Round 10 Risk Assessments

Contents

Taxonomic Name	Page Number
Madagascar giant day gecko (*Phelsuma grandis*)	2
Reeves turtle (*Mauremys reevesii*)	21
Emerald tree monitor (*Varanus prasinus*)	42
Crested gecko (*Correlophus ciliatus*)	56
Chinese softshell turtle (*Pelodiscus sinensis*)	72
Diamondback terrapin (*Malaclemys terrapin*)	93
Plantain squirrel (*Callosciurus notatus*)	114
Nyala (*Tragelaphus angasii*)	134
Barbary sheep (*Ammotragus lervia*)	153

DRAFT National Risk Assessment: EXTREME

RISK ASSESSMENT FOR AUSTRALIA: Madagascar giant day gecko (*Phelsuma grandis*)

Class - Reptilia, **Order -** Squamata, **Family -** Gekkonidae, **Genus –** *Phelsuma.*

SPECIES:	**Species description:**
Phelsuma grandis (Gray, 1879) **Synonyms:** *Phelsuma madagascariensis grandis* (Gray, 1870) *Phelsuma madagascariensis venusta* (Mertens, 1964) *Phelsuma madagascariensis notissima* (Mertens, 1970) **Subspecies:** Monotypic **Common Names:** Giant Madagascar day gecko Madagascar giant day gecko Giant day gecko	The Madagascar giant day gecko is among the largest of the day geckos. Adults can reach a maximum total length of 30 centimetres (Rocha et al. 2010; Uetz et al. 2025) and snout-to-vent lengths can reach up to 10.24 cm (Rocha et al. 2010). Although the body is robust with strong limbs, the giant day gecko is agile, exhibiting bursts of speed when startled (Fieldsend & Krysko 2019). The Madagascar giant day gecko has smooth ventral and subcaudal scales, keeled dorsal and lateral scales, absence of nostril-rostral contact and size reduced vertebral scales (Rocha et al. 2010). Colouration is vivid. The dorsal and lateral ground colour is bright green, and, in most individuals, there are variable red to orangish-red spots or bars present along these surfaces. These spots or bars may be reduced or absent in other geckos (Bartlett 1999). If stressed, the gecko may appear darker and more uniform in colouration. A red stripe runs across each side of the snout from the nostril to the eye. Some Madagascar giant day geckos have an anteriorly directed red V that may extend from above each eye onto the top of the snout (Zug 2013). The ventral surface ranges from ivory to yellowish white (Zug 2013). The tail is thick, as long or longer than its body length with a green to light golden-yellow venter (SNZCBI 2025; Zug 2013). This species has large, round pupils and lacks eyelids, using its tongue to clean its eyes (Lamar 1997; Rocha et al. 2010). Madagascar giant day geckos are diurnal, meaning they are active during daylight hours, and are arboreal (live in trees) (D'Cruze et al. 2009a, 2009b). They possess adhesive toe pads with undivided toe lamellae facilitating their arboreal lifestyle (Rocha et al. 2010). The Madagascar giant day gecko does not have claws and instead uses the adhesive toe pads (which consist of thousands of tiny hair-like structures called setae, that branch off into even smaller bristles) to cling to various surfaces including smooth vertical surfaces such as glass panes (Zhuang and Higham 2016). Males are larger in size, more brightly coloured and have a larger head than females (Fry and Roycroft 2009). In sexually active adult females, calcium-rich endolymphatic "chalk sacs" may be visible along the sides of the head;

	these serve as a calcium reserve for eggshell formation (Bartlett 1999). Juvenile Madagascar giant day geckos are morphologically similar to adults but have a darker dorsal ground colour with more intense markings (Fry & Roycroft 2009). The Madagascar giant day gecko exhibits territorial behaviour and they can be very aggressive towards each other, sometimes resulting in serious injury or death (Sacramento Zoo 2025). Given this behaviour, they can have a negative effect on other gecko populations such as reducing the abundance of *Phelsuma abbotti* and *Phelsuma inexpectata* through habitat and resource competition (D'Cruze et al. 2009b). If bitten, their strong powerful jaws can break the skin of humans (HNN 2007). Madagascar giant day geckos can autotomise (voluntarily shed part of its body) if threatened by shedding its tail (Fieldsend and Krysko 2020). The Madagascar giant day gecko is also very vocal; it will emit a distress call when handled and vocalise during courtship (Demeter 1976; SNZCBI 2025). Like all reptiles, it could play a role in the spread of diseases or parasites to other animals. In Hawaii, the gecko was recorded as a new host for one cestode, three nematodes and a pentastomida (Goldberg et al. 2010). Dervin et al. (2014) reported the first occurrence of the endoparasites *Raillietiella affinis* in Mauritius, found through testing of Madagascar giant day geckos. *Phelsuma grandis* was elevated from *Phelsuma madagascariensis grandis* on 23 June 2010, following taxonomic changes adopted at the 15th meeting of the Conference of the Parties to the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) (Raxworthy et al. 2007; Species+ 2025), and is now recognised as its own species. **General information:** Distribution: The Madagascar giant day gecko is endemic to northern Madagascar (Dubos 2013). Introduced self-sustaining populations have established on Mauritius, Réunion and the United States of America (USA): in Florida and Hawaii (CITES 2025; Goldberg et al. 2010; Kraus 2002; Species+ 2025). In Florida, they continue to expand and establish new populations within the state (Fieldsend and Krysko 2019). The Madagascar giant day gecko has been recorded as introduced to Afghanistan (Ratsoavina et al. 2011). However, a review of literature could not find any evidence of a self-sustaining population. Habitat: This species is native to the tropical and subtropical forests of northern Madagascar, inhabiting primary and secondary growth, canopy forests, dry deciduous forests and anthropogenically disturbed habitats (e.g. village orchards, plantations, buildings) (Blumgart et al. 2017; D'Cruze et al. 2009a, 2009b; Humphrey & Ward 2020; Glaw

	& Vences 2007; Ratsoavina et al. 2011). It favours warm, humid conditions typical of Madagascar's forested environments. The Madagascar giant day gecko's habitat is largely arboreal where it is commonly found on tree trunks, branches of trees, palms and building structures (D'Cruze et al. 2009b; Dubos et al. 2014). They can be found at altitudes from sea level to 900 metres above sea level (D'Cruze et al. 2009a; Ratsoavina et al. 2011). Diet: It is a generalist omnivore, consuming a range of arthropods (insects, spiders, etc.), small vertebrates (such as *Anolis carolinensis* (green anole)) and plant-derived resources such as nectar, pollen and soft fruit (Bartlett 1999; Elias et al. 2025; Fieldsend and Krysko 2020; Kraus 2002; Minnaar et al. 2013). Reproduction: In Madagascar, females lay their eggs from November to May (Zug 2013). Females are oviparous and lay clutches of two eggs several times a year (SNZCBI 2025; Uetz et al. 2025). The eggs are round and brittle with inflexible shells (Packard and Hirsch 1989). Madagascar giant day geckos exhibit temperature-dependent sex determination (Uetz et al. 2025) where females hatch at the lowest and highest temperatures and males peak at the intermediate temperatures (Viets et al 1994 as cited in Peš 2024). Incubation period is temperature-dependent, with warmer temperatures accelerating development and cooler ones prolonging it, with hatchlings emerging after approximately 48–80 days (Zug 2013). Juveniles will reach sexual maturity after one year (Dublin Zoo 2025; SNZCBI 2025). **Longevity:** In zoo captivity, the Madagascar giant day gecko can live up to 15 years (SNZCBI 2025). In the wild, due to disease, predation and environmental stressors lifespan is estimated to be between 6 to 15 years. (Dublin Zoo 2025; Sacramento Zoo 2025). **Conservation status:** **IUCN:** Least Concern – does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. **CITES:** Appendix II - species that are not necessarily threatened with extinction but require controlled international trade to prevent utilis7ation incompatible with their survival.
DATE OF ASSESSMENT: October 2025	**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 2006, 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

EIC ENDORSEMENT:	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
Risk assessment models used for the assessment: • Australian Reptile and Amphibian Model (Bomford 2006) • Australian Reptile and Amphibian Model (Bomford 2008) • Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008)	**CLIMATE**: Matching similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia is an important step for Bomford models. Climatch v3.0, a new version of the Climatch released by the Australian Bureau of Agricultural Resource Economics and Sciences in 2025 is used for climate matching. Climatch v3.0 uses WorldClim v2.1 datasets with the algorithm updated to use global variances specific to each source dataset. Climatch v3.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/. 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. Climatch v3.0 also includes an additional 3 bioclimatic variables (Diurnal temperature range, Isothermality and Temperature Seasonality) that are not included in the Bomford models. 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 at a spatial resolution of 10 arcminutes (approximately 20 km) in both longitude and latitude. ABARES recalibration thresholds applied in Climatch v3.0 are similar to those used in Climatch v2.0 (at ~20 km resolution) (Table 1). Climatch v3.0 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. Bomford Model 2006, Part A, Australian Reptile and Amphibian Model 2008, Part C and Bird and Mammal Model 2008, Part A (with both using scores that are summed to give a cumulative score).

Australian Reptile and Amphibian Model (Bomford 2006):

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
A. Climate match risk score	11.70	CMS = 327

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).*		CMRS = 100 x (327/19,235) = 1.70 As there were 12 weather stations selected, then Climatch is likely to underestimate the climate match to Australia, therefore the CMRS has been increased by ten percentage points. CMRS = 11.70 There are no weather stations located on Mauritius, Réunion, in the species distribution area of Hawaii and along the southern areas of Madagascar where sightings of Madagascar giant day geckos are recorded in GBIF (Figure 3). The Madagascar giant day gecko has been reported as being introduced to Afghanistan (Ratsoavina et al. 2011). However, a review of literature could not find any evidence of a self-sustaining population and therefore, it has not been included in the Climatch analysis.
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*	30	*Species has established breeding self-sustaining exotic population in another country.* Introduced self-sustaining populations have established on Mauritius, Réunion and the USA: Florida and Hawaii (CITES 2025; Goldberg et al. 2010; Kraus 2002; Species+ 2025).
C. Taxonomic Family Risk Score	30	*Gekkonidae*

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*	71.70	**SERIOUS establishment risk**

Australian Reptile and Amphibian Model (Bomford 2008):

FACTOR	SCORE	DETAIL
A. Family Random Effect value *A family random effect assumed drawn from a Gaussian distribution with mean zero and variance that was estimated from Bomford et al's (2008) data.*	-0.41	*Gekkonidae*
B. Prop.species value *The number of jurisdictions where a species successfully established divided by the total number of jurisdictions where species has been introduced.*	0.75	Based on the updated statistics from Kraus (2009) as directed by Bomford 2008. Based on the statistics *Phelsuma madagascariensis* as previously considered a subspecies and was not separated out until 2010. *Number of jurisdictions where a species successfully established = 3* (Mauritius, Reunion and the USA (Florida and Hawaii)) = 3 *Total number of jurisdictions where species has been introduced = 4* (Mauritius, Reunion, Florida and Hawaii and Afghanistan) *Prop.species Value = 0.75*

C. S(Climate 6) value *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 v2.1 (Version 3.0), to determine the climate match between this overseas range and Australia, selecting Euclidian Match and using all 16 climate variables for the analysis. Sum the five scores for classes 6-10. Express this as a proportion of the maximum possible score (19,235).* *Use Fig 3.4 to calculate value.*	-1.69	<u>Score as reported in Bomford Model 2008</u> Based on the statistics *Phelsuma madagascariensis* as previously considered a subspecies and was not separated out until 2010. Sum Euclidian match scores to Australia levels 6-10 = 840 Climate 6 score = 840/2,785 = 0.30161579892280 S(Climate 6) value from Figure 3.4 = 4.25(Climate 6 Score) – 1.88 S(Climate 6) value from Figure 3.4 = 4.25(0.30161579892280) – 1.88 = -0.5981328545781 Figure 3.4 = -0.60 <u>Score reflecting the version of Climatch 2.1</u> Sum Euclidian match scores to Australia levels 6-10 = 851 Climate 6 score = 851/19,235 = 0.044242266 S(Climate 6) value from Figure 3.4 = 4.25(Climate 6 Score) – 1.88 S(Climate 6) value from Figure 3.4 = 4.25(0.044242266) – 1.88 = -1.69197037 Figure 3.4 = -1.69
ESTABLISHMENT RISK RANK *A species' Establishment Risk Score = 1/ (1 + exp(0.80 – 2.90(Prop.species) – S(Climate 6) – Family Random Effect))* *Establishment Risk Rank* *Establishment Risk Score* *Low* *≤ 0.16* *Moderate* *0.17-0.39* *Serious* *0.40-0.85* *Extreme* *≥ 0.86*	0.32	1/(1 + exp(0.80 – 2.90(0.75) – -1.69 – -0.41) **=0.3263** **MODERATE establishment risk**

Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008):

A. Degree of climate match between species overseas range and Australia (1–6) *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, Value X = sum of classes 6 – 10, see Table 1.*	2	*Low climate match to Australia* Value X = 360 Climate Match Score = 1 As there are only 12 weather stations, the score needs to be increased by 1, as defined by this Bomford model (2008) = 2.
B. 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.*	4	*Exotic population established on a larger island (> 50,000 km^2) or anywhere on a continent.*
C. 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 less than 1 million square kilometres.* IUCN states that "in its native range the species has an estimated extent of occurrence, based on the extent of known sites, of 9,235 km²" (Ratsoavina et al. 2011). However, "the lizard may be more widespread in northern Madagascar, and further research is needed to establish its occurrence within this range and the exact limits of its distribution" (Ratsoavina et al. 2011). Including Florida (170,312 km²), Hawaii (28,314 km²), Mauritius (2,040 km²), Réunion (2,511 km²), the total square kilometres would still be less than 1 million square kilometres (based on information provided by World Atlas 2025).
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*	6	**MODERATE establishment risk**

Serious *Extreme*	*8-9* *10-12*		

ENVIRONMENT AND INVASIVES COMMITTEE ALLOCATED PEST RISK* *For reptiles and amphibians, the assessed Establishment Risk Rank is combined with an allocated Extreme Pest Risk Rank (based on the precautionary approach), resulting in the assignment of species into one of two EIC Threat Categories: Extreme or Serious.	**EXTREME**

ENVIRONMENT AND INVASIVES COMMITTEE **THREAT CATEGORY**	**EXTREME*** *Score assigned based on the highest Establishment Risk Rank (based on the precautionary approach).

NOTE: Where multiple Bomford risks assessment models are applicable, all models have been assessed and the threat category has been assigned based on a precautionary approach, meaning the highest threat category has been assigned and used to calculate the Environment and Invasives Committee Threat Category.

Figure 1: World distribution map (IUCN Red List); Figure 2, Figure 6 and Figure 9 Climatch distribution maps and Figure 3, Figure 7 and Figure 8 world Georeferenced records (GBIF) and Figure 4 Dubos (2013) distribution map, indicating where meteorological data was sourced for the climate analysis:

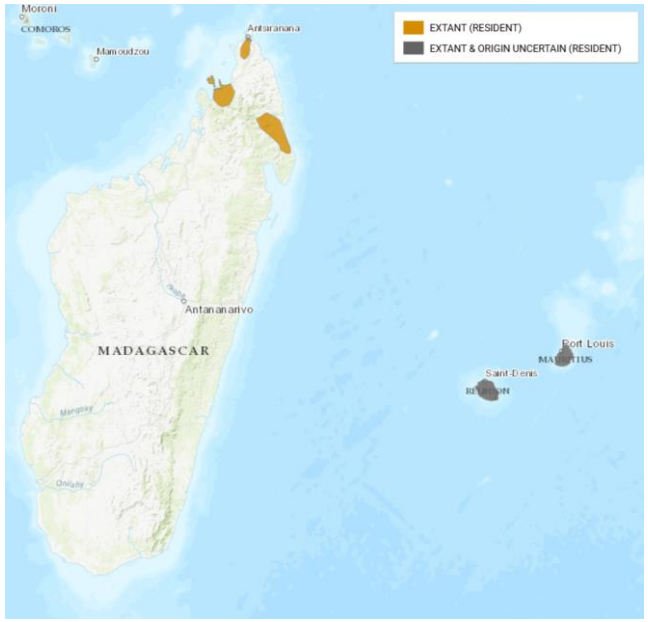


Figure 1. World Distribution Map – IUCN (Madagascar) (Madagascar)

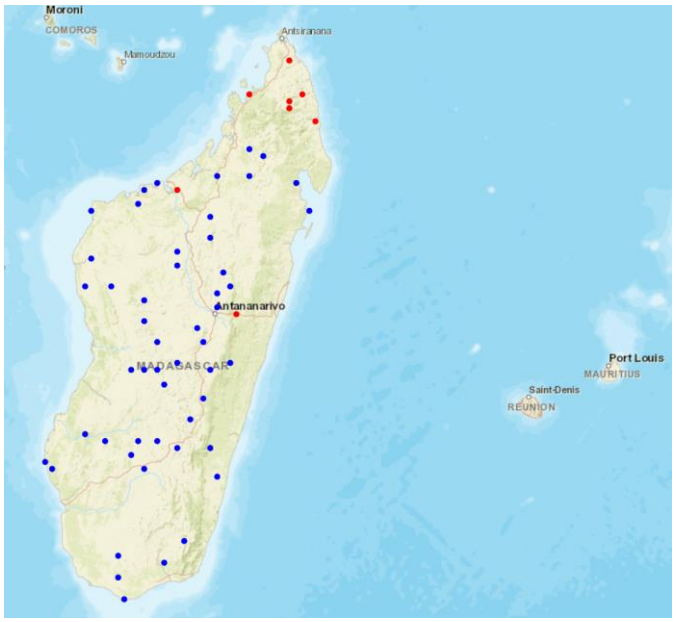


Figure 2. World Distribution map – Climatch (Madagascar)

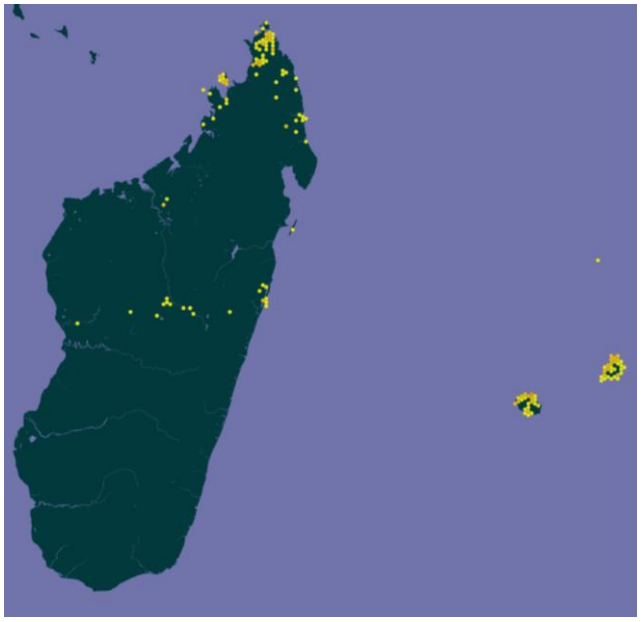


Figure 3. World Georeferenced Records (GBIF)

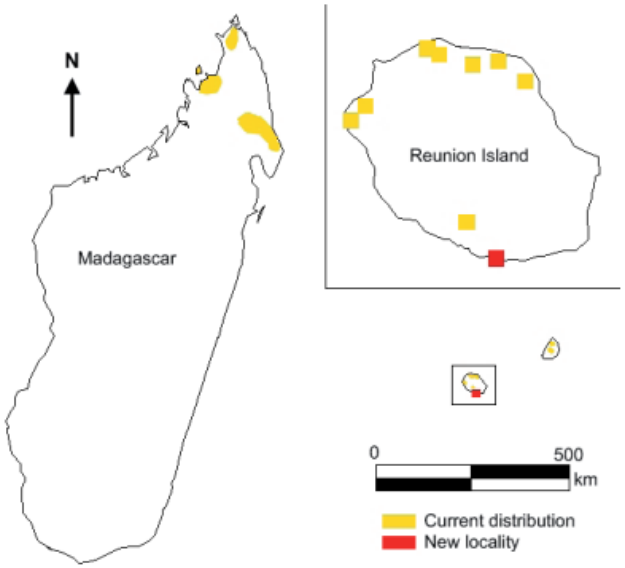


Figure 4. Taken from Dubos (2013) detailing distribution of Phelsuma grandis in south-western Indian Ocean

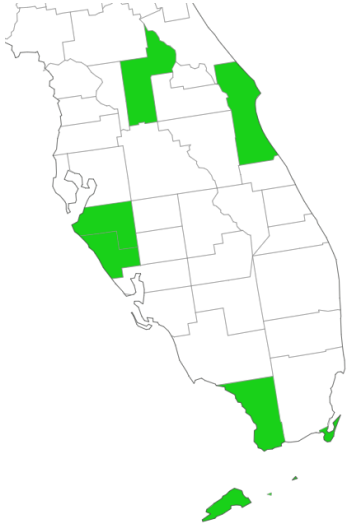


Figure 5. EDDMapS (Florida) (2025)



Figure 6. World Distribution map – Climatch (Florida))

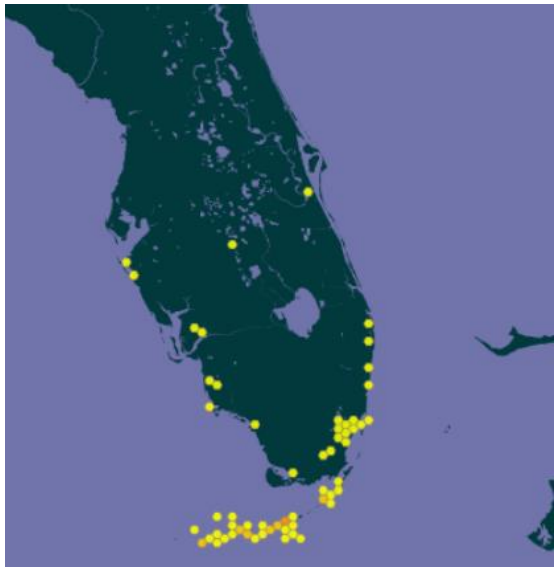


Figure 7. World Georeferenced Records (GBIF) (Florida)



Figure 8. World Georeferenced records (GBIF) – All referenced locations.

The locations in Europe have been excluded as no reference to self-sustaining populations has been found.

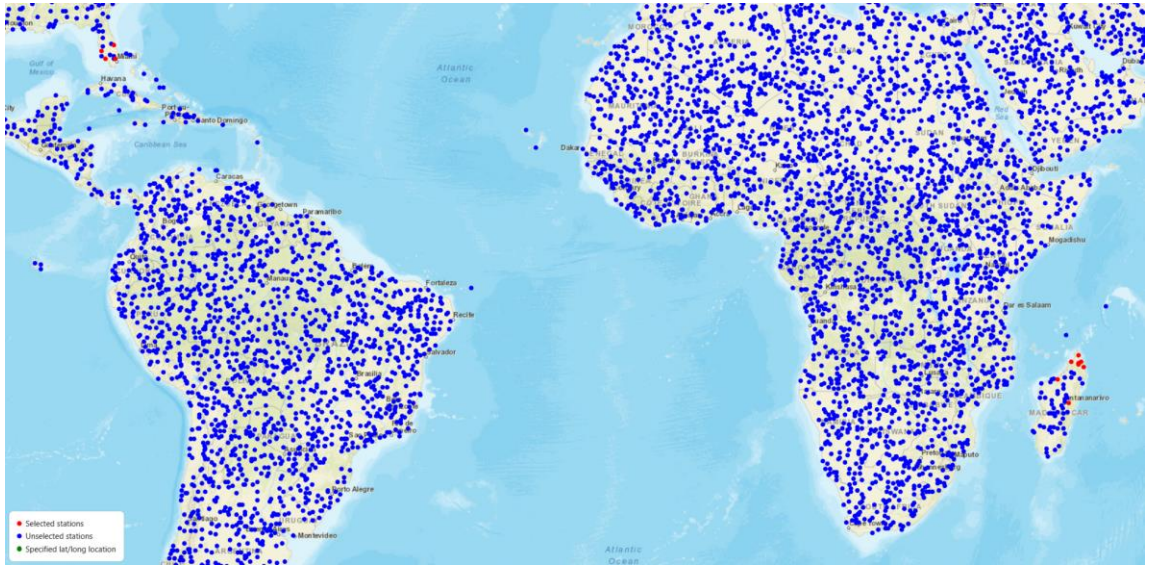


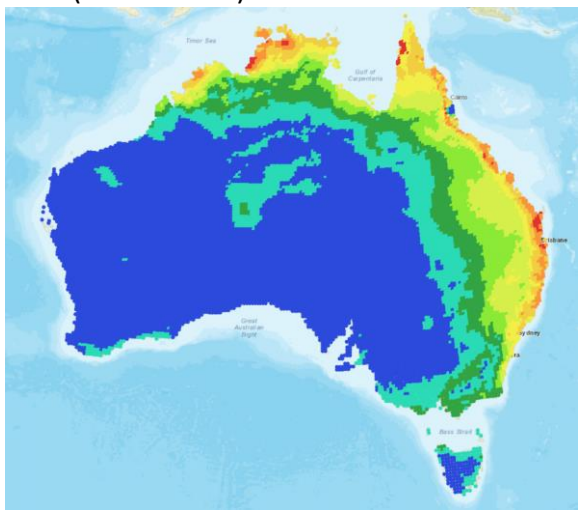
Figure 9. World Distribution Map (Climatch)

Climatch data was not available for Reunion, Mauritius and near the distribution area in Hawaii so these locations were unable to be included in the analysis.

Australian Reptile and Amphibian Model (Bomford 2006): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Phelsuma grandis*

CMS (Sum Level 7) = 327



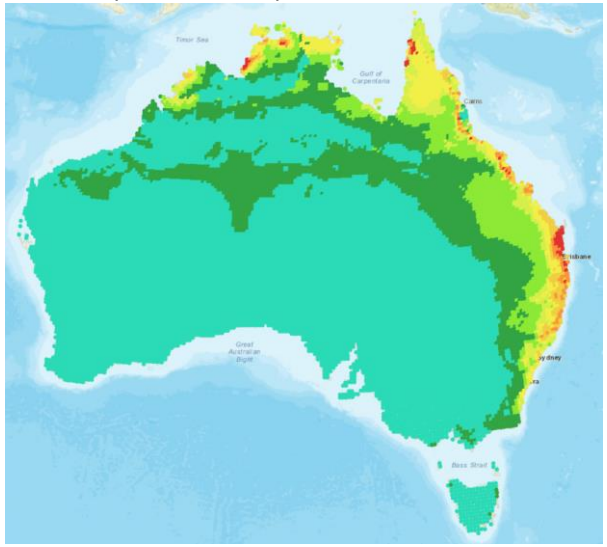
Score	Color	Count
0		10940
1		2820
2		1684
3		1253
4		1114
5		573
6		524
7		265
8		62
9		0
10		0

Species: Phelsuma grandis
Algorithm: Euclidean
12 source features selected
19235 target features selected
Approximate source selected area: 125,559 km^2
Approximate target selected area: 7,736,730 km^2

Bird and Mammal model for reptiles and amphibians (Bomford 2008): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Phelsuma grandis*

Value X (Sum Level 6) = 360



Score	Color	Count
0		0
1		12807
2		3584
3		1382
4		524
5		578
6		199
7		105
8		54
9		2
10		0

Species: Phelsuma grandis
Algorithm: Closest Standard Score
12 source features selected
19235 target features selected
Approximate source selected area: 125,559 km^2
Approximate target selected area: 7,736,730 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**		

Risk Assessor's details:

Risk Assessor's name:	Aimee Carter
Business address and contact details:	PIRSA aimee.carter@sa.gov.au
Date:	October 2025
Reviewers:	Veronica Blazely and DCCEEW employee (unnamed)

Bibliography:

ABARES (Australian Bureau of Agricultural and Resource Economics) (2025). Catchment scale land use of Australia and commodities – Update December 2023 - DAFF. Available at: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-and-commodities-update-2023 (Accessed: 14 October 2025).

Agriculture.gov.au (2025). Climatch. Available at: https://climatch.cp1.agriculture.gov.au/ (Accessed: 14 October 2025).

AnAge (2025). The Animal Ageing and Longevity Database. Available at: https://genomics.senescence.info/species/index.html (Accessed: 14 October 2025). No record.

Bartlett, R.D. (1999). *A field guide to Florida reptiles and amphibians*. Gulf Publishing Company. Houston, Texas.

Blumgart, D., Dolhem, J. and Raxworthy, C.J. (2017). Herpetological diversity across intact and modified habitats of Nosy Komba Island, Madagascar. *Journal of Natural History*, 51(11–12), pp.625–642. Available at: https://doi.org/10.1080/00222933.2017.1287312

Bomford, M. (2003). *Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2006). *Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models - A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2008). *Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand - A report produced for the Invasive Animals Cooperative Research Centre*. Bureau of Rural Sciences, Canberra.

Bomford, M., Kraus, F., Braysher, M., Walter, L. and Brown, L. (2005). *Risk Assessment Model for the Import and Keeping of Exotic Reptiles and Amphibians. A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences, Canberra.

Catalogue of Life (2025). COL: *Phelsuma grandis*. Available at: https://www.catalogueoflife.org/data/taxon/4FZTZ (Accessed: 14 October 2025).

CITES (Conservation on International Trade in Endangered Species) (2025). Checklist of CITES species. Available at: https://checklist.cites.org/#/en/search/output_layout=alphabetical&level_of_listing=0&show_synonyms=1&show_author=1&show_english=1&show_spanish=1&show_french=1&scientific_name=Phelsuma+grandis&page=1&per_page=20 (Accessed: 14 October 2025).

CMS (Convention on the Conservation of Migratory Species of Wild Animals) (2025). Available at: https://www.cms.int/ (Accessed: 15 October 2025). No record.

Cornejo-Páramo, P., Lira-Noriega, A., Ramírez-Suástegui, C., Méndez-de-la-Cruz, F.R., Székely, T., Urrutia, A.O. and Cortez, D. (2020). Sex determination systems in reptiles are related to ambient temperature but not to the level of climatic fluctuation. *BMC Evolutionary Biology*, 20(1). Available at: https://doi.org/10.1186/s12862-020-01671-y

DCCEEW Protected Matters Search Tool (Department of Climate Change, Energy, the Environment and Water) (2025). Protected Matters Search Tool: Interactive Map. Available at: https://pmst.environment.gov.au/#/map?lng=131.52832031250003&lat=-28.6905876542507&zoom=5&baseLayers=Imagery (Accessed: 14 October 2025).

D'Cruze, N., Köhler, J., Franzen, M. and Glaw, F. (2009a). A conservation assessment of the amphibians and reptiles of the Forêt d'Ambre Special Reserve, north Madagascar. *Madagascar Conservation & Development*, 3(1), pp.44–54. Available at: https://doi.org/10.4314/mcd.v3i1.44136

D'Cruze, N., Sabel, J., Dawson, J. and Kumar, D. (2009b). The influence of habitat type and structure of the abundance of *Phelsuma madagascariensis grandis* (Gekkoninae) in northern Madagascar. *Herpetological Conservation and Biology*, 4(1), pp.55–61. Available at: https://www.herpconbio.org/Volume_4/Issue_1/D'Cruze_etal_2009a.pdf (Accessed: 22 October 2025).

D'Cruze, N. and Kumar, S. (2011). Effects of anthropogenic activities on lizard communities in northern Madagascar. *Animal Conservation*, 14, pp.542–552. Available at: https://doi.org/10.1111/j.1469-1795.2011.00459.x

Dervin, S., Sanchez, M., Bursey, C.R. and Goldberg, S.R. (2014). First record of *Raillietiella affinis* Bovien, 1927 (Arthropoda: Raellietiellidae) as an endoparasite of the Madagascan giant day gecko, *Phelsuma grandis* Gray, 1870 introduced at Reunion Island. *Herpetology Notes*, 7, pp.779–781. Available at: https://www.biotaxa.org/hn/article/view/9338 (Accessed: 21 October 2025).

Dublin Zoo (2025). Madagascar giant day gecko. Available at: https://www.dublinzoo.ie/animal/madagascar-giant-day-gecko/#:~:text=How%20long%20do%20they%20live,15%20years%20in%20human%20care (Accessed: 22 October 2025).

Dubos, N. (2013). New locality record for *Phelsuma grandis* (Sauria: Gekkonidae) in Reunion, in sympatry with the critically endangered *Phelsuma inexpectata*. *Herpetology Notes*, 6, pp.309–311. Available at: https://www.researchgate.net/publication/261022213_New_locality_record_for_Phelsuma_grandis_Sauria_Gekkonidae_in_Reunion_in_sympatry_with_the_critically_endangered_Phelsuma_inexpectata (Accessed: 14 October 2025).

Dubos, N., Piludu, N., Andriantsimanarilafy, R.R., Randrianantoandro, J.C. and Andreone, F. (2014). New findings of *Phelsuma grandis* and *P. laticauda* (Sauria: Gekkonidae) at the southern edge of the range of the endangered *Phelsuma serraticauda* in eastern Madagascar. *Herpetology Notes*, 7, pp.21–23. Available at: https://www.researchgate.net/publication/261023292_New_findings_of_Phelsuma_grandis_and_P_laticauda_Sauria_Gekkonidae_at_the_southern_edge_of_the_range_of_the_endangered_Phelsuma_serraticauda_in_eastern_Madagascar (Accessed: 22 October 2025).

EDDMapS (2025). giant day gecko (*Phelsuma grandis* Gray, 1870) - EDDMapS Distribution - EDDMapS. Available at: https://www.eddmaps.org/distribution/uscounty.cfm?sub=80164 (Accessed: 14 October 2025).

Elias, S.D.S., Freitas, K.A., Travieso, R.E. and Davis, D.R. (2025). *Phelsuma grandis*. *Herpetological Review*, 55(4), p.569. Available at: https://ssarherps.org/2025/08/herpetological-review-554-is-now-available/ (Accessed: 22 October 2025).

Fieldsend, T.W. and Krysko, K.L. (2019). Madagascar Giant Day Gecko (*Phelsuma grandis*) established in Homestead, Miami-Dade County, Florida, USA. *Reptiles & Amphibians*, 26(2), pp.159–160. Available at: https://doi.org/10.17161/randa.v26i2.14392

Fry, C. and Roycroft, C. (2009). *Phelsuma madagascariensis*. Animal Diversity Web. Available at: https://animaldiversity.org/accounts/Phelsuma_madagascariensis/ (Accessed: 22 October 2025).

GBIF (Global Biodiversity Information Facility) (2025). *Phelsuma grandis* (Grey 1870). Available at: https://www.gbif.org/species/2447558 (Accessed: 14 October 2025).

GISD (Global Invasive Species Database) (2025). Available at: https://www.iucngisd.org/gisd/ (Accessed: 22 October 2025). No record.

Goldberg, S.R., Bursey, C.R. and Kraus, F. (2010). Helminth records for the Madagascan giant day gecko, *Phelsuma grandis* (Gekkonidae) from Hawaii. *Bishop Museum Occasional Papers*, 108, pp.49–52. Available at: https://hbs.bishopmuseum.org/pubs-online/pdf/op108.pdf (Accessed: 14 October 2025).

HNN (Hawaii News Now) (2007). Beware, Madagascar Giant Day Gecko Bites! Available at: https://www.hawaiinewsnow.com/story/7134531/beware-madagascar-giant-day-gecko-bites/ (Accessed: 22 October 2025).

Humphrey, J.E. and Ward, C.F.M. (2020). Madagascan Day Geckos (*Phelsuma* spp.) Exhibit Differing Responses Along a Gradient of Land-Use Change. *Tropical Conservation Science*, 11(1), p.194008291876028. Available at: https://doi.org/10.1177/1940082918760282

ITIS (Integrated Taxonomic Information System) (2025). ITIS - Report: *Phelsuma grandis*. Available at: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=819054#null (Accessed: 14 October 2025).

Kraus, F. (2002). New records of alien reptiles in Hawaii. *Bishop Museum Occasional Papers*, 69, pp.48–52. Available at: https://hbs.bishopmuseum.org/pdf/op69.pdf (Accessed: 14 October 2025).

Kraus, F. (2009). *Alien Reptiles and Amphibians: a Scientific Compendium and Analysis*. Springer. New York.

