damage Score (TCDS)				25

Assess Potential Commodity Impact Scores for each primary production commodity listed in Table 9, based on species' attributes (diet, behaviour, ecology), excluding risk of spreading disease which is addressed in Question C9, and pest status worldwide as:

0. *Nil (species does not have attributes to make it capable of damaging this commodity)*
1. *Low (species has attributes making it capable of damaging this or similar commodities and has had the opportunity but no reports or other evidence that it has caused damage in any country or region*
2. *Moderate–serious (reports of damage to this or similar commodities exist but damage levels have never been high in any country or region and no major control programs against the species have ever been conducted OR the species has attributes making it capable of damaging this or similar commodities but has not had the opportunity)*
3. *Extreme (damage occurs at high levels to this or similar commodities and/or major control programs have been conducted against the species in any country or region and the listed commodity would be vulnerable to the type of harm this species can cause).*

Climate Match to Commodity Score (0–5)

- *None of the commodity is produced in areas where the species has a climate match within the highest eight climate match classes (ie classes 10, 9, 8, 7, 6, 5, 4 and 3) = 0*
- *Less than 10% of the commodity is produced in areas where the species has a climate match within the highest eight climate match classes = 1*
- *Less than 10% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes (ie classes 10, 9, 8, 7, 6 and 5) = 2*
- *Less than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes AND less than 10% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes (ie classes 10, 9 and 8) = 3*
- *Less than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes BUT more than 10% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes = 4*
- *OR More than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes BUT less than 20% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes = 4*
- *More than 20% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes OR overseas range unknown and climate match to Australia unknown = 5.]*

Table 3: Assigning species to EIC Threat Categories (shaded cells relate to assignment of reptiles and amphibians to EIC Threat Categories based on an assessed establishment risk and an allocated pest risk of extreme) – adapted from Bomford 2008

Establishment Risk	Pest Risk	Public Safety Risk	EIC Threat Category	Implication for any proposed import into Australia	Implication for keeping and movement in Australia
Extreme	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**	Prohibited, unless sufficient risk management measures exist to reduce the potential risks to an acceptable level	Limited to those collections approved for keeping particular EXTREME Threat species
Extreme	Serious	Highly, Moderately or Not Dangerous	**EXTREME**		
Extreme	Moderate	Highly, Moderately or Not Dangerous	**EXTREME**		
Extreme	Low	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Serious	Highly, Moderately or Not Dangerous	**EXTREME**		
Moderate	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Moderate	Highly, Moderately or Not Dangerous	**SERIOUS**	Import restricted to those collections approved for keeping SERIOUS Threat species	Limited to those collections approved for keeping particular SERIOUS Threat species
Serious	Low	Highly, Moderately or Not Dangerous	**SERIOUS**		
Moderate	Serious	Highly, Moderately or Not Dangerous	**SERIOUS**		
Moderate	Moderate	Highly Dangerous	**SERIOUS**		
Moderate	Low	Highly Dangerous	**SERIOUS**		
Low	Extreme	Highly, Moderately or Not Dangerous	**SERIOUS**		
Low	Serious	Highly, Moderately or Not Dangerous	**SERIOUS**		
Low	Moderate	Highly Dangerous	**SERIOUS**		
Low	Low	Highly Dangerous	**SERIOUS**		
Moderate	Moderate	Moderately or Not Dangerous	**MODERATE**	Import restricted to those collections approved for keeping MODERATE Threat species	Limited to those collections approved for keeping particular MODERATE Threat species
Moderate	Low	Moderately or Not Dangerous	**MODERATE**		
Low	Moderate	Moderately or Not Dangerous	**MODERATE**		
Low	Low	Moderately Dangerous	**MODERATE**		
Low	Low	Not Dangerous	**LOW**	Import permitted	May be limited to those collections approved for keeping particular LOW Threat species
Any Value	Any Value	Unknown	**EXTREME until proven otherwise**	Prohibited, unless sufficient risk management measures exist to reduce the potential risks to an acceptable level	Limited to those collections approved for keeping particular EXTREME Threat species
Unknown	Any Value	Any Value	**EXTREME until proven otherwise**		
Any Value	Unknown	Any Value	**EXTREME until proven otherwise**		
Unassessed	Unassessed	Unassessed	**EXTREME until proven otherwise**		

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Date:	August 2023
Reviewers:	Win Kirkpatrick, DPAW

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National Risk Assessment: EXTREME

RISK ASSESSMENT FOR AUSTRALIA: Horse (*Equus caballus*)

Class - Mammalia**, Order -** Perissodactyla**, Family -** Equidae**, Genus -** *Equus*.

SPECIES: *Equus caballus* (Linnaeus, 1758) **Synonyms:** *Equus asinus* subsp. *hippagrus* (Smith, 1841) *Equus caballus* subsp. *caballus* (Linnaeus, 1758) *Equus caballus* subsp. *domesticus* (Linnaeus, 1758) *Equus caballus* subsp. *ferus* (Boddaert, 1785) *Equus caballus* subsp. *przewalskii* (Poliakov, 1881) *Equus caballus* subsp. *fossilis* *Equus caballus* subsp. *gallicus* *Equus caballus* subsp. *germanicus* *Equus caballus* subsp. *piveteaui* *Equus* curvidens (Owen, 1845) *Equus ferus* subsp. *caballus* (Linnaeus, 1758) *Equus hippagrus* (Smith, 1841) *Equus neogaeus* (Lund, 1840) *Equus neogeus* (Lund, 1840) *Equus rectidens* (Gervais & Ameghino, 1880) *Hippagrus bravardi* (Ameghino, 1889) *Hippidium neogaeum* (Lund, 1840)	**Species description:** Morphologically, feral horses are no different in general appearance to domestic horses. Both forms are variable, depending on breeding and origin of parent stock. Horses are large herbivores, with long, strong legs that are well adapted and facilitate efficient long-distance travel across open grassy plains in search of food and water. Average size is around 1.5 metres head height, and they average 1–1.6 metres shoulder (or wither) height (the wither can range in diameter from 0.8 metres to 1.8 metres). The average weight of a feral horse is between 350–500 kilograms, however their weight can range from 200 to 700 kilograms. Coat colour is variable, ranging from white, tan, brown, or black to patches of oranges and browns on white. Coat hairs are short and fine, growing longer in winter. The tail is relatively short but has long hairs that can reach the ground. There is also long hair along the neck (mane) and forehead (forelock). **General information:** Domestic horses arrived in Australia with the First Fleet in 1788. The first record of escape or release was in 1804. Feral horses were first recognised as “pests” in the 1860s. Currently, there may be more than 400,000 feral horses in Australia. The modern horse was domesticated 2,500–5,000 years ago from its wild ancestors. The exact date of domestication is subject to debate and mitochondrial DNA analysis suggests that domestication may have occurred independently at multiple sites across the world (Pennisi, 2001; cited in Walter, 2002). Feral horses can occupy a wide range of habitats although they are best adapted to open grassy plains. In Australia, feral horses inhabit country ranging from deserts, semi-desert plains, rocky ranges, tropical savannah grasslands, forests, scrubs, subalpine mountains, small offshore islands and even some wetlands. Feral horses are commonly found in areas of low pastoral value away from the more intensively managed areas, although they usually select the best country on which to graze. While feral horses tend to prefer grassy flats, they readily retreat to hill country to escape drought or mustering activities (Dobbie et al., 1993).

Common Names: Horse Domestic Horse Feral Horse Wild Horse Brumby Mustang	In the past, the natural range of *Equus ferus* (“tarpan” or “wild horse”), one of the ancestors of today’s domestic horse, ranged across Eurasia, from eastern Poland and Hungary east to northern Turkestan and Mongolia (Long, 2003). Feral populations of the modern domestic horse exist in France, Greece, Portugal, Spain, Sri Lanka, Iran, United States of America, Alaska, Canada, Mexico, Columbia, West Indies, New Zealand, Hawaii, Galapagos, Africa, United Kingdom, Russia, South America (Argentina, Chile and Patagonia), Falkland Islands, Kerguelen islands and Hispaniola (Lever, 1985; Long, 2003). In some countries, feral horses are strictly managed, and in some places protected, as they are a resource. In other areas they are unwanted pests, mainly where they compete with more valuable livestock, such as cattle, and cause expensive damage to fences and watering points (Long, 2003). Horses are non-ruminant herbivores. They constantly graze, eating approximately 2–2.5% of their body weight daily. Roughage is broken down by microbial fermentation in the caecum and large colon. Feral horses may spend 51–75% of their time feeding. They prefer to feed in areas with the greatest concentration of high-quality green food. Grasses are preferred, but they will also consume green or dead perennial herbaceous plants, roots, bark, buds, and fruits. Horses are selective feeders and may walk up to 50 kilometres from water to find suitable feed. In central Australia, feral horses graze near drinking water if feed is plentiful, although as feed is depleted, they are forced to forage further from water to areas that are less intensively grazed by other herbivores. Horses need to drink at least 45 litres of water each day. Harem stallions, mares and foals require reliable resources and generally favour areas surrounding permanent waterholes. Bachelor groups are more mobile and more readily occupy areas where water is less reliable, needing to maintain only their own condition for growth. They probably return to more predictable areas for food and water when they are old enough to acquire mares, or in periods of drought. Horses relying solely on temporary waters are more prone to perish during drought (Dobbie et al., 1993; NSW National Parks and Wildlife Service, 2003). Sexual maturity is reached at 18 months to 2 years with a gestation period between 320-360 days. Both males and females can reproduce at an early age, but females do not physically mature until about 4 years of age, and males generally do not breed until they have achieved dominance at about 5 years of age. Females older than 4 years are referred to as “mares”, and non-castrated males older than 4 years are referred to as “stallions”. Infertility often occurs during the mare’s first oestrus; however, pregnancy rates subsequently exceed 90%. Foaling is generally in spring and summer. A new-born foal is kept in a quiet place and not introduced to the rest of the social group until it is 9 days old. Foals are weaned gradually, sometimes not being fully dependent on solids until they are 2 years old, although this is unusual.

	A post-partum oestrus occurs in the female, with mares returning to heat 9–14 days after giving birth. Therefore, they may be pregnant and lactating at the same time, and breeding often occurs at the same time as foaling. Sex ratio is about even at birth, but male mortality is greater at all ages and adult sex ratio may be expected to be about 1:2 or more. The rate of twinning is very low. Feral horses in Australia produce on average 1 foal every 2 years (Dobbie et al., 1993; Groves, 1989). Feral horses tend to form small social units, either in a harem, which consists of a dominant stallion, his mares and their offspring, or in a bachelor group, a group of 1 to 3 males comprising mainly 2 to 4 year olds who have been forced out of their natal harem groups. Young females experiencing first oestrus are usually ignored by the dominant stallion and often leave their groups. Females may remain unattached for up to a year before forming a harem with a bachelor male or joining an existing harem. A female is likely to stay in the harem in which she first becomes pregnant. Mares may bond closely and participate in mutual grooming. Small social groups tend to coalesce into large herds of 100 or more horses at watering points during drought. When groups come into close contact, stallions will posture and threaten other stallions. Interactions can sometimes escalate into fights and chases. Intergroup dominance hierarchies have often been observed at water sources, and more dominant groups will gain access before other groups. Feral horses are diurnal and crepuscular. They may seek out shade during the middle of the day (Dobbie et al., 1993; Groves, 1989; McCort, 1984). Harem groups, bachelor groups, and all-female groups usually occupy home ranges, with well-defined boundaries. In central Australia, feral horses have a home range of about 70 square kilometres, and horses in the Australian Alps are thought to have smaller home ranges of about 32 square kilometres. Horses resist being moved from their home area, for example during mustering (NSW National Parks and Wildlife Service, 2003). **Longevity:** 57 years maximum longevity in captivity (AnAge); dwarf or miniature horses appear to live longer. One Icelandic miniature horse named "Tulle" is reported to have lived 57 years. Anecdotal evidence tells of a horse, called "Old Billy," that lived for 62 years in England, but that record is unverified (AnAge). The oldest domestic horse is recorded as being 61 years old (Willoughby, 1974). The average lifespan is from 25-30 years (Groves, 1989;). **Conservation status:** **IUCN:** Not listed

	CITES: Not listed
DATE OF ASSESSMENT: June 2023 (Jodi Buchecker) **Risk assessment model used for the assessment:** Bomford 2008, Bird and Mammal Model	**The risk assessment model:** Models for assessing the risk that exotic vertebrates could establish in Australia have been developed for mammals, birds (Bomford 2003, 2006, 2008), reptiles and amphibians (Bomford et al 2005, Bomford 2008). Developed by Dr Mary Bomford for the Bureau of Rural Sciences (BRS), the model uses criteria that have been demonstrated to have significant correlation between a risk factor and the establishment of populations of exotic species and the pest potential of those species that do establish. For example, a risk factor for establishment is similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia. For pest potential, the species' overseas pest status is a risk factor. The model is published as 'Risk assessment models for the establishment of exotic vertebrates in Australia and New Zealand' (Bomford 2008) and is available online on the PestSmart website https://pestsmart.org.au/wp-content/uploads/sites/3/2020/06/Risk_Assess_Models_2008_FINAL.pdf **CLIMATE**: In 2021 a new version of the Climatch program used to assess similarity in climate was released by the Australian Bureau of Agricultural Resource Economics and Sciences (ABARES): CLIMATCH v2.0. The increase in resolution in this new version (from 50 km to 20 km) required recalibration of Climate Match Scores. See Table 1. Sixteen climate parameters (variables) of temperature and rainfall are used to estimate the extent of similarity between data from meteorological stations located within the species' world distribution and stations in Australia. Worldwide, data from approximately 19000 locations are available for analysis. The number of locations used in an analysis will vary according to the size of the species' distribution and the number of meteorological stations located within that distribution. To represent the climate match visually, the map of Australia is divided into 19236 grid squares, each measured in 0.2 degrees in both longitude and latitude. CLIMATCH v2.0 calculates a match for each Australian grid by comparing data from all meteorological stations within the species' distribution (excluding any populations in Australia) and allocating a score ranging from ten for the highest level match to zero for the poorest match. Levels of climate match are used in the risk assessment for questions B1 (scores are summed to give a cumulative score), C6, and C8. Climatch v2.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/.

Bird and Mammal Model:

FACTOR	**SCORE**	**DETAIL**
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
A1. Risk to people from individual escapees (0–2) *Assess the risk that individuals of the species could harm people. (NB, this question only relates to aggressive behaviour shown by*	2	*Animal that sometimes attacks when unprovoked and/or is capable of causing serious injury (requiring hospitalisation) or fatality.*

escaped or released individual animals. Question C11 addresses the risk of harm from aggressive behaviour if the species establishes a wild population). *Aggressive behaviour, size, plus the possession of organs capable of inflicting harm, such as sharp teeth, claws, spines, a sharp bill, or toxin-delivering apparatus may enable individual animals to harm people. Any known history of the species attacking, injuring or killing people should also be taken into account. Assume the individual is not protecting nest or young.*		Horses can cause serious injury or fatality if cornered or handled.
A2. Risk to public safety from individual captive animals (0–2) *Assess the risk that irresponsible use of products obtained from captive individuals of the species (such as toxins) pose a public safety risk (excluding the safety of anyone entering the animals' cage/enclosure or otherwise coming within reach of the captive animals)*	0	*Nil or low risk (highly unlikely or not possible).*
STAGE A PUBLIC SAFETY RISK SCORE **SUM A1 - A2 (0-4)**	2	**Highly dangerous**
STAGE B: PROBABILITY ESCAPED OR RELEASED INDIVIDUALS WILL ESTABLISH FREE-LIVING POPULATIONS		
Model 1: FOUR-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)		
B1. Degree of climate match between species overseas range and Australia (1–6) *Map the selected mammal or bird species' overseas range, including its entire native and exotic (excluding Australia) ranges over the past 1000 years.* *Use CLIMATCH v2.0, Value X = sum of classes 6 – 10, see Table 1.*	6	*Extreme climate match to Australia.* Value X = 19,015 Climate Match Score = 6
B2. Exotic population established overseas (0–4) *An established exotic population means the introduced species must have bred outside of captivity and must currently maintain a viable free-living population where the animals are not being intentionally fed or sheltered, even though they may be living in*	4	*Exotic population established on a larger island (> 50,000 km^2) or anywhere on a continent (including elsewhere on the land mass where the natural distribution of the animal is, if this population is due to human introduction and is geographically separate from the natural range of the species).*

a highly disturbed environment with access to non-natural food supplies or shelter.		Feral populations of the modern domestic horse exist in France, Greece, Portugal, Spain, Sri Lanka, Iran, United States of America, Alaska, Canada, Mexico, Columbia, West Indies, New Zealand, Hawaii, Galapagos, Africa, United Kingdom, Russia, South America (Argentina, Chile and Patagonia), Falkland Islands, Kerguelen islands and Hispaniola (Lever, 1985; Long, 2003).
B3. Overseas range size score (0–2) < 1 = 0; 1– 70 = 1; >70 = 2 *Estimate the species overseas range size* including currently and the past 1000 years; natural and introduced range in millions of square kilometres*	1	*Overseas range size between 1 and 70 million square kilometres.*
B4. Taxonomic Class (0–1) *Bird = 0; mammal = 1*	1	*Mammal*
B. ESTABLISHMENT RISK SCORE SUM OF B1- B4 (1–13)	12	**Extreme establishment risk**
Model 2: Seven-Factor Model For Birds And Mammals (Bomford 2008)		
B5. Diet score (0–1) *Specialist = 0; generalist = 1*	1	*Generalist with a broad diet of many food types.* Horses are generalist and non-ruminant herbivores. Grasses are preferred, but they will also consume green or dead perennial herbaceous plants, roots, bark, buds, and fruits.
B6. Habitat score (0–1) *Undisturbed or disturbed habitat*	1	*Can survive and breed in human-disturbed habitats (including grazing and agricultural lands, forests that are intensively managed or planted for timber harvesting and/or urban–suburban environments) without access to undisturbed (natural) habitats.* Feral horses can live in human-disturbed habitat including grazing and agricultural lands.
B7. Migratory score (0–1) *Always migratory = 0; non-migratory = 1*	1	*Non-migratory.*
B. ESTABLISHMENT RISK SCORE SUM OF B1- B7 (1–16)	15	**Extreme establishment risk**
STAGE C: PROBABILITY AN ESTABLISHED SPECIES WILL BECOME A PEST		