Lammar, W.W. (1997). *The World's Most Spectacular Reptiles and Amphibians*. World Publications. Florida.

Minnaar, I.A., Köhler, A., Purchase, C. and Nicolson, S.W. (2013). Coloured and Toxic Nectar: Feeding Choices of the Madagascar Giant Day Gecko, *Phelsuma grandis*. *Ethology*, 119(5), pp.417–426. Available at: https://doi.org/10.1111/eth.12079

Packard, M.J. and Hirsch, K.F. (1989). Structure of shells from eggs of the geckos *Gekko gecko* and *Phelsuma madagascariensis*. *Canadian Journal of Zoology*, 67(3), pp.746–758. Available at: https://doi.org/10.1139/z89-106

Peš, T., Straková, B. and Kratochvíl, L. (2024). Environmental (and Random?) Sex Determination in Endangered and Invasive *Phelsuma* Geckos. *Sexual Development*, pp.1–6. Available at: https://doi.org/10.1159/000538906

Randriamialisoa, Andriantsimanarilafy, R.R., Rakotondrina, A.J.V., Rakotoarisoa, J.-A., Nasaina, R.T., Jeanneney Rabearivony and Raselimanana, A.P. (2023). Overview of Reptile Diversity from Bobaomby Complex, Northern Tip of Madagascar. *Animals*, 13(21), pp.3396–3396. Available at: https://doi.org/10.3390/ani13213396

Ratsoavina, F., Glaw, F. and Rakotondrazafy, N.A. (2011). *Phelsuma grandis*. *The IUCN Red List of Threatened Species 2011*. Available at: https://doi.org/10.2305/IUCN.UK.2011-2.RLTS.T193490A8863630.en

Raxworthy, C.J., Ingram, C.M., Rabibisoa, N., Pearson, R.G. and Weins, J. (2007). Applications of ecological niche modeling for species delimitation: a review and empirical evaluation using day geckos (*Phelsuma*) from Madagascar. *Systematic Biology*, 56(6), pp.907–923. Available at: https://doi.org/10.1080/10635150701775111

Rocha, S., Rösler, H., Gehring, P.-S., Glaw, F., Posada, D., Harris, J. and Vences, M. (2010). Phylogenetic systematics of day geckos, genus *Phelsuma*, based on molecular and morphological data (Squamata: Gekkonidae). *Zootaxa*, 2429, pp.1–28. Available at: https://doi.org/10.5281/zenodo.194693

Sacramento Zoo (2025). Madagascar Giant Day Gecko. Available at: https://www.saczoo.org/madagascar-giant-day-gecko (Accessed: 22 October 2025).

SNZCBI (Smithsonian's National Zoo and Conservation Biology Institute) (2025). Madagascar giant day gecko. Available at: https://nationalzoo.si.edu/animals/madagascar-giant-day-gecko (Accessed: 22 October 2025).

Species+ (2025). Species+: *Phelsuma grandis*. Available at: https://www.speciesplus.net/species#/taxon_concepts/9590/legal (Accessed: 14 October 2025).

Uetz, P., Freed, P., Aguilar, R., Reyes, F., Kudera, J. and Hošek, J. (eds.) (2025). The Reptile Database: *Phelsuma grandis*. Available at: https://reptile-database.reptarium.cz/Phelsuma/grandis?search_param=%28%28search%3D%27phelsuma+grandis%27%29%29 (Accessed: 14 October 2025).

World Life Expectancy (2025). Available at: https://www.worldlifeexpectancy.com/animal-life-expectancy (Accessed: 14 October 2025). No record.

Zhuang, M.V. and Higham, T.E. (2016). Arboreal Day Geckos (*Phelsuma madagascariensis*) Differentially Modulate Fore- and Hind Limb Kinematics in Response to Changes in Habitat Structure. *PLOS One*, 11(5), p.e0153520. Available at: https://doi.org/10.1371/journal.pone.0153520

Zug, G.R. (2013). *Reptiles and Amphibians of the Pacific Islands: A Comprehensive guide*. University of California Press. Berkeley and Los Angeles, California.

DRAFT National Risk Assessment: EXTREME

RISK ASSESSMENT FOR AUSTRALIA: Reeves' Turtle (*Mauremys reevesii*)

Class - Reptilia**, Order** - Testudines, **Family** - Geoemydidae, **Genus –** *Mauremys.*

SPECIES: *Mauremys reevesii* (Gray, 1831) **Subspecies:** Monotypic **Synonyms:** *Chinemys grangeri* (Schmidt, 1925) *Chinemys megacephala* (Fang, 1934) *Chinemys pani* (Tao, 1985) *Chinemys reevesii* (Gray, 1831) *Clemmys reevesii* (Gray, 1831) *Clemmys unicolor* (Gray, 1873) *Damonia reevesii* (Gray, 1831) *Damonia reevesii unicolor* (Boulanger, 1873) *Damonia unicolor* (Gray, 1873) *Emys japonica* (Duméril, Bibron & Duméril, 1851) *Emys reevesii* (Gray, 1831) *Emys vulgaris picta* (Schlegel, 1844) *Geoclemys grangeri* (Schmidt, 1925) *Geoclemys paracaretta* (Chang, 1929)	**Species description:** The Reeves' turtle is a medium sized semi-aquatic freshwater turtle, with adults achieving a straight-line carapace length up to approximately 30 centimetres (Lovich et al. 2011). The Reeves' turtle is identifiable by the yellow striping and blotching on the neck (Gray 1831; Kaiser et al. 2011). They weigh between 200 to 500 grams (Fauna Watch 2025). The carapace is oval and low-arched, generally light to dark in non-melanistic individuals (sometimes with broken stripes across the keels), and featuring three longitudinal keels along the shell's length (Lovich et al. 2011). These keels are "more-or-less parallel to each other and are not serrated at the posterior margin, even in juveniles" (Lovich et al. 2011). The bridge is long and has axillary and inguinal shields (Boulenger 1889). The plastron (ventral side of the shell) is large, elongated, without a hinge, smooth at the front, and deeply notched at the back (Lovich et al. 2011). The back part of the plastron is narrower than the shell opening (Smith 1931). The plastron is variable in colour from dark brown to yellowish-brown, with each plate usually having a large dark brown spot that may cover most of it (Lovich et al. 2011; Smith 1931). The head is medium-sized, with a short snout that sticks out past the lower jaw (Stejneger 1907). There are four shields on the head. Boulenger (1889) describes the Reeves' turtle as having a shield round the upper jaw, one covering the snout and the crown and one on either side between the eye and ear. The upper jaw has little or no notch in the middle. The back of the head is covered in small scales (Smith 1931). The head and neck are dark grey to brown, with several broken yellow spotted stripes that extend from the snout to the neck (Lovich et al. 2011). As males grow older and larger, they tend to become melanistic (Lovich et al. 1985, 2011). Melanistic individuals lack these markings and appear uniformly dark (Lovich et al. 2011; Stejneger 1907). The limbs and tail are brown or grey, sometimes with yellow spots (Smith 1931). The tail is between a third to a half-length of the carapace, the feet are fully webbed, and the limbs have wide, flat scales (Smith 1931; Stejneger 1907).

Geoclemys reevesii (Gray, 1831) *Geoclemys reevesii grangeri* (Schmidt, 1925) *Geoclemys reevesii reevesii* (Gray, 1831) *Geoclemys reevesii unicolor* (Gray, 1873) *Mauremys megalocephala* (Fang, 1934) *Mauremys pritchardi* (McCord, 1997) **Common Names:** Big-headed Pond Turtle Chinese Big-headed Turtle Chinese Pond Turtle Chinese Three-keeled Pond Turtle Japanese Coin Turtle Reeves' Three-keeled Pond Turtle Reeves' Turtle	Sexual dimorphism is present in this species of turtle. As described by Lovell et al. (2011) “males have a lower and narrower carapace, a shorter and narrower plastron, and shorter bridges compared to females. The plastron is flat in females and slightly concave in males. In males the tail is long and thick with the vent located beyond the posterior rim of the carapace.” Males measure 23.6 centimetres whereas females reach 30 centimetres (Lovich et al. 2011). Juvenile Reeves’ turtle have a lighter coloured carapace particularly around the outer margin (Lovich et al. 2011). **General information:** Distribution: Native to East Asia, the Reeves’ turtle is endemic to central and eastern mainland China, the Kinmen Islands, and the Korean Peninsula (Species+ 2025; TTWG 2025; Van Dijk 2011). It has been reported that the Reeves’ turtle populations established in Hong Kong, southern and central Japan (Takahashi et al. 2019; Suzuki et al. 2012), Ryukyu Archipelago (Okinawajima (Okinawa Islands)) (ISJ 2025; Lee et al. 2019; Ota et al. 2004), and Taiwan (Republic of China) (Lee et al. 2019) were potentially historic human introductions (Fong and Chen 2010 cited by Van Dijk 2011). Invasive, potentially self-sustaining populations from confirmed human introductions have been recorded in Indonesia (Lesser Sunda Islands aka Timor) (Kraus 2009), Timor-Leste (Kaiser et al. 2011; O’Shea et al. 2015), Palau (Species+ 2025; TTWG 2025; Van Dijk 2011). Escaped and released Reeves’ turtle pets have been reported in Canada, Germany, Mauritius, Guam (Kraus 2009), Ireland, the United Kingdom (Cathrine and Monir 2022), Spain (Poch et al. 2020, 2022), United States of America (Massachusetts, California, Illinois and Maryland) (Benson et al. 2004; Kraus 2009), Ryukyu Archipelago (Kumejima (Okinawa Islands) and Kikaijima (Amami Islands)) (ISJ 2025; Lee et al. 2019; Ota et al. 2004), however these have not been confirmed as established populations (Figure 4). A paper on the *Establishment risk from pet-trade freshwater turtles in the European Union* by Kopecký et al. 2013, classified the establishment risk of the Reeves’ turtle in Europe as Low. Habitat: It inhabits temperate and subtropical areas of China (Van Dijk 2011) and is found in vegetated and shallow lowland water bodies, such as ponds, marshes, agricultural wetlands, and irrigated rice paddies (Lovich et al. 2011; Van Dijk 2011). It has a preference for vegetation cover surrounding the body of water it inhabits (Lin et al. 2015). In Taiwan, the Reeves’ turtle inhabits the Tamsui River drainage “one of the most seriously polluted and disturbed rivers in Taiwan” (Lee et al. 2019). They are found close to human settlements and agricultural landscapes (Bu et al. 2022).

	Recent tracking studies reveal that, beyond aquatic environments, Reeves' turtles frequently utilize terrestrial settings for activities like nesting, foraging, thermoregulation, and hibernation (through excavating and occupying burrows) (Bu et al. 2022; Ye et al. 2025). In China's Qichun County, Hubei Province, the average hibernation period was 116 days (Bu et al. 2022). The first report of hibernation was at the end of October with the last report of arousal occurred in mid-April, with females hibernating longer than males (Bu et al. 2022, 2024). Reeves' turtles will also hibernate in aquatic environments (Bu et al. 2022). Diet: The Reeves' turtle is active both diurnally and nocturnally (Bu et al. 2024), often observed basking on logs or rocks and foraging in shallow waters or along shores (Benson et al. 2004). They are omnivorous, feeding on a variety of plant material, small invertebrates, snails, fish, tadpoles, crustaceans, and even carrion (Lovich et al. 2011; Van Dijk 2011). Reproduction: Female Reeves' turtles reach sexual maturity between the ages of 5 and 7 laying 3 to 5 clutches per year (Saka et al. 2014; Van Dijk 2011). Adult females typically nest in summer (May to July) (Fukada 1965 cited in USFWS 2022). Upon finding a suitable location, the female Reeves' turtle will dig its nest from soil before laying its egg. Once the eggs have been laid, the female will bury the eggs and return to the water (Ye et al. 2025). 4–7 eggs per clutch are laid in shaded, soft soil with incubation taking 50–80 days depending on temperature (HKSBS 2025). Notably, sex determination is temperature-dependent with temperatures below 26 degrees yielding males whereas temperatures above 30 degrees producing females (Cornejo-Páramo et al. 2020; Du et al. 2007). Reeves' turtles have been observed to hybridise with other Geoemydid species. Documented hybrids include those with Asian yellow pond turtle (*Mauremys mutica*) (Fujii et al. 2014), Chinese stripe-necked turtle (Mauremy sinensis) (Fong and Chen 2010 cited by Van Dijk 2011) and the Japanese pond turtle (*Mauremys japonica*) (Matsuda et al. 2025; Suzuki et al. 2014). Successful reproduction by hybrid crosses have established populations in Japan. Like most species, the Reeves' turtle is a vector of disease. In one report, *Amblyomma geoemydae* a tick species was found on wild Reeves' turtle. This tick has been reported in Australasia and is known to infect mammals, birds and reptiles (Kambayashi et al. 2021). Defensively, this species will emit a strong-smelling fluid to protect itself and has a painful bite that can cause injury (Lovich et al. 2011). **Longevity:**

	The maximum recorded longevity was from a wild caught adult turtle kept in captivity who lived for 24.2 years. It is likely that the lifespan of the Reeves' turtle is underestimated (AnAge 2023). In the wild, due to diseases, predation and environmental stresses that life span is estimated to be a minimum of 10 years (Van Dijk 2011). **Conservation status:** **IUCN:** Endangered **CITES:** Appendix III - list of species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation.
DATE OF ASSESSMENT: July 2025 (Aimee Carter) **EIC ENDORSEMENT:** **Risk assessment model used for the assessment:** • Australian Reptile and Amphibian Model (Bomford 2006) • Australian Reptile and Amphibian Model (Bomford 2008) • Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008)	**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 2006, 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/.

Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models (Bomford 2006):

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
D. 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).*	2.84	CMRS = 100 x (547/19,236) = 2.84 Climatch images come from Figures 3 – 6 and 8. Note: Points from Vietnam, Singapore, Indonesia, Philippines, Russia, Germany, The Netherlands, Belgium, Spain, Portugal, United States, Canada, and Colombia were excluded from the climate matching analysis. These occurrences were not found to represent established populations of Reeves' turtle and were found to represent captive individuals, museum specimens, and presumed pet releases of individual animals.
E. 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*	30	*Self-sustaining exotic populations established on several islands.*
F. Taxonomic Family Risk Score	0	*Geomydidae*

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*	32.84	**MODERATE establishment risk**

Australian Reptile and Amphibian Model (Bomford 2008):

FACTOR	**SCORE**	**DETAIL**
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
D. Family Random Effect value *A family random effect assumed drawn from a Gaussian distribution with mean zero and variance that was estimated from Bomford et al's (2008) data.*	-0.37	
E. Prop.species value *The number of jurisdictions where a species successfully established divided by the total number of jurisdictions where species has been introduced.*	0.33	Based on the updated statistics from Kraus (2009) as directed by Bomford 2008 including *Mauremys reevesii* (synonym *Chinemys reevesii*) and *Mauremys* species. Those reported with a ? by Kraus have been reviewed and populations in Germany, Palau and USA: Illinois have been included in the statistical analysis. *Number of jurisdictions where a species successfully established = 5* *Total number of jurisdictions where species has been introduced = 15* *Prop.species Value = 0.33*
F. S(Climate 6) value *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*	-0.723	<u>Score as reported in Bomford Model 2008</u> Sum Euclidian match scores to Australia levels 6-10 = 758 Climate 6 score = 758/2,785 = 0.2721723518850987 S(Climate 6) value from Figure 3.4 = 4.25(Climate 6 Score) – 1.88. S(Climate 6) value from Figure 3.4 = 4.25(0.2721723518850987) – 1.88.

Euclidian Match and using all 16 climate variables for the analysis. Sum the five scores for classes 6-10. Express this as a proportion of the maximum possible score (19,236). *Use Fig 3.4 to calculate value.*		Figure 3.4= -0.723 <u>Score reflecting the version of Climatch 2.0</u> Sum Euclidian match scores to Australia levels 6-10 = 1,973 Climate 6 score = 1,973/19,236 = 0.1025681014763984 S(Climate 6) value from Figure 3.4 = 4.25(Climate 6 Score) – 1.88. S(Climate 6) value from Figure 3.4 = 4.25(0.1025681014763984) – 1.88. Figure 3.4= -1.44
ESTABLISHMENT RISK RANK *A species' Establishment Risk Score = 1/ (1 + exp(0.80 – 2.90(Prop.species) – S(Climate 6) – Family Random Effect))* *Establishment Risk Rank — Establishment Risk Score* *Low — ≤ 0.16* *Moderate — 0.17-0.39* *Serious — 0.40-0.85* *Extreme — ≥ 0.86*	0.28	1/(1 + exp(0.80 – 2.90(0.33) – -0.723 – -0.37) 1/(1 + exp(0.80 – 0.97 + 0.723 + 0.37)) 1/(1+EXP(0.923)) **=0.2843470182** **=0.28** **MODERATE**

Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008):

A. Degree of climate match between species overseas range and Australia (1–6)	2	Low climate match to Australia Value X = 1,241 Climate Match Score = 2

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, Value X = sum of classes 6 – 10, see Table 1.*		Note: Points from Vietnam, Singapore, Indonesia, Philippines, Russia, Germany, The Netherlands, Belgium, Spain, Portugal, United States, Canada, and Colombia were excluded from the climate matching analysis. These occurrences were not found to represent established populations of Reeves' turtle and were found to represent captive individuals, museum specimens, and presumed pet releases of individual animals.
B. 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.*	4	*Exotic population established on a larger island (> 50 000 km^2) or anywhere on a Continent.*
C. 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 between 1 to 70 million square kilometres.* Overseas natural range size is estimated at 4.3 million km^2. The estimated indigenous (historical) extent of occurrence is estimated to be 4,277,816 km^2 by the Turtle Taxonomy Working Group (2025).
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*	7	**MODERATE establishment risk**

ENVIRONMENT AND INVASIVES COMMITTEE ALLOCATED PEST RISK* *For reptiles and amphibians, the assessed Establishment Risk Rank is combined with an allocated Extreme Pest Risk Rank (based on the precautionary approach),	**EXTREME**

resulting in the Assignment of species into one of two EIC Threat Categories: Extreme or Serious.	

ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY*	**EXTREME***
*For reptiles and amphibians, the assessed Establishment Risk Rank is combined with an allocated Extreme Pest Risk Rank (based on the precautionary approach), resulting in the Assignment of species into one of two EIC Threat Categories: Extreme or Serious.	*Score assigned based on the highest Establishment Risk Rank (based on the precautionary approach).

Figure 1 IUCN Red List world distribution map (no data provided), Figures 2-3; GBIF world georeferenced records, Figures 4-5; Turtle Taxonomy Working Group population map; Figure 6; Lovich et al. population map and Figure 7; Climatch data drawn from Figures 2-6:

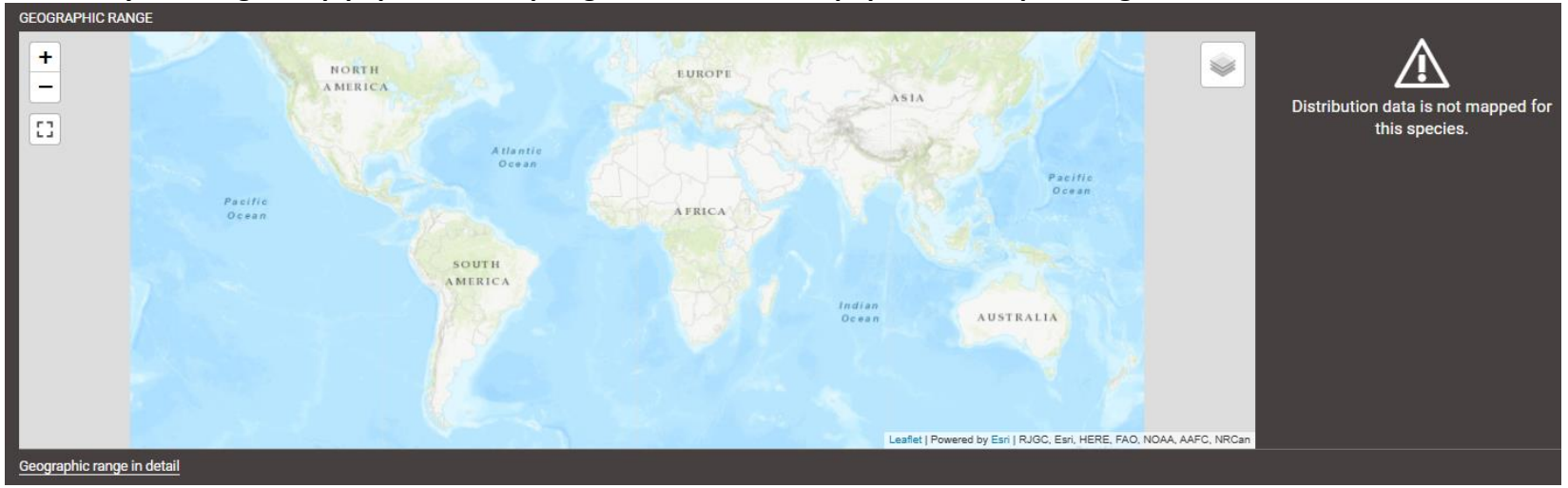


Figure 2. World Distribution Map - IUCN Red List. Distribution data is not mapped for this species on the IUCN website

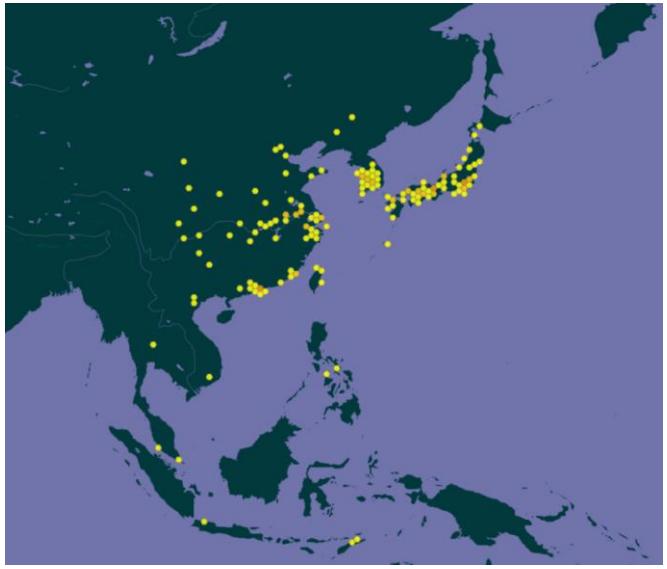


Figure 2. World Georeferenced records (GBIF) (eastern and south-eastern Asia).



Figure 3. World Georeferenced records (GBIF) – All referenced locations. As stated on page 2, populations outside of eastern and south-eastern Asia have not been confirmed as established, so have been excluded from the Climatch analysis.

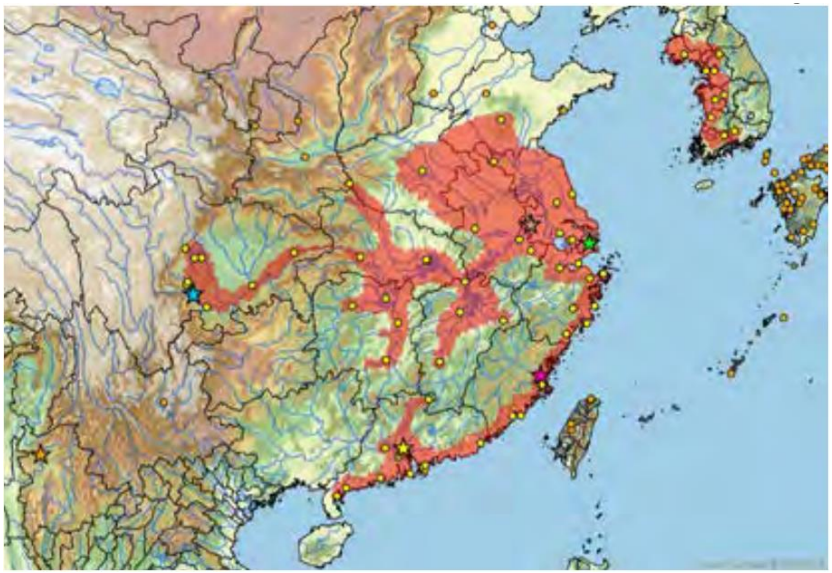


Figure 4. TTWG Map of China (2025) – Reeves' turtle populations



Figure 5. TTWG Map of Japan and Korea Peninsula (2025) – Reeves' turtle populations

Figure 4. and Figure 5. Key (TTWG 2025): native populations = red, presumed introduced populations = grey, orange dots = presumed trade and/or introduced, stars = type localities.

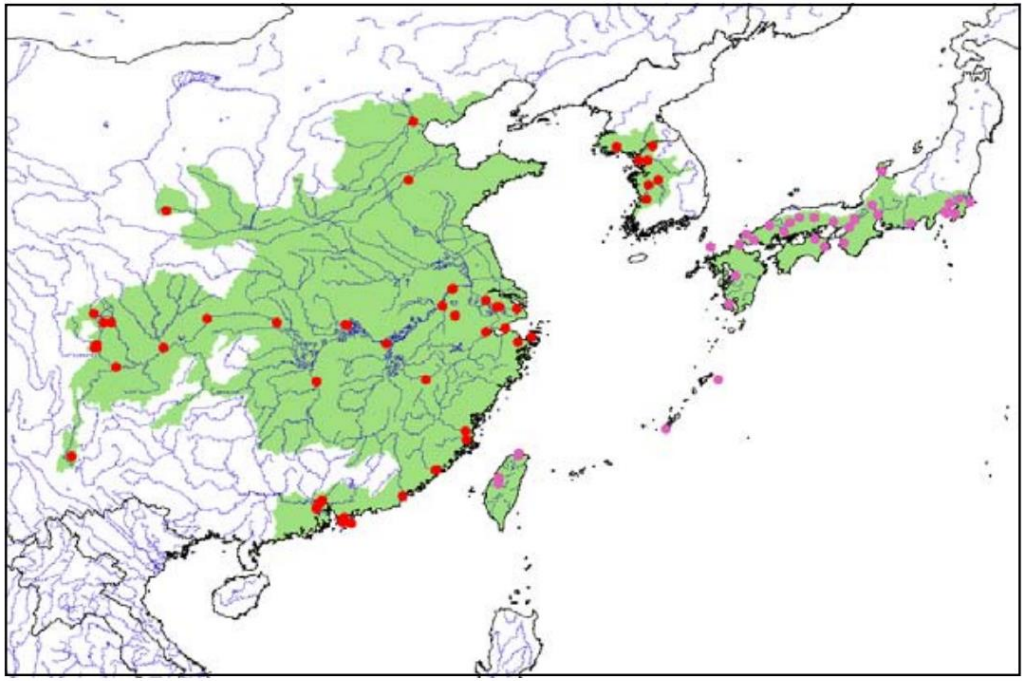


Figure 5. Distribution of *Mauremys reevesii* in China, North Korea, South Korea, Japan (introduced?), and Taiwan (introduced?). Red dots = museum and literature occurrence records of native populations based on Iverson (1992) plus more recent and authors' data; purple dots = occurrence records of apparently introduced populations; green shading = projected distribution based on GIS-defined hydrologic unit compartments (HUCs) constructed around verified localities and then adding HUCs that connect known point localities in the same watershed or physiographic region, and similar habitats and elevations as verified HUCs (Buhlmann et al. 2009), and adjusted based on authors' data.

Figure 6. Lovich et al. (2011) map – Reeves' turtle populations

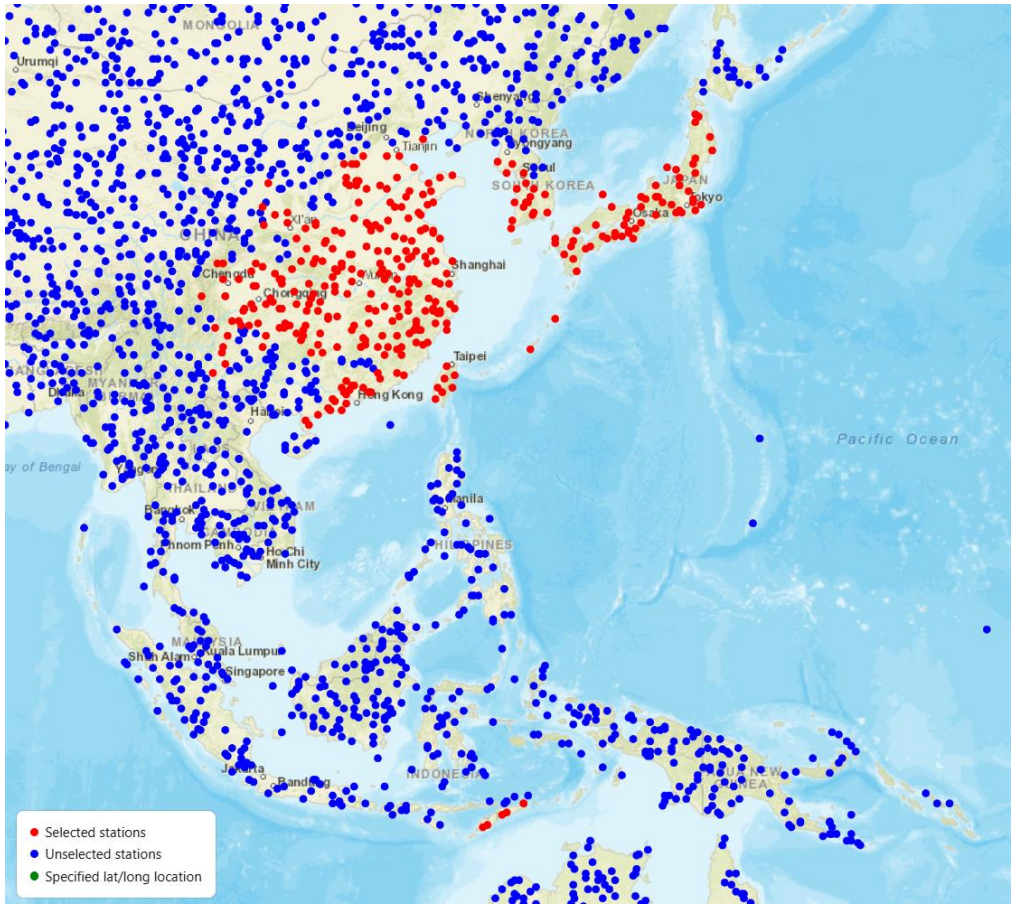
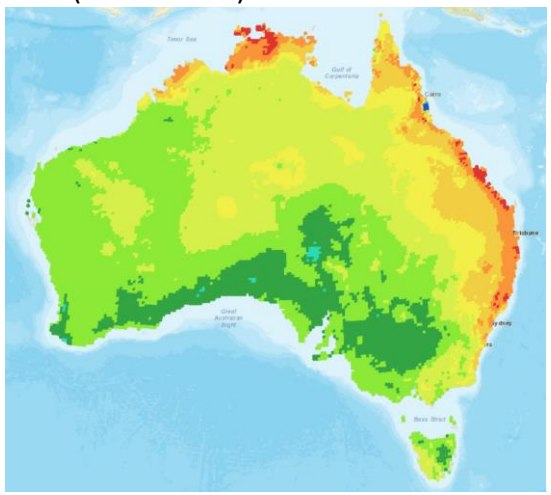


Figure 7. World Distribution map – Climatch. Data sourced from Figures 2-6.

Australian Reptile and Amphibian Model (Bomford 2006): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Mauremys reevesii*

CMS (Sum Level 7) = 867



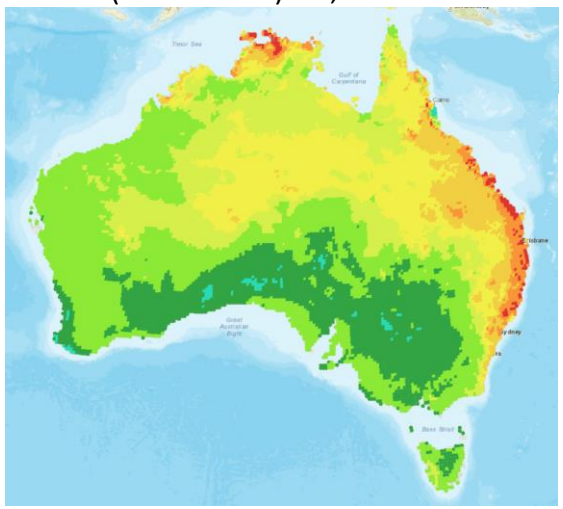
Score	Color	Count
0		6
1		43
2		2228
3		6711
4		5918
5		1939
6		1523
7		720
8		147
9		0
10		0

Species: Reeves' Turtle - Mauremys reevesii
Algorithm: Euclidean
341 source features selected
19235 target features selected
Approximate source selected area: 2,902,653 km^2
Approximate target selected area: 7,736,730 km^2

Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008) Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Mauremys reevesii*

Value X (Sum Level 6) = 1,844



Score	Color	Count
0		0
1		118
2		3304
3		6060
4		4061
5		3848
6		1267
7		445
8		128
9		4
10		0

Species: Reeves' Turtle - Mauremys reevesii
Algorithm: Closest Standard Score
341 source features selected
19235 target features selected
Approximate source selected area: 2,902,653 km^2
Approximate target selected area: 7,736,730 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**		

Risk Assessor's details:

Risk Assessor's name:	Aimee Carter
Business address and contact details:	PIRSA aimee.carter@sa.gov.au
Date:	August 2025
Reviewers:	2x DCCEEW staff (names not provided)

Bibliography:

ABARES (Australian Bureau of Agricultural and Resource Economics) (2025). Catchment scale land use of Australia and commodities – Update December 2023 – DAFF. Available at: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-and-commodities-update-2023 (Accessed: 11 July 2025).

Agriculture.gov.au (2025). Climatch. Available at: https://climatch.cp1.agriculture.gov.au/ (Accessed: 11 March 2026).

Akashi, H., Kubota, M., Yamamoto, H., Miyaoku, K., Yamagishi, G. and Miyagawa, S. (2022). Chronology of embryonic and gonadal development in the Reeves' turtle, *Mauremys reevesii*. *Scientific Reports*, 12(1), p. 11619. Available at: https://doi.org/10.1038/s41598-022-15515-w

AnAge (2023). Reeves' turtle (*Mauremys reevesii*) longevity, ageing, and life history. Available at: https://genomics.senescence.info/species/entry.php?species=Mauremys_reevesii (Accessed: 11 July 2025).

Benson, A.J., Jacono, C.C., Fuller, P.L. and McKercher, E.R. (2004). Summary Report of Nonindigenous Aquatic Species in U.S. Fish and Wildlife Service Region 5. Available at: https://nas.er.usgs.gov/publications/R5finalreport.pdf (Accessed: 11 July 2025).

Bomford, M. (2003). Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia. Bureau of Rural Sciences, Canberra.

Bomford, M. (2006). Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models - A report produced for the Department of Environment and Heritage. Bureau of Rural Sciences, Canberra.

Bomford, M. (2008). Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand - A report produced for the Invasive Animals Cooperative Research Centre. Bureau of Rural Sciences, Canberra.

Bomford, M., Kraus, F., Braysher, M., Walter, L. and Brown, L. (2005). Risk Assessment Model for the Import and Keeping of Exotic Reptiles and Amphibians. A report produced for the Department of Environment and Heritage. Bureau of Rural Sciences, Canberra.

Boulenger, G.A. (1889). *Catalogue of the chelonians, rhynchocephalians, and crocodiles in the British museum (Natural history)*. Order of the Trustees, London.

Bu, R., Ye, Z. and Shi, H. (2022). Hibernation in Reeves' Turtles (*Mauremys reevesii*) in Qichun County, Hubei Province, China: Hibernation Beginning and End and Habitat Selection. *Animals*, 12(18), p. 2411. Available at: https://doi.org/10.3390/ani12182411

Bu, R., Ye, Z. and Shi, H. (2023). Habitat Selection and Home Range of Reeves' Turtle (*Mauremys reevesii*) in Qichun County, Hubei Province, China. *Animals*, 13(1514), pp. 1–14. Available at: https://doi.org/10.3390/ani13091514

Bu, R., Ye, Z. and Shi, H.T. (2024). Daily and Seasonal Activity Rhythms of Wild Reeves' Turtles (*Mauremys reevesii*) in Qichun County, China. *Chelonian Conservation and Biology*, 23(1), pp. 23–29. Available at: https://doi.org/10.2744/CCB-1592.1

Bu, R., Ye, Z., Xiao, F. and Shi, H.-T. (2022). A Survey of Reeves' Turtle (*Mauremys reevesii*) in Qichun County, Hubei Province, China. *Chelonian Conservation and Biology*, 21(2), pp. 212–217. Available at: https://doi.org/10.2744/CCB-1544.1

Catalogue of Life (2025). COL: *Mauremys reevesii* (Gray, 1831). COL. Available at: https://www.catalogueoflife.org/data/taxon/3YFWL (Accessed: 11 July 2025).