C1. Taxonomic group (0–4)	2	*Mammal in one of the orders that have been demonstrated to have detrimental effects on prey abundance and/or habitat degradation (Perissodactyla).*
C2. Overseas range size including current and past 1000 years, natural and introduced range (0–2) *Estimate the species overseas range size (including current and past 1000 years, natural and introduced range) in millions of square kilometres*	1	*Overseas range size estimated to be between 10 and 30 million square kilometres* The overseas range is based on a combination of world distribution maps taken from GBIF (reported sightings of feral/free-roaming horses) and CABI Compendium (countries where feral/free-roaming horses are known to be present).
C3. Diet and feeding (0–3)	3	*Mammal that is primarily a grazer or browser.*
C4. Competition with native fauna for tree hollows (0–2)	0	*Does not use tree hollows.*
C5. Overseas environmental pest status (0–3) *Has the species been reported to cause declines in abundance of any native species of plant or animal or cause degradation to any natural communities in any country or region of the world?*	2	*Moderate environmental pest in any country or region.* In New Zealand, horses were introduced in 1814, and wild horses were reported in the Kaimanawa mountains on North Island by 1876 (Boyd, 2023). The descendants are now known as Kaimanawa horses. A study of their impacts found that trampling and grazing fractured the saturated turf, causing downslope sedimentation, water ponding, and opportunities for the establishment of weeds. A number of habitat types, including rare plant habitats, have been degraded by grazing feral horses (Rogers, 1994). A study in Nevada (United States of America) found that plots around springs that were protected from horses had significantly higher plant species richness, percentage ground cover, and abundance of grasses and shrubs, as well as more small mammal burrow entrances, compared with horse-grazed springs (Beever and Brussard, 2000). Subsequent research found that in areas where horses were removed, ants and ant mounds were more abundant (Beever and Herrick, 2006). At a salt marsh site, grazing and trampling by feral horses reduced above-ground biomass by 50–55%. The abundance of periwinkle snails (*Littorina irrorata*) was also reduced (Turner, 1987). A further study of salt marshes in the United States found that areas grazed by feral horses had less vegetation, a higher diversity of foraging birds,

		higher densities of crabs, and a lower density and fish species richness, compared with horse-free marshes (Levin et al., 2002). Grazing by feral horses on Assateague Island (United States) was found to significantly alter dune morphology and cause unnaturally high rates of dune erosion (De Stoppelaire et al., 2004). Research in a grass steppe area of Argentina found that feral horses increased predation of bird eggs from 12.5% (ungrazed) to 70% (grazed). It is thought that grazing increases the visibility of bird nests, increasing predation and having a significant impact on the population dynamics of local grassland birds (Zalba and Cozzani, 2004).
C6. Climate match to areas with susceptible native species or communities (0–5) *Identify any native Australian animal or plant species or communities that could be susceptible to harm by the exotic species if it were to establish a wild population here.*	5	*The species has more than 139 grid squares within the highest two climate match classes that overlap the distribution of any susceptible native species or ecological communities = 5* Examples of susceptible native species or ecological communities include (NSW Dept of Primary Industries): *Galaxias tantangara* (Stocky Galaxias) – Critically Endangered *Pseudophryne corroboree* (Southern Corroboree Frog) – Critically Endangered *Mastacomys fuscus* (Broad-toothed Rat) – Threatened Alpine Sphagnum Bogs and Associated Fens ecological community – Endangered
C7. Overseas primary production pest status (0–3) *Has the species been reported to damage crops or other primary production in any country or region of the world?*	1	*Minor pest of primary production in any country or region.* Horses are recorded as a minor pest to primary production overseas. In some areas of the world they compete with more valuable livestock, such as cattle, and cause expensive damage to fences and watering points (Long, 2003).
C8. Climate match to susceptible primary production (0–5) *Assess Potential Commodity Impact Scores for each primary production commodity listed in Table 9, based on species'*	5	Total Commodity Damage Score = 208 (see Table 2)

attributes (diet, behaviour, ecology), excluding risk of spreading disease which is addressed in Question C9. *0 = 0; 1-19 = 1; 20-49 = 2; 50-99 = 3; 100-149 = 4; ≥150 = 5*		
C9. Spread disease (1–2) *Assess the risk that the species could play a role in the spread of disease or parasites to other animals*	2	*All mammals (likely or unknown effect on native species and on livestock and other domestic animals).* Horses are susceptible to a range of exotic diseases including a number that are not yet established in Australia. Examples include: African horse sickness, borna disease, bovine brucellosis, contagious equine metritis, dourine, epizootic lymphangitis, equine babesiosis, equine encephalosis, equine influenza, equine morbillivirus pneumonia, equine viral encephalomyelitis, getah virus disease, glanders, Japanese encephalitis, louping ill and other tick-borne encephalitides, Potomac fever, rabies, screw-worm fly, surra, trichinellosis, vesicular stomatitis and warble-fly myiasis (Geering et al., 1995). As such, feral horses are a potential reservoir of exotic diseases (Dobbie et al., 1993).
C10. Harm to property (0–3) *Assess the risk that the species could inflict damage on buildings, vehicles, fences, roads, equipment or ornamental gardens by chewing or burrowing or polluting with droppings or nesting material.*	2	*$11 - $50 million dollars.* Capable of causing expensive damage to fences and watering points (Long, 2003).
C11. Harm to people (0–5) *Assess the risk that, if a wild population established, the species could cause harm to or annoy people. Aggressive behaviour, plus the possession of organs capable of inflicting harm, such as sharp teeth, tusks, claws, spines, a sharp bill, horns, antlers or toxin delivering organs may enable animals to harm people. Any known history of the species attacking, injuring or killing people should also be taken into account (see Stage A, Score A1).*	4	*Serious risk. Injuries or harm severe or fatal but few people at risk.* As feral horses often have limited or no experience with human interaction, they may view people as predators and react to them with extreme fear, flight responses, or defensive aggression (Bertone, 2006). Feral horses have the potential to cause serious motor vehicle accidents when they crossroads (Dawson et al., 2006). In remote areas of national parks, there is concern about the safety of visitors that may be confronted with an aggressive stallion (Weaver, 2007).
C. PEST RISK SCORE **SUM C 1 TO C 11 (1–37)**	27	**Extreme pest risk**

STAGE A. PUBLIC SAFETY RISK RANK – RISK TO PUBLIC SAFETY POSED BY CAPTIVE OR RELEASED INDIVIDUALS *0 = Not dangerous; 1 = Moderately dangerous; ≥ 2 = Highly dangerous*	2	Highly dangerous
STAGE B. ESTABLISHMENT RISK RANK – RISK OF ESTABLISHING A WILD POPULATION **MODEL 1: FOUR-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)** *≤ 5 = low establishment risk; 6-8 = moderate establishment risk; 9-10 = serious establishment risk; ≥ 11-13 = extreme establishment risk*	12	Extreme establishment risk
STAGE B. ESTABLISHMENT RISK RANK – RISK OF ESTABLISHING A WILD POPULATION **MODEL 2: SEVEN-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)** *≤ 6 = low establishment risk; 7-11 = moderate establishment risk; 12-13 = serious establishment risk; ≥14 = extreme establishment risk*	15	Extreme establishment risk
STAGE C. PEST RISK RANK - RISK OF BECOMING A PEST FOLLOWING ESTABLISHMENT *< 9 = low pest risk; 9-14 = moderate pest risk; 15-19 = serious pest risk; > 19 = extreme pest risk*	27	Extreme pest risk

ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY	**EXTREME**

World distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

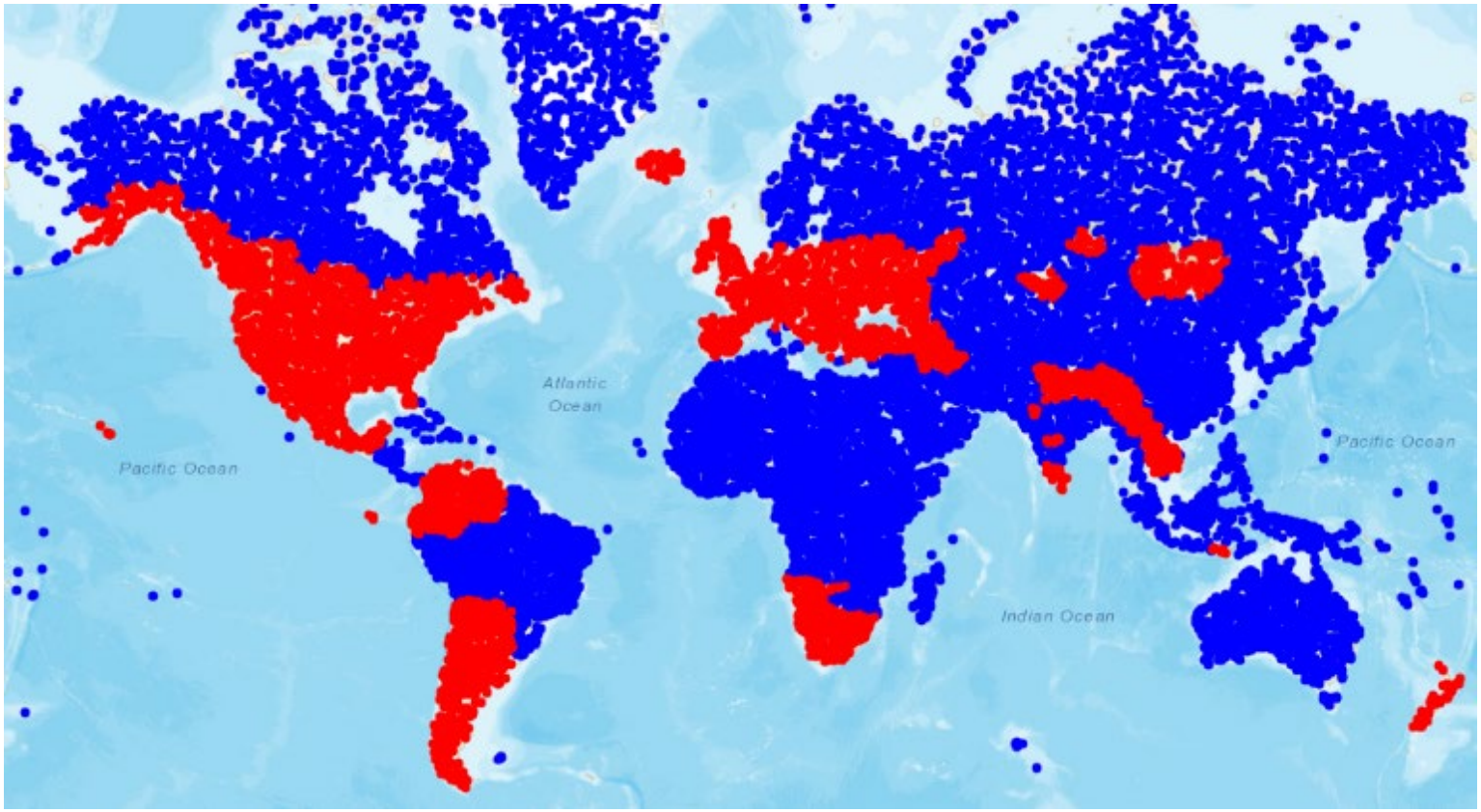


Figure 1 - World Distribution map – Climatch

No IUCN Map available.

World distribution maps GBIF:

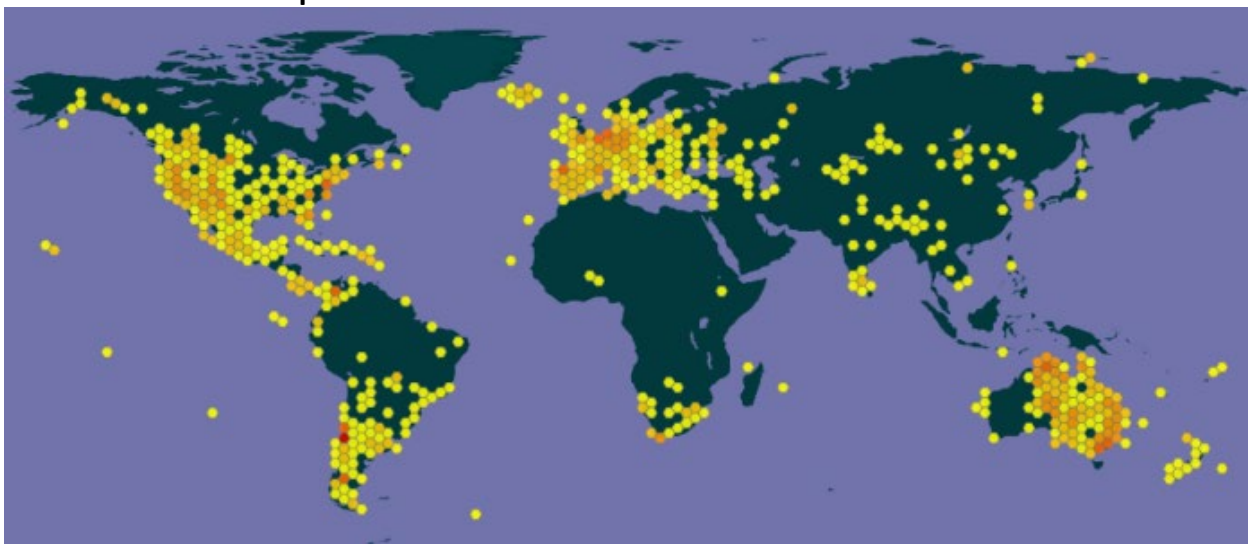


Figure 2 - World Georeferenced records (GBIF)

World distribution maps CABI Compendium Digital Library:

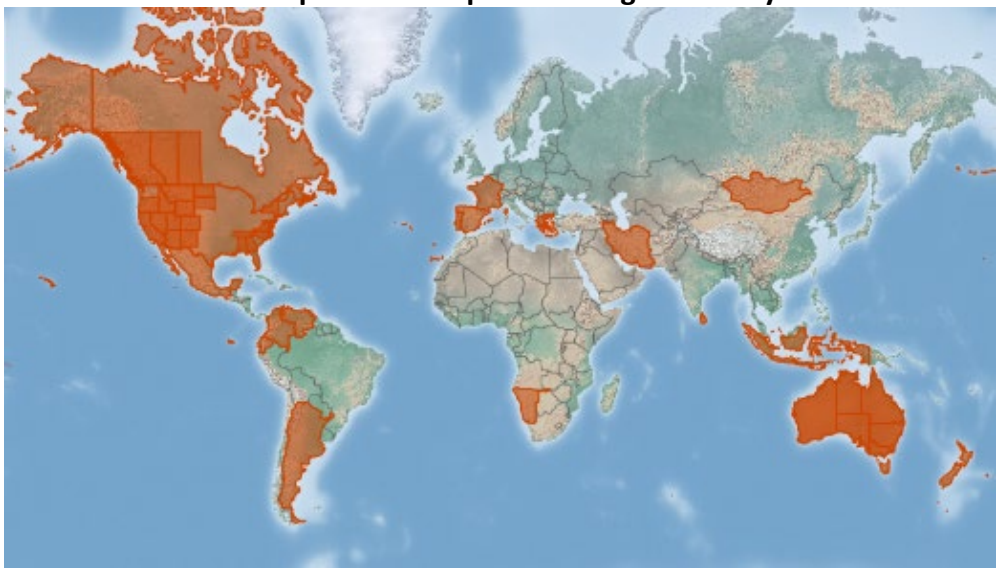
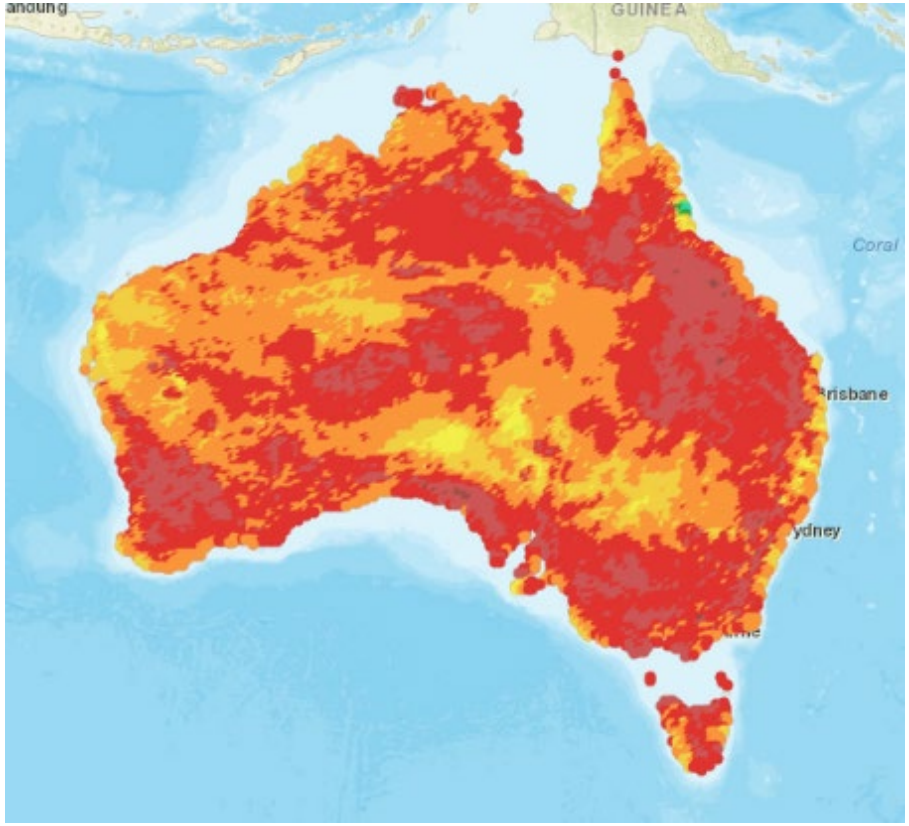


Figure 3 – CABI Compendium Digital map

Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Equus caballus*

Value X = 19,015



Score	Color	Count
0		0
1		2
2		5
3		2
4		5
5		207
6		1564
7		6643
8		8053
9		2732
10		23

Species: Horse (Equus caballus)
Algorithm: Closest Standard Score
4544 source features selected
19236 target features selected
Approximate selected area: 37,877,281 km^2

Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Climatch (50 km) Closest Standard Match Sum Level 6 (Value X)	2021 Recalibrated Climatch v2.0 (20 km) Closest Standard Match Sum Level 6 (Value X)
1 (Very low)	< 100	< 691
2 (Low)	100-599	691-4137
3 (Moderate)	600-899	4138-6209
4 (High)	900-1699	6210-11735
5 (Very high)	1700-2699	11736-18642
6 (Extreme)	≥ 2700	≥ 18643

Table 2: Susceptible Australian Primary Production – Calculating Total Commodity Damage Score

The commodity value index scores in this table are derived from Australian Bureau of Statistics 1999 – 2000 data. The values will require updating if significant change has occurred in the value of the commodity (Bomford 2008).

Industry	**Commodity Value Index 1 (CVI based on best available date)**	**Potential Commodity Impact Score (PCIS 0-3)**	**Climate Match to Commodity Score (CMCS 0–5)**	**Commodity Damage Score (CDS columns 2 X 3 X 4)**
Sheep (includes wool and sheep meat)	10	2	4	80
Cattle (includes dairy and beef)	10	2	4	80
Timber (includes native and plantation forests)	10			
Cereal grain (includes wheat, barley sorghum etc)	10	1	3	30
Pigs	2			
Poultry and eggs	2			
Aquaculture (includes coastal mariculture)	2			
Cotton	2			
Oilseeds (includes canola, sunflower etc)	2	1	3	6
Grain legumes (includes soybeans)	2	1	3	6
Sugarcane	2			
Grapes	2			
Other Fruit	2	1	1	2
Vegetables	2	1	1	2
Nuts	1			
Other livestock (includes goats, deer, camels, rabbits)	1	1	1	1
Honey and beeswax	1			
Other horticulture (includes flowers etc)	1	1	1	1
Total Commodity Damage Score (TCDS)				208

Assess Potential Commodity Impact Scores for each primary production commodity listed in Table 9, based on species' attributes (diet, behaviour, ecology), excluding risk of spreading disease, which is addressed in Question C9, and pest status worldwide as:

0. *Nil (species does not have attributes to make it capable of damaging this commodity)*
1. *Low (species has attributes making it capable of damaging this or similar commodities and has had the opportunity but no reports or other evidence that it has caused damage in any country or region*
2. *Moderate–serious (reports of damage to this or similar commodities exist but damage levels have never been high in any country or region and no major control programs against the species have ever been conducted OR the species has attributes making it capable of damaging this or similar commodities but has not had the opportunity)*
3. *Extreme (damage occurs at high levels to this or similar commodities and/or major control programs have been conducted against the species in any country or region and the listed commodity would be vulnerable to the type of harm this species can cause).*

Climate Match to Commodity Score (0–5)

- *None of the commodity is produced in areas where the species has a climate match within the highest eight climate match classes (ie classes 10, 9, 8, 7, 6, 5, 4 and 3) = 0*
- *Less than 10% of the commodity is produced in areas where the species has a climate match within the highest eight climate match classes = 1*
- *Less than 10% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes (ie classes 10, 9, 8, 7, 6 and 5) = 2*
- *Less than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes AND less than 10% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes (ie classes 10, 9 and 8) = 3*
- *Less than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes BUT more than 10% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes = 4*
- *OR More than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes BUT less than 20% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes = 4*
- *More than 20% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes OR overseas range unknown and climate match to Australia unknown = 5.]*

Table 3: Assigning species to EIC Threat Categories (shaded cells relate to assignment of reptiles and amphibians to EIC Threat Categories based on an assessed establishment risk and an allocated pest risk of extreme) – adapted from Bomford 2008

Establishment Risk	Pest Risk	Public Safety Risk	EIC Threat Category	Implication for any proposed import into Australia	Implication for keeping and movement in Australia
Extreme	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**	Prohibited, unless sufficient risk management measures exist to reduce the potential risks to an acceptable level	Limited to those collections approved for keeping particular EXTREME Threat species
Extreme	Serious	Highly, Moderately or Not Dangerous	**EXTREME**		
Extreme	Moderate	Highly, Moderately or Not Dangerous	**EXTREME**		
Extreme	Low	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Serious	Highly, Moderately or Not Dangerous	**EXTREME**		
Moderate	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Moderate	Highly, Moderately or Not Dangerous	**SERIOUS**	Import restricted to those collections approved for keeping SERIOUS Threat species	Limited to those collections approved for keeping particular SERIOUS Threat species
Serious	Low	Highly, Moderately or Not Dangerous	**SERIOUS**		
Moderate	Serious	Highly, Moderately or Not Dangerous	**SERIOUS**		
Moderate	Moderate	Highly Dangerous	**SERIOUS**		
Moderate	Low	Highly Dangerous	**SERIOUS**		
Low	Extreme	Highly, Moderately or Not Dangerous	**SERIOUS**		
Low	Serious	Highly, Moderately or Not Dangerous	**SERIOUS**		
Low	Moderate	Highly Dangerous	**SERIOUS**		
Low	Low	Highly Dangerous	**SERIOUS**		
Moderate	Moderate	Moderately or Not Dangerous	**MODERATE**	Import restricted to those collections approved for keeping MODERATE Threat species	Limited to those collections approved for keeping particular MODERATE Threat species
Moderate	Low	Moderately or Not Dangerous	**MODERATE**		
Low	Moderate	Moderately or Not Dangerous	**MODERATE**		
Low	Low	Moderately Dangerous	**MODERATE**		
Low	Low	Not Dangerous	**LOW**	Import permitted	May be limited to those collections approved for keeping particular LOW Threat species
Any Value	Any Value	Unknown	**EXTREME until proven otherwise**	Prohibited, unless sufficient risk management measures exist to reduce the potential risks to an acceptable level	Limited to those collections approved for keeping particular EXTREME Threat species
Unknown	Any Value	Any Value	**EXTREME until proven otherwise**		
Any Value	Unknown	Any Value	**EXTREME until proven otherwise**		
Unassessed	Unassessed	Unassessed	**EXTREME until proven otherwise**		

Risk Assessor's details:

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Date:	June 2023
Reviewers:	Rachel Robbins, DCCEEW Win Kirkpatrick, DPAW

Adapted from:	INVASIVE ANIMAL RISK ASSESSMENT for Feral Horse (*Equus caballus*). Steve Csurhes, Gina Paroz and Anna Markula, Dept of Agriculture and Fisheries, Biosecurity Queensland (first published 2009, updated 2016)	**By:** Jodi Buchecker	**Date:** Jun 2023

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National Risk Assessment: MODERATE

RISK ASSESSMENT FOR AUSTRALIA: Black-and-White Ruffed Lemur (*Varecia variegata*)

Class - Mammalia**, Order -** Primates**, Family -** Lemuridae**, Genus -** *Varecia*.

SPECIES: *Varecia variegata* (Kerr, 1792) **Synonyms:** *Lemur macaco variegatus* (Kerr, 1792) **Subspecies:** *Varecia variegata editorum* (Hill, 1953) *Varecia variegata subcincta* (Smith, 1833) *Varecia variegata variegata* (Kerr, 1792) **Common Names:** Black-and-White Ruffed Lemur Ruffed Lemur **Subspecies common names:** *V. v. editorum* - Southern Black-and-White Ruffed Lemur *V. v. subcincta* - Northern Black-and-White Ruffed Lemur	**Species description:** Black-and-white ruffed lemurs are variably covered in black and white fur. Head-body length measures approximately 45 centimetres and tail length at 60 - 61 centimetres. Males and females weigh between 3 - 6 kilograms and 3-7 kilograms respectively. The three subspecies differ slightly but significantly in body weight and tail length; the northern black-and-white ruffed lemur (*V. v. subcincta*) is the smallest in this respect, and the Southern black-and-white ruffed lemur (*V. v. editorum*) is the largest. Apart from longer tails in females, there is no difference in size or colouration between sexes. The coat is fluffy, the tail is long and bushy, and ears are ruffed with long thick white hair. There are some differences in distribution and pattern of black and white in the coat depending on the locality and subspecies; and intermediate forms also exist (Groves, 2001). In general, individuals are predominantly white to the south of the range (with black often restricted to shoulders and flanks) and increasingly black to the north (with a white band around the body and white forearms and flanks). In the variegated black-and-white ruffed lemur (*V. v. variegata*), fur is black on the abdomen, tail, extremities, inner aspects of limbs, forehead, circumorbital area, and top of the head. In contrast, the back, flanks, rump, and most of the hindlimbs are usually white. Shoulders are black. There is a thick white longitudinal band in the centre of the back that distinguishes the variegated black-and-white ruffed lemur from southern black-and-white ruffed lemur. **General information:** Endemic to the eastern rainforest of Madagascar, black-and-white ruffed lemurs are arboreal and spend most of their time in the tree canopy (Animalia). Three subspecies are recognised. Habitat: The variegated black-and-white ruffed lemur inhabits remnant tracts of tropical moist lowland and montane forest from sea level to 1,300 metres. The southern black-and-white ruffed lemur inhabits lowland to mid-altitude primary and secondary rainforests from sea level to 1,300 metres. The northern black-and-white ruffed lemur prefers lowland rainforest. Distribution is very patchy throughout its range, except for Nosy Mangabe, where it lives at a relatively high density (Morland, 1991).

V. v. variegata - Variegated Ruffed Lemur	Diet: almost exclusively frugivorous. As they are very selective feeders, they are especially susceptible to disturbance (Seaman, 2018; Ratsimbazafy, 2002; White, 1995). In the Vatovavy and Sangasanga regions, black-and-white ruffed lemur's favour areas far from the forest edge, and areas with a large basal area of known food species (GBIF). The black-and-white ruffed lemur is polygamous. Females have a 30-day reproductive cycle. The vulva remains closed except during oestrus. Reproduction varies considerably between years, with an average interbirth interval of 1 year. In breeding years, females usually give birth to 2 to 3 young (mean 2.7 infants per litter (Baden, 2013)), which are left in a nest when young and afterwards carried in the mother's mouth (Baden, 2011, 2013). During gestation, black-and-white ruffed lemur mothers build several nests. Nest location and density has been linked to the distribution and availability of preferred food resources within the area (Baden, 2019). Black-and-white ruffed lemurs are probably the only primates that build nests exclusively for the birth and the first days of rearing infants (Mittermeier, 2008). **Longevity:** Average lifespan = 19 years in captivity (ADW) with the maximum longevity in captivity recorded at 40 years (AnAge). Up to 35 years in zoos (GBIF). Oldest known wild animal 37-year-old female (Hakeem, 1996; Kohler, 2006). **Conservation status:** **IUCN:** Critically Endangered **CITES:** Appendix I

DATE OF ASSESSMENT: July 2023 (Jodi Buchecker) **EIC ENDORSEMENT:** 20/02/2024 **Risk assessment model used for the assessment:** Bomford 2008, Bird and Mammal Model	**The risk assessment model:** Models for assessing the risk that exotic vertebrates could establish in Australia have been developed for mammals, birds (Bomford 2003, 2006, 2008), reptiles and amphibians (Bomford et al 2005, Bomford 2008). Developed by Dr Mary Bomford for the Bureau of Rural Sciences (BRS), the model uses criteria that have been demonstrated to have significant correlation between a risk factor and the establishment of populations of exotic species and the pest potential of those species that do establish. For example, a risk factor for establishment is similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia. For pest potential, the species' overseas pest status is a risk factor.

	The model is published as 'Risk assessment models for the establishment of exotic vertebrates in Australia and New Zealand' (Bomford 2008) and is available online on the PestSmart website https://pestsmart.org.au/wpcontent/uploads/sites/3/2020/06/Risk_Assess_Models_2008_FINAL.pdf **CLIMATE**: In 2021 a new version of the Climatch program used to assess similarity in climate was released by the Australian Bureau of Agricultural Resource Economics and Sciences (ABARES): CLIMATCH v2.0. The increase in resolution in this new version (from 50 km to 20 km) required recalibration of Climate Match Scores. See Table 1. Sixteen climate parameters (variables) of temperature and rainfall are used to estimate the extent of similarity between data from meteorological stations located within the species' world distribution and stations in Australia. Worldwide, data from approximately 19000 locations are available for analysis. The number of locations used in an analysis will vary according to the size of the species' distribution and the number of meteorological stations located within that distribution. To represent the climate match visually, the map of Australia is divided into 19236 grid squares, each measured in 0.2 degrees in both longitude and latitude. CLIMATCH v2.0 calculates a match for each Australian grid by comparing data from all meteorological stations within the species' distribution (excluding any populations in Australia) and allocating a score ranging from ten for the highest level match to zero for the poorest match. Levels of climate match are used in the risk assessment for questions B1 (scores are summed to give a cumulative score), C6, and C8. Climatch v2.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/

Bird and Mammal Model:

FACTOR	**SCORE**	**DETAIL**
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
A1. Risk to people from individual escapees (0–2) *Assess the risk that individuals of the species could harm people. (NB, this question only relates to aggressive behaviour shown by escaped or released individual animals. Question C11 addresses the risk of harm from aggressive behaviour if the species establishes a wild population).* *Aggressive behaviour, size, plus the possession of organs capable of inflicting harm, such as sharp teeth, claws, spines, a sharp bill, or toxindelivering apparatus may enable individual animals to harm people. Any known history of the species attacking, injuring or killing people should also be taken into account. Assume the individual is not protecting nest or young.*	1	*Animal that is unlikely to make an unprovoked attack but which can cause serious injury (requiring hospitalisation) or fatality if cornered or handled.* Potentially could bite if cornered or handled.

A2. Risk to public safety from individual captive animals (0–2) *Assess the risk that irresponsible use of products obtained from captive individuals of the species (such as toxins) pose a public safety risk (excluding the safety of anyone entering the animals' cage/enclosure or otherwise coming within reach of the captive animals)*	0	*Nil or low risk (highly unlikely or not possible).*
STAGE A PUBLIC SAFETY RISK SCORE **SUM A1 - A2 (0-4)**	1	**Moderately dangerous**
STAGE B: PROBABILITY ESCAPED OR RELEASED INDIVIDUALS WILL ESTABLISH FREE-LIVING POPULATIONS		
Model 1: FOUR-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)		
B1. Degree of climate match between species overseas range and Australia (1–6) *Map the selected mammal or bird species' overseas range, including its entire native and exotic (excluding Australia) ranges over the past 1000 years.* *Use CLIMATCH v2.0, CMS = sum of classes 6 – 10, see Table 1.*	2	*Low climate match in Australia.* Climate Match Score = 1,055 CMS = 2
B2. Exotic population established overseas (0–4) *An established exotic population means the introduced species must have bred outside of captivity and must currently maintain a viable free-living population where the animals are not being intentionally fed or sheltered, even though they may be living in a highly disturbed environment with access to non-natural food supplies or shelter.*	2	*Exotic populations only established on small islands (< 50,000 km^2; Tasmania is 67,800 km^2).* A population of black-and-white ruffed lemurs was established on Nosy Mangabe (small island, 500 hectares, in the Bay of Antongil) in the 1930s and still occur there (Kuhn, 1972).
B3. Overseas range size score (0–2) < 1 = 0; 1– 70 = 1; >70 = 2 *Estimate the species overseas range size* including currently and the past 1000 years; natural and introduced range in millions of square kilometres*	0	*Overseas range between 1 to 70 million square kilometres.* Overseas range estimated to be <1 million km^2 (~260 000 km^2).

B4. Taxonomic Class (0–1) *Bird = 0; mammal = 1*	1	*Mammal*
B. Establishment Risk Score Sum of B1- B4 (1–13)	5	**Low establishment risk**
Model 2: Seven-Factor Model For Birds And Mammals (Bomford 2008)		
B5. Diet score (0–1) *Specialist = 0; generalist = 1*	0	*Specialist dependent on a restricted range of foods.* specialist almost exclusively frugivorous. Black-and-white ruffed lemurs eat mainly large ripe fruits, supplemented with young leaves, seeds, flowers, and nectar, depending on the season. It is one of the most frugivorous lemur species and relies heavily on large fruit trees (GBIF).
B6. Habitat score (0–1) *Undisturbed or disturbed habitat*	0	*Requires access to undisturbed (natural) habitats to survive and breed.* Very selective feeders and therefore especially susceptible to disturbance (Seaman, 2018; Ratsimbazafy, 2002; White, 1995). When human activities in Madagascar encroach upon the rainforest habitat, this lemur species is one of the first lemur species to disappear (Animalia).
B7. Migratory score (0–1) *Always migratory = 0; non-migratory = 1*	1	*Non-migratory.*
B. ESTABLISHMENT RISK SCORE SUM OF B1- B7 (1–16)	6	**Low establishment risk**
STAGE C: PROBABILITY AN ESTABLISHED SPECIES WILL BECOME A PEST		
C1. Taxonomic group (0–4)	0	*Other taxonomic group.* Family – Lemuridae.