Cathrine, C. and Monir, T. (2022). The turtles (Testudines) of Glasgow Botanic Gardens including the first record of *Mauremys reevesii* (Gray, 1831) for the U.K. outwith captivity. *The Glasgow Naturalist*, 27(4), pp. 65–68. Available at: https://doi.org/10.37208/tgn27420

Chen, T.-H. and Lue, K.Y. (2010). Population status and distribution of freshwater turtles in Taiwan. *Oryx*, 44(2), pp. 261–266. Available at: https://doi.org/10.1017/S0030605310000013

CITES (Conservation on International Trade in Endangered Species) (2025). Checklist of CITES species: *Mauremys reevesii*. Available at: https://checklist.cites.org/#/en/search/output_layout=alphabetical&level_of_listing=0&show_synonyms=1&show_author=1&show_english=1&show_spanish=1&show_french=1&scientific_name=Mauremys+reevesii&page=1&per_page=20 (Accessed: 11 July 2025).

CMS (Convention on the Conservation of Migratory Species of Wild Animals) (2025). https://www.cms.int/. No record.

Cornejo-Páramo, P., Lira-Noriega, A., Ramírez-Suástegui, C., Méndez-de-la-Cruz, F.R., Székely, T., Urrutia, A.O. and Cortez, D. (2020). Sex determination systems in reptiles are related to ambient temperature but not to the level of climatic fluctuation. *BMC Evolutionary Biology*, 20(1). Available at: https://doi.org/10.1186/s12862-020-01671-y

DCCEEW Protected Matters Search Tool (Department of Climate Change, Energy, the Environment and Water) (2025). Protected Matters Search Tool: Interactive Map. Available at: https://pmst.environment.gov.au/#/map?lng=131.52832031250003&lat=-28.6905876542507&zoom=5&baseLayers=Imagery (Accessed: 11 July 2025).

Du, W.G., Hu, L.J., Lu, J.L. and Zhu, L.J. (2007). Effects of incubation temperature on embryonic development rate, sex ratio and post-hatching growth in the Chinese three-keeled pond turtle, *Chinemys reevesii*. *Aquaculture*, 272(1–4), pp. 747–753. Available at: https://doi.org/10.1016/j.aquaculture.2007.09.009

Fong, J.J. and Chen, T.H. (2010). DNA evidence for hybridization of wild turtles in Taiwan: possible genetic pollution from trade animals. *Conservation Genetics*, 11, pp. 2061–2066. Available at: https://doi.org/10.1007/s10592-010-0066-z

Fujii, R., Ota, H. and Toda, M. (2014). Genetic and Morphological Assessments of Hybridization Between Two Non-Native Geoemydid Turtles, *Mauremys reevesii* and *Mauremys mutica*, in Northcentral Japan. *Chelonian Conservation and Biology*, 13(2), pp. 191–201. Available at: https://doi.org/10.2744/CCB-1067.1

Fukada, H. (1965). Breeding habits of some Japanese reptiles (critical review). *Bulletin Kyoto Gakugei University Series B*, 27, pp. 65–82.

GBIF (Global Biodiversity Information Facility) (2025). *Mauremys reevesii* (Gray, 1831). Available at: https://www.gbif.org/species/2443597 (Accessed: 11 July 2025).

GISD (Global Invasive Species Database) (2025). GISD. Available at: https://www.iucngisd.org/gisd/ (Accessed: 11 July 2025). No record.

Gray, J.E. (1831). *Synopsis reptillium; or, short descriptions of the species of reptiles*. Treuttel, Wurtz and Co., London.

HKSBS (Hong Kong School of Biological Sciences) (2025). Reptile of Hong Kong. Available at: https://www.biosch.hku.hk/ecology/hkreptiles/turtle/Mauremys_reevesii.html (Accessed: 28 August 2025).

ISJ (Invasive Species of Japan) (2025). *Chinemys reevesii*. Available at: https://www.nies.go.jp/biodiversity/invasive/DB/detail/30030e.html (Accessed: 28 August 2025).

ITIS (Integrated Taxonomic Information System) (2025). ITIS Standard Report Page: *Mauremys reevesii* (Gray, 1831). Available at: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=949163#null (Accessed: 14 July 2025).

Iverson, J.B., Ernst, C.H., Gotte, S. and Lovich, J.E. (1989). The Validity of *Chinemys megalocephala* (Testudines: Batagurinae). *Copeia*, 1989(2), pp. 494–498. Available at: https://doi.org/10.2307/1445452

Kaiser, H., Carvalho, V.L., Ceballos, J., Freed, P., Heacox, S., Lester, B., Richards, S.J., Trainor, C.R., Sanchez, C. and O'Shea, M. (2011). The herpetofauna of Timor-Leste: a first report. *ZooKeys*, 109, pp. 19–86. Available at: https://doi.org/10.3897/zookeys.109.1439

Kaiser, H., Carvalho, V.L., Freed, P. and O'Shea, M. (2010). A widely traveled turtle- *Mauremys reevesii* (Testudines- Geoemydidae) in Timor-Leste. *Herpetology Notes*, 3(1), pp. 93–96. Available at: https://www.researchgate.net/publication/259910939_A_widely_traveled_turtle-_Mauremys_reevesii_Testudines-_Geoemydidae_in_Timor-Leste (Accessed: 26 August 2025).

Kambayashi, C., Hemmi, K. and Kurabayashi, A. (2021). First record of *Amblyomma testudinarium* Koch, 1844 (Acari: Ixodidae) parasitising Reeves' Pond Turtle, *Mauremys reevesii* (Gray, 1831) (Testudines: Geoemydidae), in Japan. *Herpetology Notes*, 14, pp. 613–615. Available at: https://www.biotaxa.org/hn/article/view/65979 (Accessed: 26 August 2025).

Kang, H., Yun, K.Y., Jang, Y. and Koo, K.S. (2023). Vehicle incident? Reeves' Turtles, *Mauremys reevesii* (Gray, 1893), found in the Republic of Korea with cracked carapaces. *Herpetology Notes*, 16, pp. 345–347. Available at: https://www.biotaxa.org/hn/article/view/76169 (Accessed: 26 August 2025).

Kopecký, O., Kalous, L. and Patoka, J. (2013). Establishment risk from pet-trade freshwater turtles in the European Union. *Knowledge and Management of Aquatic Ecosystems*, 410(2), p. 02. Available at: https://doi.org/10.1051/kmae/2013057

Kraus, F. (2009). *Alien Reptiles and Amphibians: a Scientific Compendium and Analysis*. Springer, New York.

Lee, K.-H., Chen, T.-H., Shang, G., Clulow, S., Yang, Y.-J. and Lin, S.-M. (2019). A check list and population trends of invasive amphibians and reptiles in Taiwan. *ZooKeys*, 829, pp. 85–130. Available at: https://doi.org/10.3897/zookeys.829.27535

Lin, S., Lee, Y., Chen, T. and Lin, J. (2015). Habitat preference and management of a Chinese pond turtle population protected by the demilitarized Kinmen Islands. *Journal of Herpetology*, 49(3), pp. 399–404. Available at: https://doi.org/10.1670/14-012

Lovich, J.E., Ernst, C.H. and Gotte, S.W. (1985). Geographic Variation in the Asiatic Turtle *Chinemys reevesii* (Gray) and the Status of *Geoclemys grangeri* Schmidt. *Journal of Herpetology*, 19(2), pp. 238–245. Available at: https://doi.org/10.2307/1564177

Lovich, J.E., Yasukawa, Y. and Ota, H. (2011). *Mauremys reevesii* (Gray, 1831) – Reeves' Turtle, Chinese Three-keeled Pond Turtle. In: Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Inverson, J.B. and Mittermeier, R.A. (Eds.). *Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project*

of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs No. 5, pp. 050.1–050.10. Available at: https://doi.org/10.3854/CRM.5.050.REEVESII.V1.2011

Matsuda, Y., Kaburagi, S., Kamezaki, N., Ota, H., Takahashi, H., Imazu, T., Kagayama, S. and Kawamura, K. (2024). Density-dependent unidirectional hybridization between the Japanese pond turtle, *Mauremys japonica*, and the exotic Reeves' pond turtle, *Mauremys reevesii*, in Japan, inferred from molecular and morphological analyses. *Zoological Journal of the Linnean Society*, 203(3). Available at: https://doi.org/10.1093/zoolinnean/zlae070

O'Shea, M., Sanchez, C., Kathriner, A., Mecke, S. and Kaiser, H. (2015). Herpetological Diversity of Timor-Leste: Updates and a Review of Species Distributions. *Asian Herpetological Research*, 6(2), pp. 73–131. Available at: https://doi.org/10.16373/j.cnki.ahr.140066

Ota, H., Toda, M., Masunaga, G., Kikukawa, A. and Toda, M. (2004). Feral Populations of Amphibians and Reptiles in the Ryukyu Archipelago, Japan. *Global Environmental Resources*, 8(2), pp. 133–143. Available at: https://www.researchgate.net/publication/254303785_Feral_Populations_of_Amphibians_and_Reptiles_in_the_Ryukyu_Archipelago_Japan (Accessed: 14 July 2025).

Poch, S., Sunyer, P., Pascual, G., Boix, D., Campos, M., Cruset, E., Quer-feo, C., Fuentes, M.A., Molina, A., Porcar, A., Pérez-Novo, I., Pou-Rovire, Q., Ramos, S. and Escoriza, D. (2020). Alien chelonians in northeaster Spain: new distributional data. *The Herpetological Bulletin*, 151, pp. 1–5. Available at: https://doi.org/10.33256/hb151.15

Rho, J.R. (2023). Effects of Incubation Temperatures on Hatching Period and Growth in Korea Reeves' Turtle (*Mauremys reevesii*). *Korean Journal of Environment and Ecology*, 37(3), pp. 192–197. Available at: https://doi.org/10.13047/KJEE.2023.37.3.192

Saka, M., Tada, N. and Kamata, Y. (2014). Time Span of the Subadult Stage in Female Reeves' Pond Turtles *Mauremys reevesii* (Reptilia: Geoemydidae). *Current Herpetology*, 33(1), pp. 21–28. Available at: https://doi.org/10.5358/hsj.33.21

Shannon, F.A. (1956). The Reptiles and Amphibians of Korea. *Herpetologica*, 12(1), pp. 22–49. Available at: https://www.jstor.org/stable/3889565 (Accessed: 14 July 2025).

Smith, M.A. (1931). *The Fauna of British India, including Ceylon and Burma*. Taylor and Francis, London. Available at: https://archive.org/details/FBISmithReptiles1/mode/2up?q=%22reevesii%22&view=theater (Accessed: 11 July 2025).

Song, J., Chang, M. and Koo, K. (2014). Distribution and movement of Reeve's turtle (*Mauremys reevesii*) in South Korea. *Chinese Journal of Wildlife*, 35, pp. 329–334. Available at: https://www.researchgate.net/publication/266477056_Distribution_and_Movement_of_Reeve's_Turtle_Mauremys_reevesii_in_South_Korea (Accessed: 11 July 2025).

Species+ (2025). Species+ *Mauremys reevesii*. Available at: https://www.speciesplus.net/species#/taxon_concepts/8423/legal (Accessed: 11 July 2025).

Stejneger, L. (1907). *Herpetology of Japan and Adjacent Territory*. United States National Museum: Bulletin 58. Government Printing Office, Washington. Available at: https://www.biodiversitylibrary.org/page/7735165#page/9/mode/1up (Accessed: 11 July 2025).

Suzuki, D., Ota, H., Oh, H.-S. and Hikida, T. (2011). Origin of Japanese Populations of Reeves' Pond Turtle, *Mauremys reevesii* (Reptilia: Geoemydidae), as Inferred by a Molecular Approach. *Chelonian Conservation and Biology*, 10(2), pp. 237–249. Available at: https://doi.org/10.2744/CCB-0885.1

Suzuki, D., Yabe, T. and Hikida, T. (2014). Hybridization between *Mauremys japonica* and *Mauremys reevesii* Inferred by Nuclear and Mitochondrial DNA Analyses. *Journal of Herpetology*, 48(4), pp. 445–454. Available at: https://doi.org/10.1670/11-320

Takahashi, A., Kusaka, A. and Kamezaki, N. (2019). Skeletal Remains of *Mauremys reevesii* (Testudines: Geoemydidae) from a Late Medieval Archeological Site in Fukuyama City, Hiroshima Prefecture, Western Japan. *Current Herpetology*, 38(2), pp. 160–168. Available at: https://doi.org/10.5358/hsj.38.160

TTWG [Turtle Taxonomy Working Group: Rhodin, A.G.J., Iverson, J.B., Fritz, U., Gallego-García, N., Georges, A., Shaffer, H.B. and van Dijk, P.P.] (2025). Turtles of the World: Annotated Checklist and Atlas of Taxonomy, Synonymy, Distribution, and Conservation Status (10th Ed.). In: Rhodin, A.G.J., Iverson, J.B., van Dijk, P.P., Stanford, C.B., Goode, E.V., Buhlmann, K.A. and Mittermeier, R.A. (Eds.). *Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN SSC Tortoise and Freshwater Turtle Specialist Group*. *Chelonian Research Monographs*, 10, pp. 1–575. Available at: https://doi.org/10.3854/crm.10.checklist.atlas.v10.2025

USFWS (U.S. Fish and Wildlife Service) (2022). Reeves' Turtle (*Mauremys reevesii*): Ecological Risk Screening Summary. Available at: https://www.fws.gov/sites/default/files/documents/Ecological-Risk-Screening-Summary-Reeves-Turtle.pdf (Accessed: 11 July 2025).

Van Dijk, P.P. (2011). IUCN Red List of Threatened Species: *Mauremys reevesii*. *IUCN Red List of Threatened Species*. Available at: https://www.iucnredlist.org/fr/species/170502/97431862 (Accessed: 11 July 2025).

World Life Expectancy (2025). Reeves' Turtle Life Expectancy. *World Life Expectancy*. Available at: https://www.worldlifeexpectancy.com/reptile-life-expectancy-reeves-turtle (Accessed: 11 July 2025).

Ye, Z., Bu, R. and Shi, H. (2025). Nest Site Selection and Nesting Behavior of Reeves' Turtle (*Mauremys reevesii*) in Qichun County, Hubei Province, China. *Ecology and Evolution*, 15(7). Available at: https://doi.org/10.1002/ece3.71630

DRAFT National Risk Assessment: SERIOUS

RISK ASSESSMENT FOR AUSTRALIA: Emerald monitor (*Varanus prasinus*)

Class - Reptilia, **Order -** Squamata, **Family –** Varanidae, **Genus –** *Varanus*

SPECIES: *Varanus prasinus* (Schlegel, 1839) **Synonyms:** *Monitor prasinus* (Schlegel, 1839) *Varanus (odatria) prasinus prasinus* (Mertens, 1942) *Monitor beccarii* (Doria, 1874) *Monitor viridis* (Gray, 1831) *Varanus prasinus bogerti* (Mertens, 1950) *Varanus prasinus kordensis* (Meyer, 1874) *Varanus (Hapturosaurus) prasinus* (Bucklitsch et al., 2016) **Subspecies:** Monotypic **Common Names:** New Guinea green tree monitor Emerald monitor Green tree monitor	**Species description:** The emerald monitor is a medium-sized, green, arboreal monitor lizard native to New Guinea and several islands in the Torres Strait. Adults grow to approximately 30 centimetres snout to vent length (SVL), have a long prehensile tail (Greene 1986; Greene 2004) and an average adult weight of 280 grams. The emerald monitor belongs to the *Varanus prasinus* species complex, a group of nine morphologically similar species which all exhibit similar arboreal habits (Koch et al. 2010). It is an obligate rainforest species that is highly sought after for the pet trade (Janssen 2018). It is thought that the colouration provides camouflage in the rainforest canopy (Koch & Eidenmüller 2019). The species is difficult to find in the wild as it prefers thick vegetation and can be shy. Little is known about the ecology and behaviour of the emerald monitor in the wild. However, they are solitary (Pianka et al. 2004), and it is assumed they only congregate to mate (Greene 2004). They are not considered a threat to humans, however, they do have sharp claws and teeth that are capable of superficial damage to the skin by scratching and biting. With the propensity to keep reptiles as pets globally, zoonotic disease transfer to humans continues to pose a potential risk to the public and environment. Novel parasites, such as ticks (González-Acunã et al. 2005), any zoonoses they may be carrying (Pernetta 2009), and pathogens such as Salmonella species, Crimean-Congo haemorrhagic fever virus, eastern equine encephalitis virus and western equine encephalitis virus have been recorded in other imported reptile species (van Roon et al. 2019; Masila et al. 2020). Wellehan et al. (2005) first reported a herpesvirus associated disease in varanids; presence of a proliferative stomatitis in captive emerald monitors. **General information:** Distribution: The emerald monitor is endemic to Indonesia, Papua New Guinea and the Torres Strait islands of Australia. It is distributed throughout mainland New Guinea and surrounding islands (Sorong, Manokwari, Fakfak, Yapen-Waropen, Mimika, Jayapura, Merauke), and the Torres Strait Islands, including Kirriri (Hammond), Muralag (Prince of Wales); Dauan (Cornwallis), Mabuiag (Mabuyag/Jervis), Mer (Murray), Moa (Mua/Banks),

	Boigu (Talbot), Badu (Mulgrave), and Saibai (Günther 1879; Loveridge 1934; Whittier & Moeller 1993; Wilson 1996; Philip & Philip 2004; Clarke 2004; Borsboom 2007; Ingram 2008; Schaffer 2010; Cogger 2018; Koch & Eidenmüller 2019; Shea et al. 2018; ALA 2022). Lavery et al. (2012) questions the presence of this species on Mer. Koch & Eidenmüller (2019) discuss unconfirmed reports about sightings of large green lizards in rainforests in Cape York Peninsula, Australia, and the likelihood of the emerald monitor existing on mainland Australia concluding that the evidence for this claim is inconclusive. The Torres Strait Regional Authority Land and Sea Management Unit (2013) stated that the emerald monitor might also occur on Ugar (Stephens) Island, although verified reports were not yet available. Habitat: Emerald monitors are primarily arboreal, inhabiting a variety of habitats including subtropical and tropical rainforest and modified habitats such as cocoa plantations. While primarily tree-dwelling, the species is capable of swimming and may cross small water bodies such as mangrove swamps, rivers and lagoons to forage or evade predators. They prefer high humidity (an average of 70%) and dense vegetation up to 830 metres above sea level (Greene 2004; Pattiselanno et al. 2007; Philip & Philip 2007; Shea et al. 2018). They exhibit a range of highly specialised behaviours related to foraging and prey capture (Hartdegen et al. 1999, 2000). Diet: Studies examining stomach contents of the emerald monitor have shown that this species is insectivorous and carnivorous. Recorded prey items include insects (katydids, stick insects, cockroaches, beetles), spiders, frogs, geckos, crabs, mammals such as *Melomys* spp. and birds. It has also been observed scavenging (Greene 1986; Pattiselanno et al. 2007; Philipp & Philipp 2007; Struck 2002; Shuter 2014). Captive specimens occasionally consume vegetable and fruit, but as they are unable to digest cellulose, these items are not thought to be part of their normal diet (Greene 1986; Losos & Greene 1988). Reproduction: oviparous and reaching sexual maturity at approximately two years of age (Baldwin 2006; Mendyk 2012; Lemm 2014). Mating usually occurs in the wetter months, from November to April (Pianka et al. 2004). In the wild, clutches are thought to be deposited in tree hollows and burrows in termite mounds that have been dug by females; it is hypothesised that these environments provide constant temperature (approximately 29 degrees centigrade) and humidity (70% or higher) in addition to protection from predators (Greene 1986; Andrews et al. 2017). Several other varanid species are also known to nest in termite mounds, and at least two, *V. panoptes* and *V. gouldii,* excavate deep (3 metres or more in depth) complex warrens with helical tunnels that are used for nesting by several females (Doody et al. 2014; 2015). Clutches are laid 4 to 8 weeks after mating, with up to 4 clutches produced a year (Nijman & Shepherd, 2009; Mendyk 2011). In captivity, the emerald monitor lays clutches of up to 7 eggs that hatch within 166 to 205 days (Jacobs 2004; Nijman & Shepherd 2009). Mendyk (2011) reports the shortest interval between successive clutches is 68 days.

	Compared to other squamates, varanids have a prolonged incubation length primarily as an adaptation to maximize hatchling fitness (Andrews et al. 2017). It is thought to be capable of parthenogenesis (Grabbe & Koch 2014). Members of the *V. prasinus* complex are considered allopatric and no successful interbreeding has been recorded between different members of the complex (Greene 2004). **Longevity:** Adults have been recorded to live an average of 14.4 years in captivity (AnAge, 2023), with the oldest living 25 years (Mendyk 2014). **Conservation status:** **IUCN:** Least Concern. Does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. **CITES:** Appendix II - species that are not necessarily threatened with extinction but require controlled international trade to prevent utilization incompatible with their survival.
DATE OF ORIGINAL ASSESSMENT: August 2022 (Jodi Buchecker) **EIC ENDORSEMENT:** **Risk assessment models used for the assessment:** • Australian Reptile and Amphibian Model (Bomford 2006) • Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008)	**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 2006, 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**: Matching similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia is an important step for Bomford models. Climatch v3.0, a new version of the Climatch released by the Australian Bureau of Agricultural Resource Economics and Sciences in 2025 is used for climate matching. Climatch v3.0 uses WorldClim v2.1 datasets with the algorithm updated to use global variances specific to each source dataset. Climatch v3.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/. 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. Climatch v3.0 also includes an additional 3 bioclimatic variables (Diurnal temperature range, Isothermality and Temperature Seasonality) that are not included in the Bomford models. 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 19235 grid squares, each measured at a spatial resolution of 10 arcminutes (approximately 20 km) in both longitude and latitude. ABARES recalibration thresholds applied in Climatch v3.0 are similar to those used in Climatch v2.0 (at ~20 km resolution) (Table 1).

	Climatch v3.0 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. Bomford Model 2006, Part A, Australian Reptile and Amphibian Model 2008, Part C and Bird and Mammal Model 2008, Part A (with both using scores that are summed to give a cumulative score).

Australian Reptile and Amphibian Model (Bomford 2006):

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
G. 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 v2.1 (Version 3.0), 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/19235)*	5.19	CMRS = 100 x (1/19,235) = 5.198856252 Only the Torres Strait Islands and parts of Cape York Peninsula in far north Queensland may provide suitable habitat for the emerald monitor in Australia. On the mainland, the Kutini-Payamu (Iron) and Kulla (McIlwraith) ranges near Coen and a mangrove inlet near Bowen are considered suitable habitat. Kutini-Payamu and Kulla ranges are the locations where the only mainland Australian member of the *V. prasinus* complex, *V. keithhornei*, is found. Mangrove swamps exist along the Queensland east coast and may provide small pockets of potentially suitable habitat. In captivity, the emerald monitor does not usually reproduce in environments where humidity falls below 70% or the temperature below 24 degrees centigrade.
H. 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	*Species has not established an exotic population (including species not known to have been introduced anywhere).*
I. Taxonomic Family Risk Score	15	*Varanidae*

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*	20.19	5.19 + 0 + 15 = 20.19 **LOW establishment risk**

Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008):

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
A. Degree of climate match between species overseas range and Australia (1–6) *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 v2.1 (Version 3.0), Value X = sum of classes 6 – 10, see Table 1.*	1	*Very Low climate match to Australia* Value X = 34 Climate Match Score = 1 (Very low)
B. 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 population ever established.* The Global Invasive Species Database (GISD 2025) does not record these species forming feral populations or having any detrimental environmental impacts anywhere in the world. It is not considered a pest in its natural range (Shea et al. 2018).
C. Overseas range size score (0–2) < 1 = 0; 1– 70 = 1; >70 = 2	0	*Overseas range less than 1 million square kilometres.* Overseas natural range size is estimated at 737,802 km^2.

Estimate the species overseas range size including currently and the past 1000 years; natural and introduced range in millions of square kilometres		
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	**LOW establishment risk**

ENVIRONMENT AND INVASIVES COMMITTEE ALLOCATED PEST RISK* *For reptiles and amphibians, the assessed Establishment Risk Rank is combined with an allocated Extreme Pest Risk Rank (based on the precautionary approach), resulting in the assignment of species into one of two EIC Threat Categories: Extreme or Serious.	**SERIOUS**

ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY	**SERIOUS*** *Score assigned based on the highest Establishment Risk Rank (based on the precautionary approach).

NOTE: Where multiple Bomford risks assessment models are applicable, all models have been assessed and the threat category has been assigned based on a precautionary approach, meaning the highest threat category has been assigned and used to calculate the Environment and Invasives Committee Threat Category.

Figure 1. World distribution map (IUCN Red List), Figure 2. Climatch world distribution map and Figure 3. world Georeferenced records (GBIF) indicating where meteorological data was sourced for the climate analysis:



Figure 3. World Distribution Map - IUCN Red List

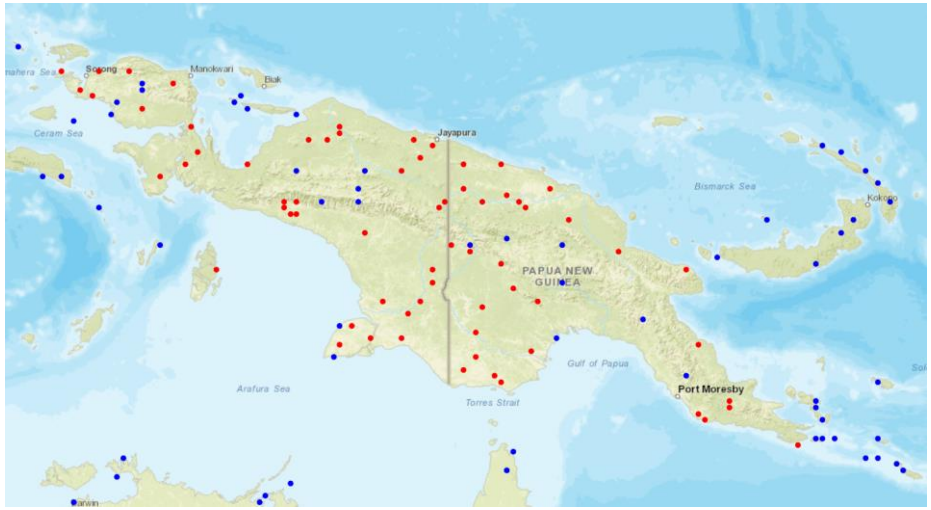


Figure 2. World Distribution map – Climatch

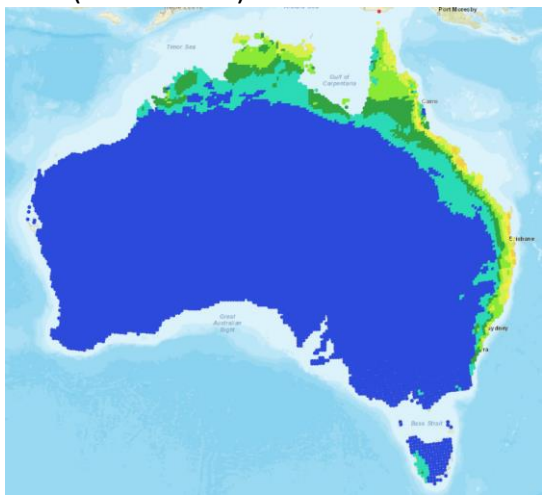


Figure 3. World Georeferenced records (GBIF)

Australian Reptile and Amphibian Model (Bomford 2006): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Varanus prasinus*

CMS (Sum Level 7) = 1



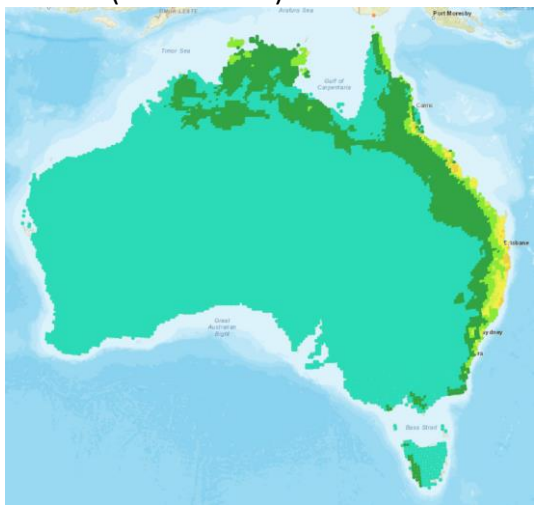
Score	Color	Count
0		15797
1		1514
2		854
3		645
4		296
5		98
6		30
7		0
8		1
9		0
10		0

Species: Varanus prasinus
Algorithm: Euclidean
67 source features selected
19235 target features selected
Approximate source selected area: 740,323 km^2
Approximate target selected area: 7,736,730 km^2

Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Varanus prasinus*

Value X (Sum Level 6) = 34



Score	Color	Count
0		0
1		15845
2		2763
3		393
4		106
5		94
6		33
7		1
8		0
9		0
10		0

Species: Varanus prasinus
Algorithm: Closest Standard Score
67 source features selected
19235 target features selected
Approximate source selected area: 740,323 km^2
Approximate target selected area: 7,736,730 km^2

Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Climatch v1.0 (50 km resolution) Closest Standard Match Sum Level 6 (Value X)	Climatch v3.0 (20 km resolution) 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**		

Risk Assessor's details:

Risk Assessor's name:	Aimee Carter
Business address and contact details:	PIRSA aimee.carter@sa.gov.au
Date:	October 2025
Reviewers:	Catriona Dowd (DCCEEW) Victoria Greentree (NSW DPI)

Adapted from:	DCCEEW 2022, Assessment of the Impacts of Varanus prasinus (Emerald Tree Monitor) on the Environment, Department of Climate Change, Energy, the Environment and Water, Canberra.	**By:** Aimee Carter	**Date:** October 2025

Bibliography:

ABARES (Australian Bureau of Agricultural and Resource Economics). (2025). Catchment scale land use of Australia and commodities – Update December 2023 - DAFF. Department of Agriculture, Fisheries and Forestry. Available at: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-and-commodities-update-2023 (Accessed: 7 October 2025).

Agriculture.gov.au. (2025). Climatch. Department of Agriculture, Fisheries and Forestry. Available at: https://climatch.cp1.agriculture.gov.au/ (Accessed: 31 March 2026).

ALA (Atlas of Living Australia). (2022). *Varanus prasinus* (Schlegel, 1839). Available at: https://bie.ala.org.au/species/Varanus_prasinus (Accessed: 31 March 2026).

AnAge. (2023). New Guinea green tree monitor (*Varanus prasinus*) longevity, ageing, and life history. AnAge Database. Available at: https://genomics.senescence.info/species/entry.php?species=Varanus_prasinus (Accessed: 7 October 2025).

Andrews, R.M., Pezaro, N., Doody, S., Guarino, F. and Green, B. (2017). Oviposition to Hatching: Development of *Varanus rosenbergi*. *Journal of Herpetology*, 51(3), pp. 396–401. Available at: https://doi.org/10.1670/16-124

Baldwin, B. (2006). Successful care and reproduction of green tree monitors (*Varanus prasinus*) at the San Diego Zoo. *Iguana*, 13(4), pp. 283–287. Available at: https://journals.ku.edu/iguana/article/download/17646/15906 (Accessed: 31 March 2026).

Bomford, M. (2003). *Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia*. Bureau of Rural Sciences.

Bomford, M. (2006). *Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models - A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences.

Bomford, M. (2008). *Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand - A report produced for the Invasive Animals Cooperative Research Centre*. Bureau of Rural Sciences.

Bomford, M., Kraus, F., Braysher, M., Walter, L. and Brown, L. (2005). *Risk Assessment Model for the Import and Keeping of Exotic Reptiles and Amphibians - A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences.

Borsboom, A. (2007). *Nomination to re-classify the 'rare' Varanus prasinus to 'near threatened' under the Nature Conservation Act 1992*. Environmental Protection Agency Queensland Government.

Catalogue of Life. (2025). COL: *Varanus prasinus*. Available at: https://www.catalogueoflife.org/data/taxon/7FG6L (Accessed: 7 October 2025).

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). (2025). Checklist of CITES species. Available at: https://checklist.cites.org/#/en/search/output_layout=alphabetical&level_of_listing=0&show_synonyms=1&show_author=1&show_english=1&show_spanish=1&show_french=1&scientific_name=+Varanus+prasinus&page=1&per_page=20 (Accessed: 7 October 2025).

Clarke, R.H. (2004). A record of the emerald monitor *Varanus prasinus* from Boigu Island, Torres Strait, Australia. *Herpetofauna*, 34, pp. 70–71.

Cogger, H.G. (2018). *Reptiles and Amphibians*. CSIRO Publishing.

DCCEEW (Department of Climate Change, Energy, the Environment and Water). (2025). Protected Matters Search Tool: Interactive Map. Available at: https://pmst.environment.gov.au/#/map?lng=131.52832031250003&lat=-28.6905876542507&zoom=5&baseLayers=Imagery (Accessed: 7 October 2025).

Doody, J.S., James, H., Colyvas, K., Mchenry, C. and Clulow, S. (2015). Deep nesting déjà vu devil's corkscrews: first helical reptile burrow and deepest vertebrate nest. *Biological Journal of the Linnean Society*, 116, pp. 13–26.

Doody, J.S., James, H., Ellis, H., Gibson, N., Raven, M., Mahony, S., Hamilton, D.J., Rhind, D., Clulow, S. and Mchenry, C.R. (2014). Cryptic and complex nesting in the yellow-spotted monitor, *Varanus panoptes*. *Journal of Herpetology*, 48, pp. 363–370.

GBIF (Global Biodiversity Information Facility). (2025). *Varanus prasinus* (Schlegel, 1839). Available at: https://www.gbif.org/species/8491752 (Accessed: 7 October 2025).

González-Acuña, D., Beldoménico, P.M., Venzal, J.M., Fabry, M., Kierans, J.E. and Guglielmone, A.A. (2005). Reptile trade and the risk of exotic tick introductions into southern South American countries. *Experimental and Applied Acarology*, 35, pp. 335–339.

Grabbe, J. and Koch, A. (2014). First and repeated cases of parthenogenesis in the varanid subgenus *Euprepiosaurus* (*Varanus indicus* Species Group) and the first successful breeding of *V. rainerguentheri* in captivity. *Biawak*, 8(2), pp. 79–87.

Greene, H.W. (1986). Diet and arboreality in *Varanus prasinus*, with comments on the study of adaptation. *Fieldiana Zoology*, 31, pp. 1–12.

Greene, H.W. (2004). '*Varanus prasinus*', in *Varanoid Lizards of the World*. Indiana University Press.

Günther, A. (1879). Notice of a collection of reptiles from Islands of Torres Strait. *Annals and Magazine of Natural History*, 3, pp. 84–87.

Hartdegen, R.W., Chiszar, D. and Murphy, J.B. (1999). Observations on the feeding behavior of captive black tree monitors, *Varanus beccari*. *Amphibia-Reptilia*, 20, pp. 330–332.

Hartdegen, R.W., Roberts, D.T. and Chiszar, D. (2000). Laceration of prey integument by *Varanus prasinus* (Schlegel, 1839) and *V. beccarii* (Doria, 1874). *Hamadryad*, 25, pp. 196–198.

Ingram, G. (2008). The terrestrial vertebrates of Mua, Western Torres Strait. *Memoirs of the Queensland Museum, Cultural Heritage Series*, 4, pp. 619–628.

Irwin, S. (2004). '*Varanus keithhornei*', in *Varanoid Lizards of the World*. Indiana University Press.

ITIS (Integrated Taxonomic Information System). (2025). *Varanus prasinus*. Available at: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=716533 (Accessed: 7 October 2025).

Jacobs, H.J. (2004). *Varanus prasinus*, in *Varanoid Lizards of the World*. Indiana University Press.