C2. Overseas range size including current and past 1000 years, natural and introduced range (0–2) *Estimate the species overseas range size (including current and past 1000 years, natural and introduced range) in millions of square kilometres*	0	*Overseas geographic range less than 10 million square kilometres.* Black-and-white ruffed lemurs' overseas range is estimated at ~260,000 km^2.
C3. Diet and feeding (0–3)	3	*Mammal that is a primarily a grazer or browser.*
C4. Competition with native fauna for tree hollows (0–2)	0	*Does not use tree hollows.*
C5. Overseas environmental pest status (0–3) *Has the species been reported to cause declines in abundance of any native species of plant or animal or cause degradation to any natural communities in any country or region of the world?*	0	*Never reported as an environmental pest in any country or region.*
C6. Climate match to areas with susceptible native species or communities (0–5) *Identify any native Australian animal or plant species or communities that could be susceptible to harm by the exotic species if it were to establish a wild population here.*	4	*The species has 201–691 grid squares within the highest four climate match classes, that overlap the distribution of any susceptible native species or ecological communities = 4* Examples of susceptible native species or ecological communities include (DAWE Protected Matters Search Tool): *Pteropus conspicillatus* (Spectacled Flying-fox) – Endangered *Denhamia megacarpa* (Large-fruited Denhamia) – Endangered
C7. Overseas primary production pest status (0–3) *Has the species been reported to damage crops or other primary production in any country or region of the world?*	0	*No reports of damage to crops or other primary production in any country or region.*

C8. Climate match to susceptible primary production (0–5) *Assess Potential Commodity Impact Scores for each primary production commodity listed in Table 9, based on species' attributes (diet, behaviour, ecology), excluding risk of spreading disease which is addressed in Question C9.* *0 = 0; 1-19 = 1; 20-49 = 2; 50-99 = 3; 100-149 = 4; ≥150 = 5*	2	Total Commodity Damage Score = 21 (see Table 2)
C9. Spread disease (1–2) *Assess the risk that the species could play a role in the spread of disease or parasites to other animals*	2	*All mammals (likely or unknown effect on native species and on livestock and other domestic animals).*
C10. Harm to property (0–3) *Assess the risk that the species could inflict damage on buildings, vehicles, fences, roads, equipment or ornamental gardens by chewing or burrowing or polluting with droppings or nesting material.*	1	*$1.00–$10 million.* <$100,000 per year.
C11. Harm to people (0–5) *Assess the risk that, if a wild population established, the species could cause harm to or annoy people. Aggressive behaviour, plus the possession of organs capable of inflicting harm, such as sharp teeth, tusks, claws, spines, a sharp bill, horns, antlers or toxin delivering organs may enable animals to harm people. Any known history of the species attacking, injuring or killing people should also be taken into account (see Stage A, Score A1).*	2	*Injuries or harm or annoyance likely to be minor and few people exposed: Low risk = 2.*
C. PEST RISK SCORE **SUM C 1 TO C 11 (1–37)**	14	**Moderate pest risk**
STAGE A. PUBLIC SAFETY RISK RANK – RISK TO PUBLIC SAFETY POSED BY CAPTIVE OR RELEASED INDIVIDUALS *0 = Not dangerous; 1 = Moderately dangerous; ≥ 2 = Highly dangerous*	1	Moderately dangerous

STAGE B. ESTABLISHMENT RISK RANK – RISK OF ESTABLISHING A WILD POPULATION **MODEL 1: FOUR-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)** *≤ 5 = low establishment risk; 6-8 = moderate establishment risk; 9-10 = serious establishment risk; ≥ 11-13 = extreme establishment risk*	5	Low establishment risk
STAGE B. ESTABLISHMENT RISK RANK – RISK OF ESTABLISHING A WILD POPULATION **MODEL 2: SEVEN-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)** *≤ 6 = low establishment risk; 7-11 = moderate establishment risk; 12-13 = serious establishment risk; ≥14 = extreme establishment risk*	6	Low establishment risk
STAGE C. PEST RISK RANK - RISK OF BECOMING A PEST FOLLOWING ESTABLISHMENT *< 9 = low pest risk; 9-14 = moderate pest risk; 15-19 = serious pest risk; > 19 = extreme pest risk*	14	Moderate pest risk

ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY	**MODERATE**

World distribution map (IUCN Red List) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

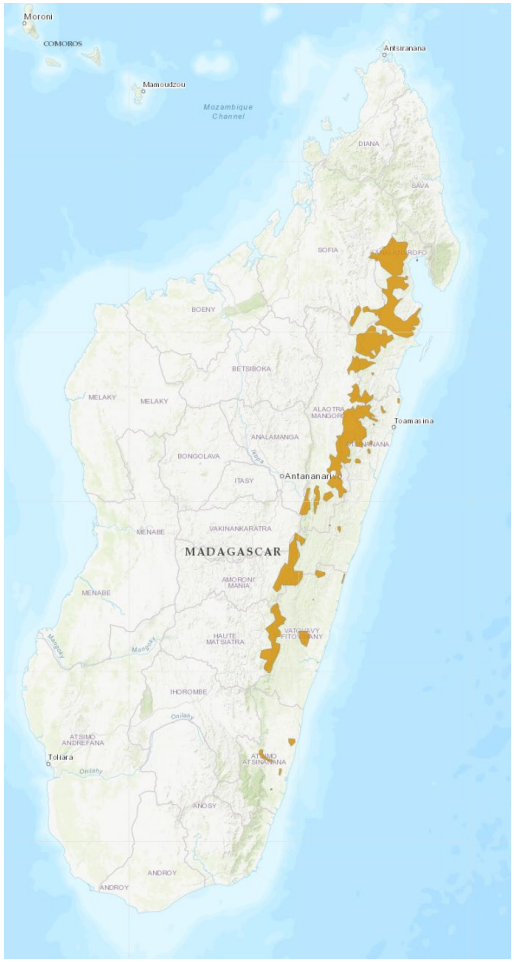


Figure 1 - World Distribution Map - IUCN Red List

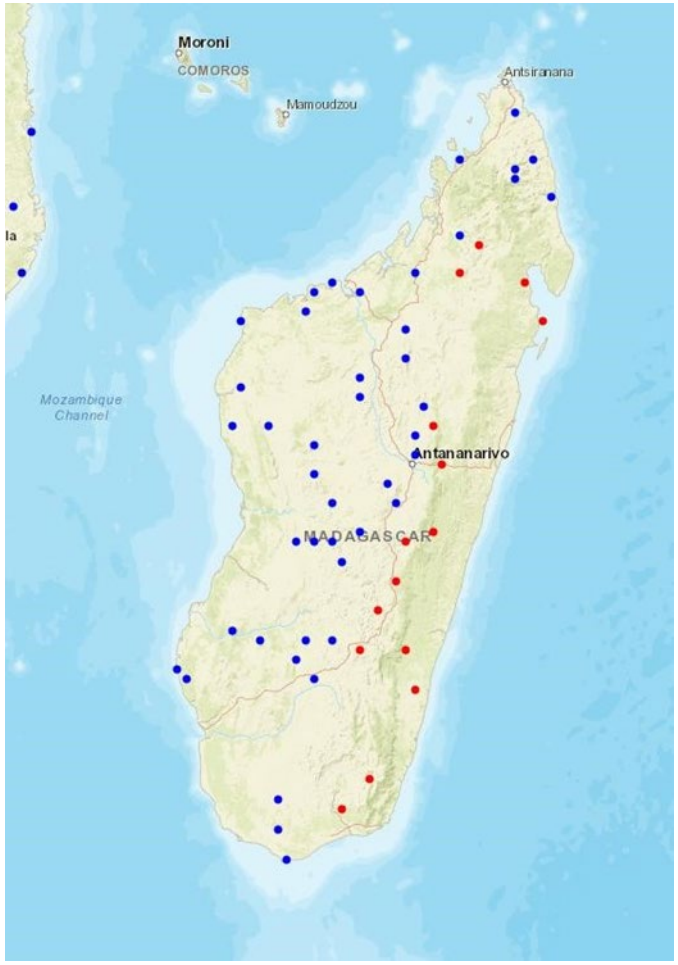
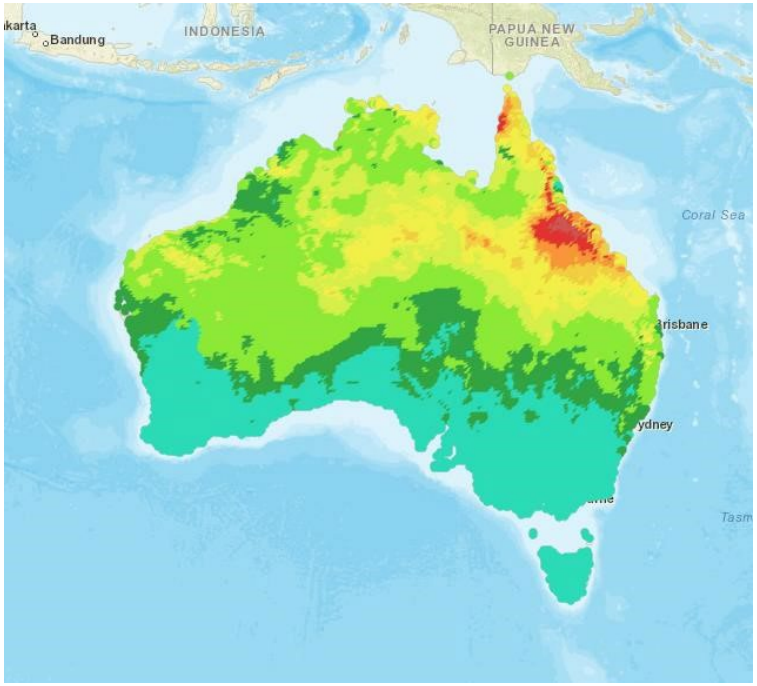


Figure 2 - World Distribution Map - Climatch

Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Varecia variegata*

CMS = 1,055



Score	Color	Count
0		0
1		4242
2		2696
3		6270
4		3147
5		1826
6		502
7		304
8		195
9		54
10		0

Species: Varecia variegata (Black and White Ruffed Lemur)
Algorithm: Closest Standard Score
15 source features selected
19236 target features selected
Approximate selected area: 261,272 km^2

Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Current Bomford 2008 model classes (50 km)	Recalibrated classes to Climatch v2.0 (20 km)
1 (Very low)	< 100	< 691
2 (Low)	100-599	691-4137
3 (Moderate)	600-899	4138-6209
4 (High)	900-1699	6210-11735
5 (Very high)	1700-2699	11736-18642
6 (Extreme)	≥ 2700	≥ 18643

Table 2: Susceptible Australian Primary Production – Calculating Total Commodity Damage Score

The commodity value index scores in this table are derived from Australian Bureau of Statistics 2005 – 2006 data. The values will require updating if significant change has occurred in the value of the commodity (Bomford 2008).

Industry	Commodity Value Index 1 (CVI based on best available date)	Potential Commodity Impact Score (PCIS 0-3)	Climate Match to Commodity Score (CMCS 0–5)	Commodity Damage Score (CDS columns 2 X 3 X 4)
Cattle (includes dairy and beef)	*11*			
Timber (includes native and plantation forests)	*10*			
Cereal grain (includes wheat, barley sorghum etc)	*8*			
Sheep (includes wool and sheep meat)	*5*			
Fruit (includes wine grapes)	*4*	2	2	16
Vegetables	*3*	1	1	3
Poultry and eggs	*2*			
Aquaculture (includes coastal mariculture)	*2*			
Oilseeds (includes canola, sunflower etc)	*1*			
Grain legumes (includes soybeans)	*1*			
Sugarcane	*1*			
Cotton	*1*			
Other crops and horticulture (includes nuts tobacco and flowers etc)	*1*	1	2	2
Pigs	*1*			
Other livestock (includes goats, deer, camels, rabbits)	*0.5*			
Bees (included honey, beeswax and pollination)	*0.5*			
Total Commodity Damage Score (TCDS)				21

NB The Commodity Value Index scores in this table are derived from Australian Bureau of Statistics 2005–2006 data and will need to be updated if these values change significantly.

Assess Potential Commodity Impact Scores for each primary production commodity listed in Table 9, based on species' attributes (diet, behaviour, ecology), excluding risk of spreading disease which is addressed in Question C9, and pest status worldwide as:

0. *Nil (species does not have attributes to make it capable of damaging this commodity)*
1. *Low (species has attributes making it capable of damaging this or similar commodities and has had the opportunity but no reports or other evidence that it has caused damage in any country or region*
2. *Moderate–serious (reports of damage to this or similar commodities exist but damage levels have never been high in any country or region and no major control programs against the species have ever been conducted OR the species has attributes making it capable of damaging this or similar commodities but has not had the opportunity)*
3. *Extreme (damage occurs at high levels to this or similar commodities and/or major control programs have been conducted against the species in any country or region and the listed commodity would be vulnerable to the type of harm this species can cause).*

Climate Match to Commodity Score (0–5)

- *None of the commodity is produced in areas where the species has a climate match within the highest eight climate match classes (ie classes 10, 9, 8, 7, 6, 5, 4 and 3) = 0*
- *Less than 10% of the commodity is produced in areas where the species has a climate match within the highest eight climate match classes = 1*
- *Less than 10% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes (ie classes 10, 9, 8, 7, 6 and 5) = 2*
- *Less than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes AND less than 10% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes (ie classes 10, 9 and 8) = 3*
- *Less than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes BUT more than 10% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes = 4*
- *OR More than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes BUT less than 20% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes = 4*
- *More than 20% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes OR overseas range unknown and climate match to Australia unknown = 5.]*

Table 3: Assigning species to EIC Threat Categories (shaded cells relate to assignment of reptiles and amphibians to EIC Threat Categories based on an assessed establishment risk and an allocated pest risk of extreme) – adapted from Bomford 2008

Establishment Risk	Pest Risk	Public Safety Risk	EIC Threat Category	Implication for any proposed import into Australia	Implication for keeping and movement in Australia
Extreme	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**	Prohibited, unless sufficient risk management measures exist to reduce the potential risks to an acceptable level	Limited to those collections approved for keeping particular EXTREME Threat species
Extreme	Serious	Highly, Moderately or Not Dangerous	**EXTREME**		
Extreme	Moderate	Highly, Moderately or Not Dangerous	**EXTREME**		
Extreme	Low	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Serious	Highly, Moderately or Not Dangerous	**EXTREME**		
Moderate	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Moderate	Highly, Moderately or Not Dangerous	**SERIOUS**	Import restricted to those collections approved for keeping SERIOUS Threat species	Limited to those collections approved for keeping particular SERIOUS Threat species
Serious	Low	Highly, Moderately or Not Dangerous	**SERIOUS**		
Moderate	Serious	Highly, Moderately or Not Dangerous	**SERIOUS**		
Moderate	Moderate	Highly Dangerous	**SERIOUS**		
Moderate	Low	Highly Dangerous	**SERIOUS**		
Low	Extreme	Highly, Moderately or Not Dangerous	**SERIOUS**		
Low	Serious	Highly, Moderately or Not Dangerous	**SERIOUS**		
Low	Moderate	Highly Dangerous	**SERIOUS**		
Low	Low	Highly Dangerous	**SERIOUS**		
Moderate	Moderate	Moderately or Not Dangerous	**MODERATE**	Import restricted to those collections approved for keeping MODERATE Threat species	Limited to those collections approved for keeping particular MODERATE Threat species
Moderate	Low	Moderately or Not Dangerous	**MODERATE**		
Low	Moderate	Moderately or Not Dangerous	**MODERATE**		
Low	Low	Moderately Dangerous	**MODERATE**		
Low	Low	Not Dangerous	**LOW**	Import permitted	May be limited to those collections approved for keeping particular LOW Threat species
Any Value	Any Value	Unknown	**EXTREME until proven otherwise**	Prohibited, unless sufficient risk management measures exist to reduce the potential risks to an acceptable level	Limited to those collections approved for keeping particular EXTREME Threat species
Unknown	Any Value	Any Value	**EXTREME until proven otherwise**		
Any Value	Unknown	Any Value	**EXTREME until proven otherwise**		
Unassessed	Unassessed	Unassessed	**EXTREME until proven otherwise**		

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National Risk Assessment: MODERATE (*Pyrrhura cruentata, Pyrrhura leucotis*)
SERIOUS (*Pyrrhura frontalis, Pyrrhura molinae*)

RISK ASSESSMENT FOR AUSTRALIA: **Four 'central South American' Conure species (*Pyrrhura* Sp.)**

Class - Aves**, Order -** Psittaciformes**, Family -** Psittacidae**, Genus -** *Pyrrhura*.