Janssen, J. (2018). Valuable varanoids: surveys of reptile traders in Japan reveal monitor lizards without import records. *Biawak*, 12(2), pp. 84–90.

Koch, A. and Eidenmüller, B. (2019). Is the New Guinea emerald tree monitor lizard (*Varanus prasinus*) native to mainland Australia? *Biawak*, 13(1), pp. 32–42.

Koch, A., Ziegler, T., Böhme, W., Arida, E. and Auliya, M. (2013). Pressing problems: distribution, threats, and conservation status of the monitor lizards (Varanidae: *Varanus* spp.) of Southeast Asia and the Indo-Australian Archipelago. *Herpetological Conservation and Biology*, 8(3), pp. 1–62.

Kraus, F. (2009). *Alien Reptiles and Amphibians: a Scientific Compendium and Analysis*. Springer.

Lavery, T.H., Watson, J.J. and Leung, L.K.P. (2012). Terrestrial vertebrate richness of the inhabited Torres Strait Islands, Australia. *Australian Journal of Zoology*, 60(3), pp. 180–191.

Lemm, J. (2014). Keen on green: Natural history and captive husbandry of green tree monitors (*Varanus prasinus*). *Herp Nation*, 16, pp. 32–39.

Losos, J.B. and Greene, H.W. (1988). Ecological and evolutionary implications of diet in monitor lizards. *Biological Journal of the Linnean Society*, 35, pp. 379–407.

Loveridge, A. (1934). Australian reptiles in the Museum of Comparative Zoology. *Bulletin of the Museum of Comparative Zoology*, 77, pp. 244–380.

Masila, N.M., Ross, K.E., Gardner, M.G. and Whiley, H. (2020). Zoonotic and public health implications of *Campylobacter* species and squamates (lizards, snakes and amphisbaenians). *Pathogens*, 9(10), p. 799.

Mendyk, R.W. (2011). Care Sheet: The Tree Monitors. *Reptiles Magazine*. No record.

Mendyk, R.W. (2012). Reproduction of varanid lizards (Reptilia: Squamata: Varanidae) at the Bronx Zoo. *Zoo Biology*, 31, pp. 374–389.

Nijman, V. and Shepherd, C.R. (2009). *Wildlife trade from ASEAN to the EU: issues with the trade in captive-bred reptiles from Indonesia*. TRAFFIC Europe.

Pattiselanno, F., Rayayu, E. and Wanggai, J. (2007). *Varanus* species at the Arfak Strict Nature Reserve. *Biodiversitas Journal of Biological Diversity*, 8(2), pp. 114–117.

Pernetta, A. (2009). Monitoring the trade: using the CITES trade database to examine the dynamics of the trade in live monitor lizards (*Varanus* spp.). *Biawak*, 3(2), pp. 37–45.

Philip, K.M. and Philip, D.P. (2007). 'Monitor Lizards of Papua', in *The Ecology of Papua, Part One*. Periplus Editions.

Pianka, E.R., King, D.R. and King, R.A. (2004). *Varanoid Lizards of the World*. Indiana University Press.

Schaffer, J. (2010). *Wetland Assessment of Boigu Island, Torres Strait: Part B - Reptiles*. James Cook University.

Shea, G., Allison, A., Parker, F. and Tallowin, O. (2018). *Varanus prasinus*. *The IUCN Red List of Threatened Species*. Available at: https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T42485751A101752115.en

Shuter, A.D. (2014). A novel underwater foraging behavior observed in *Varanus prasinus* at the Wildlife Conservation Society's Bronx Zoo. *Biawak*, 8(2), pp. 61–63.

Species+. (2025). Species+: *Varanus prasinus*. Available at: https://www.speciesplus.net/species#/taxon_concepts/10922/legal (Accessed: 7 October 2025).

van Roon, A., Maas, M., Toale, D., Tafro, N. and van der Giessen, J. (2019). Live exotic animals legally and illegally imported via the main Dutch airport and considerations for public health. *PLoS ONE*, 14(7), p. e0220122.

Wellehan, J.F., Johnson, A.J., Latimer, K.S., Whiteside, D.P., Crawshaw, G.J., Detrisac, C.J., Terrell, S.P., Heard, D.J., Childress, A. and Jacobson, E.R. (2005). Varanid herpesvirus 1: a novel herpesvirus associated with proliferative stomatitis in green tree monitors (*Varanus prasinus*). *Veterinary Microbiology*, 105, pp. 83–92.

Whittier, J.M. and Moeller, D.R. (1993). *Varanus prasinus* (the emerald goanna) on Moa Island, Torres Strait, Australia. *Memoirs of the Queensland Museum*, 34, p. 130.

Wilson, S. (1996). Wildlife that crossed the strait from Cape York to New Guinea, or vice versa. *GEO Australasia*, 18(3), pp. 90–96.

World Life Expectancy. (2025). World Life Expectancy: *Varanus prasinus*. Available at: https://www.worldlifeexpectancy.com/reptile-life-expectancy-emerald-monitor (Accessed: 7 October 2025).

DRAFT National Risk Assessment: EXTREME

RISK ASSESSMENT FOR AUSTRALIA: Crested gecko (*Correlophus ciliatus*)

Class - Reptilia, **Order -** Squamata, **Family -** Diplodactylidae, **Genus –** *Correlophus.*

SPECIES: *Correlophus ciliatus* (Guichenot, 1866) **Synonyms:** *Rhacodactylus ciliatus* (Guichenot, 1866) **Subspecies:** Monotypic **Common Names:** Crested gecko Eyelash gecko Crested giant gecko	**Species description:** The crested gecko is a medium sized lizard measuring up to 135 millimetres snout-to-vent length (SVL) (Bauer et al. 2012) with a total length approximately 190 to 210 millimetres (Exo Terra 2023). Adults can weigh between 35 to 60 grams (Exo Terra 2023). The crested gecko is also known as the eyelash gecko due to the enlarged triangular scales or pale markings defining the same area of the scales (or crests) above the eye and along the dorsal side of the body (Bauer et al. 2012). The crested gecko has a large triangular and flattened head, weak to moderately developed webbing between the digits and large lidless eyes with vertical pupils. The crested gecko has mostly uniform granular scales, with only small skin folds in some species (Bauer et al. 2012). The dorsal section of the crested gecko has considerable variation in colouration and patterning across individuals and populations. The dorsal can be brown, olive, yellowish, reddish, or orange, usually with or without contrasting markings on the crown, vertebral area or on the flanks. The venter is usually beige with a colour variation at the dorsum (Bauer et al. 2012). Both their toes (which are equipped with expanded undivided sub digital lamellae) and their tail tip bear setae, microscopic hair-like projections that exploit van der Waals forces, allowing the crested gecko to adhere and manoeuvre across smooth vertical and inverted surfaces (Bauer et al. 2012; Griffing et al. 2021). The tail is approximately 80–92% of the SVL and assists with its ability to jump (Bauer et al. 2012; Grabar et al. 2016). However, unlike most geckos, the crested gecko is unable to regenerate an amputated tail (Griffing et al. 2021; Gunmangan et al. 2024). **General information:** Distribution: This species is endemic to New Caledonia, occurring in Grande Terre and Isle des Pines (Bauer & Sadlier 1998; Bauer et al. 2012). On Grande Terre, it was known to be present in localities widely scattered across the southern half of the island (Canala to Rivière Bleue) and it has been found recently in the northern part (Néhoué)

	(Sadlier et al. 2021; Sanchez et al. 2015). It was once thought to be extinct in the wild until a small population was uncovered in 1994 (RSPCA 2024; Sadlier et al. 2021; Sanchez et al. 2015). Six specimens were reported in Brazil (exotic species) but these may have been released or escaped individuals (Nehemy et al. 2022) with no evidence to suggest that this is an established population. The IUCN Red List (Sadlier et al. 2021) stated that "a molecular phylogenetic analysis of the New Caledonia giant geckos has revealed that Rhacodactylus [the previous name] is polyphyletic (Bauer et al. 2012). The results show that *R. ciliatus* and *R. sarasinorum* are sister taxa but are not part of the same clade as the other giant geckos hence the generic name *Correlophus* has been resurrected for them (Bauer et al. 2012)". Habitat: This species is terrestrial and arboreal, inhabiting coastal forests, closed humid forests and montane forests of southern Grande Terre and the Isle of Pines and occurring at elevations between 150 and 1,000 metres (Bauer et al. 2012; Hudel et al. 2020; Sadlier et al. 2021; Uetz et al. 2026). Restricted to forested areas, it is possible that this species can occur in intervening forested areas (Bauer & Sadlier 1993; Sadlier et al. 2021). It is a nocturnal reptile, sheltering during the day in tree crevices and holes or amongst dense foliage whilst foraging at night in the canopy (Rilwater Reptiles 2026; Sadlier et al. 2021; Uetz et al. 2026). Diet: Diet in the wild is omnivorous, consisting of insects, nectar, fruit, and pollen (De Vosjoli 2016). The crested gecko has endolymphatic calcium storage sacs on the roof of the mouth, which facilitate calcium uptake and metabolic balance (Brusso 2013). Reproduction: Reproductive biology in natural settings is not fully described, but captive data indicates that female crested geckos are oviparous laying 2 soft-shelled eggs (the shells are flexible and weakly mineralised) (Andrews 2017). Eggs are laid at monthly intervals during the breeding season with incubation periods from approximately 90 to 190 days, depending on environmental conditions (Andrews 2017; Brusso 2013). Newly hatched juveniles are independent. Males are reported to reach sexual maturity between 9 to 15 months whereas the average age at sexual maturity for females is 12 months (Brusso 2013; Exo Terra 2023). In captivity *Correlophus ciliatus* x *Mniarogekko chahoua* (mossy New Caledonian gecko) hybrids (often called a crested chahoua) have been reported (Saunders 2013; Seipp & Henkel 2011 cited by Bauer et al. 2012). **Longevity:** The record longevity in captivity is 14.7 years (AnAge 2023) whilst World Life Expectancy estimates that the life span is between 7 to 9 years (World Life Expectancy 2026).

	Deutsch and Agostini (2025) estimate that the generation length is 5 years. **Conservation status:** **IUCN:** Vulnerable: considered to be facing a high risk of extinction in the wild (Sadlier et al. 2021) **CITES:** Not Listed
DATE OF ASSESSMENT: January 2026 (Aimee Carter) **EIC ENDORSEMENT:** **Risk assessment models used for the assessment:** • Australian Reptile and Amphibian Model(Bomford 2006) • Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008)	**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 2006, 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**: Matching similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia is an important step for Bomford models. Climatch v3.0, a new version of the Climatch released by the Australian Bureau of Agricultural Resource Economics and Sciences in 2025 is used for climate matching. Climatch v3.0 uses WorldClim v2.1 datasets with the algorithm updated to use global variances specific to each source dataset. Climatch v3.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/. 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. Climatch v3.0 also includes an additional 3 bioclimatic variables (Diurnal temperature range, Isothermality and Temperature Seasonality) that are not included in the Bomford models. 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 19235 grid squares, each measured at a spatial resolution of 10 arcminutes (approximately 20 km) in both longitude and latitude. ABARES recalibration thresholds applied in Climatch v3.0 are similar to those used in Climatch v2.0 (at ~20 km resolution) (Table 1).

	Climatch v3.0 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.

Australian Reptile and Amphibian Model (Bomford 2006):

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
J. 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 v3.0 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/19235).*	10	CMRS = 100 x (0/19,235) = 0 Increase score by 10 percentage points as per Bomford Model CMRS = 10 Using both IUCN (where the distribution data is not mapped for this species) and GBIF mapping, there are no weather stations available on southern New Caledonia where the crested gecko is located. Therefore, as there are less than 12 weather stations, the score has been increased by 10 percentage points as defined by Bomford. A Köppen-Geiger has also been provided on page 11 for analysis. Note: The species has several GBIF georeferenced occurrences from outside its natural range. Whilst most of these occurrences are presumed to be waifs rather than established populations.
K. 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*	0	*Species has not established an exotic population (including species not known to have been introduced anywhere).*

• *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*		The species is endemic to New Caledonia. The extent of occurrence is estimated to be 5,861 km^2 and the area of occupancy is estimated to be 44 km^2 (Sadlier et al. 2021).
L. Taxonomic Family Risk Score	30	*Diplodactylidae* – not listed in the Bomford model for comparison. Maximum score provided as precautionary approach.
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*	40	**MODERATE establishment risk**

Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008):

A. Degree of climate match between species overseas range and Australia (1–6) *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 v3.0, Value X = sum of classes 6 – 10, see Table 1.*	2	Very Low climate match to Australia Value X = 0 Climate Match Score = 1 Increase score by 1 *Low climate match to Australia* Climate Match Score = 2 Using both IUCN (where the distribution data is not mapped for this species) and GBIF mapping, there are no weather stations available on southern New Caledonia where the crested gecko is located.

		Therefore, as there are less than 12 weather stations, the score has been increased by 1 as defined by Bomford (2008). A Köppen-Geiger analysis has also been provided on page 11. Note: The species has many GBIF georeferenced occurrences from outside its natural range. Whilst most of these occurrences are presumed to be waifs rather than established populations.
B. 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 population ever established.* The species is endemic to New Caledonia with no exotic populations ever established.
C. 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 less than 1 million square kilometres.* The species is endemic to New Caledonia. The extent of occurrence is estimated to be 5,861 km^2 and the area of occupancy is estimated to be 44 km^2 (Sadlier et al. 2021).
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*	2	**LOW establishment risk**

ENVIRONMENT AND INVASIVES COMMITTEE ALLOCATED PEST RISK* *For reptiles and amphibians, the assessed Establishment Risk Rank is combined with an allocated Extreme Pest Risk Rank (based on the precautionary approach), resulting in the Assignment of species into one of two EIC Threat Categories: Extreme or Serious.	**EXTREME**

ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY	**EXTREME*** *Score assigned based on the highest Establishment Risk Rank (based on the precautionary approach).

NOTE: Where multiple Bomford risks assessment models are applicable, all models have been assessed and the threat category has been assigned based on a precautionary approach, meaning the highest threat category has been assigned and used to calculate the Environment and Invasives Committee Threat Category.

World distribution map (IUCN Red List; Figure 1); Climatch world distribution map (Figure 2 and 3) and world Georeferenced records (GBIF; Figure 4 and 5); indicating where meteorological data was sourced for the climate analysis:



Figure 4. World Distribution Map - IUCN Red List



Figure 2. World Distribution map – Climatch



Figure 3. World Distribution map – Climatch with GBIF Data



Figure 4. World Georeferenced records (GBIF) – All referenced locations

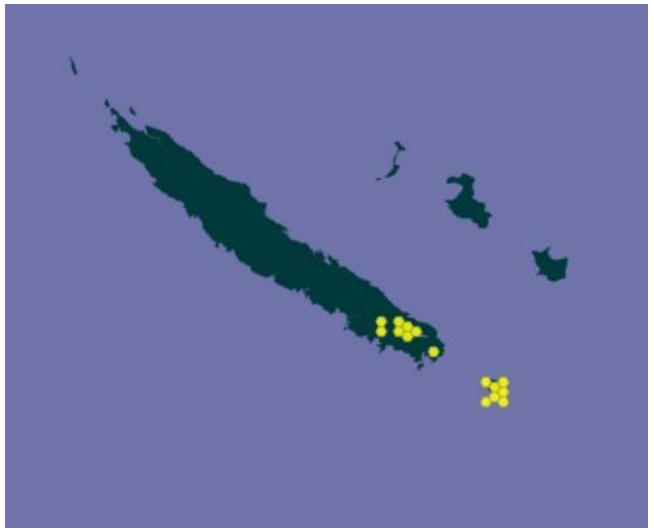
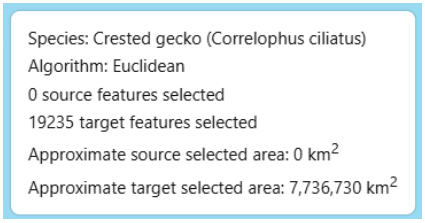
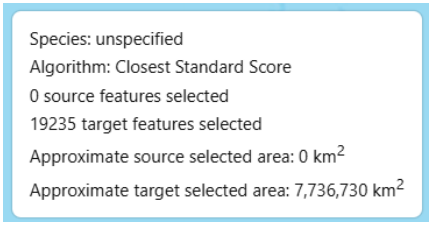


Figure 5. World Georeferenced records (GBIF) – New Caledonia

Australian Reptile and Amphibian Model (Bomford 2006): Climate match between world distribution of species and Australia:
Areas of Australia where the climate appears suitable for *Correlophus ciliatus*
CMS (Sum Level 7) = 0
CMRS = 10
There are 0 weather stations available for analysis. Therefore, the Climatch score will be increased by 10 percentage points.



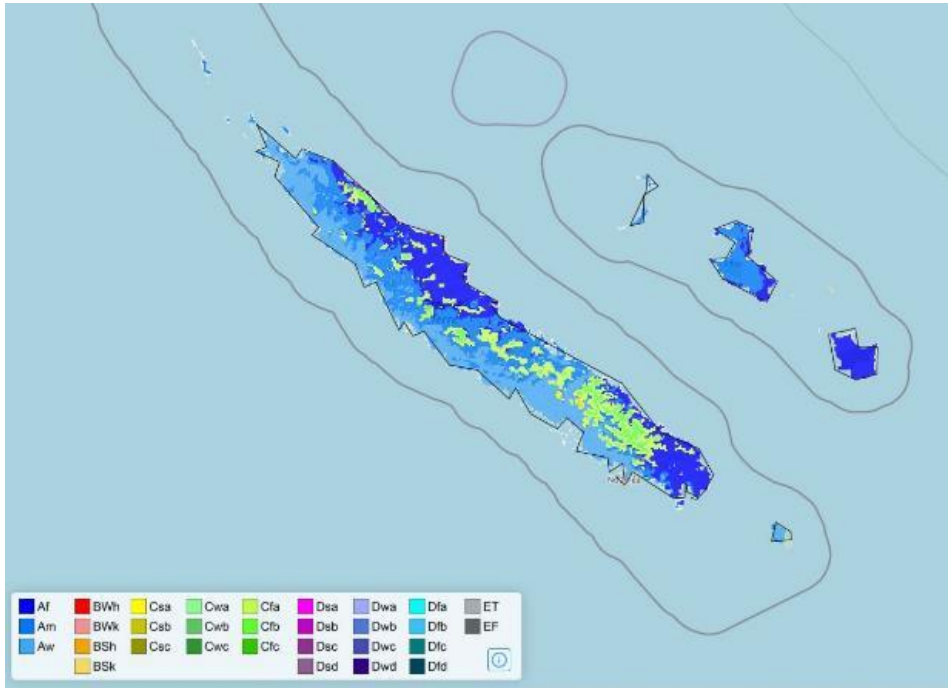
Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008):
Areas of Australia where the climate appears suitable for *Correlophus ciliatus*
Value X (Sum Level 6) = 0
CMS = 2
There are 0 weather stations available for analysis. Therefore, the Climatch Score will be increased by 1 increment.



Köppen-Geiger Analysis

A Köppen-Geiger analysis shows that the major climate zones on New Caledonia are present within the north and eastern coastlines of Australia, demonstrating a suitability of climate and the potential to establish exotic populations in Australia.

Af – Tropical, rainforest
Am – Tropical, monsoon
Aw – Tropical, savannah
Cfa – Temperate, no dry season, hot
Cfb - Temperate, no dry season, warm summer



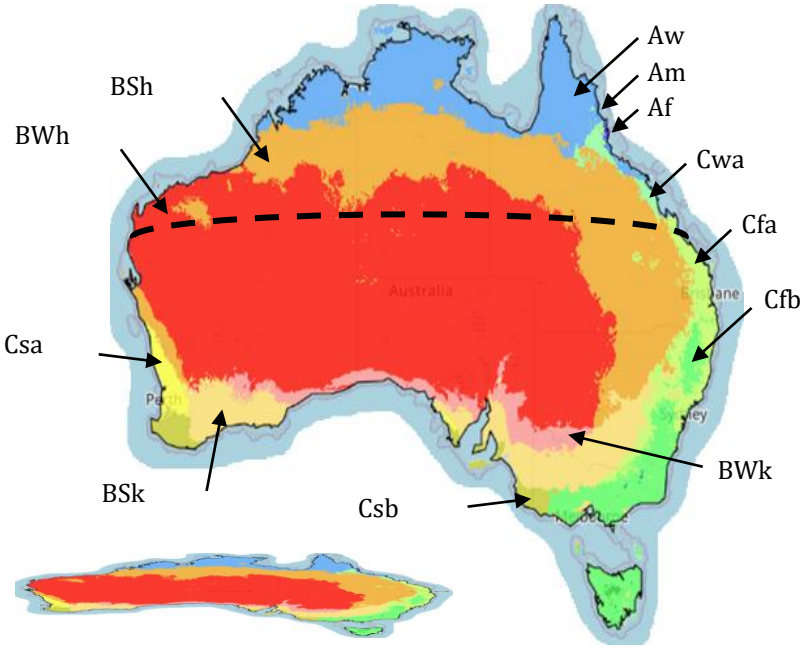


Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Climatch v1.0 (50 km resolution) Closest Standard Match Sum Level 6 (Value X)	Climatch v3.0 (20 km resolution) 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**		

Risk Assessor's details:

Risk Assessor's name:	Aimee Carter
Business address and contact details:	PIRSA aimee.carter@sa.gov.au
Date:	January 2026
Reviewers:	Noah Smith and Louise Prosser, DCCEEW

Bibliography:

ABARES (Australian Bureau of Agricultural and Resource Economics and Sciences). (2026). Catchment scale land use of Australia and commodities – Update December 2023. Department of Agriculture, Fisheries and Forestry. Available at: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-and-commodities-update-2023 (Accessed: 1 January 2026).

Agriculture.gov.au. (2026). *Climatch*. Department of Agriculture, Fisheries and Forestry. Available at: https://climatch.cp1.agriculture.gov.au/ (Accessed: 23 January 2026).

AnAge. (2026). The Animal Ageing and Longevity Database. Human Ageing Genomic Resources. Available at: https://genomics.senescence.info/species/query.php?search=*Correlophus+ciliatus* (Accessed: 21 January 2026). No record.

Andrews, R.M. (2017). Novel eggshell of the New Caledonian diplodactylid gecko species *Correlophus ciliatus* (= *Rhacodactylus ciliatus*). *Journal of Herpetology*, 51(2), pp.173–177. Available at: https://doi.org/10.1670/16-048

Bauer, A.M. and Sadlier, R.A. (1993). Systematics, biogeography and conservation of the lizards of New Caledonia. *Biodiversity Letters*, 1(3–4), pp.107–122. Available at: https://doi.org/10.2307/2999755

Bauer, A.M. and Sadlier, R.A. (1998). New data on the distribution, status and biology of the New Caledonian giant geckos (Squamata: Diplodactylidae: *Rhacodactylus* spp.). *Amphibian and Reptile Conservation*, 2(1), pp.24–29. Available at: https://amphibian-reptile-conservation.org/archive.php (Accessed: 22 January 2026).

Bauer, A.M., Jackman, T.R., Sadlier, R.A. and Whitaker, A.H. (2012). Revision of the giant geckos of New Caledonia (Reptilia: Diplodactylidae: *Rhacodactylus*). *Zootaxa*, 3404, pp.1–52. Available at: https://doi.org/10.11646/zootaxa.3404.1.1

Bomford, M. (2003). *Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia*. Bureau of Rural Sciences.

Bomford, M. (2006). *Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models - A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences.

Bomford, M. (2008). *Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand - A report produced for the Invasive Animals Cooperative Research Centre*. Bureau of Rural Sciences.

Bomford, M., Kraus, F., Braysher, M., Walter, L. and Brown, L. (2005). *Risk Assessment Model for the Import and Keeping of Exotic Reptiles and Amphibians - A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences.

Brusso, K. (2013). *Rhacodactylus ciliatus*. Animal Diversity Web, University of Michigan. Available at: https://animaldiversity.org/accounts/Rhacodactylus_ciliatus/ (Accessed: 22 January 2026).

Catalogue of Life. (2026). *Correlophus ciliatus* Guichenot, 1866. *Catalogue of Life*. Available at: https://www.catalogueoflife.org/data/taxon/YHKB (Accessed: 21 January 2026).

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). (2026). Available at: https://cites.org/eng/search?search_api_fulltext=Correlophus+ciliatus+ (Accessed: 1 January 2026). No record.

CMS (Convention on the Conservation of Migratory Species of Wild Animals). (2026). Available at: https://www.cms.int/search?fulltext=Correlophus+ciliatus (Accessed: 21 January 2026). No record.

DCCEEW (Department of Climate Change, Energy, the Environment and Water). (2026). *Protected Matters Search Tool: Interactive Map*. Australian Government. Available at: https://pmst.environment.gov.au (Accessed: 23 January 2026).

De Vosjoli, P. (2016). *Crested Gecko*. Lumina Media, Irvine, California.

Exo Terra. (2023). Crested gecko care guide. Exo Terra. Available at: https://exo-terra.com/explore/care-guides/lizards/correlophus-ciliatus/ (Accessed: 22 January 2026).

GBIF (Global Biodiversity Information Facility). (2026). *Correlophus ciliatus* Guichenot, 1866. GBIF Secretariat. Available at: https://www.gbif.org/species/2446592 (Accessed: 21 January 2026).

GISD (Global Invasive Species Database). (2026). IUCN SSC Invasive Species Specialist Group. Available at: https://www.iucngisd.org/gisd/search.php (Accessed: 22 January 2026). No record.

Grabar, R., Gilman, C. and Irschick, D. (2016). Effects of surface diameter on jumping kinematics and performance in two arboreal gecko species (*Correlophus ciliatus* and *Rhacodactylus auriculatus*). *Herpetologica*, 72(1), pp.32–39. Available at: https://doi.org/10.1655/HERPETOLOGICA-D-15-00034

Griffing, A.H., Sanger, T.J., Epperlein, L., Bauer, A.M., Cobos, A., Higham, T.E., Naylor, E. and Gamble, T (2021). And thereby hangs a tail: morphology, developmental patterns and biomechanics of the adhesive tails of crested geckos (*Correlophus ciliatus*). *Proceedings of the Royal Society B: Biological Sciences*, 288(1953), p.20210650. Available at: https://doi.org/10.1098/rspb.2021.0650

Gumangan, M.A., Pan, Z. and Lozito, T. (2024). Chromosome-level genome assembly and annotation of the crested gecko, *Correlophus ciliatus*. *Preprints*. Available at: https://doi.org/10.20944/preprints202409.2389.v1

Haziea Analytics, King Abdullah University of Science and Technology, GloH2O and the Australian National University. (2026). Köppen Climate Explorer. Available at: https://koppen.earth/ (Accessed: 22 January 2026).

Hudel, L., Georg, L. and Henkel, L. (2020). New distribution records: four species of giant geckos occur in syntopy on Île des Pins, New Caledonia. *Herpetology Notes*, 13, pp.261–265. Available at: https://www.researchgate.net/publication/339998680_New_distribution_records_four_species_of_giant_geckos_Gekkota_Diplodactylidae_occur_in_syntopy_on_Ile_des_Pins_New_Caledonia (Accessed: 22 January 2026).

ITIS (Integrated Taxonomic Information System). (2026). Available at: https://www.itis.gov/ (Accessed: 22 January 2026). No record.

Kraus, F. (2009). *Alien reptiles and amphibians: A scientific compendium and analysis*. Springer, New York.

Nehemy, I.K.R. *et al.* (2022). Herpeto-commerce: a look at the illegal online trade of amphibians and reptiles in Brazil. *Cuadernos de Herpetología*, 36(2), pp.185–196. Available at: https://www.cuadernosdeherpetologia.com/index.php/CdH/article/view/40/31 (Accessed: 22 January 2026).

Rilwater Reptiles. (2026). Owning a crested gecko: What to expect. Available at: https://sites.google.com/view/rilwater-reptiles/owning-a-crested-gecko-what-to-expect (Accessed: 22 January 2026).

RSPCA. (2024). Crested gecko. Royal Society for the Prevention of Cruelty to Animals. Available at: https://www.rspca.org.uk/adviceandwelfare/pets/other/crestedgecko (Accessed: 22 January 2026).

Sadlier, R.A., Bauer, A.M., Jourdan , H., Astrongatt, S., Deuss, M., Duval, T., Bourguet, E., McCoy, S., Bouteiller, A. and Lagrange, A., R.A. *et al.* (2021). *Correlophus ciliatus*. *The IUCN Red List of Threatened Species*. Available at: https://doi.org/10.2305/IUCN.UK.2021-2.RLTS.T176173A123253756.en

Sanchez, M., Cassan, J-J. and Duval, T. (2015). A new locality for *Correlophus ciliatus* and *Rhacodactylus leachianus* from Néhoué River, northern New Caledonia. *Herpetology Notes*, 8, pp.553–555. Available at: https://www.researchgate.net/publication/290453242_A_new_locality_for_correlophus_ciliatus_and_rhacodactylus_leachianus_Sauria_Diplodactylidae_from_nehoue_river_Northern_New_Caledonia (Accessed: 21 January 2026).

Saunders, K. (2013). Gecko hybridization. *Gecko Time*. Available at: https://geckotime.com/gecko-hybridization/ (Accessed: 22 January 2026).

Seipp, R. and Henkel, F-W. (2011). *Rhacodactylus: Biology, natural history and husbandry*. 2nd edn. Edition Chimaira, Frankfurt am Main.

Species+. (2025). *Species+*. UNEP-WCMC and CITES Secretariat. Available at: https://www.speciesplus.net/species#/taxon_concepts/3783/legal (Accessed: 21 January 2026).

Uetz, P. *et al.* (2026). *Correlophus ciliatus Guichenot, 1866*. *The Reptile Database*. Available at: https://reptile-database.reptarium.cz/Correlophus/ciliatus?search_param=%28%28search%3D%27Correlophus+ciliatus%27%29%29 (Accessed: 23 January 2026).

Uetz, P.H., Patel, M., Gbadamosi, Z., Nguyen, A. and Shoope, S. (2024). A reference database of reptile images. *Taxonomy*, 4(4), pp.723–732. Available at: https://doi.org/10.3390/taxonomy4040038

World Life Expectancy. (2025). Available at: https://www.worldlifeexpectancy.com/reptile-life-expectancy (Accessed: 23 January 2026). No record.

Zoological Society of London. (1833). *Proceedings of the Zoological Society of London*. Academic Press. Available at: https://www.biodiversitylibrary.org/page/28679922 (Accessed: 21 January 2026).

DRAFT National Risk Assessment: EXTREME

RISK ASSESSMENT FOR AUSTRALIA: Chinese Softshell Turtle (*Pelodiscus sinensis*)

Class - Reptilia, **Order -** Testudines, **Family -** Trionychidae, **Genus -** *Pelodiscus.*

SPECIES: *Pelodiscus sinensis* (Wiegmann, 1834) **Subspecies:** Monotypic **Synonyms:** *Amyda japonica* (Stejneger, 1907) *Amyda schlegelii* (Stejneger, 1907) *Amyda schlegelii haseri* (Pavlov (Pawlow), 1932) *Amyda schlegelii laoshanica* (Pavlov (Pawlow), 1933) *Amyda schlegelii licenti* (Pavlov (Pawlow), 1932) *Amyda sinensis* (Stejneger, 1907) *Amyda sinensis sinensis* (Mertens, Müller and Rust, 1934) *Amyda sinensis tuberculata* (Mertens, Müller and Rust, 1934) *Amyda tuberculata* (Schmidt, 1927) *Ceramopelta latirostris* (Heude, 1880) *Cinctisternum bicinctum* (Heude, 1880) *Coelognathus novemcostatus* (Heude, 1880) *Coelognathus novem-costatus* (Heude, 1880) *Coptopelta septemcostata* (Heude, 1880) *Coptopelta septem-costata* (Heude, 1880) *Emydes rostrata* (Brongniart, 1805)	**Species description:** Adult Chinese softshell turtles can reach a maximum carapace length of around 33 centimetres (Ernst & Lovich 2009) but are generally between 11 to 25 centimetres (Somma and Freedman 2025). They can weigh up to 6 kilograms. Their carapaces are round or oval, “flattened, keelless, slightly longer than wide and has a marginal ridge” (Ernst & Lovich 2009). Solid bone is present centrally in the carapace but absent toward the edges. The flexible shell allows easier movement allowing the Chinese softshell turtle to move quickly on the land and in water (Francis & Ferguson 2025; TNP 2025). Colouration of the carapace is olive green to olive-grey, with yellow-bordered black spots (FAO 2025). Some adults may have no pattern and will be uniform in colour. The plastron can be snow to pinkish white, sometimes with faint irregular markings, whereas the underside of the leathery margin of the carapace is unmarked (Farkas et al. 2019). The head and limbs are olive to yellowish white and the throat has “small whitish spots or large, light dark-edged markings” (Farkas et al. 2019). Fine black lines (sometimes accentuated with white) radiate before and from the eyes with some lines also located along the head and neck; lips may have small bars (Farkas et al. 2019; TNP 2025). A pair of dark blotches are found anterior to the tail and bands may ring on the posterior side of each thigh (TNP 2025). Juveniles have a distinct yellow spotting that fades with age. The shell is covered with soft leathery skin (Francis & Ferguson 2025; Shannon 1956). The first three digits project beyond the web and are covered by hard claws (Tokita & Kuratani 2001). Chinese softshell turtles are poikilothermic (Wang & Lang 1998 cited on Yang et al. 2019), and bask in the sun to control their body temperature (FAO 2025). They are highly aquatic and capable of prolonged submersion. The species possesses tubular nostrils which are used as a “snorkel” to help it breathe whilst buried in mud during the day. They breathe not only via lungs but also through their skin and by buccopharyngeal respiration allowing them to remain

Gomphopelta officinae (Heude, 1880) *Gymnopus perocellatus* (David, 1872) *Gymnopus simonii* (Duméril, 1875) *Landemania irrorata* (Gray, 1869) *Landemania perocellata* (Gray, 1869) *Oscaria swinhoei* (Gray, 1873) *Pelodiscus sinensis* (Fitzinger, 1843) *Pelodiscus sinensis japonicus* (Joseph-Ouni, 2004) *Pelodiscus sinensis sinensis* (Ferri, 2002) *Pelodiscus sinensis tuberculatus* (Ferri, 2002) *Potamochelys perocellatus* (Gray, 1864) *Potamochelys tuberculatus* (Gray, 1864) *Psilognathus laevis* (Heude, 1880) *Temnognathus mordax* (Heude, 1880) *Testudo rostrata* (Thunberg, 1787) *Testudo semimembranacea* (Hermann, 1804) *Testudo striata* (Suckow, 1798) *Tortisternum nomem-costatum* (Heude, 1880) *Tortisternum nomen-costatum* (Heude, 1880) *Tortisternum novemcostatum* (Heude, 1880) *Tortisternum novem-costatum* (Heude, 1880) *Tortisternum noven-costatum* (Heude, 1880) *Trionix sinensis* (Richard, 1999) *Trionyx (Aspidonectes) sinensis* (Wiegmann, 1834) *Trionyx cartilagineus newtoni* (Ferreira, 1897) *Trionyx japonica* (Temminck and Schlegel, 1838) *Trionyx japonicus* (Temminck and Schlegel, 1835) *Trionyx perocellatus* (Gray, 1844) *Trionyx peroculatus* (Günther, 1869) (ex errore) *Trionyx rostratus* (Thunberg, 1787) *Trionyx schlegeli* (Brandt, 1857) *Trionyx sinensis* (Wiegmann, 1834)	submerged for extended periods - in one experiment between 20 to 100 minutes at a time (FAO 2025; Ip et al. 2012). Chinese softshell turtles can excrete urea via their mouths during immersion and by the cloaca. During extended emersion buccopharyngeal respiration and urea excretion will occur simultaneously (Ip et al. 2012). There is sexual dimorphism within the species. Females are larger than males, due to egg development (FAO 2025). Females are more domed with a thicker tail that barely extends beyond the rim of the carapace, whereas males are shallower (Ernst & Lovich 2009; FAO 2025). The neck and tail are longer in males, with the cloaca positioned near the tip of the tail (Ernst & Lovich 2009; FAO 2025). **General information:** Distribution: Chinese softshell turtles are widely distributed, ranging from the Amur and Ussuri Rivers in the Russian Far East through the Korean Peninsula, Japan, and eastern, central, and southern China to southern Vietnam and Taiwan (Republic of China) (ATTWG 2000; Chen & Lue 2010; Gong et al. 2018; Species+ 2025). Introduced populations exist in many parts of Asia (Thailand, Japan, Kyrgyzstan, Malaysia, Indonesia, Republic of Korea, Singapore, Timor-Leste, Laos, Northern Mariana Islands, Philippines and Guam), Europe (Bosnia and Herzegovina, Spain, Serbia, Slovenia) and beyond (Brazil, Iran, and the United States of America (US): Hawaii and Virginia) through escapes from farming and trade (ATTWG 2000; Chen et al. 2000; CITES 2025; Koppetsch 2021; Species+ 2025). Chinese softshell turtles are continuously reported in other areas throughout Europe; High and Upper Rhine in Germany and Switzerland (Koppetsch 2021), Croatia (Brejcha et al. 2014), France, Great Britain (Somma & Freedman 2025) and Latvia (TTWG 2025) as well as Canada (Dupuis-Desormeaux et al. 2021) and US states (Maryland, Massachusetts, New Jersey and New York) (USFWS 2016; USGS 2025). Some of these cases are due to release or escaped pets, with established feral populations unconfirmed. Habitat: Chinese softshell turtles are found in disturbed and undisturbed habitats in both their native and introduced ranges. They inhabit freshwater, inland waters and brackish ecosystems and can be found in cultivated and forested areas along natural and artificial lakes, ponds, canals, slow-moving rivers, rice paddies, marshes and drainage ditches. Their preference is for deep water normally between 1 to 2 metres (Zhou et al. 2024). Primarily nocturnal, they often

Trionyx sinensis cyphus (Vogt, 1922) *Trionyx sinensis newtoni* (Bethencourt-Ferreira, 1897) *Trionyx sinensis sinensis* (Smith, 1931) *Trionyx sinensis tuberculatus* (Smith, 1931) *Trionyx stellatus japon* (Temminck and Schlegel, 1834) *Trionyx stellatus japonica* (Temminck, 1835) *Trionyx swinhonis* (Boulenger, 1889) *Trionyx tuberculatus* (Cantor, 1842) *Tyrse perocellata* (Gray, 1844) *Tyrse perocellatus* (Gray, 1855) *Tyrse sinensis* (Hay, 1904) *Yuen leprosus* (Heude, 1880) *Yuen pallens* (Heude, 1880) *Yuen viridis* (Heude, 1880) **Common Names:** Chinese Softshell Turtle Chinese Softshell	hide buried in mud or sand during daylight (ATTWG 2000; Diesmos et al. 2008; Supsup et al. 2016). In Europe, Chinese softshell turtles thrive in areas with high precipitation during the warmest quarter and stable upstream temperatures (Nekrasova et al. 2024), in Brazil, they are found in artificial lakes (Félix-Silva et al. 2013), in Bosnia and Herzegovina, they are found living in a flooded brick clay quarry (Brejcha et al. 2014) and in Koronadal City on Mindanao Island in the Philippines they have been observed in a creek (Sy 2014). Chinese softshell turtles have small home ranges. In the Yellow River, northwestern China, 9 Chinese softshell turtles were monitored with radio transmitters averaging a daily movement of 35 ± 18 metres Standard Deviation (SD) for males and 43 ± 18 metres SD for females (Kong et al. 2021). Diet: The Chinese softshell turtle's diet is largely carnivorous (Works & Olson 2018), feeding on fish, crustaceans, molluscs, insects and occasionally aquatic plants, algae and seeds of terrestrial plants (Wang & Lang 1998 cited in Yang et al. 2019). They are opportunistic predators capable of ambushing fish and other adult vertebrates (Bour 2008). Turtle stomach content analyses from Kawai Nui Marsh, Hawaii, showed that the Chinese softshell turtle consumed Pomacea species, crayfish, thiarid snails and Corbicula fluminea (Works & Olson 2018). When they are starving, they are cannibalistic (FAO 2025). Reproduction: Chinese softshell turtles are oviparous with sexual maturity typically reached at 4 years of age (Masin et al. 2013). Breeding season beings in early spring to late autumn (FAO 2025). In Taiwan, nesting season extends from late March to early November (Chen et al. 2000). Females can store sperm for up to a year before laying eggs (Chen et al. 2020). In captivity, clutch sizes range from 10 to 35 eggs, and females may lay up to 5 to 6 clutches per year (Chen et al. 2000; Masin et al. 2013). Eggs are spherical (averaging 20 millimetres in diameter) and buried in soil or sand; incubation lasts between 48 to 60 days, depending on temperature (FAO 2025; Tokita and Kuratani 2001; Wu et al. 2023). Sex determination is not temperature-dependent in this species (Choo & Chou 1992). Hybridisation between turtles within the same Family have been reported in captivity (Gong et al. 2018; Mat et al. 2025).