SPECIES:	**Species description:**
Pyrrhura cruentata (Wied-Neuwied, 1820) *Pyrrhura frontalis* (Vieillot, 1818) *Pyrrhura leucotis* (Kuhl, 1820) *Pyrrhura molinae* (Massena & Souance, 1854) **Subspecies:** *P. frontalis chiripepe* (Vieillot, 1818) *P. frontalis frontalis* (Vieillot, 1818) *P. leucotis emma* (Salvadori, 1891) *P. leucotis griseipectus* (Salvadori, 1900) *P. leucotis leucotis* (Kuhl, 1820) *P. molinae australis* (Todd, 1915) *P. molinae flavoptera* (Maijer, Herzog, Kessler, Friggens & Fjeldsa, 1998) *P. molinae molinae* (Massena & Souance, 1854) *P. molinae phoenicura* (Schlegel, 1864)	1. ***Pyrrhura cruentata* (Blue-throated Conure):** 30 centimetres; predominantly green with conspicuous red patches on its belly, shoulder, rump and under the eye. The crown is dark brown to blackish, becoming mottled on the nape of the neck. There is a broad, bright blue bib on the chest, extending thinly around the back of the neck to form a faint collar. The tail is olive-green above, and brownish red below. The outer primaries are blue. 2. ***Pyrrhura frontalis* (Maroon-bellied Conure):** 25-28 centimetres; primarily green with a maroon patch on its belly, a maroon undertail, yellow-green-barred breast and sides of neck, and a whitish ear-patch (often tinged brown). 3. ***Pyrrhura leucotis* (White-eared Conure):** 23 centimetres; top of head grey-brown, nape pale blue. Eye region, lower cheeks, and a narrow band on forehead reddish brown. Ear coverts grey-white; sides of neck and throat green with yellowish striations. Brownish red spot-on belly; red shoulders; brownish red rump; tail reddish brown. 4. ***Pyrrhura molinae* (Green-cheeked Conure):** 27 centimetres; green, top of head dark brown. Sides of neck, throat, and upper breast pale brown with dark brown and white bands. A few blue feathers on the nape; brownish red spot on the belly; tail reddish brown. **General information:** The four *Pyrrhura* species assessed here all have ranges in the central tropical region of South America. Not a singles species of the genus *Pyrrhura* occurs naturally in the colder zones (del Hoya, 1997). Habitat: **Blue-throated Conure:** forest (artificial and terrestrial) (Birdlife International, 2023). Inhabits the canopy of lowland humid forest and edge, occasionally up to 960 metres, though generally below around 400 metres (del Hoya, 1997). It has also been recorded in small clearings and selectively logged forest and persists

P. molinae restricta (Todd, 1947) *P. molinae sordida* (Todd, 1947) **Common Names:** ***Pyrrhura cruentata*:** Blue-throated Conure Blue-throated Parakeet Blue-chested Conure Ochre-marked Conure Ochre-marked Parakeet Red-eared Conure Black-tailed Conure ***Pyrrhura frontalis*:** Maroon-bellied Conure Maroon-bellied Parakeet Red-bellied Conure Reddish-bellied Conure Reddish-bellied Parakeet Brown-eared Conure ***Pyrrhura leucotis*:** White-eared Conure White-eared Parakeet Maroon-face Conure ***Pyrrhura molinae*:** Green-cheeked Conure Turquoise-fronted Conure **Hybridisation:** White-eared Conure known to hybridise with Maroon-bellied Conure	(or at least persisted) in agricultural areas where many forest trees are retained (such as shade cocoa plantations) (Birdlife International, 2016). **Maroon-bellied Conure:** all types of forest, apart from eucalyptus plantations at altitudes between 800 and 1,300 metres (Kolar, 1990). **White-eared Conure:** forest, shrubland (artificial and terrestrial) (Birdlife International, 2016). Inhabits the interior and edges of forest, clearings and other modified habitats such as naturally shaded cacao plantations, urban parks and gardens up to 600 metres (del Hoyo et al., 1997). **Green-cheeked Conure:** forest (artificial and terrestrial) (Birdlife International, 2016); observed in altitudes up to 2,000 metres (Kolar, 1990); up to 3,000 metres (Forshaw, 2010). All four species feed on fruits, seeds, nuts, berries, and flowers (del Hoyo et al., 1997; Ragusa-Netto, 2007; Thompson, 1994). Also known to eat insects and their larvae (del Hoyo et al., 1997; Kolar, 1990;). All four species nest in tree hollows (ADW; del Hoyo et al., 1997; Kolar, 1990). **Longevity:** *P. leucotis* max longevity 18.5 years (AnAge). Lifespan is between 25-30 years (ADW). **Conservation status:** **IUCN:** *P. frontalis* and *P. molinae* - Least Concern *P. cruentata* and *P. leucotis* - Vulnerable **CITES:** *P. cruentata* - Appendix I *P. frontalis, P. leucotis*, *P. molinae* - Appendix II

DATE OF ASSESSMENT: July 2023 (Jodi Buchecker) **EIC ENDORSEMENT:** **Risk assessment model used for the assessment:** Bomford 2008, Bird and Mammal Model	**The risk assessment model:** Models for assessing the risk that exotic vertebrates could establish in Australia have been developed for mammals, birds (Bomford 2003, 2006, 2008), reptiles and amphibians (Bomford et al 2005, Bomford 2008). Developed by Dr Mary Bomford for the Bureau of Rural Sciences (BRS), the model uses criteria that have been demonstrated to have significant correlation between a risk factor and the establishment of populations of exotic species and the pest potential of those species that do establish. For example, a risk factor for establishment is similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia. For pest potential, the species' overseas pest status is a risk factor. The model is published as 'Risk assessment models for the establishment of exotic vertebrates in Australia and New Zealand' (Bomford 2008) and is available online on the PestSmart website https://pestsmart.org.au/wp-content/uploads/sites/3/2020/06/Risk_Assess_Models_2008_FINAL.pdf **CLIMATE**: In 2021 a new version of the Climatch program used to assess similarity in climate was released by the Australian Bureau of Agricultural Resource Economics and Sciences (ABARES): CLIMATCH v2.0. The increase in resolution in this new version (from 50 km to 20 km) required recalibration of Climate Match Scores. See Table 1. Sixteen climate parameters (variables) of temperature and rainfall are used to estimate the extent of similarity between data from meteorological stations located within the species' world distribution and stations in Australia. Worldwide, data from approximately 19000 locations are available for analysis. The number of locations used in an analysis will vary according to the size of the species' distribution and the number of meteorological stations located within that distribution. To represent the climate match visually, the map of Australia is divided into 19236 grid squares, each measured in 0.2 degrees in both longitude and latitude. CLIMATCH v2.0 calculates a match for each Australian grid by comparing data from all meteorological stations within the species' distribution (excluding any populations in Australia) and allocating a score ranging from ten for the highest level match to zero for the poorest match. Levels of climate match are used in the risk assessment for questions B1 (scores are summed to give a cumulative score), C6, and C8. Climatch v2.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/.

Bird and Mammal Model:

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
A1. Risk to people from individual escapees (0–2) *Assess the risk that individuals of the species could harm people. (NB, this question only relates to aggressive behaviour shown by escaped or released individual animals. Question C11 addresses the risk of harm from aggressive behaviour if the species establishes a wild population).*	0	*All other animals posing a lower risk of harm to people (ie animals that will not make unprovoked attacks causing injury requiring medical attention, and which, even if cornered or handled, are unlikely to cause injury requiring hospitalisation).*

Aggressive behaviour, size, plus the possession of organs capable of inflicting harm, such as sharp teeth, claws, spines, a sharp bill, or toxin-delivering apparatus may enable individual animals to harm people. Any known history of the species attacking, injuring or killing people should also be taken into account. Assume the individual is not protecting nest or young.		Low risk of harm to people. Conures are small parakeets with small beaks (World Parrot Trust, 2018) making them unable to inflict much harm.
A2. Risk to public safety from individual captive animals (0–2) *Assess the risk that irresponsible use of products obtained from captive individuals of the species (such as toxins) pose a public safety risk (excluding the safety of anyone entering the animals' cage/enclosure or otherwise coming within reach of the captive animals)*	0	*Nil or low risk (highly unlikely or not possible).*
STAGE A PUBLIC SAFETY RISK SCORE **SUM A1 - A2 (0-4)**	0	**Not dangerous**
STAGE B: PROBABILITY ESCAPED OR RELEASED INDIVIDUALS WILL ESTABLISH FREE-LIVING POPULATIONS		
Model 1: FOUR-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)		
B1. Degree of climate match between species overseas range and Australia (1–6) *Map the selected mammal or bird species' overseas range, including its entire native and exotic (excluding Australia) ranges over the past 1000 years.* *Use CLIMATCH v2.0, Value X = sum of classes 6 – 10, see Table 1.*	2 2 2 2	**1. Blue-throated Conure:** *Low climate match to Australia* Value X = 798 CMS = 2 **2. Maroon-bellied Conure:** *Low climate match to Australia* Value X = 1,632 CMS = 2 **3. White-eared Conure:** *Low climate match to Australia* Value X = 769 CMS = 2 **4. Green-cheeked Conure:** *Low climate match to Australia* Value X = 3,549 CMS = 2

B2. Exotic population established overseas (0–4) *An established exotic population means the introduced species must have bred outside of captivity and must currently maintain a viable free-living population where the animals are not being intentionally fed or sheltered, even though they may be living in a highly disturbed environment with access to non-natural food supplies or shelter.*	0 0 0 4	**1. Blue-throated Conure:** *No exotic populations have been established.* **2. Maroon-bellied Conure:** *No exotic populations have been established.* **3. White-eared Conure:** *No exotic populations have been established.* **4. Green-cheeked Conure:** *Exotic population established on a larger island (> 50 000 km2) or anywhere on a continent (including elsewhere on the land mass where the natural distribution of the animal is, if this population is due to human introduction and is geographically separate from the natural range of the species).* Anecdotal accounts found of this species being introduced to Florida and Hawaii with evidence of breeding in Florida (Florida Fish and Wildlife Conservation Commission).
B3. Overseas range size score (0–2) < 1 = 0; 1– 70 = 1; >70 = 2 *Estimate the species overseas range size* including currently and the past 1000 years; natural and introduced range in millions of square kilometres*	 0 1 0 1	*Overseas range between 1 to 70 million square kilometres.* Overseas range for *Pyrrhura* species is estimated to be between 650,000 and 2.2 million km^2. **1. Blue-throated Conure:** Overseas range estimated in Climatch: ~650,000 km^2. Extant (breeding): Brazil (Birdlife International, 2016). **2. Maroon-bellied Conure:** Overseas range estimated in Climatch: ~2.2 million km^2. Extant (resident): Argentina, Brazil and Paraguay. Extant (breeding): Uruguay (Birdlife International, 2016). **3. White-eared Conure:** Overseas range estimated in Climatch: ~650,000 km^2. Extant (resident): Brazil (Birdlife International, 2016). **4. Green-cheeked Conure:** Overseas range estimated in Climatch: ~1.4 million km^2. Extant (breeding): Paraguay. Extant (resident): Argentina; Plurinational States of Bolivia and Brazil, (Birdlife International, 2018). Anecdotal accounts found of this species being introduced to Florida and Hawaii with evidence found of breeding in Florida (Brevard and Dade counties).
B4. Taxonomic Class (0–1) *Bird = 0; mammal = 1*	0	*Bird*
B. Establishment Risk Score **Sum of B1- B4 (1–13)**	2 3	**1. Blue-throated Conure: Low establishment risk** **2. Maroon-bellied Conure: Low establishment risk**

	2 7	**3. White-eared Conure: Low establishment risk** **4. Green-cheeked Conure: Moderate establishment risk**
Model 2: Seven-Factor Model For Birds And Mammals (Bomford 2008)		
B5. Diet score (0–1) *Specialist = 0; generalist = 1*	1	*Generalists with a broad diet of many food types.* Diverse diet consisting of a fruits, seeds, nuts, berries, and flowers (del Hoyo et al., 1997; Ragusa-Netto, 2007; Thompson, 1994). Also known to eat insects and their larvae (Kolar 1990; del Hoyo et al. 1997).
B6. Habitat score (0–1) *Undisturbed or disturbed habitat*	1	*Can survive and breed in human-disturbed habitats (including grazing and agricultural lands, forests that are intensively managed or planted for timber harvesting and/or urban–suburban environments) without access to undisturbed (natural) habitats.* *P. leucotis* and *P. frontalis* known to inhabit modified habitats such as naturally shaded cacao plantations, urban parks and gardens (del Hoyo et al., 1997). *P. cruentata* known to live in agricultural areas where many forest trees are retained (such as shade cocoa plantations) (Birdlife International, 2016).
B7. Migratory score (0–1) *Always migratory = 0; non-migratory = 1*	1	*Facultative migrant - Not always migratory* Birdlife International (2016) reports 3 species to be non-migrants; Green-cheeked Conures reported to be altitudinal migrants.
B. ESTABLISHMENT RISK SCORE **SUM OF B1- B7 (1–16)**	5 6 5 10	**1. Blue-throated Conure: Low establishment risk** **2. Maroon-bellied Conure: Low establishment risk** **3. White-eared Conure: Low establishment risk** **4. Green-cheeked Conure: Moderate establishment risk**
STAGE C: PROBABILITY AN ESTABLISHED SPECIES WILL BECOME A PEST		
C1. Taxonomic group (0–4)	3	*Bird in one of the taxa that are particularly prone to cause agricultural damage (*Psittaciformes) = 2.

		Bird in one of the families likely to hybridise with native species (Psittacidae) = 1.
C2. Overseas range size including current and past 1000 years, natural and introduced range (0–2) *Estimate the species overseas range size (including current and past 1000 years, natural and introduced range) in millions of square kilometres*	0	*Overseas geographic range less than 10 million square kilometres.* **1. Blue-throated Conure:** ~650,000 km^2 (see B3). **2. Maroon-bellied Conure:** ~2.2 million km^2(see B3). **3. White-eared Conure:** ~650,000 km^2 (see B3). **4. Green-cheeked Conure:** ~1.4 million km^2(see B3).
C3. Diet and feeding (0–3)	0	*Not a mammal.*
C4. Competition with native fauna for tree hollows (0–2)	2	*Can nest or shelter in tree hollows.* All species nest and shelter in tree hollows (del Hoyo et al., 1997).
C5. Overseas environmental pest status (0–3) *Has the species been reported to cause declines in abundance of any native species of plant or animal or cause degradation to any natural communities in any country or region of the world?*	0	*These species have never been reported as an environmental pest in any country or region* No reports found for any of the species assessed here.
C6. Climate match to areas with susceptible native species or communities (0–5) *Identify any native Australian animal or plant species or communities that could be susceptible to harm by the exotic species if it were to establish a wild population here.*	4 5 4 5	**1. Blue-throated Conure:** *63–138 grid squares within the highest two climate match classes that overlap the distribution of any susceptible native species or ecological communities = 4* **2. Maroon-bellied Conure:** *more than 692 grid squares within the highest four climate match classes that overlap the distribution of any susceptible native species or ecological communities = 5* **3. White-eared Conure:** 2*01-691 grid squares within the highest four climate match classes that overlap the distribution of any susceptible native species or ecological communities = 4* **4. Green-cheeked Conure:** *more than 692 grid squares within the highest four climate match classes that overlap the distribution of any susceptible native species or ecological communities = 5* **Example of susceptible species:**

		Parrot species such as Coxen's Fig Parrot (*Cyclopsitta diophthalma coxeni*, Critically Endangered) and Golden-shouldered Parrot (*Psephotus chrysopterygius*, Endangered) possibly impacted.
C7. Overseas primary production pest status (0–3) *Has the species been reported to damage crops or other primary production in any country or region of the world?*	0 1 0 0	**1. Blue-throated Conure:** *Never reported as an environmental pest in any country or region.* Feeding on agricultural crops has not been observed in the wild in *P. cruentata* (Birdlife International, 2016). del Hoyo et al. (1997) note that consumption of maize has been reported but not confirmed. **2. Maroon-bellied Conure:** *Minor environmental pest in any country or region.* *P. frontalis* known to feed on cultivated oranges, persimmons and maize (del Hoyo et al., 1997). Classified as an "injurious pest" in Argentina (del Hoyo et al., 1997). **3. White-eared Conure:** *Never reported as an environmental pest in any country or region.* No record found. **4. Green-cheeked Conure:** *Never reported as an environmental pest in any country or region.* No record found.
C8. Climate match to susceptible primary production (0–5) *Assess Potential Commodity Impact Scores for each primary production commodity listed in Table 9, based on species' attributes (diet, behaviour, ecology), excluding risk of spreading disease which is addressed in Question C9.* *0 = 0; 1-19 = 1; 20-49 = 2; 50-99 = 3; 100-149 = 4; ≥150 = 5*	2	Total Commodity Damage Score = 25 (see Table 2) These species have attributes making them capable of damaging fruit, flower and other horticultural crops.
C9. Spread disease (1–2) *Assess the risk that the species could play a role in the spread of disease or parasites to other animals*	2	*All birds (likely or unknown effect on native species and on livestock and other domestic animals).*
C10. Harm to property (0–3) *Assess the risk that the species could inflict damage on buildings, vehicles, fences, roads, equipment or ornamental*	1	*$1.00 - $10 million.*

gardens by chewing or burrowing or polluting with droppings or nesting material.		No reports of damage to property but could possibly damage gardens or buildings as parrots are known to chew.
C11. Harm to people (0–5) *Assess the risk that, if a wild population established, the species could cause harm to or annoy people. Aggressive behaviour, plus the possession of organs capable of inflicting harm, such as sharp teeth, tusks, claws, spines, a sharp bill, horns, antlers or toxin delivering organs may enable animals to harm people. Any known history of the species attacking, injuring or killing people should also be taken into account (see Stage A, Score A1).*	0	*Nil risk.*
C. PEST RISK SCORE **SUM C 1 TO C 11 (1–37)**	14 16 14 15	**1. Blue-throated Conure: Moderate pest risk** **2. Maroon-bellied Conure: Serous pest risk** **3. White-eared Conure: Moderate pest risk** **4. Green-cheeked Conure: Serious pest risk**
STAGE A. PUBLIC SAFETY RISK RANK – RISK TO PUBLIC SAFETY POSED BY CAPTIVE OR RELEASED INDIVIDUALS *0 = Not dangerous; 1 = Moderately dangerous; ≥ 2 = Highly dangerous*	0	Not dangerous
STAGE B. ESTABLISHMENT RISK RANK – RISK OF ESTABLISHING A WILD POPULATION **MODEL 1: FOUR-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)** *≤ 5 = low establishment risk; 6-8 = moderate establishment risk; 9-10 = serious establishment risk; ≥ 11-13 = extreme establishment risk*	2 3 2 7	**1. Blue-throated Conure:** Low establishment risk **2. Maroon-bellied Conure:** Low establishment risk **3. White-eared Conure:** Low establishment risk **4. Green-cheeked Conure:** Moderate establishment risk
STAGE B. ESTABLISHMENT RISK RANK – RISK OF ESTABLISHING A WILD POPULATION **MODEL 2: SEVEN-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)**	5 6 5 10	**1. Blue-throated Conure:** Low establishment risk **2. Maroon-bellied Conure:** Low establishment risk **3. White-eared Conure:** Low establishment risk **4. Green-cheeked Conure:** Moderate establishment risk