	Chinese softshell turtles are known to be aggressive. Although females tend to be timorous and meek (FAO 2025), their sharp claws and bite may break the skin of their handler (DEECA 2023; Koppetsch 2021). They also harbour and transmit diseases or parasites that could affect humans and native species such as white abdominal disease (Zhang et al. 2023), soft shell disease (Chen et al. 2013) and haemorrhagic sepsis caused by Aeromonas hydrophila infection (Lv et al. 2021). Soft shell disease (WHA 2023) and Aeromonas hydrophila infection (Ariel et al. 2017) have both been reported in native wild turtle populations within Australia, however white abdominal disease has not been reported within Australia. Chinese softshell turtles are a valuable commodity for food and trade. The annual production in China alone equates to 340,000 tonne (Gong et al. 2018). In Asia, it is commonly found in food markets for its meat content and medicinal properties and for purchase from the exotic pet trade (Diesmos et al. 2008; Gong et al. 2017; Suzuki et al. 2015). **Longevity:** The record longevity in captivity is 47.5 years (AnAge 2023). In the wild, due to diseases, predation and environmental stresses the lifespan of the Chinese softshell turtle is expected to be 20 years (WildArk 2025). **Conservation status:** **IUCN:** Vulnerable: considered to be facing an extremely high risk of extinction in the wild (ATTWG 2000) **CITES:** Not Listed
DATE OF ASSESSMENT: July 2025 (Aimee Carter) **EIC ENDORSEMENT:** **Risk assessment model used for the assessment:** • Australian Reptile and Amphibian Model (Bomford 2006) • Australian Reptile and Amphibian Model (Bomford 2008)	**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 2006, 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

• Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008)	**CLIMATE**: Matching similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia is an important step for Bomford models. Climatch v3.0, a new version of the Climatch released by the Australian Bureau of Agricultural Resource Economics and Sciences in 2025 is used for climate matching. Climatch v3.0 uses WorldClim v2.1 datasets with the algorithm updated to use global variances specific to each source dataset. Climatch v3.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/. 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. Climatch v3.0 also includes an additional 3 bioclimatic variables (Diurnal temperature range, Isothermality and Temperature Seasonality) that are not included in the Bomford models. 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 19235 grid squares, each measured at a spatial resolution of 10 arcminutes (approximately 20 km) in both longitude and latitude. ABARES recalibration thresholds applied in Climatch v3.0 are similar to those used in Climatch v2.0 (at ~20 km resolution) (Table 1). Climatch v3.0 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. Bomford Model 2006, Part A, Australian Reptile and Amphibian Model 2008, Part C and Bird and Mammal Model 2008, Part A (with both using scores that are summed to give a cumulative score).

Australian Reptile and Amphibian Model (Bomford 2006):

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
M. 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 v2.1 (Version 3.0), 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/19235).*	24.07	CMS = 4,629 CMRS = 100 x (4,629/19,235) = 24.07 Note: The species has many GBIF georeferenced (Figure 3 and 4) occurrences from outside its natural range. These coordinates, along with the map from the TTWG (2025) showing the distribution of the species, have been calculated together. Estimated indigenous area of occupancy is approximately 867,951 square kilometres. Estimated indigenous extent of occurrence is approximately 3,303,687 square kilometres (TTWG 2025).

N. 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*	30	*Self-sustaining exotic populations established on several islands.*
O. Taxonomic Family Risk Score	20	*Trionychidae.*
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*	74.07	**SERIOUS establishment risk**

Australian Reptile and Amphibian Model (Bomford 2008):

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
G. Family Random Effect value	-0.07	*Trionychidae = -0.07*

A family random effect assumed drawn from a Gaussian distribution with mean zero and variance that was estimated from Bomford et al's (2008) data.		
H. Prop.species value *The number of jurisdictions where a species successfully established divided by the total number of jurisdictions where species has been introduced.*	0.69	Based on the updated statistics from Kraus (2009) as directed by Bomford (2008), including *Pelodiscus sinensis* and the genus-level synonym *Trionyx sinensis*. Populations in the Philippines have been included in the statistical analysis. *Number of jurisdictions where a species successfully established = 9* *Total number of jurisdictions where species has been introduced = 13* *Prop.species Value = 0.69*
I. S(Climate 6) value *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 v2.1 (Version 3.0), to determine the climate match between this overseas range and Australia, selecting Euclidian Match and using all 16 climate variables for the analysis. Sum the five scores for classes 6-10. Express this as a proportion of the maximum possible score (19,235).* *Use Fig 3.4 to calculate value.*	0.266	<u>Score as reported in Bomford Model 2008</u> Sum Euclidian match scores to Australia levels 6-10 = 775 Climate 6 score = 775/2,785 = 0.27827648 S(Climate 6) value from Figure 3.4 = 4.25(Climate 6 Score) – 1.88. S(Climate 6) value from Figure 3.4 = 4.25(0.27827648) – 1.88. Figure 3.4= -0.69732496* =-0.70 *Figure calculated incorrectly in Bomford 2008. Therefore, Climatch 3.0 statistics have been used in this calculation. <u>Score reflecting the version of Climatch 3.0</u> Sum Euclidian match scores to Australia levels 6-10 = 9,713 Climate 6 score = 9,713/19,235 = 0.50496491 S(Climate 6) value from Figure 3.4 = 4.25(Climate 6 Score) – 1.88. S(Climate 6) value from Figure 3.4 = 4.25(0.50496491) – 1.88.

		Figure 3.4= 0.26610087 = 0.266
ESTABLISHMENT RISK RANK *A species' Establishment Risk Score = 1/ (1 + exp(0.80 – 2.90(Prop.species) – S(Climate 6) – Family Random Effect))* *Establishment Risk Rank* *Establishment Risk Score* *Low* *≤ 0.16* *Moderate* *0.17-0.39* *Serious* *0.40-0.85* *Extreme* *≥ 0.86*	0.79	1/(1 + exp(0.80 – 2.90(0.69) – 0.266 – (-0.07)) 1/(1 + exp(0.80 – 2.001 - 0.266 + 0.07)) 1/(1+EXP(-1.397)) **=0.802** **=0.80** **SERIOUS**

Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008):

FACTOR	**SCORE**	**DETAIL**
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
A. Degree of climate match between species overseas range and Australia (1–6) *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 v2.1 (Version 3.0), Value X = sum of classes 6 – 10, see Table 1.*	3	*Moderate climate match to Australia* Value X = 5,745 Climate Match Score = 3 Note: The species has many GBIF georeferenced (Figure 3 and 4) occurrences from outside its natural range. These coordinates, along with the map from the TTWG (2025) showing the distribution of the species, have been calculated together.
B. 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*	4	*Exotic population established on a larger island (> 50 000 km^2) or anywhere on a continent.*

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.		The Chinese softshell turtle has adapted to tropical, subtropical and temperate regions outside its natural range across a global scale (Masin et al. 2013).
C. 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 between 1 to 70 million square kilometres.* Estimated indigenous extent of occurrence is estimated to be 3,303,687 square kilometres. Estimated indigenous area of occupancy estimated to be 867,951 square kilometres (TTWG 2025).
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*	8	**SERIOUS establishment risk**

ENVIRONMENT AND INVASIVES COMMITTEE ALLOCATED PEST RISK* *For reptiles and amphibians, the assessed Establishment Risk Rank is combined with an allocated Extreme Pest Risk Rank (based on the precautionary approach), resulting in the Assignment of species into one of two EIC Threat Categories: Extreme or Serious.	**EXTREME**

ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY	**EXTREME*** *Score assigned based on the highest Establishment Risk Rank (based on the precautionary approach).

World distribution map (IUCN Red List; Figure 1); Climatch world distribution map (Figure 2) and world Georeferenced records (GBIF; Figures 3 and 4) indicating where meteorological data was sourced for the climate analysis:

Note: The species has many GBIF georeferenced occurrences from outside its natural range. Where possible, these have been included in the Climatch statistics. No weather stations are present in the species range for Slovenia and Bosnia and Herzegovina (Figure 7), United States and Guam (Figure 8 – only points from Hawaii and Virginia have been included in Climatch analysis), state of Para Brazil (but no map available).



Figure 5. World Distribution Map - IUCN Red List



Figure 2. World Distribution map – Climatch



Figure 3. World Georeferenced records (GBIF)

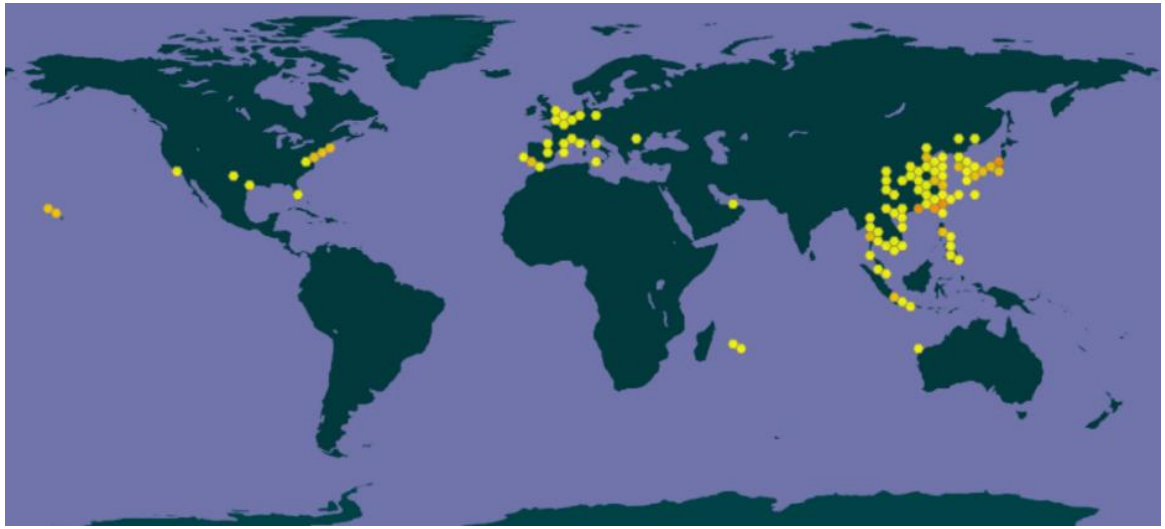


Figure 4. World Georeferenced records (GBIF) – All referenced locations

Alternative scientific distribution maps for *P. sinensis*

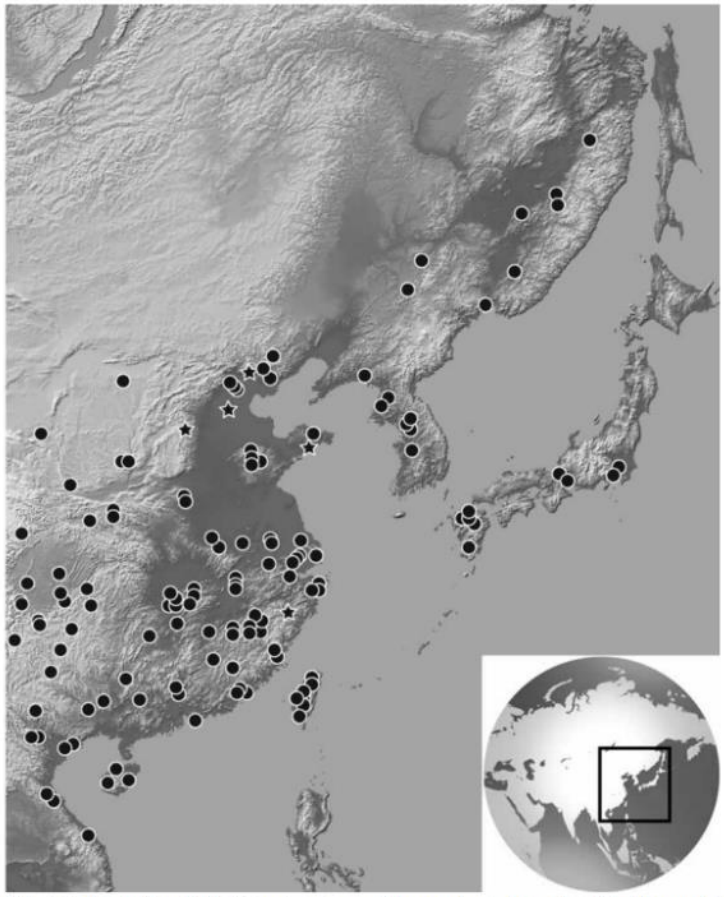
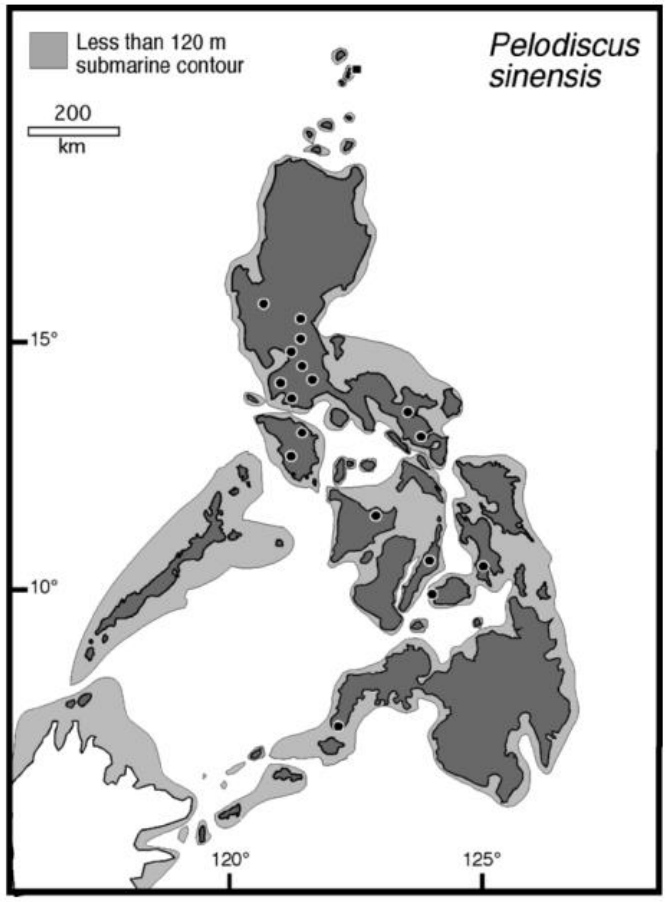


FIGURE 3. Revised distribution of *Pelodiscus sinensis* combining previously known localities (Iverson, 1992; Iverson *et al.*, 2000) with records from the Institute of Zoology, China. Circles represent 132 previously reported localities, stars represent 6 new records.

Figure 5. Distribution localities for P. sinensis reported by Fong & Qiao 2010 China. Philippines.



Map 4. Distribution of *Pelodiscus sinensis* in the Philippines. Circles = recent confirmed records; square (Batan Isl.) = historical record.

Figure 6. Distribution localities for P. sinensis reported by Diesmos et al. 2008

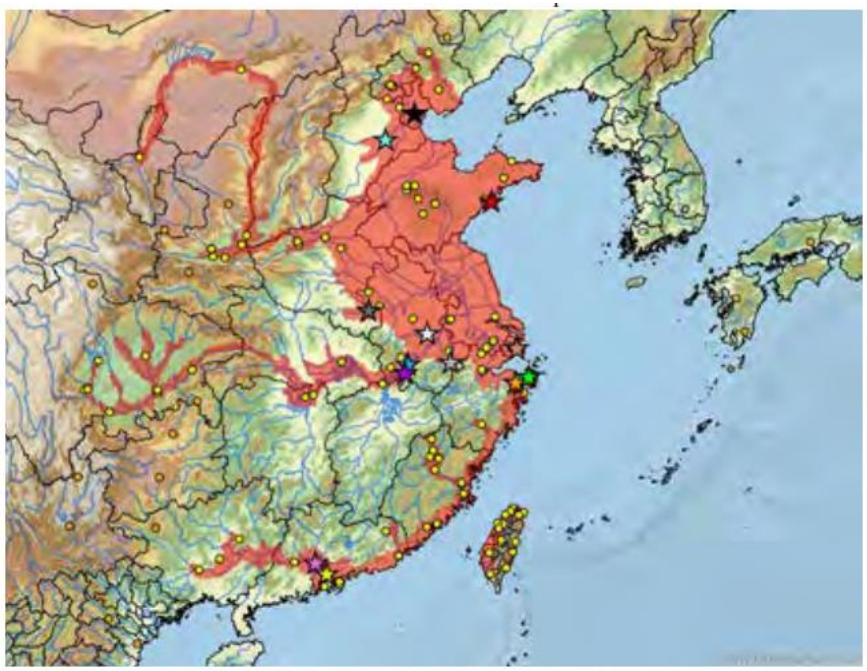
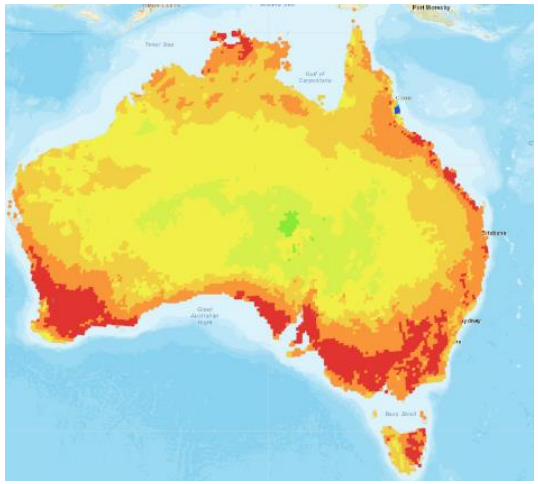


Figure 7. Map of reported locations of P. sinensis by the TTWG (2025).

Australian Reptile and Amphibian Model (Bomford 2006): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pelodiscus sinensis*

CMS (Sum Level 7) = 4,629



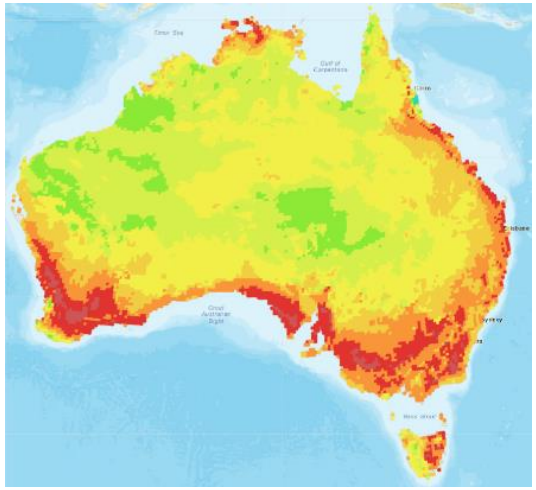
Score	Color	Count
0		6
1		1
2		0
3		68
4		1960
5		7487
6		5084
7		3106
8		1514
9		9
10		0

Species: Pelodiscus sinensis (Chinese Softshell Turtle)
Algorithm: Euclidean
308 source features selected
19235 target features selected
Approximate source selected area: 3,586,294 km^2
Approximate target selected area: 7,736,730 km^2

Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Pelodiscus sinensis*

Value X (Sum Level 6) = 5,745



Score	Color	Count
0		0
1		7
2		0
3		1530
4		5615
5		6338
6		2347
7		1988
8		1195
9		215
10		0

Species: Pelodiscus sinensis (Chinese Softshell Turtle)
Algorithm: Closest Standard Score
308 source features selected
19235 target features selected
Approximate source selected area: 3,586,294 km^2
Approximate target selected area: 7,736,730 km^2

Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Climatch (50 km) Closest Standard Match Sum Level 6 (Value X)	Climatch v3.0 (20 km resolution) 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**		

Risk Assessor's details:

Risk Assessor's name:	Aimee Carter
Business address and contact details:	PIRSA aimee.carter@sa.gov.au
Date:	August 2025
Reviewers:	Louise Prosser and Danielle Azevedo, DCCEEW

Bibliography:

ABARES (Australian Bureau of Agricultural and Resource Economics). (2025). Catchment scale land use of Australia and commodities – Update December 2023 - DAFF. Australian Government Department of Agriculture, Fisheries and Forestry. Available at: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-and-commodities-update-2023 (Accessed: 15 July 2025).

Agriculture.gov.au. (2025). *Climatch*. Australian Government Department of Agriculture, Fisheries and Forestry. Available at: https://climatch.cp1.agriculture.gov.au/ (Accessed: 15 July 2025).

AnAge. (2025). The Animal Ageing and Longevity Database. Human Ageing Genomic Resources. Available at: https://genomics.senescence.info/species/query.php?search=*Pelodiscus+sinensis* (Accessed: 15 July 2025). No record.

Ariel, E., Freeman, A., Elliott, E., Wirth, W., Mashkour, N. and Scott, J. (2017). An unusual mortality event in Johnstone River snapping turtles *Elseya irwini* (Johnstone) in Far North Queensland, Australia. *Australian Veterinary Journal*, 95(10), pp.355–361. Available at: https://doi.org/10.1111/avj.12627

ATTWG (Asian Turtle Trade Working Group). (2000). IUCN Red List of Threatened Species: *Pelodiscus sinensis*. *IUCN Red List of Threatened Species*. Available at: https://www.iucnredlist.org/fr/species/39620/97401140 (Accessed: 15 July 2025).

Bain, R.H. and Hurley, M.M. (n.d.). A biogeographic synthesis of the amphibians and reptiles of Indochina. *Bulletin of the American Museum of Natural History*, 360, pp.90–117. Available at: http://hdl.handle.net/2246/6141 (Accessed: 15 July 2025).

Bomford, M. (2003). *Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2006). *Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models - A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2008). *Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand - A report produced for the Invasive Animals Cooperative Research Centre*. Bureau of Rural Sciences, Canberra.

Bomford, M., Kraus, F., Braysher, M., Walter, L. and Brown, L. (2005). *Risk Assessment Model for the Import and Keeping of Exotic Reptiles and Amphibians*. Bureau of Rural Sciences, Canberra.

Bour, R. (2008). Global diversity of turtles (*Chelonii*; Reptilia) in freshwater. *Hydrobiologia*, 595(1), pp.593–598. Available at: https://doi.org/10.1007/978-1-4020-8259-7_57

Brejcha, J., Cizelj, I., Maric, D., Smid, J., Vamberger, M. and Sanda, R. (2014). First records of the soft-shelled turtle, *Pelodiscus sinensis* (Wiegmann, 1834), in the Balkans. *Herpetozoa*, 26(3/4), pp.189–192. Available at: https://www.researchgate.net/publication/260984997_First_records_of_the_soft-shelled_turtle_Pelodiscus_sinensis_WIEGMANN_1834_in_the_Balkans (Accessed: 15 July 2025).

Brock, V.E. (1947). The Establishment of *Trionyx sinensis* in Hawaii. *Copeia*, 1947(2), p.142. Available at: https://doi.org/10.2307/1438656

Catalogue of Life. (2025). COL: *Pelodiscus sinensis*. *Catalogue of Life*. Available at: https://www.catalogueoflife.org/data/taxon/76CTF (Accessed: 15 July 2025).

Chen, H., Liu, T., Holt, W.V., Yang, P., Zhang, L., Zhang, L., Han, X., Bian, X. and Chen, Q. (2020). Advances in understanding mechanisms of long-term sperm storage - the soft-shelled turtle model. *Histology and Histopathology*, 35(1), pp.1–23. Available at: https://doi.org/10.14670/HH-18-148

Chen, J., Zhu, N., Kong, L., Bei, Y., Zheng, T., Ding, X. and He, Z. (2013). First case of soft shell disease in Chinese soft-shelled turtle (*Trionyx sinens*) associated with *Aeromonas sobria–A. veronii* complex. *Aquaculture*, 406–407, pp.62–67. Available at: https://doi.org/10.1016/j.aquaculture.2013.05.006

Chen, T.H., Lin, C.H. and Chang, H.C. (2000). Current Status and Utilisation of Chelonians in Taiwan. In: van Dijk, P.P., Stuart, B.L. and Rhodin, A.G.J. (eds.) *Asian Turtle Trade: Proceedings of a Workshop on Conservation and Trade of Freshwater Turtles and Tortoises in Asia*. *Chelonian Research Monographs* 2. Chelonian Research Foundation, Massachusetts, pp.45–51. Available at: https://chelonian.org/crm/crm-2/ (Accessed: 15 July 2025).

Chen, T.H. and Lue, K.Y. (2010). Population status and distribution of freshwater turtles in Taiwan. *Oryx*, 44(2), pp.261–266. Available at: https://doi.org/10.1017/S0030605310000013

Choo, B.L. and Chou, L.M. (1992). Does Incubation Temperature Influence the Sex of Embryos in *Trionyx sinensis*? *Journal of Herpetology*, 26(3), pp.341–342. Available at: https://doi.org/10.2307/1564893

CITES (Convention on International Trade in Endangered Species). (2025). Checklist of CITES species: *Pelodiscus sinensis*. Available at: https://cites.org/eng/search?search_api_fulltext=Pelodiscus+sinensis (Accessed: 15 July 2025). No record.

CMS (Convention on the Conservation of Migratory Species of Wild Animals). (2025). Available at: https://www.cms.int/search?fulltext=Pelodiscus+sinensis (Accessed: 15 July 2025). No record.

DCCEEW (Department of Climate Change, Energy, the Environment and Water). (2025). *Protected Matters Search Tool: Interactive Map*. Australian Government. Available at: https://pmst.environment.gov.au (Accessed: 15 July 2025).

DEECA (Department of Energy, Environment and Climate Action). (2023). Chapter 3. Turtles. In: *Victorian Wildlife Rehabilitation Guidelines: Part B Reptiles and Amphibians*. Victorian Government. Available at: https://www.wildlife.vic.gov.au/__data/assets/pdf_file/0023/668120/Victorian-Wildlife-Rehabilitation-Guidelines-Part-B-Reptiles-and-Amphibians.pdf (Accessed: 15 July 2025).

Diesmos, A.C., Brown, R.M., Alcala, A.C. and Sison, R.V. (2008). Status and Distribution of Nonmarine Turtles of the Philippines. *Chelonian Conservation and Biology*, 7(2), pp.157–177. Available at: https://doi.org/10.2744/ccb-0672.1

Dupuis-Desormeaux, M., McDonald, K., Moro, D., Reid, T., Agnew, C., Johnson, R. and MacDonald, S.E. (2021). A snapshot of the distribution and demographics of freshwater turtles along Toronto's Lake Ontario coastal wetlands. *Journal of Great Lakes Research*, 47(2), pp.283–294. Available at: https://doi.org/10.1016/j.jglr.2021.01.020

EDDMapS. (2025). Chinese softshelled turtle (*Pelodiscus sinensis* Wiegmann 1835). *EDDMapS*. Available at: https://www.eddmaps.org/species/subject.cfm?sub=59130 (Accessed: 4 September 2025).

Ernst, C.H. and Lovich, J.E. (2009). *Turtles of the United States and Canada*. 2nd edn. Johns Hopkins University Press, Baltimore.

FAO (Food and Agriculture Organization of the United Nations). (2025). *Pelodiscus sinensis*. *Cultured Aquatic Species Information Programme*. Available at: https://www.fao.org/fishery/en/culturedspecies/trionyx_sinensis/en (Accessed: 6 August 2025).

Farkas, B., Ziegler, T., Pham, C.T., Ong, A.V. and Fritz, U. (2019). A new species of *Pelodiscus* from northeastern Indochina (Testudines, Trionychidae). *ZooKeys*, 824, pp.71–86. Available at: https://doi.org/10.3897/zookeys.824.31376

Félix-Silva, D., Hernández-Ruz, E.J., Figueiredo, M.W. and Brito Pezzuti, J.C. (2013). *Pelodiscus sinensis* (Chinese Softshell Turtle). *Herpetological Review*, 44(2), pp.272–273. Available at: https://www.lacerta.de/AF/Bibliografie/BIB_9673.pdf (Accessed: 15 July 2025).

Fong, J.J. and Qiao, G.X. (2010). New localities of endangered Chinese turtles from museum specimens and the practical and ethical challenges using and reporting natural history collection data. *Zootaxa*, 2393(1), p.59. Available at: https://doi.org/10.11646/zootaxa.2393.1.5

Francis, A. and Ferguson, R. (2025). *Chinese Soft Shell Turtle Pelodiscus sinensis*. Hong Kong Snake ID. Available at: https://www.hongkongsnakeid.com/chinese-soft-shell-turtle (Accessed: 3 September 2025).

GBIF (Global Biodiversity Information Facility). (2025). *Pelodiscus sinensis* Wiegmann, 1835. Available at: https://www.gbif.org/species/5220435 (Accessed: 15 July 2025).

GISD (Global Invasive Species Database). (2025). GISD: *Pelodiscus sinensis*. Available at: https://www.iucngisd.org/gisd/search.php (Accessed: 15 July 2025). No record.

Gong, S., Shi, H., Jiang, A., Fong, J.J., Gaillard, D. and Wang, J. (2017). Disappearance of endangered turtles within China's nature reserves. *Current Biology*, 27(5), pp.R170–R171. Available at: https://doi.org/10.1016/j.cub.2017.01.039

Gong, S., Vamberger, M., Auer, M., Praschag, P. and Fritz, U. (2018). Millennium-old farm breeding of Chinese softshell turtles (*Pelodiscus* spp.) results in massive erosion of biodiversity. *The Science of Nature*, 105(5–6). Available at: https://doi.org/10.1007/s00114-018-1558-9

Ip, Y.K., Loong, A.M., Lee, S.M.L., Ong, J.L.Y., Wong, W.P. and Chew, S.F. (2012). The Chinese soft-shelled turtle, *Pelodiscus sinensis*, excretes urea mainly through the mouth instead of the kidney. *Journal of Experimental Biology*, 215(21), pp.3723–3733. Available at: https://doi.org/10.1242/jeb.068916

ITIS (Integrated Taxonomic Information System). (2025). ITIS - Report: *Pelodiscus sinensis*. Available at: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=208697#null (Accessed: 15 July 2025).

Kong, F., Zhu, Q., Xiao, F., Hong, Z., Zhang, H. and Shi, H. (2021). Home Ranges and Movement Patterns of the Chinese Softshell Turtle (*Pelodiscus sinensis*) in the Yellow River, Northwestern China. *Chelonian Conservation and Biology*, 20(1), pp.2–9. Available at: https://doi.org/10.2744/ccb-1402.1

Koppetsch, T. (2021). The Chinese Soft-shelled Turtle *Pelodiscus sinensis* (Testudines: Trionychidae) near the High and Upper Rhine in Germany and Switzerland. *Herpetology Notes*, 14, pp.1263–1267. Available at: https://www.biotaxa.org/hn/article/view/70296 (Accessed: 5 August 2025).

Lv, Z., Hu, Y., Tan, J., Wang, X., Liu, X. and Zeng, C. (2021). Comparative Transcriptome Analysis Reveals the Molecular Immunopathogenesis of Chinese Soft-Shelled Turtle (*Trionyx sinensis*) Infected with *Aeromonas hydrophila*. *Biology*, 10(11), p.1218. Available at: https://doi.org/10.3390/biology10111218

Ma, X., Tan, K., He, M., Yin, X., Liu, Y., Yang, Y., Lu, M., Zhang, Y. and Wu, X. (2025). First successful artificial distant hybridization of softshell turtle between *Palea steindachneri* and *Pelodiscus sinensis*. *Aquaculture*, 602, p.742329. Available at: https://doi.org/10.1016/j.aquaculture.2025.742329

Masin, S., Bonardi, A., Padoa-Schioppa, E., Bottoni, L. and Ficetola, G.F. (2013). Risk of invasion by frequently traded freshwater turtles. *Biological Invasions*, 16(1), pp.217–231. Available at: https://doi.org/10.1007/s10530-013-0515-y

Mitchell, J.C., Steury, B.W., Buhlmann, K.A. and van Dijk, P.P. (2007). Chinese softshell turtle (*Pelodiscus sinensis*) in the Potomac River and notes on eastern spiny softshells (*Apalone spinifera*) in northern Virginia. *Banisteria*, 30, pp.41–43. Available at: https://www.biodiversitylibrary.org/page/56873619#page/44/mode/1up (Accessed: 5 August 2025).

Nagashima, H., Sugahara, F., Takechi, M., Ericsson, R., Kawashima-Ohya, Y., Narita, Y. and Kuratani, S. (2009). Evolution of the Turtle Body Plan by the Folding and Creation of New Muscle Connections. *Science*, 325, pp.193–196. Available at: https://doi.org/10.1126/science.1173826

Nekrasova, O., Pupins, M., Marushchak, O., Tytar, V., Martinez-Silvestre, A., Škute, A., Čeirāns, A., Theissinger, K. and Georges, J.Y. (2024). Present and future distribution of the European pond turtle versus seven exotic freshwater turtles, with a focus on Eastern Europe. *Scientific Reports*, 14(1). Available at: https://doi.org/10.1038/s41598-024-71911-4

Reptiletalk. (2025). Chinese Soft-shelled Turtle (*Pelodiscus sinensis*). *ReptileTalk NET*. Available at: https://www.reptiletalk.net/chinese-soft-shelled-turtle/ (Accessed: 3 September 2025).

Shannon, F.A. (1956). The Reptiles and Amphibians of Korea. *Herpetologica*, 12(1), pp.22–49. Available at: https://www.jstor.org/stable/3889565 (Accessed: 3 September 2025).

Somma, L.A. and Freedman, J.A. (2025). *Pelodiscus sinensis* (Wiegmann, 1835): U.S. Geological Survey, Nonindigenous Aquatic Species Database. USGS. Available at: https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=1278 (Accessed: 6 August 2025).

Species+. (2025). Species+ *Pelodiscus sinensis*. *Species+*. Available at: https://www.speciesplus.net/species#/taxon_concepts/8566/legal (Accessed: 15 July 2025).

Supsup, C.E., Puna, N.M., Asis, A.A., Redoblado, B.R. Panaguinit, M.F.G., Guinto, F.M., Rico, E.B., Diesmos, A.C., Brown, R.M. and Mallari, N.A.D. (2016). Amphibians and Reptiles of Cebu, Philippines: The Poorly Understood Herpetofauna of an Island with Very Little Remaining Natural Habitat. *Asian Herpetological Research*, 7(3), pp.151–179. Available at: https://doi.org/10.16373/j.cnki.ahr.150049

Suzuki, D., Fuse, K., Aizu, M., Yoshizawa, S., Tanaka, W., Araya, K. and Praxaysombath, B. (2015). Reptile Diversity in Food Markets in Laos. *Current Herpetology*, 34(2), pp.112–119. Available at: https://doi.org/10.5358/hsj.34.112

Sy, E.Y. (2014). Geographic distribution: *Pelodiscus sinensis* in South Cotabato, Mindanao, PH. *Herpetological Review*, 45(2), pp.280–281. Available at: https://www.researchgate.net/publication/264534100 (Accessed: 15 July 2025).

TNP (Thai National Parks). (n.d.). *Pelodiscus sinensis*, Chinese softshell turtle. *Thai National Parks*. Available at: https://www.thainationalparks.com/species/chinese-softshell-turtle (Accessed: 3 September 2025).

Tokita, M. and Kuratani, S. (2001). Normal Embryonic Stages of the Chinese Softshelled Turtle *Pelodiscus sinensis* (Trionychidae). *Zoological Science*, 18(5), pp.705–715. Available at: https://doi.org/10.2108/zsj.18.705

TTWG (Turtle Taxonomy Working Group). (2025). *Turtles of the World: Annotated Checklist and Atlas of Taxonomy, Synonymy, Distribution, and Conservation Status* (10th ed.). *Chelonian Research Monographs*. Available at: https://doi.org/10.3854/crm.10.checklist.atlas.v10.2025

USFWS (U.S. Fish and Wildlife Service). (2016). *Chinese Softshell Turtle (Pelodiscus sinensis) Ecological Risk Screening Summary*. U.S. Fish and Wildlife Service. Available at: https://www.fws.gov/sites/default/files/documents/Ecological-Risk-Screening-Summary-Chinese-Softshell-Turtle.pdf (Accessed: 6 August 2025).

Van Dijk, P.P., Iverson, J.B., Rhodin, A.G.J., Shaffer, H.B. and Bour, R. (2014). Annotated checklist of taxonomy, synonymy, distribution with maps, and conservation status. In: Rhodin, A.G.J. *et al.* (eds.) *Conservation Biology of Freshwater Turtles and Tortoises*. Chelonian Research Foundation, pp.329–479. Available at: https://iucn-tftsg.org/cbftt/ (Accessed: 6 August 2025).

Wang, G.X. and Lan, Y.L. (1998). *New In House Fast Culture Technology on Trionyx sinensis*. China Agricultural Press, Beijing.

WHA (Wildlife Health Australia). (2023). Diseases of concern in wild Australian marine turtles: Fact sheet. Wildlife Health Australia. Available at: https://wildlifehealthaustralia.com.au (Accessed: 15 July 2025).

WildArk. (2025). Chinese Softshell Turtle (*Pelodiscus sinensis*). *WildArk*. Available at: https://wildark.org/species/chinese-softshell-turtle/ (Accessed: 4 September 2025).

Wingham Wildlife Park. (2025). *Chinese Softshell Turtle*. Wingham Wildlife Park. Available at: https://winghamwildlifepark.co.uk/animal/chinese-softshell-turtle/ (Accessed: 4 September 2025).

Works, A.J. and Olson, D.H. (2018). Diets of Two Nonnative Freshwater Turtle Species (*Trachemys scripta* and *Pelodiscus sinensis*) in Kawai Nui Marsh, Hawaii. *Journal of Herpetology*, 52(4), pp.444–452. Available at: https://doi.org/10.1670/17-137

World Life Expectancy. (2025). Reptile Life Expectancy. Available at: https://www.worldlifeexpectancy.com/reptile-life-expectancy (Accessed: 15 July 2025). No record.

Wu, D.Y., Han, X.Z., Li, T., Sun, B.J. and Qin, X.Y. (2023). How incubation temperature affects hatchling performance in reptiles: an integrative insight based on plasticity in metabolic enzyme. *Current Zoology*, 70(2), pp.195–203. Available at: https://doi.org/10.1093/cz/zoad012

Yang, N., Haiying, O. and Caiping, Y. (2022). *Trionyx sinensis* (softshell turtle). *CABI Compendium*. Available at: https://doi.org/10.1079/cabicompendium.61443

Zhang, P., Liu, N., Xue, M., Xiao, Z., Zhang, M., Meng, Y., Fan, Y., Hu, X., Qiu, J., Zhang, Q. and Zhou, Y. (2023). Pathological characteristics of Chinese soft-shelled turtle (*Pelodiscus sinensis*) with white abdominal disease. *Aquaculture Reports*, 31, p.101670. Available at: https://doi.org/10.1016/j.aqrep.2023.101670

Zhou, L., Lei, J., Zhai, X., Lu, N., Shi, H. and Wang, J. (2023). Diversity of Underwater Vocalizations in Chinese Soft-Shelled Turtle (*Pelodiscus sinensis*). *Animals*, 13(5), p.812. Available at: https://doi.org/10.3390/ani13050812

Zhu, Q., Lin, L., Kong, F., Zhang, T. and Shi, H. (2023). Nocturnal emergence facilitated by thermally-induced hatching in the Chinese softshell turtle, *Pelodiscus sinensis*. *Ecology and Evolution*, 13(3), p.e9922. Available at: https://doi.org/10.1002/ece3.9922

DRAFT National Risk Assessment: SERIOUS

RISK ASSESSMENT FOR AUSTRALIA: Diamondback Terrapin (*Malaclemys terrapin*)

Class - Reptilia, **Order -** Testudines, **Family -** Emydidae, **Genus –** *Malaclemys.*

SPECIES: *Malaclemys terrapin* (Schoepff 1793) **Synonyms:** *Malococlemmys terrapin* (Boulenger 1889) *Testudo concentrata* (Kuhl 1820) *Testudo concentrica* (Shaw 1802) *Testudo terrapin* (Schoepff 1793) **1. *Malaclemys terrapin centrata*** *Clemmys (Clemmys) centrata* *Emys centrata* (Schweigger 1814) *Emys concentrica livida* (Gray 1831) *Emys livida* (Gray 1831) *Malaclemmys centrata* *Malaclemmys terrapin centrata* *Malaclemys centrata* *Malaclemys centrata centrata* **2. *Malaclemys terrapin littoralis*** *Malaclemmys littoralis* (Hay 1904) *Malaclemys centrata littoralis* (Siebenrock 1909) *Malaclemys littoralis* (Hay 1904) *Malaclemys pileata littoralis* (Stejneger & Barbour 1917)	**Species description:** The diamondback terrapin is a small to medium-sized turtle uniquely adapted to life in salt marshes along the Atlantic and Gulf of Mexico coasts. There is considerable geographic variation among populations, including carapace, skin and plastron colouration, keel development, body shape and pattern (Ernst & Lovich 2018). The carapace is oval and depressed with its central scutes raised or pronounced in many individuals. The carapace's colouration ranges from greys and light browns to nearly black and is often marked with concentric rings, spots, or streaks (Cagle 1952; Ernst & Lovich 2018). The plastron is solid and firmly attached, lacking a hinge, and varying in colour from yellow to green to black due to increased melanin production (Ernst & Lovich 2009; Reinke et al. 2018). The plastron may also be heavily marked with dark blotches or wispy patterns (Camper 2018). Other features of the diamondback terrapin include a high shell with a deep bridge, a deep gular notch in the plastron, and a long temporal arch in the skull (Alderton 1998; Carr 2018). The head is large and depressed, covered with soft, spongy skin that ranges from light grey to black, often adorned with flecks, spots or stripes (Gray 1844; Ernst & Lovich 2018). The jaws are broad and smooth, usually with a white upper jaw (Camper 2019; Ernst & Lovich 2016). The hind limbs are notably large and heavily webbed while the forefeet possess strong curved claws (Ernst & Lovich 2018; Park 2000). Females are significantly larger than males. Females reach a maximum straight carapace length (SCL) of 32 centimetres whereas males reach 18 centimetres (TTWG 2025). Females also tend to have larger heads relative to body size compared to males (Tucker et al. 1995; Underwood et al. 2013) and weigh 2 to 4 times more than males (Roosenburg & Kelley 1996). Males have longer, thicker tails, and the cloaca opens at or posterior to the carapace (Camper 2019; Roosenburg & Kelley 1996). Juveniles have a similar appearance in markings to adults but are brighter in colouration (Camper 2019; Reid 1955). There are 7 subspecies (Roosenburg et al 2019):

3. *Malaclemys terrapin macrospilota* *Emys macrocephalus* (Gray 1844) *Malaclemmys macrospilota* (Hay 1904) *Malaclemys centrata macrospilota* *Malaclemys pileata macrospilota* (Hay 1904) **4. *Malaclemys terrapin pileata*** *Emys pileata* (Wied 1865) *Malaclemmys pileata* *Malaclemys centrata pileata* *Malaclemys pileata pileata* **5. *Malaclemys terrapin rhizophorarum*** *Malaclemmys littoralis rhizophorarum* (Fowler 1906) *Malaclemmys terrapin rhizophorarum* (Fowler 1906) *Malaclemys tuberculifera* (Gray 1844) **6. *Malaclemys terrapin tequesta*** NA **7. *Malaclemys terrapin terrapin*** *Clemmys terrapin* (Strauch 1862) *Emys concentrica* (Gray 1831) and (Dumeril & Bibron 1854) *Emys concentrica polita* (Gray 1830) *Emys macrocephala* (Gray 1844) *Emys macrocephalus* (Gray 1844) *Emys megacephalus* (Gray 1844) *Emys palustris* (De Kay 1842)	***M.t. centrata***: Male maximum SCL is 15 centimetres and female is 20.4 centimetres. The carapace central keel does not possess knobs and its sides are parallel, with the posterior marginals curled upwards (Carr 2018; Ernst & Lovich 2009). ***M.t. littoralis***: Male maximum SCL is 14.8 centimetres and female is 20.1 centimetres. This turtle has an oval, deeply keeled carapace, often with knobs along the central ridge and large scutes featuring deep concentric grooves. The carapace is typically light brown, grey or black sometimes with concentric markings, and its sides are not parallel. There are no light centres on the scutes, and the seams on the shell are not distinctly black-bordered. The plastron is pale or nearly white, oblong in shape, and not hinged. The head, upper jaw and neck are nearly white or whitish, marked with dark flecks or heavy black spotting, but lacking pale stripes. The limbs and tail are greenish grey, also heavily spotted with black (Cagle 1952; Carr 2018; Dixon 2013; Ernst & Lovich 2009; Garrett & Barker 1994). ***M.t. macrospilota***: Female maximum SCL is 20.8 centimetres. Suarez et al. (2021) reported a maximum midline carapace length for a male was 13.6 centimetres. The carapace's central keel has terminal knobs which may be bulbous, and the carapace's scutes have light centres ranging in colour from orange to yellow (Carr 2018; Ernst & Lovich 2009). ***M.t. pileata***: Male maximum SCL is 15.3 centimetres and female is 24.3 centimetres. The carapace is oval with its central ridge ending in bumpy knobs and is black or dark brown with nearly parallel sides and lacking light-coloured centres in the scutes. The plastron is yellow, often with a dull or olive tint and irregularly bordered along the seams. The upper jaw's horny covering is typically white but may have dark markings in males. The skin on the legs, tail, and body is almost black. The head, neck, upper lip and limbs' upper surfaces are dark brown or black, while the raised edges of the marginal scutes are orange or yellow (Cagle 1952; Carr 2018; Ernst & Lovich 2009). ***M.t. rhizophorarum***: Male maximum SCL is 14.7 centimetres and female is 22 centimetres. It has an oblong carapace with its central keel featuring bulbous knobs. Its carapace is brown or black, lacking any pale centres on the scutes. The seams on the plastron and lower marginal scutes are often edged with black. The neck and front limbs are typically a uniform grey, while the hind limbs are grey and may show black streaks. Neck spots may merge, creating a streaked appearance (Carr 2018; Ernst et al. 1994; Ernst & Lovich 2009).

Emys terrapin (Holbrook 1838) *Malaclemmys centrata concentrica* (Hay 1904) *Malaclemmys concentrica* (Gray 1844) *Malaclemys centrata concentrica* (Cochran 1932) *Malaclemys concentrica* (Gray 1844) *Malaclemys terrapin* (Bangs 1896) *Malaclemys terrapin concentrica* (Shaw 1802) *Malaclemys terrapin terrapin* (Bangs 1896) *Malacoclemmys palustris* (Agassiz 1857) *Malacoclemmys terrapen* (Boulenger 1889) *Malacoclemmys terrapin* (Schoepff 1793) *Testudo concentrica* (Gray 1831) *Testudo ocellata* (Link 1807) *Testudo palustris* (Le Conte 1830) **Subspecies:** 1. *Malaclemys terrapin centrata* (Latreille 1802) 2. *Malaclemys terrapin littoralis* (Hay 1904) 3. *Malaclemys terrapin macrospilota* (Hay 1904) 4. *Malaclemys terrapin pileata* (Wied 1865)	***M.t. tequesta***: Male maximum SCL is 14.2 centimetres and female is 20.1 centimetres. The carapace's central ridge has backward-pointing knobs. The carapace is dark or tan, without light concentric circular patterns. The centres of the scutes may appear lighter (Ernst & Lovich 2009). ***M.t. terrapin***: Male maximum SCL is 18 centimetres and female is 32 centimetres. The carapace central keel does not possess knobs, with its sides widening toward the rear. The carapace ranges in colour from black to light brown, often showing clear concentric rings. The plastron varies in shade from orange to greenish grey (Carr 2018; Ernst & Lovich 2009). **General information:** Distribution: This terrapin is native to the coastal waters of the eastern United States and the Gulf of Mexico coast, with its range extending from Cape Cod, Massachusetts in the north, down through Florida (including the Keys), and westwards to Texas (CITES 2025). Its range extends through the states of Louisiana, Delaware, Texas, Mississippi, Georgia, New York, Massachusetts, Florida, North Carolina, South Carolina, New Jersey, Maryland, Alabama, Connecticut, Rhode Island and Virginia as well as Bermuda (Parnham et al. 2008; Roosenburg et al 2019; TTWG 2025). In 1932, several diamondback terrapins were introduced to Cuba, however "no alien populations" have established (Borroto-Páez et al. 2015). The 7 subspecies are distributed as follows (Roosenburg et al 2019): ***M.t. centrata***: found in the United States in Georgia, Florida, North Carolina and South Carolina, from the vicinity of Cape Hatteras, North Carolina southward to northern peninsular Florida, where it meets and intergrades with *M.t. tequesta* (Figure 7). It is also found in Bermuda. ***M.t. littoralis***: found in western Louisiana and the coast of Texas, at least as far south as Corpus Christi Bay (Figure 8). ***M.t. macrospilota***: present in the Gulf Coast of peninsular Florida, intergrading with *M.t. pileata* in the 'panhandle' and with *M.t. rhizophorarum* in Florida Bay (Figure 9). ***M.t. pileata***: from the Florida panhandle, where it intergrades with *M.t. macrospilota*, to Louisiana, where it intergrades with *M.t. littoralis*. Distribution also extends through Alabama, Florida Louisiana and Mississippi (Figure 10).

5. *Malaclemys terrapin rhizophorarum* (Fowler 1906)
6. *Malaclemys terrapin tequesta* (Schwartz 1955)
7. *Malaclemys terrapin terrapin* (Schoepff 1793)

Common Names:
Diamondback Terrapin
Diamond-backed Terrapin
Terrapin

Subspecies Common Names:

1. ***Malaclemys terrapin centrata***

Carolina Diamondback Terrapin

2. ***Malaclemys terrapin littoralis***

Texas Diamondback Terrapin

3. ***Malaclemys terrapin macrospilota***

Ornate Diamondback Terrapin

4. ***Malaclemys terrapin pileata***

Mississippi Diamondback Terrapin

5. ***Malaclemys terrapin rhizophorarum***

Mangrove Diamondback Terrapin

6. ***Malaclemys terrapin tequesta***

Eastern Florida Diamondback Terrapin
Florida East Coast Terrapin

7. ***Malaclemys terrapin terrapin***

Northern Diamondback Terrapin

M.t. rhizophorarum: distributed from the Florida Keys westward to the Marquesas Keys (Figure 11).

M.t. tequesta: found in the Atlantic east coast of peninsular Florida to Biscayne Bay, where it intergrades with *M.t. rhizophorarum* (Figure 12).

M.t. terrapin: from Cape Cod, Massachusetts southward to the vicinity of Cape Hatteras, North Carolina, where it intergrades with *M.t. centrata*. The area of distribution extends through Connecticut, Delaware, Massachusetts, New Jersey, New York, North Carolina, Maryland, Rhode Island and Virginia (Figure 6).

Habitat: Diamondback terrapins inhabit brackish environments along the Atlantic and Gulf Coasts including salt marshes, estuaries, lagoons, tidal creeks and mangrove swamps (Rasmussen et al. 2011). They are adapted behaviourally to select low salinity drinking water and physiologically as they possess a salt gland that enables them to tolerate saline environments, though they do still require access to fresh water for drinking (Dahl et al. 2024; Rasmussen et al. 2011). Primarily diurnal when active, the diamondback terrapin will hibernate during the winter months, from November/December through to April/May (Ernst & Lovich 2009; Lawler & Musick 1972). In a captive study, diamondback terrapin basking behaviour was associated with osmotic control (Davenport & Magill 1996) as well as for thermoregulation. Juveniles often shelter among vegetation or flotsam in shallow or intertidal areas (Burger 1976; Selman 2018). They bury themselves in the mud during the night (Ernst & Lovich 2009).

Diet: Primarily carnivorous, their diet includes molluscs, snails, crustaceans, shellfish, small fish, salt marsh periwinkles (*Littoraria irrorate*) aquatic insects, and carrion (Cagle 1952; Mercer et al. 2023; Tucker et al. 1995). In some locations, individuals will also consume plant matter or algae (Tucker et al. 1995; Underwood et al. 2013). They will often spread into the marsh to feed during high tide and then move back into tidal creeks as the tide recedes (Camper 2019). Mature females have crushing plates on their jaws allowing them to consume larger hard-shelled prey compared to males and juvenile females (Tucker et al. 1995; Underwood et al. 2013).

Reproduction: Males typically reach sexual maturity earlier (around their third year) (Roosenburg & Kelley 1996) whereas females mature more slowly — often taking 6 years (Cagle 1952) and attaining larger size. Mating tends to occur in spring where terrapins form large aggregations, primarily in coves and tidal creeks (Camper 2019; Seigel 1980). Females nest from late April to early August, laying clutches of eggs in nests of sandy or soft soil substrate on the dunes, shrubland, uplands or beach margins near their aquatic habitat

	(Burger & Montevecchi 1975; Feinbeg & Burke 2003; Mercer et al. 2023). The female will bury the eggs in the substrate (Reid 1955). The clutch size varies, usually 4 to 18 eggs per clutch depending on female size and subspecies/population with potentially multiple clutches a season (Ernst & Lovich 2009; Garrett 1994). Incubation occurs over the summer months and varies between geographical distribution and temperature. Typically, incubation is between 60 to 85 days (Park 2000) with hatchlings emerging in late summer or early fall (Burger 1973). Sex determination of hatchlings is temperature dependent with warmer incubation (30-32 degrees Celsius) producing females (Burke & Calichio 2014; Dahl et al. 2024). Hatchlings emerge from the nest 0 to 11 days after hatching and will generally have a carapace width that is equal or greater than the plastron length (Ernst & Lovich 2009; Burger 1973). Diamondback terrapins have been reported to dig up eggs of conspecific species (Burger & Montevecchi 1975). Diamondback terrapins are mild mannered and are likely to flee from humans (Garrett & Barker 1994). **Longevity:** Maximum longevity is not yet established on AnAge (2023). The record longevity in captivity is 14.1 years, however it is probable that they live much longer (AnAge, 2023). World Life Expectancy (2025) estimates that the life expectancy of diamondback terrapins is 9.3 years. **Conservation status:** **IUCN:** Vulnerable; considered to be facing a high risk of extinction in the wild (Roosenberg 2019). **CITES:** Appendix II - species that are not necessarily threatened with extinction but require controlled international trade to prevent utilisation incompatible with their survival (CITES 2025).
DATE OF ASSESSMENT: October 2025 **EIC ENDORSEMENT:** **Risk assessment model used for the assessment:** • Australian Reptile and Amphibian Model (Bomford 2006)	**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 2006, 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**: Matching similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia is an important step for Bomford models. Climatch v3.0, a new version of the Climatch released by the Australian Bureau of Agricultural Resource Economics and Sciences in 2025 is used for climate matching. Climatch v3.0 uses WorldClim v2.1 datasets with the

• Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008)	algorithm updated to use global variances specific to each source dataset. Climatch v3.0 can be Accessed: on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/. 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. Climatch v3.0 also includes an additional 3 bioclimatic variables (Diurnal temperature range, Isothermality and Temperature Seasonality) that are not included in the Bomford models. 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 19235 grid squares, each measured at a spatial resolution of 10 arcminutes (approximately 20 km) in both longitude and latitude. ABARES recalibration thresholds applied in Climatch v3.0 are similar to those used in Climatch v2.0 (at ~20 km resolution) (Table 1). Climatch v3.0 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: Bomford Model 2006, Part A and Bird and Mammal Model 2008, Part A (with both using scores that are summed to give a cumulative score).

Australian Reptile and Amphibian Model (Bomford 2006):

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
P. 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 v2.1 (Version 3.0), 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/19235).*	3.78	CMRS = 100 x (727/19,235) = 3.779568494931115 CMRS = 3.78 Note: The species has several georeferenced occurrences recorded around the world (Figure 4) and no weather station located on Bermuda. These figures are presumed to be waifs, escaped or released pets and have not been recorded in the Climatch modelling.
Q. 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*	0	*Species has not established an exotic population (including species not known to have been introduced anywhere)*.

• *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*		
R. Taxonomic Family Risk Score	15	*Emydidae*
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*	18.78	**LOW establishment risk**

Bird and Mammal Model for Reptiles and Amphibians (Bomford 2008):

FACTOR	SCORE	DETAIL
STAGE A: RISKS POSED BY CAPTIVE OR RELEASED ANIMALS		
A. Degree of climate match between species overseas range and Australia (1–6) *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 v2.1 (Version 3.0), Value X = sum of classes 6 – 10, see Table 1.*	2	*Low climate match to Australia* Value X = 1,295 Climate Match Score = 2 Note: The species has several georeferenced occurrences recorded around the world (Figure 4) and no weather station located on Bermuda. These figures are presumed to be waifs, released or escaped pets and have not been recorded in the Climatch modelling.
B. Exotic population established overseas (0–4)	0	*No exotic population ever established.*

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.		
C. 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 between 1 and 70 million square kilometres.* Overseas extent of occurrence is estimated to be 209,000 km^2 (Roosenburg et al. 2019). Estimated indigenous area of occupancy is 124,589 km^2 and estimated indigenous extent of occurrence is 2,089,477 km^2 (TTWG 2025).
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*	3	**LOW establishment risk**

ENVIRONMENT AND INVASIVES COMMITTEE ALLOCATED PEST RISK* *For reptiles and amphibians, the assessed Establishment Risk Rank is combined with an allocated Extreme Pest Risk Rank (based on the precautionary approach), resulting in the Assignment of species into one of two EIC Threat Categories: Extreme or Serious.	**EXTREME**

ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY	**SERIOUS*** *Score assigned based on the highest Establishment Risk Rank (based on the precautionary approach).

NOTE: Where multiple Bomford risks assessment models are applicable, all models have been assessed and the threat category has been assigned based on a precautionary approach, meaning the highest threat category has been assigned and used to calculate the Environment and Invasives Committee Threat Category.

IUCN Red List World distribution map (Figure 1); Climatch world distribution map (Figure 2); world Georeferenced records (GBIF; Figures 3 and 4); and maps reported by the Turtle Taxonomy Working Group (Figures 5 to 12) indicating where meteorological data was sourced for the climate analysis:



Figure 6. World Distribution Map - IUCN Red List

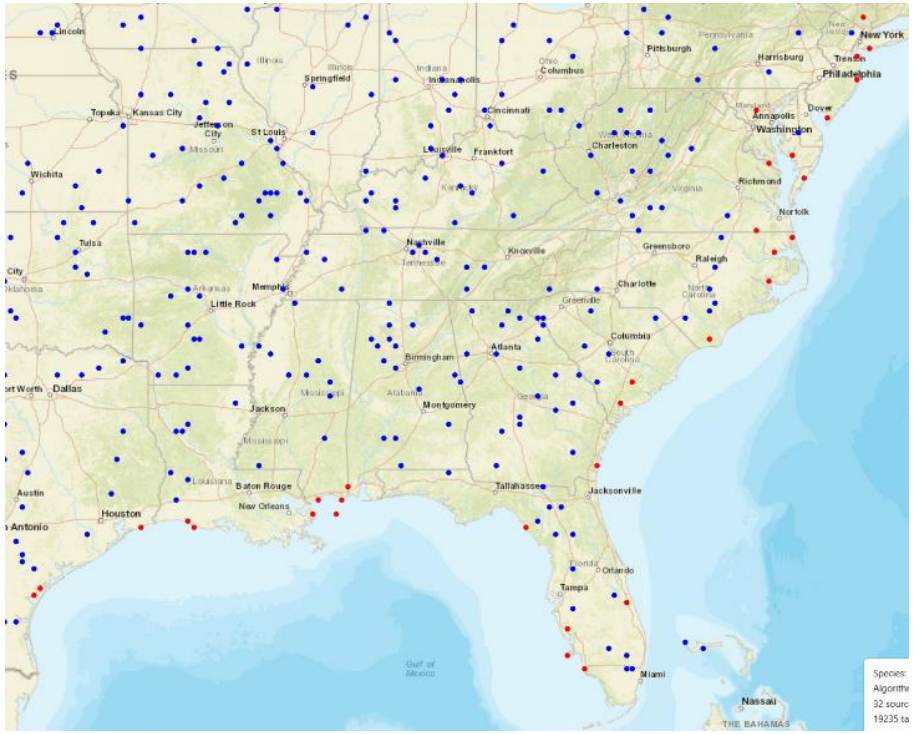


Figure 2. World Distribution map – Climatch

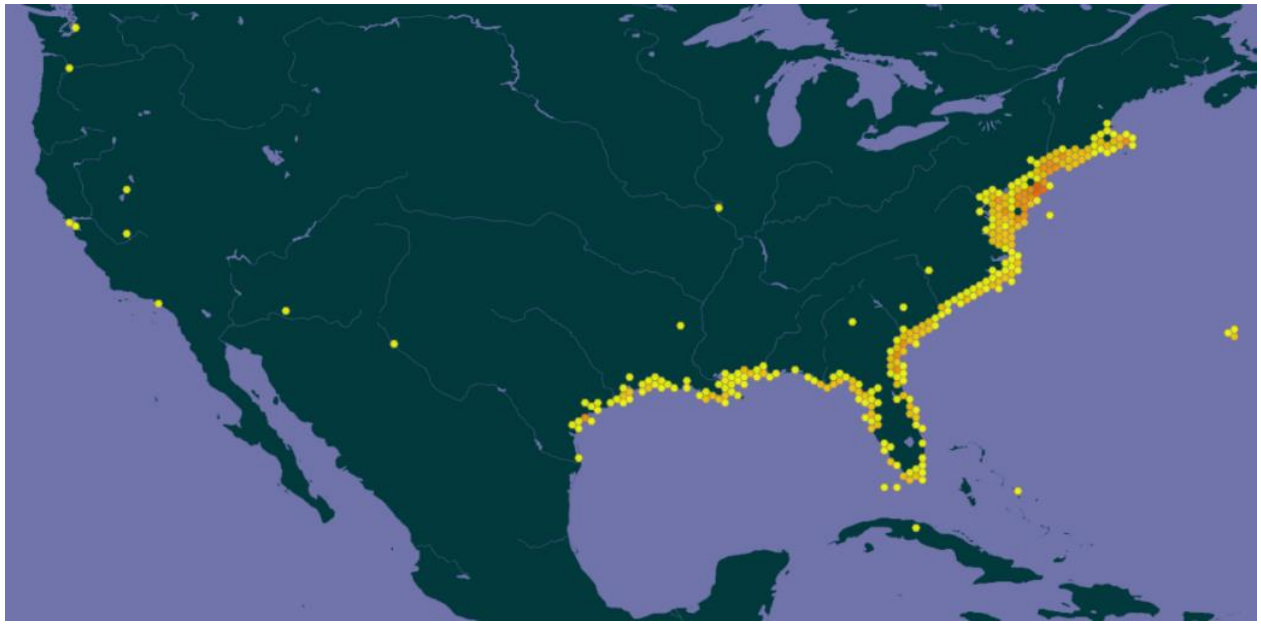


Figure 3. World Georeferenced records (GBIF)



Figure 4. World Georeferenced records (GBIF) – All referenced locations



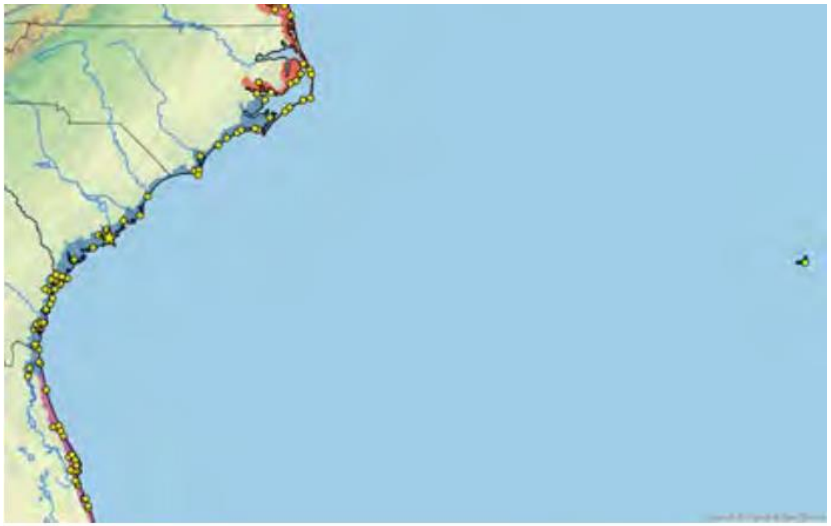
(subspecies: *terrapin* = red, *centrata* = blue, *littoralis* = orange, *macrospilota* = green, *pileata* = pink, *rhizophorarum* = tourmaline, *tequesta* = purple; orange dots = trade or extralimital)

Figure 5. Distribution Map of Malaclemys terrapin – all subspecies (TTWG 2025)



** (subspecies: *terrapin* = red, *centrata* = blue; orange dot and star = trade and type locality; stars = type localities)

Figure 6. Distribution Map of Malaclemys terrapin terrapin (red) (TTWG 2025)



(subspecies: *terrapin* = red, *centrata* = blue, including Bermuda, *tequesta* = purple; star = type locality)

Figure 7. Distribution Map of Malaclemys terrapin centrata (blue) (TTWG 2025)



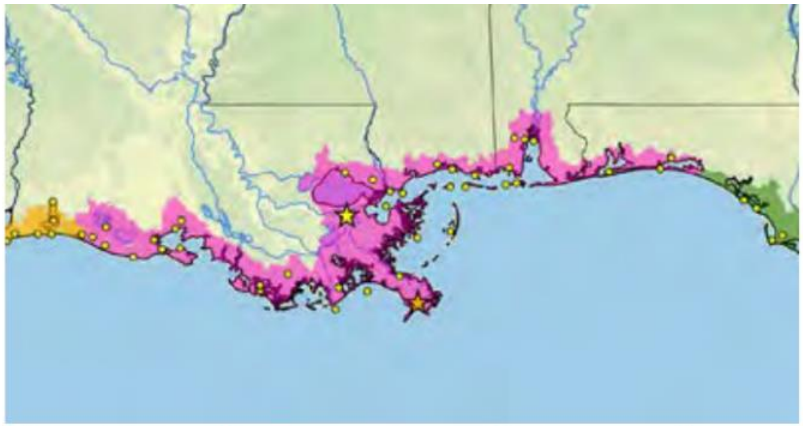
** (subspecies: *littoralis* = orange, *pileata* = pink; orange dot = extralimital, star = type locality)

Figure 8. Distribution Map of Malaclemys terrapin littoralis (orange) (TTWG 2025)



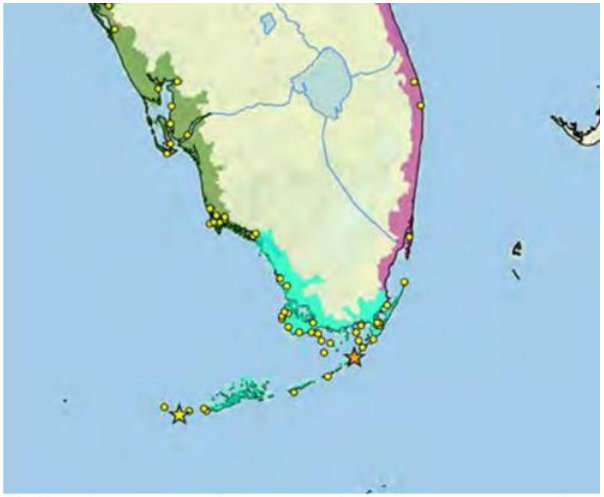
* (subspecies: *centrata* = blue, *macrospilota* = green, *rhizophorarum* = tourmaline, *tequesta* = purple; star = type locality)

Figure 9. Distribution Map of Malaclemys terrapin macrospilota (green) (TTWG 2025)