≤ 6 = low establishment risk; 7-11 = moderate establishment risk; 12-13 = serious establishment risk; ≥14 = extreme establishment risk		
STAGE C. PEST RISK RANK - RISK OF BECOMING A PEST FOLLOWING ESTABLISHMENT *< 9 = low pest risk; 9-14 = moderate pest risk; 15-19 = serious pest risk; > 19 = extreme pest risk*	14 16 14 15	**1. Blue-throated Conure:** Moderate pest risk **2. Maroon-bellied Conure:** Serious pest risk **3. White-eared Conure:** Moderate pest risk **4. Green-cheeked Conure:** Serious pest risk
ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY		**1. Blue-throated Conure: MODERATE** **2. Maroon-bellied Conure: SERIOUS** **3. White-eared Conure: MODERATE** **4. Green-cheeked Conure: SERIOUS**

World distribution map for four 'central South American' Conure species (*Pyrrhura sp*) (IUCN RedList) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis:

Figure 1 – IUCN Map - Pyrrhura cruentata

Figure 2 – IUCN Map - Pyrrhura frontalis

Figure 3 – IUCN Map - Pyrrhura leucotis

Figure 4 – IUCN Map - Pyrrhura molinae

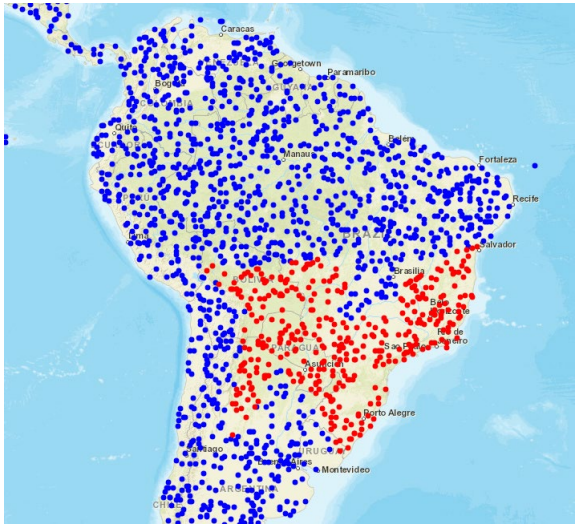
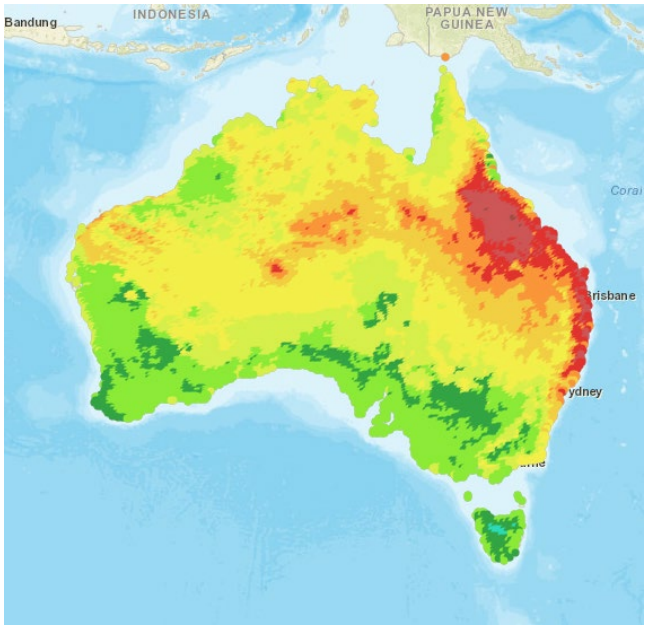


Figure 5 - World Distribution map – Climatch – Combined distributions

Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for combined *Pyrrhura* species.



Score	Color	Count
0		0
1		14
2		1062
3		3182
4		3620
5		6182
6		2749
7		1287
8		658
9		477
10		5

Species: Pyrrhura sp mid-eastern South America
Algorithm: Closest Standard Score
383 source features selected
19236 target features selected
Approximate selected area: 3,903,472 km^2

Value X = 5,176 = 3 (Moderate)

1a. World distribution map for Blue-throated/Ochre-marked Parakeet (*Pyrrhura cruentata*) (IUCN RedList) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

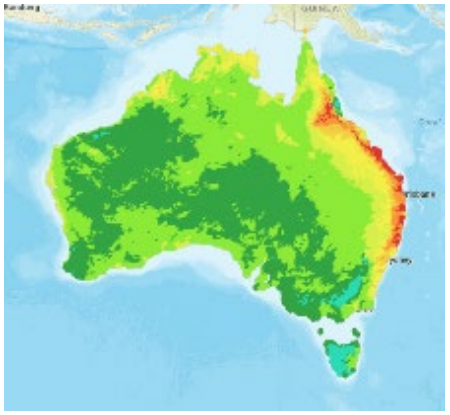
Figure 2 - World Distribution Map - IUCN RedList

Figure 2 – World Distribution map – Climatch

1b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura cruentata*

Value X = 798



Score	Color	Count
0		0
1		274
2		7476
3		8192
4		1599
5		897
6		346
7		319
8		131
9		2
10		0

Species: Blue-throated Conure (Pyrrhura cruentata)
Algorithm: Closest Standard Score
71 source features selected
19236 target features selected
Approximate selected area: 648,454 km^2

2a. World distribution map for Maroon-bellied Conure (*Pyrrhura frontalis*) (IUCN RedList) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

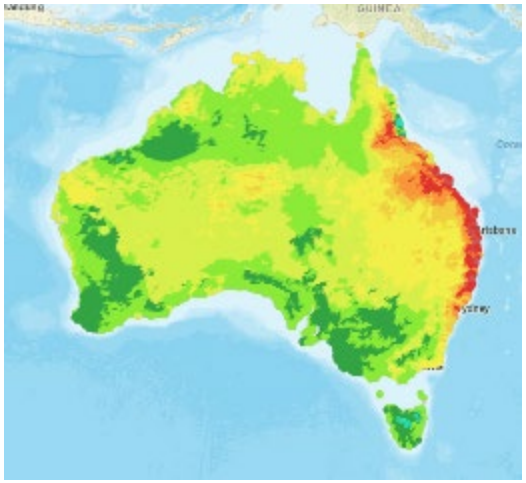
Figure 3 - World Distribution Map - IUCN RedList

Figure 2 – World Distribution map – Climatch

2b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura frontalis*

Value X = 1,632



Score	Color	Count
0		0
1		33
2		2341
3		5831
4		6446
5		2953
6		772
7		521
8		291
9		48
10		0

Species: Maroon-bellied Conure (Pyrrhura frontalis)
Algorithm: Closest Standard Score
227 source features selected
19236 target features selected
Approximate selected area: 2,185,045 km^2

3a. World distribution map for White-eared Conure (*Pyrrhura leucotis*) (IUCN RedList) and Climatch world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

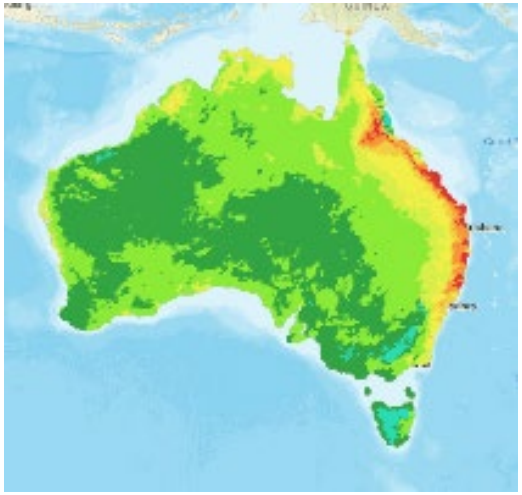
Figure 1 - World Distribution Map - IUCN RedList

Figure 2 – World Distribution map – Climatch

3b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura leucotis*

Value X = 769



Score	Color	Count
0		0
1		231
2		8032
3		7765
4		1540
5		899
6		347
7		300
8		121
9		1
10		0

Species: White-eared Conure (Pyrrhura leucotis)
Algorithm: Closest Standard Score
61 source features selected
19236 target features selected
Approximate selected area: 639,092 km^2

4a. World distribution map for Green-cheeked Conure (*Pyrrhura molinae*) (IUCN RedList and Florida Fish and Wildlife Conservation Commission) and Climatch world distribution maps indicating where meteorological data was sourced for the climate analysis (see B1):

Figure 1 - World Distribution Map - IUCN RedList

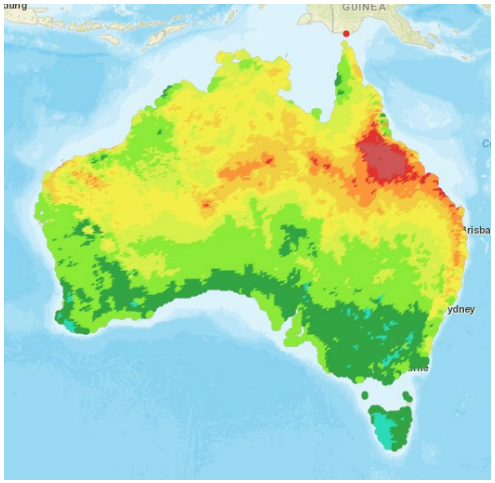
Figure 2 & 3 – World Distribution map – Climatch (South America and Florida)

Figure 4 - Florida Fish and Wildlife Conservation Commission map

4b. Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pyrrhura molinae*

Value X = 3,549



Score	Color	Count
0		0
1		174
2		2534
3		5130
4		3418
5		4431
6		2146
7		885
8		261
9		256
10		1

Species: Green-cheeked Conure (Pyrrhura molinae)
Algorithm: Closest Standard Score
116 source features selected
19236 target features selected
Approximate selected area: 1,441,409 km^2

Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Climatch (50 km) Closest Standard Match Sum Level 6 (Value X)	2021 Recalibrated Climatch v2.0 (20 km) Closest Standard Match Sum Level 6 (Value X)
1 (Very low)	< 100	< 691
2 (Low)	100-599	691-4137
3 (Moderate)	600-899	4138-6209
4 (High)	900-1699	6210-11735
5 (Very high)	1700-2699	11736-18642
6 (Extreme)	≥ 2700	≥ 18643

Table 2: Susceptible Australian Primary Production – Calculating Total Commodity Damage Score
The commodity value index scores in this table are derived from Australian Bureau of Statistics 1999 – 2000 data. The values will require updating if significant change has occurred in the value of the commodity (Bomford 2008).

Industry	**Commodity Value Index 1 (CVI based on best available date)**	**Potential Commodity Impact Score (PCIS 0-3)**	**Climate Match to Commodity Score (CMCS 0–5)**	**Commodity Damage Score (CDS columns 2 X 3 X 4)**
Sheep (includes wool and sheep meat)	10			
Cattle (includes dairy and beef)	10			
Timber (includes native and plantation forests)	10			
Cereal grain (includes wheat, barley sorghum etc)	10	1	1	10
Pigs	2			
Poultry and eggs	2			
Aquaculture (includes coastal mariculture)	2			
Cotton	2			
Oilseeds (includes canola, sunflower etc)	2			
Grain legumes (includes soybeans)	2			
Sugarcane	2			
Grapes	2	1	1	2
Other Fruit	2	2	3	12
Vegetables	2			
Nuts	1			
Other livestock (includes goats, deer, camels, rabbits)	1			
Honey and beeswax	1			
Other horticulture (includes flowers etc)	1	1	1	1
Total Commodity Damage Score (TCDS)				25

Assess Potential Commodity Impact Scores for each primary production commodity listed in Table 9, based on species' attributes (diet, behaviour, ecology), excluding risk of spreading disease which is addressed in Question C9, and pest status worldwide as:

0. *Nil (species does not have attributes to make it capable of damaging this commodity)*
1. *Low (species has attributes making it capable of damaging this or similar commodities and has had the opportunity but no reports or other evidence that it has caused damage in any country or region*
2. *Moderate–serious (reports of damage to this or similar commodities exist but damage levels have never been high in any country or region and no major control programs against the species have ever been conducted OR the species has attributes making it capable of damaging this or similar commodities but has not had the opportunity)*
3. *Extreme (damage occurs at high levels to this or similar commodities and/or major control programs have been conducted against the species in any country or region and the listed commodity would be vulnerable to the type of harm this species can cause).*

Climate Match to Commodity Score (0–5)

- *None of the commodity is produced in areas where the species has a climate match within the highest eight climate match classes (ie classes 10, 9, 8, 7, 6, 5, 4 and 3) = 0*
- *Less than 10% of the commodity is produced in areas where the species has a climate match within the highest eight climate match classes = 1*
- *Less than 10% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes (ie classes 10, 9, 8, 7, 6 and 5) = 2*
- *Less than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes AND less than 10% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes (ie classes 10, 9 and 8) = 3*
- *Less than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes BUT more than 10% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes = 4*
- *OR More than 50% of the commodity is produced in areas where the species has a climate match within the highest six climate match classes BUT less than 20% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes = 4*
- *More than 20% of the commodity is produced in areas where the species has a climate match within the highest three climate match classes OR overseas range unknown and climate match to Australia unknown = 5.]*

Table 3: Assigning species to EIC Threat Categories (shaded cells relate to assignment of reptiles and amphibians to EIC Threat Categories based on an assessed establishment risk and an allocated pest risk of extreme) – adapted from Bomford 2008

Establishment Risk	Pest Risk	Public Safety Risk	EIC Threat Category	Implication for any proposed import into Australia	Implication for keeping and movement in Australia
Extreme	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**	Prohibited, unless sufficient risk management measures exist to reduce the potential risks to an acceptable level	Limited to those collections approved for keeping particular EXTREME Threat species
Extreme	Serious	Highly, Moderately or Not Dangerous	**EXTREME**		
Extreme	Moderate	Highly, Moderately or Not Dangerous	**EXTREME**		
Extreme	Low	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Serious	Highly, Moderately or Not Dangerous	**EXTREME**		
Moderate	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Moderate	Highly, Moderately or Not Dangerous	**SERIOUS**	Import restricted to those collections approved for keeping SERIOUS Threat species	Limited to those collections approved for keeping particular SERIOUS Threat species
Serious	Low	Highly, Moderately or Not Dangerous	**SERIOUS**		
Moderate	Serious	Highly, Moderately or Not Dangerous	**SERIOUS**		
Moderate	Moderate	Highly Dangerous	**SERIOUS**		
Moderate	Low	Highly Dangerous	**SERIOUS**		
Low	Extreme	Highly, Moderately or Not Dangerous	**SERIOUS**		
Low	Serious	Highly, Moderately or Not Dangerous	**SERIOUS**		
Low	Moderate	Highly Dangerous	**SERIOUS**		
Low	Low	Highly Dangerous	**SERIOUS**		
Moderate	Moderate	Moderately or Not Dangerous	**MODERATE**	Import restricted to those collections approved for keeping MODERATE Threat species	Limited to those collections approved for keeping particular MODERATE Threat species
Moderate	Low	Moderately or Not Dangerous	**MODERATE**		
Low	Moderate	Moderately or Not Dangerous	**MODERATE**		
Low	Low	Moderately Dangerous	**MODERATE**		
Low	Low	Not Dangerous	**LOW**	Import permitted	May be limited to those collections approved for keeping particular LOW Threat species
Any Value	Any Value	Unknown	**EXTREME until proven otherwise**	Prohibited, unless sufficient risk management measures exist to reduce the potential risks to an acceptable level	Limited to those collections approved for keeping particular EXTREME Threat species
Unknown	Any Value	Any Value	**EXTREME until proven otherwise**		
Any Value	Unknown	Any Value	**EXTREME until proven otherwise**		
Unassessed	Unassessed	Unassessed	**EXTREME until proven otherwise**		

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Date:	July 2023
Reviewers:	Win Kirkpatrick, DPAW

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National Risk Assessment: EXTREME (*Crotalus atrox*, *Crotalus durissus and Crotalus lepidus*)
SERIOUS (*Crotalus adamanteus*)

RISK ASSESSMENT FOR AUSTRALIA: **Rattlesnake Sp. (*Crotalus*)**

Class - Reptilia**, Order -** Squamata**, Family -** Viperidae**, Genus –** *Crotalus.*