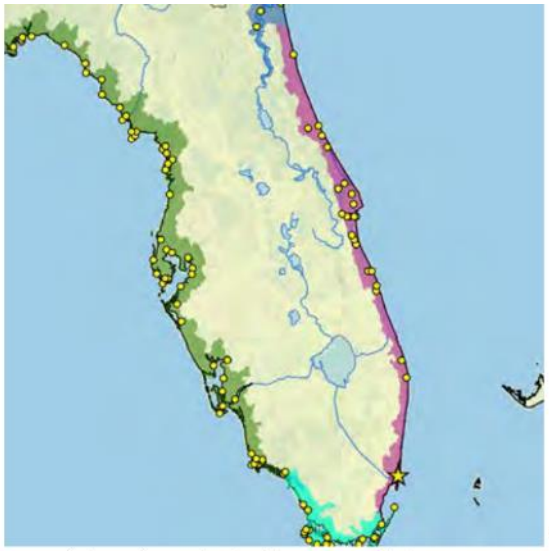
** (subspecies: *littoralis* = orange, *macrospilota* = green, *pileata* = pink; stars = type localities)

Figure 10. Distribution Map of Malaclemys terrapin pileata (pink) (TTWG 2025)



(subspecies: *macrospilota* = green, *rhizophorarum* = tourmaline, *tequesta* = purple; stars = type localities)

Figure 11. Distribution Map of Malaclemys terrapin rhizophorarum (aqua) (TTWG 2025)



* (subspecies: *centrata* = blue, *macrospilota* = green, *rhizophorarum* = tourmaline, *tequesta* = purple; star = type locality)

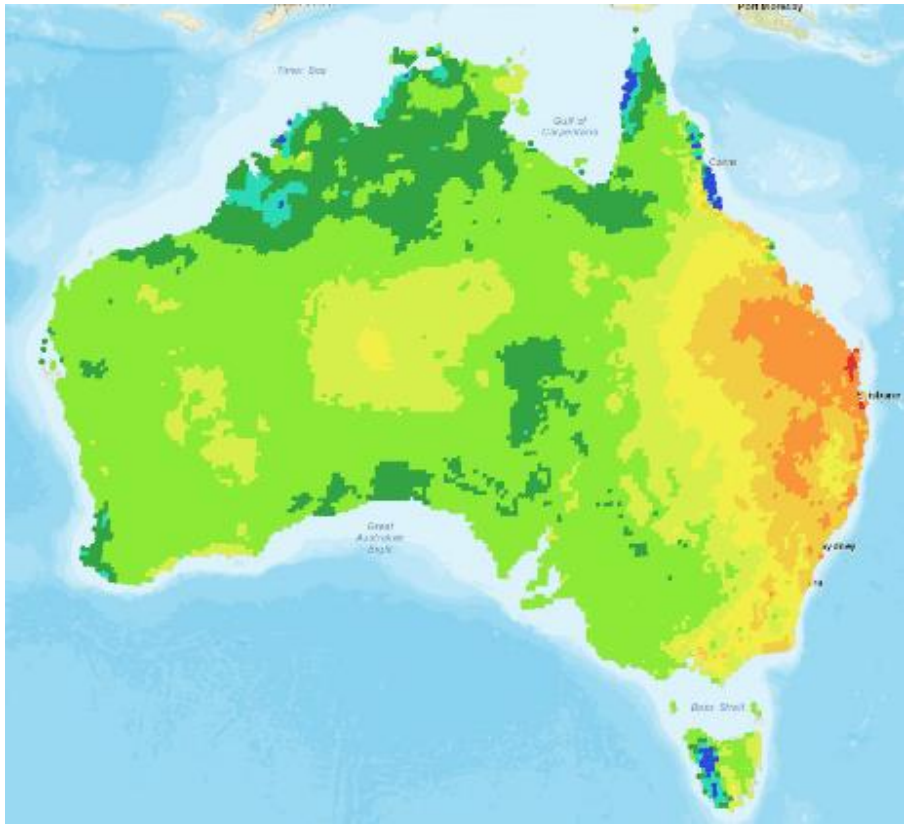
Figure 12. Distribution Map of Malaclemys terrapin tequesta (purple) (TTWG 2025)

Australian Reptile and Amphibian Model (Bomford 2006): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Malaclemys terrapin*

CMS (Sum Level 7) = 727

CMRS = 100 x (727/19,235) = 3.78



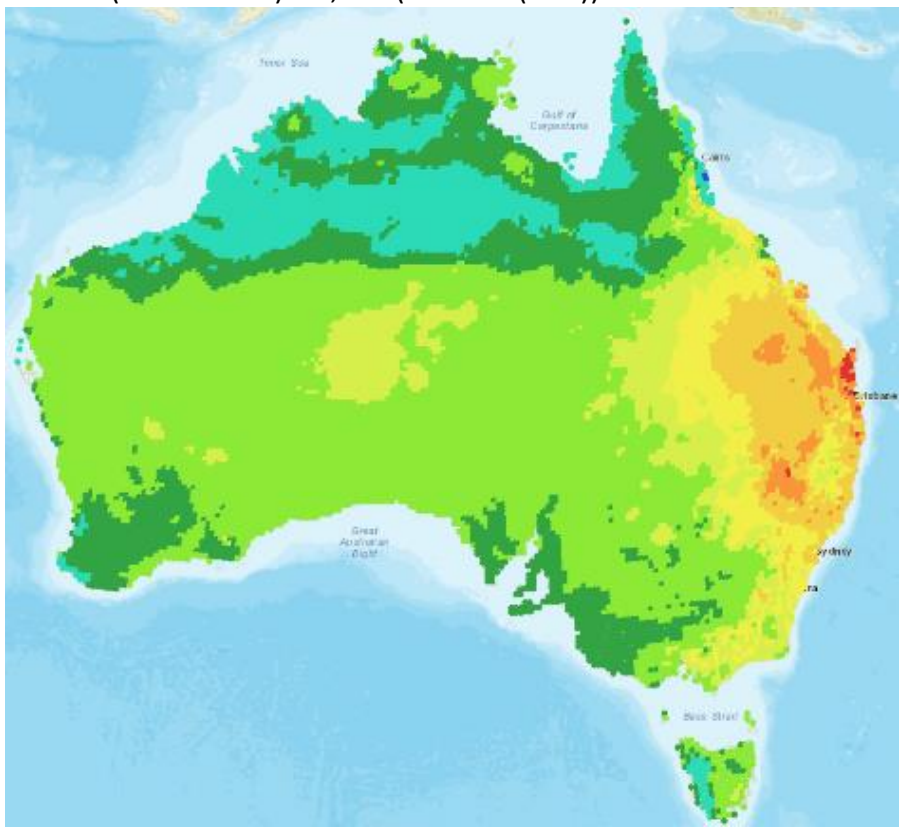
Score	Color	Count
0		77
1		310
2		2804
3		9789
4		3129
5		1247
6		1152
7		713
8		14
9		0
10		0

Species: Diamondback Terrapin (Malaclemys terrapin)
Algorithm: Euclidean
32 source features selected
19235 target features selected
Approximate source selected area: 449,019 km^2
Approximate target selected area: 7,736,730 km^2

Bird and Mammal model for reptiles and amphibians (Bomford 2008): Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Malaclemys terrapin*

Value X (Sum Level 6) = 1,295 (CMS = 2 (Low))



Score	Color	Count
0		2
1		2523
2		3763
3		9031
4		1678
5		943
6		1025
7		248
8		22
9		0
10		0

Species: Diamondback Terrapin (Malaclemys terrapin)
Algorithm: Closest Standard Score
32 source features selected
19235 target features selected
Approximate source selected area: 449,019 km^2
Approximate target selected area: 7,736,730 km^2

Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Climatch (50 km) Closest Standard Match Sum Level 6 (Value X)	Climatch v3.0 (20 km resolution) 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**		

Risk Assessor's details:

Risk Assessor's name:	Aimee Carter and Emily Strong, PIRSA
Business address and contact details:	PIRSA aimee.carter@sa.gov.au
Date:	October 2025
Reviewers:	Louise Prosser, DCCEEW

Bibliography:

ABARES (Australian Bureau of Agricultural and Resource Economics). (2025). Catchment scale land use of Australia and commodities – Update December 2023 - DAFF. Department of Agriculture, Fisheries and Forestry. Available at: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-and-commodities-update-2023 (Accessed: 22 August 2025).

Agriculture.gov.au. (2025). Climatch. Department of Agriculture, Fisheries and Forestry. Available at: https://climatch.cp1.agriculture.gov.au/ (Accessed: 22 August 2025).

Alderton, D. (1998). *Turtles and Tortoises of the World*. Blandford Press, New York and London.

AnAge. (2023). Diamondback terrapin (*Malaclemys terrapin*) longevity, ageing, and life history. The Animal Ageing and Longevity Database. Available at: https://genomics.senescence.info/species/entry.php?species=Malaclemys_terrapin (Accessed: 22 August 2025).

Animal Life Expectancy. (2025). Reptile Life Expectancy: Diamondback Terrapin. World Life Expectancy. Available at: https://www.worldlifeexpectancy.com/reptile-life-expectancy-diamondback-terrapin (Accessed: 22 August 2025).

Bomford, M. (2003). *Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2006). *Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models - A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2008). *Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand - A report produced for the Invasive Animals Cooperative Research Centre*. Bureau of Rural Sciences, Canberra.

Bomford, M., Kraus, F., Braysher, M., Walter, L. and Brown, L. (2005). *Risk Assessment Model for the Import and Keeping of Exotic Reptiles and Amphibians*. A report produced for the Department of Environment and Heritage. Bureau of Rural Sciences, Canberra.

Borroto-Páez, R., Bosch, R.A., Fabres, B.A. and García, O.A. (2015). Introduced Amphibians and Reptiles in the Cuban Archipelago. *Herpetological Conservation and Biology*, 10(3), pp.985–1012. Available at: https://www.herpconbio.org/contents_vol10_issue3.html (Accessed: 22 August 2025).

Burger, J. (1976). Behavior of Hatchling Diamondback Terrapins (*Malaclemys terrapin*) in the Field. *Copeia*, 1976(4), pp.742–780. Available at: https://doi.org/10.2307/1443457

Burger, J. and Montevecchi, W.A. (1975). Nest Site Selection in the Terrapin *Malaclemys terrapin*. *Copeia*, 1975(1), p.113. Available at: https://doi.org/10.2307/1442413

Burke, R.L. and Calichio, A.M. (2014). Temperature-Dependent Sex Determination in the Diamond-backed Terrapin (*Malaclemys terrapin*). *Journal of Herpetology*, 48(4), pp.466–470. Available at: https://doi.org/10.1670/13-188

Cagle, F.R. (1952). A Louisiana Terrapin Population (*Malaclemys*). *Copeia*, 1952(2), pp.74–76. Available at: https://doi.org/10.2307/1438535

Camper, J.D. (2019). *The Reptiles of South Carolina*. University of South Carolina Press, South Carolina.

Carr, A. (1952). *Handbook of Turtles*. Cornell University Press, Ithaca.

Carr, A. (2018). *Handbook of Turtles: The Turtles of the United States, Canada and Baja California*. Cornell University Press, Ithaca, New York and London.

Catalogue of Life. (2025). *Malaclemys terrapin*. Catalogue of Life. Available at: https://www.catalogueoflife.org/data/taxon/3XKD4 (Accessed: 22 August 2025).

CITES (Convention on International Trade in Endangered Species). (2025). Checklist of CITES species: *Malaclemys terrapin*. Available at: https://checklist.cites.org/#/en/search/output_layout=alphabetical&level_of_listing=0&show_synonyms=1&show_author=1&show_english=1&show_spanish=1&show_french=1&scientific_name=Malaclemys+terrapin&page=1&per_page=20 (Accessed: 22 August 2025).

CMS (Convention on the Conservation of Migratory Species of Wild Animals). (2025). Available at: https://www.cms.int/search?fulltext=Malaclemys+terrapin (Accessed: 22 August 2025). No record.

Dahl, E., Banner, H. and Vatnick, I. (2024). Salinity preferences of Diamondback Terrapin (*Malaclemys terrapin*) headstarts: a laboratory study. *Reptiles & Amphibians*, 31(1), pp.e21078–e21078. Available at: https://doi.org/10.17161/randa.v31i1.21078

Davenport, J. and Magill, S.H. (1996). Thermoregulation or osmotic control? Some preliminary observations on the function of emersion in the diamondback terrapin *Malaclemys terrapin* (Latreille). *Herpetological Journal*, 6(1), pp.26–29. Available at: https://www.thebhs.org/publications/the-herpetological-journal/volume-6-number-1-january-1996/1432-05-thermoregulation-or-osmotic-control-some-preliminary-observations-on-the-function-of-emersion-in-the-diamondback-terrapin-malaclemys-terrapin-latreille (Accessed: 22 August 2025).

DCCEEW (Department of Climate Change, Energy, the Environment and Water). (2025). Protected Matters Search Tool: Interactive Map. Available at: https://pmst.environment.gov.au/#/map?lng=131.52832031250003&lat=-28.6905876542507&zoom=5&baseLayers=Imagery (Accessed: 22 August 2025).

Dixon, J. (2013). *Amphibians and Reptiles of Texas: Third Edition*. Texas A&M University Press, Texas.

Donini, J., Selman, W., Pearson, S. and Valverde, R.A. (2021). Trends in ovarian development, plasma vitellogenin, and steroid hormones in female *Malaclemys terrapin* (Schoepff, 1793) from coastal Louisiana. *Amphibian and Reptile Conservation*, 15(2), pp.40–49. Available at: https://amphibian-reptile-conservation.org/pdfs/Volume/Vol_15_no_2/ARC_15_2_[General_Section]_40-49_e282.pdf (Accessed: 22 August 2025).

Ernst, C.H. and Lovich, J.E. (2009). *Turtles of the United States and Canada: Second Edition*. Johns Hopkins University Press, Baltimore.

Ernst, C.H., Lovich, J.E. and Barbour, R.W. (1994). *Turtles of the United States and Canada*. Smithsonian Institution Press, Washington and London.

Feinberg, J.A. and Burke, R.L. (2003). Nesting Ecology and Predation of Diamondback Terrapins, *Malaclemys terrapin*, at Gateway National Recreation Area, New York. *Journal of Herpetology*, 37(3), pp.517–526. Available at: https://doi.org/10.1670/207-02A

Garrett, J.M. and Barker, D.G. (1987). *A field guide to reptiles and amphibians of Texas*. Texas Monthly Press Inc., Texas.

GBIF (Global Biodiversity Information Facility). (2025). *Malaclemys terrapin* (Schoepff, 1793). Available at: https://www.gbif.org/species/2443212 (Accessed: 22 August 2025).

GISD (Global Invasive Species Database). (2025). Available at: https://www.iucngisd.org/gisd/search.php (Accessed: 26 August 2025). No record.

Gray, J.E. (1844). *Catalogue of the tortoises, crocodiles and amphisbaenians in the collection of the British Museum*. British Museum, London.

Hart, K.M. and McIvor, C.C. (2008). Demography and Ecology of Mangrove Diamondback Terrapins in a Wilderness Area of Everglades National Park, Florida, USA. *Copeia*, 2008(1), pp.200–208. Available at: https://doi.org/10.1643/CE-06-161

ITIS (Integrated Taxonomic Information System). (2025). ITIS Standard Report Page: *Malaclemys terrapin* (Schoepff, 1793). Available at: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173780#null (Accessed: 26 August 2025).

Lawler, A.R. and Musick, J.A. (1972). Sand Beach Hibernation by a Northern Diamondback Terrapin, *Malaclemys terrapin terrapin* (Schoepff). *Copeia*, 1972(2), p.389. Available at: https://doi.org/10.2307/1442512

Lieb, C.S. (2023). Catalog 3: Type Specimens, Type Localities, Synonymies, and Authors/Collectors of Recent Amphibians and Reptiles Described From Texas. In: Schmidly, D.J. et al. (eds.). *Taxonomic Catalogs for the Recent Terrestrial Vertebrates (Species and Subspecies) Described from Texas*. Museum of Texas Tech University, 77, pp.249–250. Available at: https://www.depts.ttu.edu/nsrl/publications/downloads/SP77.pdf (Accessed: 22 August 2025).

Mercer, R.D., DeVos, T.B., Corcoran, L.S., Buchanan, S.W., Beauchamp, K.A., Linck, M.H. and Karraker, N.E. (2023). Characterization of Diamondback Terrapin (*Malaclemys terrapin*) nesting and nest predation at a site in northeastern USA. *Herpetological Conservation and Biology*, 18(2), pp.392–403. Available at: https://www.herpconbio.org/Volume_18/Issue_2/Mercer_etal_2023.pdf (Accessed: 22 August 2025).

Mittleman, M.B. (1944). The Status of *Testudo terrapin* Schoepf. *Copeia*, 1944(4), pp.245–245. Available at: https://doi.org/10.2307/1438681

Mittleman, M.B. (1945). Additional Notes on the Name *Testudo terrapin* Schoepf. *Copeia*, 1945(4), pp.233–234. Available at: https://doi.org/10.2307/1438362

Parham, J.F. Outerbridge, M.E., Stuart, B.L., Wingate, D.B., Erlenkeuser, H. and Papenfuss, T.J. (2008). Introduced delicacy or native species? A natural origin of Bermudian terrapins supported by fossil and genetic data. *Biology Letters*, 4(2), pp.216–219. Available at: https://doi.org/10.1098/rsbl.2007.0599

Park, I. (2000). *Malaclemys terrapin*. Animal Diversity Web. Available at: https://animaldiversity.org/accounts/Malaclemys_terrapin/ (Accessed: 10 October 2025).

Pearson, S.H. and Wiebe, J.J. (2018). Distribution, Sex Ratios, and Size Distributions of Diamond Backed Terrapins (*Malaclemys terrapin*) in the Deltaic Plain of Louisiana. *Herpetologica*, 74(2), pp.135–140. Available at: https://doi.org/10.1655/Herpetologica-D-17-00057.1

Rasmussen, A.R., Murphy, J.C., Ompi, M., Gibbons, J.W. and Uetz, P. (2011). Marine Reptiles. *PLOS ONE*, 6(11). Available at: https://doi.org/10.1371/journal.pone.0027373

Reid, G.K. (1955). Reproduction and Development in the Northern Diamondback Terrapin, *Malaclemys terrapin terrapin*. *Copeia*, 1955(4), p.310. Available at: https://doi.org/10.2307/1440314

Reinke, B., Pearson, S. and Selman, W. (2018). Plastron Pigmentation Variation in a Coastal Turtle Species of Conservation Concern (*Malaclemys terrapin*). *Herpetologica*, 74(2), pp.141–145. Available at: https://doi.org/10.1655/HERPETOLOGICA-D-17-00046.1

Reynolds, R.P., Gotte, S.W. and Ernst, C.H. (2007). Catalogue of Type Specimens of Recent Crocodilia and Testudines in the National Museum of Natural History, Smithsonian Institution. *Smithsonian Contributions to Zoology*, (626), pp.1–49. Available at: https://doi.org/10.5479/si.00810282.626

Roosenburg, W.M. and Kelley, K.C. (1996). The Effect of Egg Size and Incubation Temperature on Growth in the Turtle, *Malaclemys terrapin*. *Journal of Herpetology*, 30(2), p.198. Available at: https://doi.org/10.2307/1565510

Roosenburg, W.M., Baker, P.J., Burke, R., Dorcas, M.E. and Wood, R.C. (2019). *IUCN Red List of Threatened Species*: *Malaclemys terrapin*. Available at: https://doi.org/10.2305/IUCN.UK.2019-1.RLTS.T12695A507698.en

Seigel, R.A. (1980). Courtship and Mating Behavior of the Diamondback Terrapin *Malaclemys terrapin tequesta*. *Journal of Herpetology*, 14(4), p.420. Available at: https://doi.org/10.2307/1563703

Selman, W. (2018). Life in skinny water: observations of juvenile diamondback terrapin (*Malaclemys terrapin*) utilizing shallow water habitats. *Herpetological Conservation and Biology*, 13(2), pp.399–407. Available at: https://www.herpconbio.org/Volume_13/Issue_2/Selman_2018.pdf (Accessed: 22 August 2025).

Species+. (2025). *Malaclemys terrapin*. Species+. Available at: https://www.speciesplus.net/species#/taxon_concepts/5107/legal (Accessed: 21 August 2025).

Suarez, E., Thomas, T.M., Turner, W.M., Gandy, R.L., Enge, K.M. and Johnson, S.A. (2021). Population Size and Structure of the Ornate Diamondback Terrapin (*Malaclemys terrapin macrospilota*) on Small Gulf Coast Islands in Florida. *Chelonian Conservation and Biology*, 20(2). Available at: https://doi.org/10.2744/ccb-1485.1

TTWG. (2025). *Turtles of the World: Annotated Checklist and Atlas of Taxonomy, Synonymy, Distribution, and Conservation Status* (10th Ed.). *Chelonian Research Monographs*. Available at: https://doi.org/10.3854/crm.10.checklist.atlas.v10.2025

Tucker, A.D., FitzSimmons, N.N. and Whitfield, G.J. (1995). Resource Partitioning by the Estuarine Turtle *Malaclemys terrapin*: Trophic, Spatial, and Temporal Foraging Constraints. *Herpetologica*, 51(2), pp.167–181. Available at: https://www.jstor.org/stable/3892585 (Accessed: 21 August 2025).

Tucker, A.D., Yeomans, S.R. and Gibbons, J.W. (1997). Shell Strength of Mud Snails (*Ilyanassa obsoleta*) May Deter Foraging by Diamondback Terrapins (*Malaclemys terrapin*). *American Midland Naturalist*, 138(1), pp.186–191. Available at: https://doi.org/10.2307/2426670

Uetz, P. and Hallermann, J. (2025). *The Reptile Database*: *Malaclemys terrapin*. Available at: https://reptile-database.reptarium.cz/species?genus=Malaclemys&species=terrapin (Accessed: 22 August 2025).

Underwood, E.B., Bowers, S., Guzy, J.C., Lovich, J.E., Taylor, C.A., Gibbons, W. and Dorcas, M.E. (2013). Sexual dimorphism and feeding ecology of diamond backed terrapins (*Malaclemys terrapin*). *Herpetologica*, 69(4), pp.397–404. Available at: https://www.jstor.org/stable/24634292 (Accessed: 21 August 2025).

DRAFT National Risk Assessment: SERIOUS

RISK ASSESSMENT FOR AUSTRALIA: Plantain Squirrel (*Callosciurus notatus*)

Class - Mammalia, **Order -** Rodentia, **Family -** Sciuridae, **Genus -** *Callosciurus*.

SPECIES: *Callosciurus notatus* (Boddaert, 1785) **Synonyms:** *Sciurus notatus* (Boddaert, 1785) *Sciurus (Callosciurus) notatus* *Sciurus hippurus* *Sciurus prevostii notatus* *Callosciurus hypopyrrhus* (sometimes misapplied) **Subspecies:** - *Callosciurus notatus albescens* (Bonhote, 1901) - *Callosciurus notatus diardii* (Jentink, 1879) - *Callosciurus notatus miniatus* (Miller, 1900) - *Callosciurus notatus notatus* (Boddaert, 1785) - *Callosciurus notatus suffusus* (Bonhote, 1901) - *Callosciurus notatus vittatus* (Raffles, 1821)	**Species description:** *Callosciurus notatus* is a medium-sized tree-dwelling rodent of the family Sciuridae. There are six subspecies with varying sizes but adults typically measure around 152–224 mm in head-body length, with tails of about 146–211 mm, hind foot 38-47 mm and weigh between approximately 160–259 g (Constantine & Dewey 2006). Their dorsal fur is olive-brown, while the venter (belly) and inner limbs are reddish-brown; a narrow black stripe (often overlaying a buff stripe) runs down the flank, and they bear a distinctive white eye-ring (Ng 2025). Plantain squirrels possess the typical sciurid dental formula; 2 upper and 2 lower incisors, no canines, and a series of premolars and molars (Constantine & Dewey 2006). There are six subspecies of plantain squirrel. The nominate (subspecies *notatus)* has a slight buff tint on the venter. Subspecies *albescens* is a paler form and is sometimes considered a distinct species (GBIF 2025). Subspecies *diardii* has buff on venter and around eye; it is darker in eastern part of its distribution. Subspecies *miniatus* has a grey venter with a slight brown to dull orange-brown tinge, the pale flank stripe is narrow and the tip of the tail is reddish brown, particularly in the western part of its distribution. Subspecies *suffusus* has dark-chestnut or maroon venter colour. Subspecies *vittatus* resembles *miniatus*, but the venter is usually orange-brown and it does not have the red tail tip (GBIF 2025). **General information:** Distribution: Plantain squirrels are distributed across Southeast Asia; throughout the Malay Peninsula (including southern Thailand), the islands of Sumatra, Java, Borneo, and in Singapore among other small islands of the Sunda Shelf (Ng 2025; Duckworth 2016). In Singapore it occurs commonly in parks, gardens and even high-rise housing estates (Ng 2025), indicating urban tolerance (Lim & Baker 2008). The species is considered of Least Concern in IUCN assessments due in part to this wide distribution and tolerance of a degree of habitat modification (Duckworth 2016). Elevation records show occurrences from approximately 500 m to 1,100 m above sea level, though most commonly they are encountered in lower elevation tropical forests rather than high montane zones (Constantine & Dewey

Common Names: Plantain squirrel Oriental squirrel Three-striped squirrel Common squirrel Tricoloured squirrel Kloss's Squirrel	2006). Their ability to persist across multiple islands and habitats has contributed to their relatively stable conservation status. Subspecies distributions (GBIF 2025): - *Callosciurus notatus albescens* (Bonhote, 1901) - occurs in northern Sumatra. - *Callosciurus notatus diardii* (Jentink, 1879) - found in southern Java and nearby coastal islands. - *Callosciurus notatus miniatus* (Miller, 1900) - found throughout the Malay Peninsula and Singapore. - *Callosciurus notatus notatus* (Boddaert, 1785) - occurs in Java and nearby islands. - *Callosciurus notatus suffusus* (Bonhote, 1901) – found on the island of Borneo. - *Callosciurus notatus vittatus* (Raffles, 1821) - found in Sumatra. Habitat: Plantain squirrels occupy a range of forested habitats from primary and secondary lowland rainforest, mangrove and swamp forest to degraded forest, plantations, urban parks and gardens (Constantine & Dewey 2006). They are not so common in pristine forests (Payne et al. 2005 as cited in Duckworth 2016). Duckworth (2016) stated that their population has greatly expanded with human encroachment on forests in the Sundaic region. They are diurnal and mainly arboreal, spending most of their time in trees, typically in the lower to mid-canopy strata, though they may forage lower down when resources dictate (Duckworth 2016). In urban settings, plantain squirrels are frequently found in gardens and parks, demonstrating considerable ecological flexibility (Lim & Baker 2008). They build spherical twig-and-leaf nests (dreys) in branches of small trees or large bushes (Constantine & Dewey 2006) which helps protect young from many ground predators. Plantain squirrels are usually found alone or in small groups. Home ranges vary between 0-8 hectares with females showing less overlap in their home range than males (Constantine & Dewey 2006; GBIF 2025). Diet: Plantain squirrels exhibit an omnivorous but largely plant-oriented diet. Studies reveal consumption of fruit, seeds, flowers, leafy shoots, bark/wood, sap/latex, and occasionally insects or bird eggs (Constantine & Dewey 2006). One forest-based study found fruits and seeds comprise a large portion of the diet, with insects contributing a smaller but notable amount (Constantine & Dewey 2006). Plantain squirrels have also been observed gnawing on the bark of rubber trees to extract sap or latex and they may feed on ant larvae by breaking open twigs. Duckworth (2016) estimated that the diet consists of 42% fruit, 30% bark and the remainder a mixture of insects and rubber tree latex. Through their fruit and seed consumption, they may play a role in seed dispersal or tree recruitment in their forest habitats.

	Reproduction: Plantain squirrels have a polygynandrous mating system in which multiple males (typically 5-7) compete for access to an oestrous female and 2–4 males may mate with her (Constantine & Dewey 2006). Breeding can occur year-round but is most frequently observed between April and June, with fewer pregnant females noted in the October–December period (GBIF 2025). Gestation is around 40 days and litter sizes range from 1 to 4 young, with an average around 2.2 per litter (Constantine & Dewey 2006). Newborns are altricial - hairless and blind and nest in a drey made of twigs and leaves and lined with fibrous material such as shredded palm spathe placed high in a tree or shrub (GBIF 2025). They typically leave the nest after about 6 weeks, at which point they begin independent foraging (Constantine & Dewey 2006). **Longevity:** Animal Diversity Web (Constantine & Dewey 2006) states the recorded maximum lifespan in captivity is around 9.6 years and AnAge (2025) recorded up to 14.8 years in captivity. Lifespan is expected to be lower in the wild. **Conservation status:** **IUCN:** Least Concern; does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened (Duckworth 2016). **CITES:** Not listed (CITES 2025).
DATE OF ORIGINAL ASSESSMENT: December 2025 Tim Mellonie and Emily Strong, PIRSA **Reviewer:** Unnamed, DCCEEW **Risk assessment model used for the assessment:**	**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 2006, 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**: Matching similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia is an important step for Bomford models. Climatch v3.0, a new version of the Climatch released by the Australian Bureau of Agricultural Resource Economics and Sciences in 2025 is used for climate matching. Climatch v3.0 uses WorldClim v2.1 datasets with the algorithm updated to

Bomford 2008, Bird and Mammal Model	use global variances specific to each source dataset. Climatch v3.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/. 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. Climatch v3.0 also includes an additional 3 bioclimatic variables (Diurnal temperature range, Isothermality and Temperature Seasonality) that are not included in the Bomford models. 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 19235 grid squares, each measured at a spatial resolution of 10 arcminutes (approximately 20 km) in both longitude and latitude. ABARES recalibration thresholds applied in Climatch v3.0 are similar to those used in Climatch v2.0 (at ~20 km resolution) (Table 1). Climatch v3.0 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.

The Australian 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 attacking, injuring or killing people should also be taken into account. Assume the individual is not protecting nest or young.*	1	*Animal that can make unprovoked attacks causing moderate injury (requiring medical attention) or severe discomfort but is highly unlikely (few if any records) to cause serious injury (requiring hospitalisation) if unprovoked.* Unprovoked attacks by the Plantain Squirrel (*Callosciurus notatus*) are extremely rare and generally occur only when animals become habituated to humans or are competing for food resources. In such cases, individuals may approach people in search of food and occasionally inflict minor bites or scratches when food is withheld or hands are extended (Bertolino and Lurz, 2013). These interactions are typically defensive or food-motivated rather than genuinely aggressive. The species lacks the body size and jaw strength to cause serious injury, and there are no verified records of severe wounds or zoonotic disease transmission from this species (Francis 2008). Medical attention, when required, usually involves basic wound cleaning and standard tetanus vaccination consistent with treatment for

		minor rodent bites. Overall, *Callosciurus notatus* presents a negligible physical risk to humans, with any injuries arising from opportunistic food-seeking behaviour rather than predatory or territorial aggression.
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)* The risk to public safety from individual captive plantain squirrels, excluding direct contact within cages or enclosures, is negligible. The species does not produce venom or toxic secretions, and there is no evidence that any products derived from captive individuals pose a chemical hazard to humans.
STAGE A PUBLIC SAFETY RISK SCORE **SUM A1 - A2 (0-4)**	1	**MODERATELY dangerous**
STAGE B: RISK OF ESTABLISHMENT **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 v2.1 (Version 3.0), Value X = sum of classes 6 – 10, see Table 1.*	1	Very Low climate match to Australia Value X = 41 Climate Match Score = 1 (Very low)
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 population ever established = 0.* The plantain squirrel (*Callosciurus notatus*) does not appear to have an established exotic population outside its native range. Although some secondary sources have suggested that the species may have been introduced to Sulawesi, this claim is not supported by the main scholarly literature on squirrel introductions.

		Comprehensive reviews of introductions within the genus *Callosciurus*, such as those by Bertolino and Lurz (2013) and subsequent analyses of tree squirrels in the exotic pet trade, document established non-native populations only for species such as *Callosciurus erythraeus* and *Callosciurus finlaysonii*, not *C. notatus*. No peer-reviewed evidence indicates that *C. notatus* has formed a self-sustaining, free-living population outside its native distribution, nor is it listed as invasive in global or regional invasive species assessments (Bertolino & Lurz 2013).
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	Approximately 1,463,111 km^2 (Climatch 2025). IUCN estimated extent of occurrence 3,617,998 km^2 (Duckworth 2016).
B4. Taxonomic Class (0–1) *Bird = 0; mammal = 1*	1	Mammal = 1
B. ESTABLISHMENT RISK SCORE **SUM OF B1- B4 (1–13)**	3	**LOW 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 or diet unknown = 1* The diet of *Callosciurus notatus* is broad and flexible, consisting of fruits, seeds, young leaves, nectar, insects and occasionally bird eggs allowing the species to exploit a range of food resources across different environments (Bertolino & Lurz 2013).
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 = 1.

		Callosciurus notatus can survive and breed in a wide variety of human-modified habitats, including urban parks, gardens, plantations, secondary forest and even high rise housing estates (Ng 2025). It does not rely on undisturbed natural habitats for persistence, and is commonly recorded in disturbed landscapes where human activity is intense.
B7. Migratory score (0–1) *Always migratory = 0; non-migratory = 1*	1	*Non-migratory or facultative migrant in its native range, or unknown = 1* This species is non-migratory within its native range, maintaining stable home ranges and showing no evidence of seasonal or long-distance movements. Its year-round residency and absence of migratory behaviour support assigning a score of 1 for the migratory criterion (Mdpi, 2021).
B. ESTABLISHMENT RISK SCORE SUM OF B1- B7 (1–16)	6	**LOW establishment risk**
STAGE C: RISK OF BECOMING A PEST 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 (Carnivora, Artiodactyla, Rodentia, Lagomorpha, Perissodactyla and Marsupialia) = 2* Order – Rodentia
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 = 0* Approximately 1,448,299 km^2
C3. Diet and feeding (0–3)	1	*Mammal that is a non-strict carnivore (mixed animal–plant matter in diet) = 1.*

		The Plantain Squirrel is an omnivorous generalist. It feeds primarily on fruit, seeds, and nuts, but also consumes insects, bird eggs, and occasionally small vertebrates. It forages across diverse habitats, including forests, plantations, gardens, and urban areas (Francis 2008; Bertolino & Lurz 2013).
C4. Competition with native fauna for tree hollows (0–2)	0	*Does not use tree hollows = 0.* There is no strong evidence that plantain squirrels compete directly with native fauna for tree hollows. The species is primarily arboreal and typically constructs leaf nests (dreys) in tree canopies or uses natural tree forks, branches, or dense vegetation rather than occupying hollows (Francis 2008). However, in some urban and plantation settings, individuals have been observed using roof cavities when suitable nesting sites are limited (Bertolino & Lurz 2013).
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?*	3	*Unknown overseas environmental pest status = 3.* Outside its native range, plantain squirrels have established introduced populations in parts of Indonesia (beyond its native islands) and have been recorded from isolated introductions in Japan and Thailand, although not all have persisted (Bertolino & Lurz 2013). Evidence of substantial ecological degradation or measurable declines in native species outside its natural range is limited but emerging.
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.*	2	*The species has no grid squares within the highest two climate match classes (i.e. in classes 10 and 9) 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.* <u>Animals:</u> Greater glider (*Petauroides minor*) – vulnerable Mahogany Glider (*Petaurus gracilis)* – endangered

		Grey-headed Flying-fox (*Pteropus poliocephalus*) – vulnerable Masked Owl (northern) (*Tyto novaehollandiae Kimberli*) - vulnerable Superb parrot (*Polytelis swainsonii*) – vulnerable Swift parrot (*Lathamus discolor*) – critically endangered Red goshawk (*Erythrotriorchis radiatus*) – endangered <u>Plants / Ecological Communities</u> Littoral Rainforest and Coastal Vine Thickets of Eastern Australia – Critically Endangered Lowland tropical rainforest of the Wet Tropics – Endangered Mabi Forest (Complex Notophyll Vine Forest 5b) – Critically Endangered Broad leaf tea-tree (*Melaleuca viridiflora*) woodlands in high rainfall coastal north Queensland – Endangered If plantain squirrels established in Australia, they could compete with small arboreal mammals and cavity-nesting birds for food and nest sites, and their feeding could damage vegetation and alter habitats, potentially affecting threatened species and ecological communities.
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?*	2	*Moderate pest of primary production in any country or region = 2.* Plantain squirrels have been reported to cause damage to crops and other primary production within their native range and in areas where they have been locally introduced or expanded. In Malaysia, Indonesia and Singapore, the species feeds on fruit orchards, oil palm and cocoa plantations and garden crops, consuming fruits, seeds and young shoots (Francis 2008; Medway 1969; Bertolino & Lurz, 2013). Such feeding can reduce yields, damage marketable produce and require additional management effort, particularly in small-scale plantations and peri-urban gardens. Duckworth (2016) states plantain squirrels are very common in oil palm plantations in Sabah, Sarawak and the Malaysian Peninsula to the extent of becoming a pest.