SPECIES: *Crotalus adamanteus* (Beauvois, 1799) *Crotalus atrox* (Baird & Girard, 1853) *Crotalus durissus* (Linnaeus, 1758) *Crotalus lepidus* (Kennicott, 1861) **Synonyms:** ***Crotalus adamanteus*:** *Crotalus adamanteus ruber* (Cope, 1892) *Crotalus durissus* (Boulenger, 1896) *Crotalus adamanteus* (Stejneger, 1895) ***Crotalus atrox*:** *Caudisona atrox sonoraensis* (Kennicott, 1861) *Crotalus cinereous* (Le Conte, 1852) *Crotalus confluentus* (Boulenger, 1896) *Crotalus tortugensis* (Van Denburgh & Slevin, 1921) ***Crotalus durissus*:** *Crotalus cascavella* (Wagler, 1824) *Crotalus cumanensis* (Humboldt, 1811) *Crotalus dryinas* (Linnaeus, 1758) *Crotalus loeflingii* (Humboldt, 1811) *Crotalus terrificus* (Bouleger, 1896) ***Crotalus lepidus*:** *Caudisona lepida* (Kennicott, 1861) **Subspecies:**	**Species description:** Rattlesnake species are venomous, and all have a “rattle” at the tip of their tail. The rattle is formed from hollow interlocked keratin segments. The segments fit loosely inside one another and make a rattling sound when the snake twitches a set of small muscles on either side of its tail. **1. *Crotalus adamanteus* (Eastern Diamondback Rattlesnake):** Largest of the rattlesnake species. Its average length is between 0.8 to 1.8 metres and it can weigh up 15.4 kilograms (Conant, 1975; Mallow, 2003; Wood, 1983). Colour pattern consists of a brownish, brownish-yellow, brownish-grey or olive ground colour, overlaid with a series of 24–35 dark brown to black diamonds with slightly lighter centres. Each of these diamond-shaped blotches is outlined with a row of cream or yellowish scales. The belly is yellowish or cream-colored with dark mottling along the sides (Campbell, 2004). **2. *Crotalus atrox* (Western Diamondback Rattlesnake):** Commonly grow to 1.20 metres in length. Specimens over 1.5 metres are infrequently encountered, while those over 1.8 metres are very rare. The largest reported length considered to be reliable is 2.13 metres (Feldman, 2012; Klauber, 1972; Norris, 2004). Colour pattern generally consists of a dusty-looking grey-brown ground colour, but it may also be pinkish-brown, brick red, yellowish, pinkish, or chalky white. There are distinctive diamond shaped patterns along the back and the belly is off-white (Ernst, 2003). **3. *Crotalus durissus* (Cascabel Rattlesnake):** Grows to 1.5 metres and rarely to a maximum length of 1.9 metres (Campbell, 2004). Colour and pattern are quite variable with most having a darker diamond pattern and rhombic spots. *C. durissus* has two distinct stripes starting at the base of the head. Within the lines the colour is lighter than the stripes. Belly colour varies and can be yellowish or white with light grey spots becoming darker towards the tail. **4. *Crotalus lepidus* (Rock Rattlesnake):** Rarely exceeds 81.3 centimetres in length. *C. lepidus* has a large, rounded head and fairly heavy body for its size. Colour pattern varies greatly, generally reflecting the colour of the rock in the snake’s natural environment. Snakes found near areas of predominantly limestone tend to be a light grey in colour, with darker grey banding. Snakes found at higher altitudes have darker colours (Hammerson, 2007a).

***Crotalus adamanteus*:** Monotypic ***Crotalus atrox*:** Monotypic ***Crotalus durissus*:** *Crotalus durissus cumanensis* (Humboldt, 1811) *Crotalus durissus durissus* (Linnaeus, 1758) *Crotalus durissus marajoensis* (Hoge, 1966) *Crotalus durissus ruruima* (Hoge, 1966) *Crotalus durissus terrificus* (Laurenti, 1768) *Crotalus durissus trigonicus* (Harris & Simmons, 1978) (Rupununi Savanna Rattlesnake) *Crotalus durissus unicolor* (Van Lidth de Jeude, 1887) (Aruba Island Rattlesnake) ***Crotalus lepidus*:** *Crotalus lepidus klauberi* (Gloyd, 1936) (Banded Rock Rattlesnake) *Crotalus lepidus lepidus* (Kennicott, 1861) (Mottled Rock Rattlesnake) *Crotalus lepidus maculosus* (Tanner, Dixon and Harris, 1972) (Durangan Rock Rattlesnake) **Common Names:** ***Crotalus adamanteus*:** Eastern Diamondback Rattlesnake Eastern Diamond-backed Rattlesnake ***Crotalus atrox*:** Western Diamondback Rattlesnake Western Diamond-backed Rattlesnake Adobe Snake Arizona Diamond Rattlesnake Coon Tail	**General information:** All rattlesnakes assessed here are viviparous (give birth to live young) (Neill, 1964). All hunt small mammals (mainly rodents), reptiles, birds and amphibians. They can survive on 3 to 4 big meals a year (Funderburg, 1968; Gibbons and Dorcas, 2005; Means, 1999; Rokyta, 2012). **1. Eastern Diamondback Rattlesnake:** Range: encompasses the Coastal Plain of the southeastern United States of America from North Carolina to south Florida, and west to Mississippi and the Florida parishes of Louisiana (Campbell and Lamar, 2004, Dundee and Rossman, 1989; Ernst and Ernst, 2003; Mount, 1975). *C. adamanteus* is known to hybridise with *C. horridus* (Harrison et al., 2022). **2. Western Diamondback Rattlesnake:** Range: from southeastern California, possibly southern Nevada, central and southern Arizona, New Mexico, Texas, Oklahoma, and Arkansas in the United States of America, south in Mexico to extreme northeastern Baja California, northern Sinaloa, Veracruz, and (at least formerly) disjointly to Oaxaca (Campbell and Lamar, 2004; Ernst, 1992). It is unclear whether specimens collected in Kansas represent translocated individuals or part of a natural population (Matlack and Rehmeier, 2002). The elevational range extends from near sea level up to at least 2,440 metres above sea level in San Luis Potosi (Klauber, 1972), but most locations are below elevations of 1,500 metres above sea level (Campbell and Lamar, 2004). *C. atrox* and *C. horridus* may hybridise in nature (Meik, 2008). Levine et al. (2021) presented evidence for long-term sperm storage up to 6 years (or longer). **3. Cascabel Rattlesnake:** Most widely distributed member of the genus (Mehrtens, 1987). Range: discontinuously from Colombia to Argentina in South America. It occurs in all mainland countries in South America except Ecuador and Chile. *C. durissus* is generally found at elevations from sea level up to 2,000 metres above sea level. However, there is an isolated record in Boyacá, Colombia, of *C. durissus* at 2,100 metres (Cacciali, 2021) and another from Venezuela at 2,800 metres (Campbell and Lamar, 2004). **4. Rock Rattlesnake:** Range: southeastern Arizona, southern New Mexico, southwestern Texas in the United States of America, and eastern Sonora, Chihuahua, Durango, eastern Sinaloa, Zacatecas, eastern Nayarit, northern Jalisco, Aguascalientes, western San Luis Potosi, western Nuevo Leon, Coahuila, and southwestern Tamaulipas in Mexico (Armstrong and Murphy, 1979; Degenhardt et al., 1996; Ernst and Ernst, 2003; Stebbins, 2003; Campbell and Lamar, 2004). Its elevational range extends from about 300 to 2,930 metres above sea level (Stebbins, 2003). *C. lepidus* and *C. aquilus* are known to hybridise (Bryson, 2007).

Desert Diamond-back Fierce Rattlesnake Spitting Rattlesnake Buzz Tail Texan Rattlesnake ***Crotalus durissus*:** Cascabel Rattlesnake Neotropical Rattlesnake Tropical Rattlesnake South American Rattlesnake Yucatan Rattlesnake Rupununi Savanna Rattlesnake Aruba Island Rattlesnake ***Crotalus lepidus*:** Rock Rattlesnake Banded Rock Rattlesnake Mottled Rock Rattlesnake Durangan Rock Rattlesnake Blue Rattlesnake	**Longevity:** **1. Eastern Diamondback Rattlesnake:** 22.8 years (AnAge) **2. Western Diamondback Rattlesnake:** 27 years (AnAge) **3. Cascabel Rattlesnake:** 19.8 years (AnAge) **4. Rock Rattlesnake:** 33.6 years (AnAge) **Conservation status:** **IUCN:** All species assessed as 'Least Concern'. **CITES:** *C. adamanteus, C. atrox* & *C. lepidus* Not Listed; *C. durissus* Appendix III
DATE OF ASSESSMENT: April 2023 (Jodi Buchecker) **Risk assessment model used for the assessment:** Bomford 2006, Reptiles Bomford 2008, Bird and Mammal Model for Reptiles and Amphibians	**The risk assessment model:** Models for assessing the risk that exotic vertebrates could establish in Australia have been developed for mammals, birds (Bomford 2003, 2006, 2008), reptiles and amphibians (Bomford et al 2005, Bomford 2008). Developed by Dr Mary Bomford for the Bureau of Rural Sciences (BRS), the model uses criteria that have been demonstrated to have significant correlation between a risk factor and the establishment of populations of exotic species and the pest potential of those species that do establish. For example, a risk factor for establishment is similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia. For pest potential, the species' overseas pest status is a risk factor. The model is published as 'Risk assessment models for the establishment of exotic vertebrates in Australia and New Zealand' (Bomford 2008) and is available online on the PestSmart website https://pestsmart.org.au/wp-content/uploads/sites/3/2020/06/Risk_Assess_Models_2008_FINAL.pdf **CLIMATE**: In 2021 a new version of the Climatch program used to assess similarity in climate was released by the Australian Bureau of Agricultural Resource Economics and Sciences (ABARES): CLIMATCH v2.0. The increase in resolution in this new version (from 50 km to 20 km) required recalibration of Climate Match Scores. See Table 1. Sixteen climate parameters (variables) of temperature and rainfall are used to estimate the extent of similarity between data from meteorological stations located within the species' world distribution and stations in Australia. Worldwide,

	data from approximately 19000 locations are available for analysis. The number of locations used in an analysis will vary according to the size of the species' distribution and the number of meteorological stations located within that distribution. To represent the climate match visually, the map of Australia is divided into 19236 grid squares, each measured in 0.2 degrees in both longitude and latitude. CLIMATCH v2.0 calculates a match for each Australian grid by comparing data from all meteorological stations within the species' distribution (excluding any populations in Australia) and allocating a score ranging from ten for the highest level match to zero for the poorest match. Levels of climate match are used in the risk assessment for questions B1 (scores are summed to give a cumulative score), C6, and C8. Climatch v2.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/.

Reptile Model (2006):

FACTOR	**SCORE**	**DETAIL**
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
A. Climate match risk score *Map the selected reptile or amphibian species' overseas range, including its entire native and exotic (excluding Australia) ranges over the past 1000 years. Use CLIMATCH v2.0 to determine the climate match between this overseas range and Australia, selecting Euclidian Match and using all 16 climate variables for the analysis.* *CMS = sum of classes 7 – 10* *CMRS = 100 x (CMS/19236).*	0.48 70.83 30.58 41.90	1. Eastern Diamondback Rattlesnake: CMRS = 100 x (93/19,236) = 0.48 2. Western Diamondback Rattlesnake: CMRS = 100 x (13,621/19,236) = 70.83 3. Cascabel Rattlesnake: CMRS = 100 x (5,883/19,236) = 30.58 4. Rock Rattlesnake: CMRS = 100 x (8,054/19,236) = 41.90
B. Exotic Elsewhere Risk score (0, 15 or 30) *Score B = A species' Exotic Elsewhere Risk Score, calculated as follows:* • *Species has established breeding self-sustaining exotic population in another country = 30* • *Species has been introduced into another country and records exist of it in the wild, but it is uncertain if a breeding self-sustaining population has established = 15* • *Species has not established an exotic population (including species not known to have been introduced anywhere) = 0*	 0	*No evidence found that any of the species assessed here have ever established an exotic population.* *C. atrox* is recorded in GBIF as being introduced to Belgium (Alien Herpetofauna of Belgium; escape release of pets) and South Africa (no data for this recording), but no evidence found that a viable free-living population has ever been established. 1. Eastern Diamondback Rattlesnake

	15 0 0	2. Western Diamondback Rattlesnake 3. Cascabel Rattlesnake 4. Rock Rattlesnake
C. Taxonomic Family Risk Score	10	*Viperidae*
ESTABLISHMENT RISK RANK *A species' Establishment Risk Score = Score A + Score B + Score C.* *Establishment Risk Rank* *Establishment Risk Score* *Low* *≤ 22* *Moderate* *23-60* *Serious* *61-115* *Extreme* *≥ 116*	10.48 95.83 40.58 51.90	1. Eastern Diamondback Rattlesnake: **LOW** 2. Western Diamondback Rattlesnake: **SERIOUS** 3. Cascabel Rattlesnake: **MODERATE** 4. Rock Rattlesnake: **MODERATE**

Bird and Mammal Model for Reptiles and Amphibians:

B1. Degree of climate match between species overseas range and Australia (1–6) *Map the selected mammal or bird species' overseas range, including its entire native and exotic (excluding Australia) ranges over the past 1000 years.* *Use CLIMATCH v2.0, Value X = sum of classes 6 – 10, see Table 1.*	1 5 4	1. Eastern Diamondback Rattlesnake: *Very Low climate match to Australia* Value X = 202 Climate Match Score = 1 2. Western Diamondback Rattlesnake: *Very High climate match to Australia* Value X = 14,579 Climate Match Score = 5 3. Cascabel Rattlesnake: *High climate match to Australia* Value X = 9,342 Climate Match Score = 4

	4	4. Rock Rattlesnake: *High climate match to Australia* Value X = 9,319 Climate Match Score = 4
B2. Exotic population established overseas (0–4) *An established exotic population means the introduced species must have bred outside of captivity and must currently maintain a viable free-living population where the animals are not being intentionally fed or sheltered, even though they may be living in a highly disturbed environment with access to non-natural food supplies or shelter.*	0	*No evidence found that any of the species assessed here have ever established an exotic population.* *C. atrox* is recorded in GBIF as being introduced to Belgium (Alien Herpetofauna of Belgium; escape release of pets) and South Africa (no data for this recording), but no evidence found that a viable free-living population has ever been established.
B3. Overseas range size score (0–2) < 1 = 0; 1– 70 = 1; >70 = 2 *Estimate the species overseas range size* including currently and the past 1000 years; natural and introduced range in millions of square kilometres*	0 1 1 1	1. Eastern Diamondback Rattlesnake: *Overseas range size estimated at ~0.4 million km^2. Includes current and past 1000 years, natural and introduced range.* 2. Western Diamondback Rattlesnake: *Overseas range size estimated at ~2.9 million km^2. Includes current and past 1000 years, natural and introduced range.* 3. Cascabel Rattlesnake: *Overseas range size estimated at ~15.5 million km^2. Includes current and past 1000 years, natural and introduced range.* 4. Rock Rattlesnake: *Overseas range size estimated at ~1.5 million km^2. Includes current and past 1000 years, natural and introduced range.*
ESTABLISHMENT RISK RANK *A species' Establishment Risk Score = Score A + Score B + Score C.* *Establishment Risk Rank — Establishment Risk Score* *Low — ≤ 4* *Moderate — 5-7* *Serious — 8-9* *Extreme — 10-12*	1 6 5 5	1. Eastern Diamondback Rattlesnake: **LOW** 2. Western Diamondback Rattlesnake: **MODERATE** 3. Cascabel Rattlesnake: **MODERATE** 4. Rock Rattlesnake: **MODERATE**

ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY	1. Eastern Diamondback Rattlesnake: **SERIOUS** 2. Western Diamondback Rattlesnake: **EXTREME** 3. Cascabel Rattlesnake: **EXTREME** 4. Rock Rattlesnake: **EXTREME**

1. Eastern Diamondback Rattlesnake (*Crotalus adamanteus*):
World distribution map (IUCN) of the and World distribution map (including current and past 1000 years) indicating where meteorological data was sourced for the climate analysis (see B1):

Figure 1- World Distribution Map - IUCN RedList

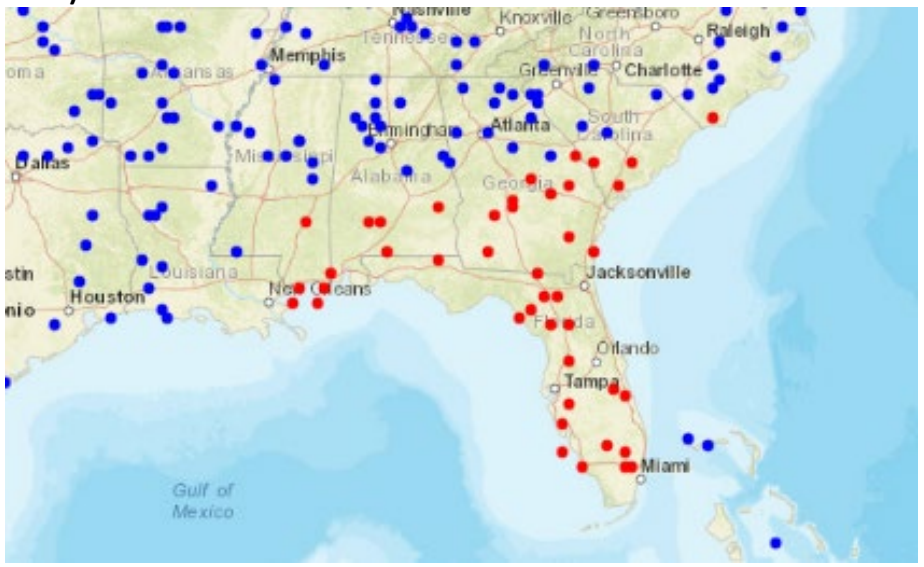


Figure 2 – World Distribution map – Climatch

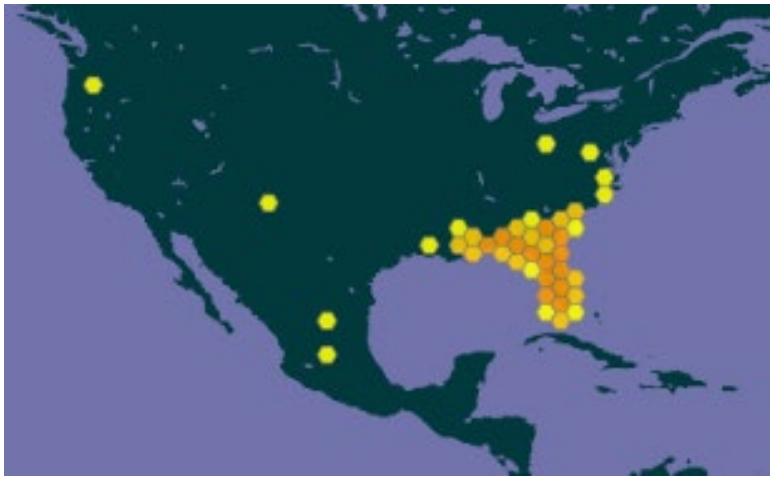
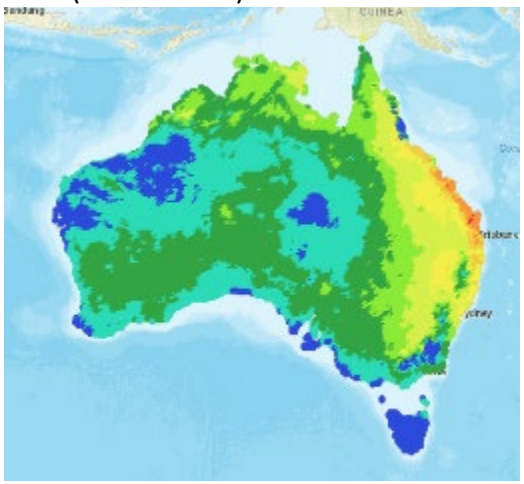


Figure 3 - World Georeferenced records (GBIF)

Reptile model (2006): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Crotalus adamanteus*

CMS (Sum Level 7) = 93



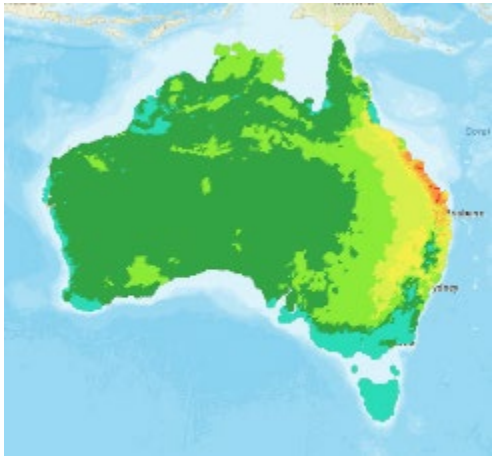
Score	Color	Count
0		1709
1		5698
2		6812
3		2402
4		1689
5		652
6		181
7		87
8		6
9		0
10		0

Species: Eastern Diamondback Rattle Snake (Crotalus adamanteus)
Algorithm: Euclidean
43 source features selected
19236 target features selected
Approximate selected area: 402,151 km^2

Bird and Mammal model: Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Crotalus adamanteus*

Value X (Sum Level 6) = 202



Score	Color	Count
0		0
1		1010
2		12385
3		3926
4		1286
5		427
6		123
7		70
8		9
9		0
10		0

Species: Eastern Diamondback Rattle Snake (Crotalus adamanteus)
Algorithm: Closest Standard Score
43 source features selected
19236 target features selected
Approximate selected area: 402,151 km^2

2. Western Diamondback Rattlesnake (*Crotalus atrox*):
World distribution map (GBIF and IUCN) of the and World distribution map (including current and past 1000 years) indicating where meteorological data was sourced for the climate analysis (see B1):

Figure 1 - - World Distribution Map - IUCN RedList

Figure 2 – World Distribution map – Climatch

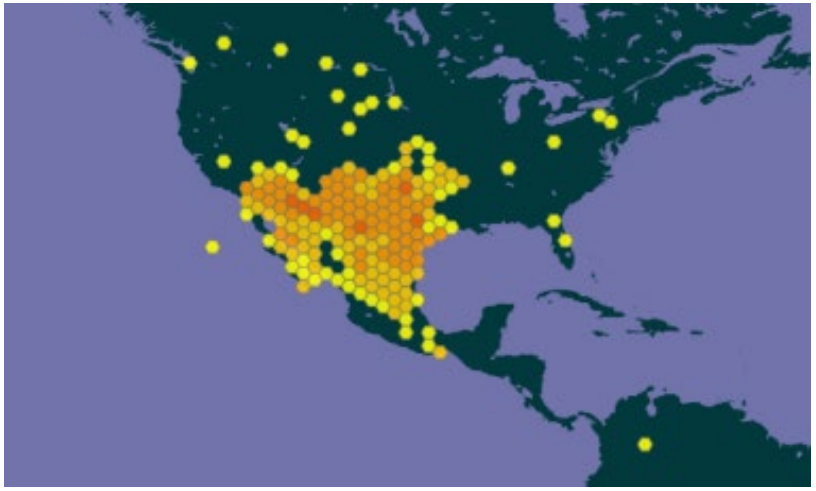
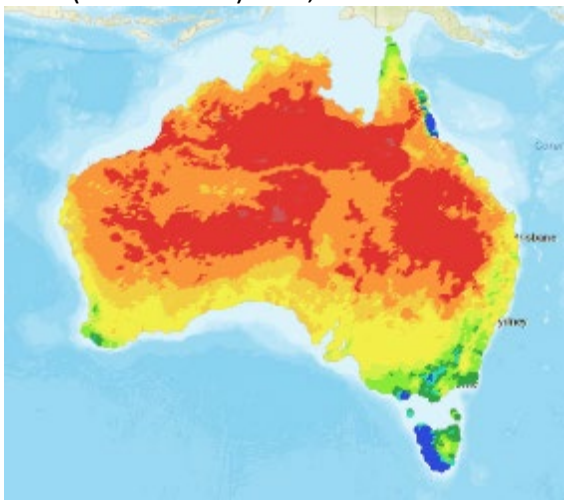


Figure 3 - World Georeferenced records (GBIF

Reptile model (2006): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Crotalus atrox*

CMS (Sum Level 7) = 13,621



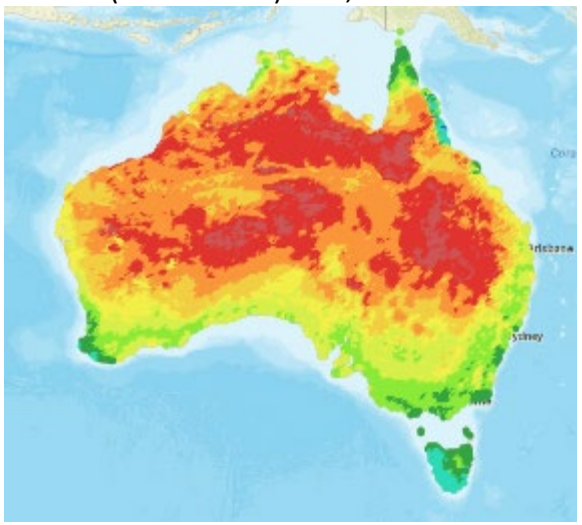
Score	Color	Count
0		106
1		66
2		185
3		392
4		557
5		2012
6		2297
7		6712
8		6807
9		102
10		0

Species: Western Diamondback Rattlesnake (Crotalus atrox)
Algorithm: Euclidean
284 source features selected
19236 target features selected
Approximate selected area: 2,852,980 km^2

Bird and Mammal model: Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Crotalus atrox*

Value X (Sum Level 6) = 14,579



Score	Color	Count
0		1
1		115
2		348
3		1105
4		1616
5		1472
6		2777
7		5847
8		4933
9		1019
10		3

Species: Western Diamondback Rattlesnake (Crotalus atrox)
Algorithm: Closest Standard Score
284 source features selected
19236 target features selected
Approximate selected area: 2,852,980 km^2

3. Cascabel Rattlesnake (*Crotalus durissus*):
World distribution map (GBIF and IUCN) of the and World distribution map (including current and past 1000 years) indicating where meteorological data was sourced for the climate analysis (see B1):

Figure 1 - World Distribution Map - IUCN RedList

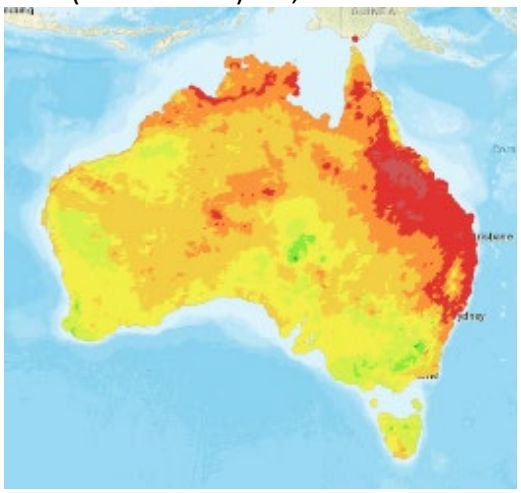
Figure 2 – World Distribution map – Climatch

Figure 2 - World Georeferenced records (GBIF)

Reptile model (2006): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Crotalus durissus*

CMS (Sum Level 7) = 5,883



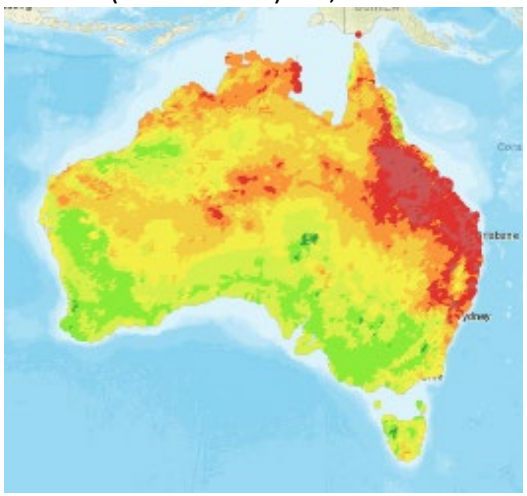
Score	Color	Count
0		0
1		0
2		3
3		174
4		1524
5		4496
6		7156
7		3743
8		1866
9		274
10		0

Species: Cascabel Rattlesnake (Crotalus durissus)
Algorithm: Euclidean
1528 source features selected
19236 target features selected
Approximate selected area: 15,556,589 km^2

Bird and Mammal model: Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Crotalus durissus*

Value X (Sum Level 6) = 9,342



Score	Color	Count
0		0
1		0
2		53
3		2355
4		3410
5		4076
6		4682
7		2662
8		1253
9		737
10		8

Species: Cascabel Rattlesnake (Crotalus durissus)
Algorithm: Closest Standard Score
1528 source features selected
19236 target features selected
Approximate selected area: 15,556,589 km^2

4. Rock Rattlesnake (*Crotalus lepidus*):

World distribution map (GBIF and IUCN) of the and World distribution map (including current and past 1000 years) indicating where meteorological data was sourced for the climate analysis (see B1):

Figure 1 - World Distribution Map - IUCN RedList

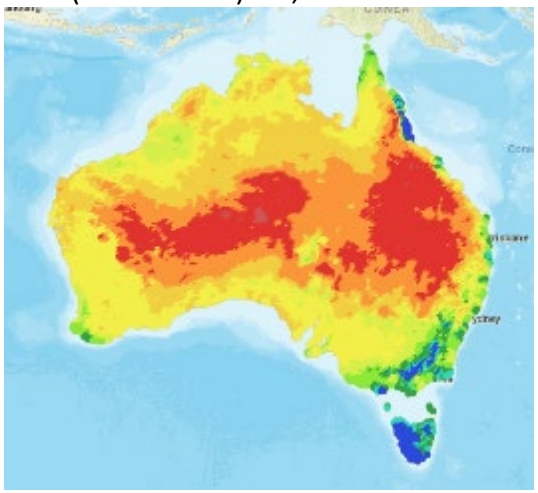
Figure 2 – World Distribution map – Climatch

Figure 3 - World Georeferenced records (GBIF)

Reptile model (2006): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Crotalus lepidus*

CMS (Sum Level 7) = 8,054



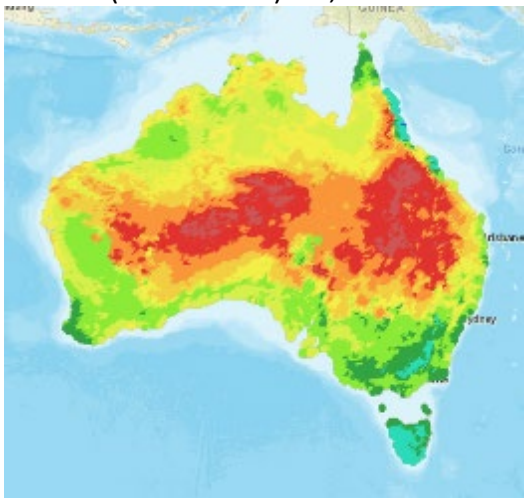
Score	Color	Count
0		194
1		127
2		241
3		418
4		1284
5		4710
6		4208
7		4240
8		3747
9		67
10		0

Species: Rock Rattlesnake (Crotalus lepidus)
Algorithm: Euclidean
131 source features selected
19236 target features selected
Approximate selected area: 1,504,068 km^2

Bird and Mammal model: Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Crotalus lepidus*

Value X (Sum Level 6) = 9,319



Score	Color	Count
0		1
1		256
2		723
3		2998
4		3059
5		2880
6		2549
7		3263
8		2851
9		653
10		3

Species: Rock Rattlesnake (Crotalus lepidus)
Algorithm: Closest Standard Score
131 source features selected
19236 target features selected
Approximate selected area: 1,504,068 km^2

Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Climatch (50 km) Closest Standard Match Sum Level 6 (Value X)	2021 Recalibrated Climatch v2.0 (20 km) Closest Standard Match Sum Level 6 (Value X)
1 (Very low)	< 100	< 691
2 (Low)	100-599	691-4137
3 (Moderate)	600-899	4138-6209
4 (High)	900-1699	6210-11735
5 (Very high)	1700-2699	11736-18642
6 (Extreme)	≥ 2700	≥ 18643

Table 2: Assigning species to EIC Threat Categories (shaded cells relate to assignment of reptiles and amphibians to EIC Threat Categories based on an assessed establishment risk and an allocated pest risk of extreme) – adapted from Bomford 2008

Establishment Risk	Pest Risk	Public Safety Risk	EIC Threat Category	Implication for any proposed import into Australia	Implication for keeping and movement in Australia
Extreme	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**	Prohibited, unless sufficient risk management measures exist to reduce the potential risks to an acceptable level	Limited to those collections approved for keeping particular EXTREME Threat species
Extreme	Serious	Highly, Moderately or Not Dangerous	**EXTREME**		
Extreme	Moderate	Highly, Moderately or Not Dangerous	**EXTREME**		
Extreme	Low	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Serious	Highly, Moderately or Not Dangerous	**EXTREME**		
Moderate	Extreme	Highly, Moderately or Not Dangerous	**EXTREME**		
Serious	Moderate	Highly, Moderately or Not Dangerous	**SERIOUS**	Import restricted to those collections approved for keeping SERIOUS Threat species	Limited to those collections approved for keeping particular SERIOUS Threat species
Serious	Low	Highly, Moderately or Not Dangerous	**SERIOUS**		
Moderate	Serious	Highly, Moderately or Not Dangerous	**SERIOUS**		
Moderate	Moderate	Highly Dangerous	**SERIOUS**		
Moderate	Low	Highly Dangerous	**SERIOUS**		
Low	Extreme	Highly, Moderately or Not Dangerous	**SERIOUS**		
Low	Serious	Highly, Moderately or Not Dangerous	**SERIOUS**		
Low	Moderate	Highly Dangerous	**SERIOUS**		
Low	Low	Highly Dangerous	**SERIOUS**		
Moderate	Moderate	Moderately or Not Dangerous	**MODERATE**	Import restricted to those collections approved for keeping MODERATE Threat species	Limited to those collections approved for keeping particular MODERATE Threat species
Moderate	Low	Moderately or Not Dangerous	**MODERATE**		
Low	Moderate	Moderately or Not Dangerous	**MODERATE**		
Low	Low	Moderately Dangerous	**MODERATE**		
Low	Low	Not Dangerous	**LOW**	Import permitted	May be limited to those collections approved for keeping particular LOW Threat species
Any Value	Any Value	Unknown	**EXTREME until proven otherwise**	Prohibited, unless sufficient risk management measures exist to reduce the potential risks to an acceptable level	Limited to those collections approved for keeping particular EXTREME Threat species
Unknown	Any Value	Any Value	**EXTREME until proven otherwise**		
Any Value	Unknown	Any Value	**EXTREME until proven otherwise**		
Unassessed	Unassessed	Unassessed	**EXTREME until proven otherwise**		

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