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 = 48 (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 birds and mammals (likely or unknown effect on native species and on livestock and other domestic animals) = 2.* According to the Department of Agriculture, Fisheries and Forestry (DAFF) Exotic Environmental Pest List (2025), squirrels in general can act as carriers of ectoparasites, endoparasites and some zoonotic pathogens, although there are no documented major outbreaks. All species can play a role in the spread of diseases or parasites to other animals (native species and on livestock and other domestic animals) or to humans (zoonotic). For further information on the impacts of zoonotic diseases, the following links are available: Department of Agriculture, Fisheries and Forestry - Animal Import Risk Analysis Department of Agriculture, Fisheries and Forestry - Exotic Environmental Pest List Wildlife Health Australia - Fact Sheets
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 C10 = 2* The risk that plantain squirrels could cause damage to buildings, vehicles, fences, roads, equipment or ornamental gardens is low to moderate. The species is arboreal and diurnal, primarily nesting in leaf dreys in tree canopies rather than in structures or underground. Unlike some rodent species, it does not routinely burrow or gnaw on hard materials, which limits its potential to damage buildings, roads or equipment (Bertolino & Lurz 2013; Francis 2008). However, it may cause

		localised damage to ornamental gardens and cultivated plants through feeding on fruits, nuts, flowers and young shoots, and its leaf nests or droppings can accumulate in garden vegetation, potentially causing minor contamination (Medway, 1969). Damage is likely to be most pronounced near human habitation or plantations, where squirrels are attracted to food sources, but it is not expected to reach the level of structural or infrastructural destruction associated with invasive burrowing rodents or larger mammals.
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, harm or annoyance likely to be minor and few people exposed: Low risk = 2.* There is no documented history of the species attacking, injuring or killing people in its native or introduced range; unprovoked bites occur very rarely and are usually associated with food-seeking behaviour or handling in captivity (Bertolino and Lurz, 2013; Francis, 2008). Minor bites or scratches could result from defensive reactions if handled, but these would not typically require medical attention beyond basic wound care. Nuisance behaviour is most likely to arise from foraging in gardens or near human habitations but does not constitute a significant public safety threat.
C. PEST RISK SCORE SUM C 1 TO C 11 (1–37)	18	**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*	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*	3	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

≤ 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*	18	SERIOUS pest risk

ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY	**SERIOUS**

World distribution map (IUCN Red List; Figure 1) and Climatch world distribution map (Figure 2) indicating where meteorological data was sourced for the climate analysis (see B1):



Figure 1. World Distribution Map - IUCN Red List

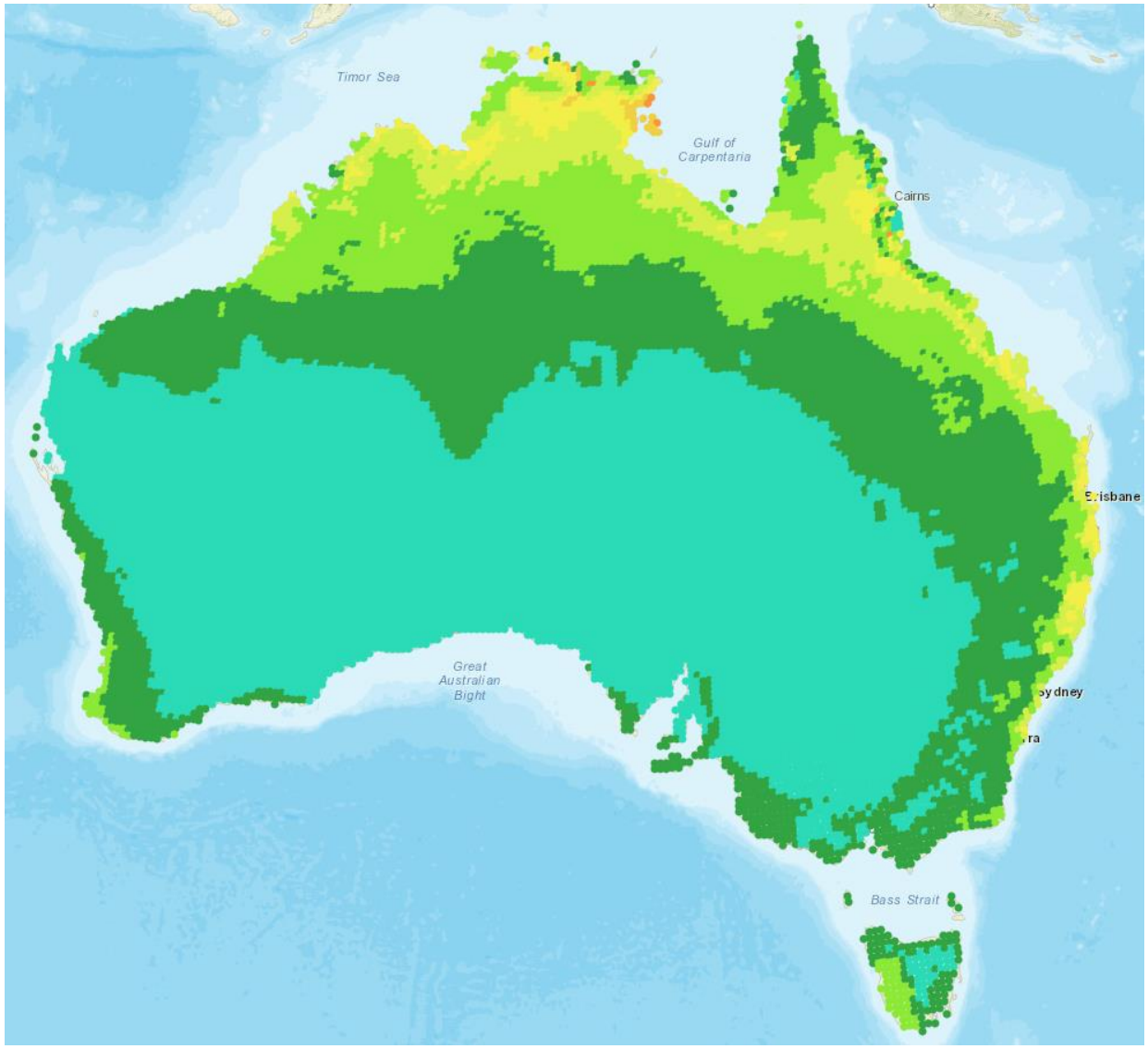


Figure 2. World Distribution Map - Climatch

Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Callosciurus notatus*

Value X = 41



Score	Color	Count
0		0
1		9314
2		5408
3		2832
4		1251
5		389
6		35
7		6
8		0
9		0
10		0

Species: Callosciurus notatus (plantain squirrel)
Algorithm: Closest Standard Score
186 source features selected
19235 target features selected
Approximate source selected area: 1,463,111 km^2
Approximate target selected area: 7,736,730 km^2

Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Climatch (50 km) Closest Standard Match Sum Level 6 (Value X)	Climatch v3.0 (20 km resolution) 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 and Australian Bureau of Agricultural and Resource Economics and Sciences 2024- 2025 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 data)	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 (cattle and calf slaughtering, live bovine exports, milk)	12			
Cereal grains (wheat, barley, sorghum, corn, oats, rice, triticale, rye, canary seed, panicum, millet)	9			
Fruit and nuts (includes wine grapes)	5	2	2	20
Sheep (sheep and lamb slaughtering, live sheep exports, wool)	4			
Other crops (hay, silage, pasture seed and grasses, nurseries, cut flowers, turf, coffee, spices, tea)	3	2	2	12
Vegetables	3	1	1	3
Poultry slaughtering and chicken egg production	3			
Oilseeds (canola, soybeans, sunflower, linseed, safflower, peanuts)	3			
Pulses (chickpeas, lentils, field peas, lupins, faba beans, mung beans, navy beans)	2	1	1	2
Fisheries products	2			
Cotton lint	2	1	2	4
Forestry (hardwood and softwood)	1	2	2	4
Pig slaughtering	1			
Sugarcane	1	1	3	3
Other livestock slaughtering (goats, deer, crocodile, camels, rabbits, buffalo slaughtered at a commercial processing establishment)	0.1			
Other live animal exports (live breeding horses–excluding horses temporarily traded for racing or breeding purposes–and other live birds, mammals and insects not elsewhere specified)	0.1			
Honey and bee products (honey, beeswax, pollination services, package bees and queens)	0.1			
Total Commodity Damage Score (TCDS)				48

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 (i.e. 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 (i.e. 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 (i.e. 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**		

Bibliography:

ABARES (Australian Bureau of Agricultural and Resource Economics). (2025). Catchment scale land use of Australia and commodities – update December 2023. Department of Agriculture, Fisheries and Forestry. Available at: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-and-commodities-update-2023 (Accessed: 11 December 2025).

Agriculture.gov.au. (2025). Climatch. Available at: https://climatch.cp1.agriculture.gov.au/ (Accessed: 11 December 2025).

AnAge. (2025). The Animal Ageing and Longevity Database. Human Ageing Genomics Resources. Available at: https://genomics.senescence.info/species/entry.php?species=Callosciurus_notatus (Accessed: 11 December 2025).

Bertolino, S. and Lurz, P.W.W. (2013). Callosciurus squirrels: worldwide introductions, ecological impacts and recommendations to prevent the establishment of new invasive populations. *Mammal Review*, 43(1), pp. 22–33. Available at: https://doi.org/10.1111/j.1365-2907.2011.00204.x

Bomford, M. (2003). *Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2006). *Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models - A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2008). *Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand. A report produced for the Invasive Animals Cooperative Research Centre*. Bureau of Rural Sciences, Canberra.

Bomford, M., Kraus, F., Braysher, M., Walter, L. and Brown, L. (2005). *Risk Assessment Model for the Import and Keeping of Exotic Reptiles and Amphibians. A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences, Canberra.

Catalogue of Life. (2025). *Callosciurus notatus* (Boddaert, 1785). Available at: https://www.catalogueoflife.org/data/taxon/PW62 (Accessed: 11 December 2025).

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). (2025). Available at: https://cites.org/eng/search?search_api_fulltext=Callosciurus+notatus (Accessed: 8 December 2025). No record.

CMS (Convention on the Conservation of Migratory Species of Wild Animals). (2025). Available at: https://www.cms.int/search?fulltext=Callosciurus+notatus (Accessed: 8 December 2025). No record.

Constantine, J. and Dewey, T. (2006). *Callosciurus notatus*: Plantain squirrel. ADW: Animal Diversity Web. University of Michigan. Available at: https://animaldiversity.org/accounts/Callosciurus_notatus/ (Accessed: 8 December 2025).

DCCEEW (Department of Climate Change, Energy, the Environment and Water) Protected Matters Search Tool. (2025). Protected Matters Search Tool: Interactive Map. Available at: https://pmst.environment.gov.au/#/map?lng=131.52832031250003&lat=-28.6905876542507&zoom=5&baseLayers=Imagery (Accessed: 8 December 2025).

Department of Agriculture, Fisheries and Forestry. (2025). Exotic Environmental Pest List. Available at: https://www.agriculture.gov.au/biosecurity-trade/policy/environmental/priority-list#vertebrates (Accessed: 11 December 2025). Not listed.

Duckworth, J.W. (2016). Plantain Squirrel *Callosciurus notatus* (errata version published in 2017). *The IUCN Red List of Threatened Species*. Available at: https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T3600A22254046.en

Francis, C.M. (2008). *A field guide to the mammals of South-East Asia*. New Holland Publishers, London.

Global Biodiversity Information Facility (GBIF). (2025). *Callosciurus notatus* (Boddaert, 1785). Available at: https://www.gbif.org/species/2437396 (Accessed: 6 November 2025).

GISD (Global Invasive Species Database). (2025). Invasive Species Specialist Group. Available at: https://www.iucngisd.org/gisd/ (Accessed: 6 November 2025). No record.

Lim, N. and Baker, N. (2008). *Wild mammals of Singapore*. Draco Publishing and Distribution Pty Ltd, Singapore.

Medway, L. (1969). *The wild mammals of Malaya (Peninsular Malaysia) and Singapore*. Oxford University Press, Kuala Lumpur.

Ng, P.K.L. (2025). Flora and Fauna Web: Plantain Squirrel (*Callosciurus notatus*). National Parks Board Singapore. Available at: https://www.nparks.gov.sg/florafaunaweb/fauna/4/8/488 (Accessed: 6 November 2025).

Adapted from:	DAWE 2020, Application to add *Callosciurus notatus* (Plantain squirrel) to the Environment Protection and Biodiversity Conservation Act 1999 List of Specimens taken to be Suitable for Live Import, Department of Agriculture, Water and the Environment, Canberra.	**By:** Tim Mellonie, PIRSA	**Date:** Dec 2025

DRAFT National Risk Assessment: EXTREME

RISK ASSESSMENT FOR AUSTRALIA: Nyala (*Tragelaphus angasii*)

Class - Mammalia, **Order -** Artiodactyla, **Family -** Bovidae, **Genus -** *Tragelaphus*.

SPECIES: *Tragelaphus angasii* (Angas, 1849) **Synonyms:** Nil **Subspecies:** Monotypic **Common Names:** Nyala Lowland Nyala Njala (Afrikaans)	**Species description:** The nyala is a medium-sized antelope native to south-eastern Africa. Nyala exhibit pronounced sexual dimorphism with a large male and a much smaller female. The adult male (bull) weighs between 92-126 kg with a shoulder height of 104-121 cm (Furstenburg 2015). Adult females (ewes) weigh between 54-68 kg and have a shoulder height of 82-106 cm (Furstenburg 2015). Bulls are characterised by dark brown coats that darken to greyish-black with age, light reddish-brown legs and a prominent mane (Furstenburg 2015). Bulls have spiralled horns reaching up to 80 cm in length (Ciszek 1999). Females do not have horns. Females and males under one year of age have reddish-brown coats (Nowak 1991). Both sexes display white facial markings, a white underbelly with 10-14 vertical, parallel, white stripes on the flanks in varying patterns (Furstenburg 2015). Nyala differ from other species of *Tragelaphus* in having a fringe of long hairs that forms a line around the lower neck, lower shoulders sides of the belly and on the back and sides of the thighs (Nowak 1991). Nyala are generally solitary or found in small family groups comprising females and their offspring, while males are often solitary or in bachelor groups. Herds of up to 30 individuals have been observed (Nowak 1991). They are non-territorial, and their home ranges can overlap extensively (Furstenberg 2015). During the breeding season, bulls engage in visual displays, such as erecting their mane and raising their tail, and sparring with horns to assert dominance and attract ewes in oestrus (Nowak 1991; Ciszek 1999). Nyala are predominantly active during the day, but they become more active in the evening and at night in open marginal habitats, with increased human interference or in the rainy season (Furstenburg 2015). They spend much of the day concealed in brush, particularly during the hottest part of the day (Furstenburg 2015). **General information:** Distribution: The nyala's natural range comprises the Lower Shire Valley in Malawi through Mozambique and Zimbabwe to eastern South Africa and Eswatini (formerly known as Swaziland). Nyala were reintroduced into Eswatini after becoming extinct in the 1950s. Exotic populations have been established in Botswana and Namibia (IUCN 2016) and South Africa by the game industry (Furstenburg 2015). While nyala were severely depleted in the past, population numbers are now estimated to be 20,000-27,500 (IUCN 2016). Nyala

	distribution is almost entirely restricted to protected areas and private land. Population trends are generally stable or increasing as a result of efforts to rehabilitate wildlife areas (Furstenburg 2015). Demand, especially for adult males by trophy hunters, has led to the artificial dispersion of nyala from game reserves in KwaZulu-Natal, South Africa, to other protected areas and private ranches in areas both within and outside of their former distribution (IUCN 2016). Habitat: Nyala inhabit dense lowland woodlands, thickets, and savanna woodlands, typically near water sources such as rivers and waterholes. They are naturally restricted to environments that are both humid and well wooded (Furstenburg 2015). Nyala spend most of their life in thickets, however they also thrive in marginal habitats such as dry savannah provided there are sufficient clumps of bushes and permanent water is available (Furstenburg 2015). They become more nocturnal in areas where they have less thicket available. Their preference for dense vegetation provides camouflage from predators such as lions, leopards, and hyenas. When threatened by predators, members of female groups give an alarm call, a deep barking vocalisation that triggers other nyala within hearing range to run. They also react to the calls of impala, baboons and kudu (Ciszek 1999). Diet: Feeding activity occurs mainly in the early morning and late afternoon (Nowak 1991). During the dry season when food is less available, nyala may wander large distances between sunrise and sunset (Tello et al, 1975). Nyala are grazers and browsers and feed on a variety of plant materials including grasses, leaves, twigs, fruits, flowers and bark. They require a constant supply of fresh drinking water and a large diversity of browse, grasses and broadleaf forbs (Furstenburg 2015). Reproduction: Nyala can breed at any time of the year, but there is a breeding peak in the spring and a smaller peak in the autumn. A female's oestrus cycle is about 19 days long. Males court females for two days of this cycle, but females are receptive to mating for only 6 hours per cycle (Ciszek 1999). Nyala are viviparous and will have 1 calf per birth cycle. The ewe’s gestation period lasts approximately 7-8 months, culminating in the birth of a single calf, typically in late winter to early spring (August to September). Newborns weigh between 4.1 to 5.5 kg, are initially concealed by the mother out of the sight of potential predators in a thicket (Ciszek 1999) and are nursed for at least 7 months (Nowak 1991). Nyala ewes are polyoestrous and can conceive again 1-2 weeks after giving birth, leading to overlapping generations within groups (Nowak 1991). Offspring remain with their mothers until her next calf is born, but after that courting bulls drive adolescent males away from their mother (Ciszek 1999). Males reach puberty at around 12 months but are not socially mature and able to mate until 5 years. Females attain sexual maturity between 20 to 36 months and are reproductively active until 14 years old (Nowak 1991).

	Longevity: The maximum recorded longevity for this species in captivity is 23 years (AnAge 2023) and Animal Diversity Web (2026) estimates an average lifespan in captivity of 18.5 years. World Life Expectancy (2025) estimates that the average life span for the nyala is 16 years. **Conservation status:** IUCN: Least Concern: does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened (IUCN 2016). CITES: Not listed (CITES 2026).
DATE OF ORIGINAL ASSESSMENT: February 2026 Aimee Carter and Emily Strong (PIRSA) **Reviewers:** Louise Prosser and Noah Smith (DCCEEW) **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**: Matching similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia is an important step for Bomford models. Climatch v3.0, a new version of the Climatch released by the Australian Bureau of Agricultural Resource Economics and Sciences in 2025 is used for climate matching. Climatch v3.0 uses WorldClim v2.1 datasets with the algorithm updated to use global variances specific to each source dataset. Climatch v3.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/. 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. Climatch v3.0 also includes an additional 3 bioclimatic variables (Diurnal temperature range, Isothermality and Temperature Seasonality) that are not included in the Bomford models. 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 19235 grid squares, each measured at a spatial resolution of 10 arcminutes (approximately 20 km) in both longitude and latitude. ABARES recalibration thresholds applied in Climatch v3.0 are similar to those used in Climatch v2.0 (at ~20 km resolution) (Table 1). Climatch v3.0 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.

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 attacking, injuring or killing people should also be taken into account. Assume the individual is not protecting nest or young.*	2	*Animal that sometimes attacks when unprovoked and/or is capable of causing serious injury (requiring hospitalisation) or fatality.* - The male nyala is aggressive when asserting dominance and when in the presence of a female in oestrus. Bulls have been known to kill a rival by goring with horns (ADW 2026). - Other aggressive behaviour exhibited by bulls includes biting, kicking and charging. - Nyala bulls can kill conspecific bulls in fights for dominance and allospecific bulls, for browsing locations. Walker (2015) states the nyala is known to compete aggressively for browse with bushbuck. There are several incidents on public record of the nyala injuring and killing members of the public: - Reports of unprovoked nyala's goring humans resulting in hospitalisations (Llewellyn 2018; Mackie 2017; Opperman 2022). - Reports of unprovoked nyala's killing people (Independent Online 2013; Louw 2023).
A2. Risk to public safety from individual captive animals (0–2) *Assess the risk that irresponsible use of products obtained from captive individuals of*	0	*Nil or low risk (highly unlikely or not possible).*

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)		
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 v2.1 (Version 3.0), Value X = sum of classes 6 – 10, see Table 1.*	5	*Very High climate match to Australia.* Value X = 16,349 Climate Match Score = 5
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.*	4	*Exotic population established on a continent.* No exotic population has been reported on the Global Invasive Species Database (GISD 2026), however, nyala has been introduced for game hunting purposes to Namibia on private land in the northern farming districts. It has also colonised some farms in the east of Botswana as a result of the spread from populations introduced to farms in the adjacent region of South Africa (IUCN 2016). It was illegally introduced into Kissama National Park in Angola in 2014 (Walker 2015).
B3. Overseas range size score (0–2) < 1 = 0; 1– 70 = 1; >70 = 2	1	*Overseas range between 1 to 70 million square kilometres.* Approximately 1,963,913 km^2 (Climatch, 2026)

Estimate the species overseas range size including currently and the past 1000 years; natural and introduced range in millions of square kilometres*		
B4. Taxonomic Class (0–1) *Bird = 0; mammal = 1*	1	*Mammal*
B. ESTABLISHMENT RISK SCORE SUM OF B1- B4 (1–13)	11	**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* Nyala feed selectively on both the leaves and fruits of woody plants as well as grasses (IUCN 2016). Nyala eat a large variety of species. In Mozambique they have been recorded eating up to 108 species of sweet grasses, forbs and browse (Furstenberg 2015).
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.* Nyala have been introduced to Namibia on private land in the northern commercial farming districts and also to farms in Botswana (IUCN 2016).
B7. Migratory score (0–1) *Always migratory = 0; non-migratory = 1*	1	*Non-migratory* Not listed in Convention on the Conservation of Migratory Species of Wild Animals (CMS 2026).
B. ESTABLISHMENT RISK SCORE SUM OF B1- B7 (1–16)	14	**EXTREME establishment risk**
STAGE C: PROBABILITY AN ESTABLISHED SPECIES WILL BECOME A PEST		
C1. Taxonomic group (0–4)	4	*Mammal in one of the orders that have been demonstrated to have detrimental effects on prey abundance and/or habitat degradation (Artiodactyla) = 2.*

		Mammal in one of the families that are particularly prone to cause agricultural damage (Bovidae) = 2.
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.* Nyala have an overseas range size of approximately 1,964,000 km^2 (Climatch 2026). In Eswatini, the species was extinct by the 1950s, but it has been successfully reintroduced (IUCN 2016).
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.* Nyala are a highly valued game species and population potential has been limited by hunting activities. Nyala occupy the same feeding niche as the bushbuck and, if allowed to overpopulate, tend to displace them (Furstenburg 2015).
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 138 grid squares within the highest two climate match classes and has more than 691 within the highest four climate match classes, that overlap the distribution of any susceptible native species or ecological communities.* Climate match score for classes 9-10 = 354. Climate match score for classes 7-10 = 8,450. Examples of susceptible native species or ecological communities include (DCCEEW Protected Matters Search Tool 2026): *Acacia harpophylla* (Brigalow) - Endangered *Dasyurus hallucatus* (Northern Quoll) - Endangered *Petrogale sharmani* (Mount Claro Rock Wallaby) - Vulnerable

		Nyala browse on several *Acacia* species in their natural habitat (Furstenberg 2015). The woodland habitat created by Brigalow is similar to the nyala's preferred environment. Nyala could compete with the northern quoll for habitat.
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*	4	Total Commodity Damage Score = 119 (see Table 2) Nyala have the potential to compete with grazing animals for food resources and trample broadacre 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 mammals (likely or unknown effect on native species and on livestock and other domestic animals).* Nyala can act as carriers and spreaders of various parasites, particularly tick-borne haemoparasites and internal helminth worms (Pfitzer 2011). They have also been found to carry Bovine Tuberculosis (Roux et al 2019). All species can play a role in the spread of diseases or parasites to other animals (native species and on livestock and other domestic animals) or to humans (zoonotic). For further information on the impacts of zoonotic diseases, the following links are available: Department of Agriculture, Fisheries and Forestry - Animal Import Risk Analysis

		Department of Agriculture, Fisheries and Forestry - Exotic Environmental Pest List Wildlife Health Australia - Fact Sheets
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*
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	*Injuries or harm severe or fatal but few people at risk: Serious risk.* Nyala bucks have horns up to 80cm long and there are records of them severely injuring (Llewellyn 2018; Mackie 2017; Opperman 2022) and killing people (Independent Online 2013; Louw 2023).
C. PEST RISK SCORE SUM C 1 TO C 11 (1–37)	23	**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)**	11	*EXTREME establishment risk*

≤ 5 = low establishment risk; 6-8 = moderate establishment risk; 9-10 = serious establishment risk; ≥ 11-13 = 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*	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*	23	*EXTREME pest risk*

ENVIRONMENT AND INVASIVES COMMITTEE THREAT CATEGORY	**EXTREME**

World distribution map (IUCN RedList) showing the whole African continent and close up of the extant geographic range.



Figure 1- World Distribution Map - IUCN RedList

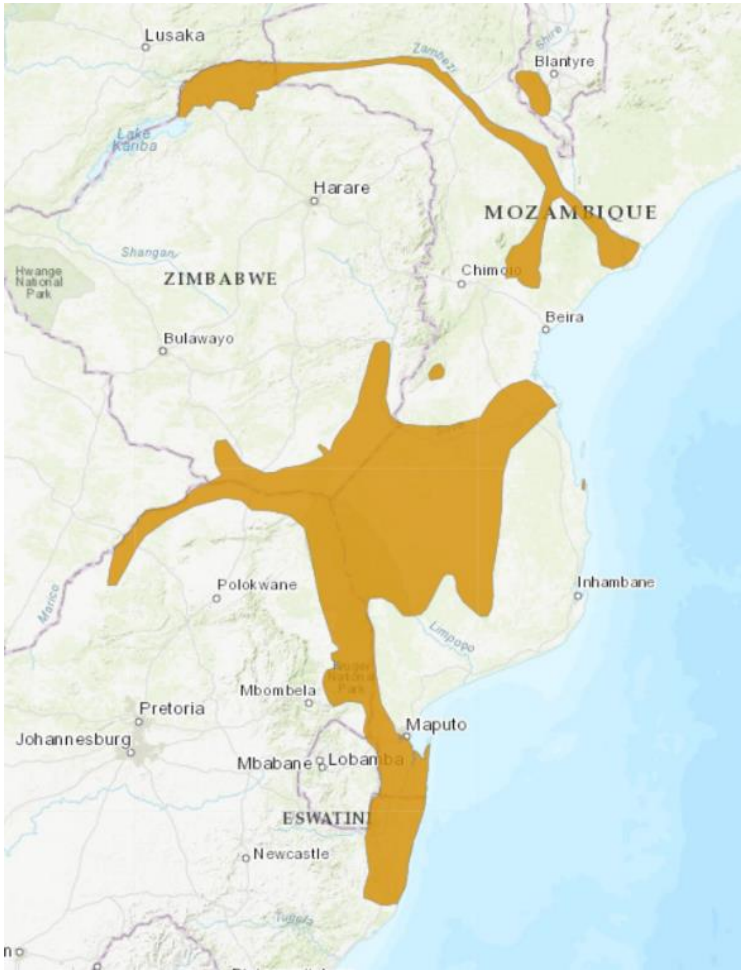


Figure 2 - World Distribution Map -IUCN Red List – Close Up

World distribution maps - GBIF and Climatch.
Meteorological data was sourced from the IUCN Red List (fig. 2) and GIBF maps for the Climatch analysis (see B1):

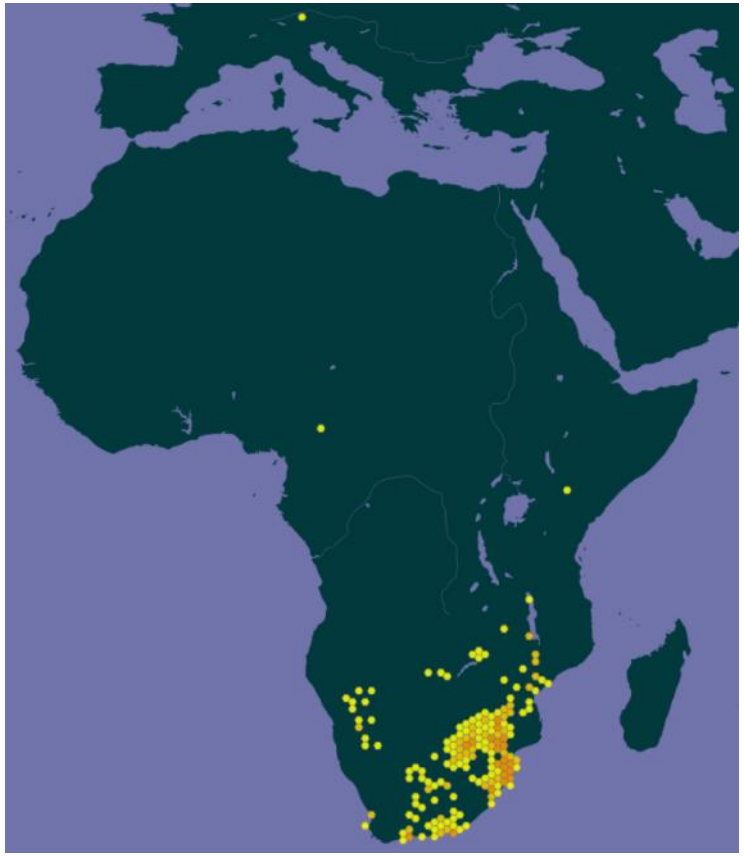


Figure 3- World Distribution Map – GIBF.

The three northernmost points have been assumed to be outliers and removed from the analysis.

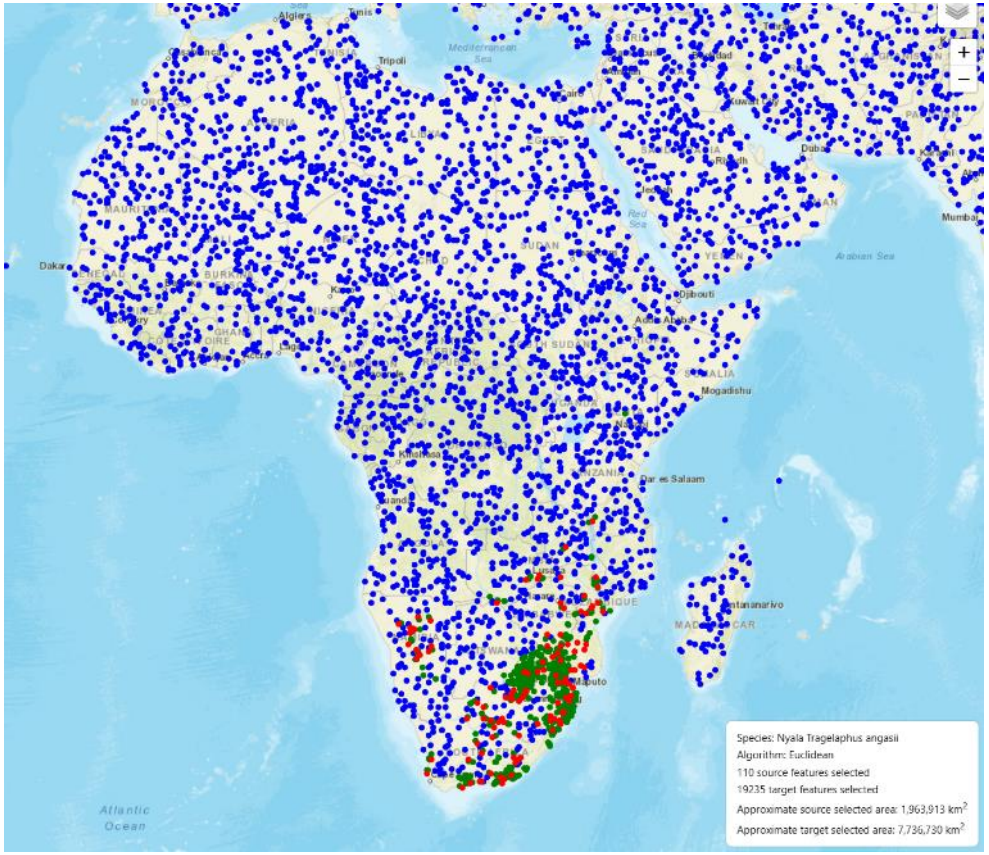
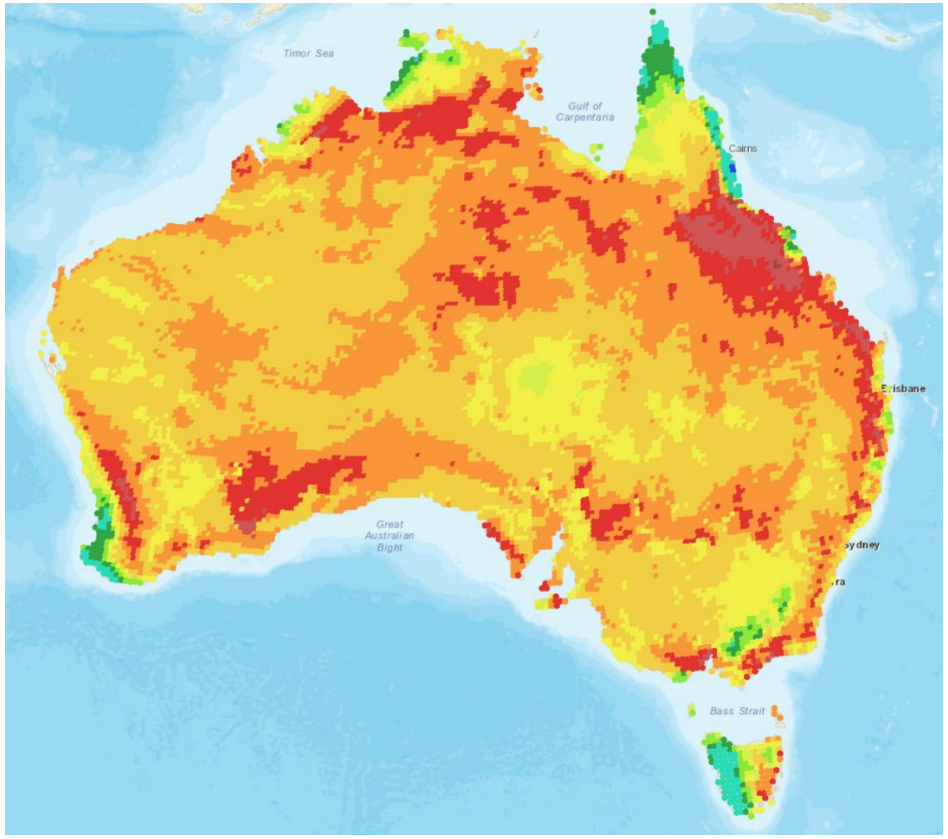


Figure 4 - World Distribution Map - Climatch

Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Tragelaphus angasii*

Value X = 16,349



Score	Color	Count
0		2
1		158
2		188
3		233
4		312
5		1993
6		7899
7		6311
8		1785
9		350
10		4

Species: Nyala Tragelaphus angasii
Algorithm: Closest Standard Score
110 source features selected
19235 target features selected
Approximate source selected area: 1,963,913 km^2
Approximate target selected area: 7,736,730 km^2

Table 1: ABARES recalibration thresholds

Climate Match Score (CMS)	Climatch (50 km) Closest Standard Match Sum Level 6 (Value X)	Climatch v3.0 (20 km resolution) 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 and Australian Bureau of Agricultural and Resource Economics and Sciences 2024 – 2025 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 data)	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 (cattle and calf slaughtering, live bovine exports, milk)	12	1	4	48
Cereal grains (wheat, barley, sorghum, corn, oats, rice, triticale, rye, canary seed, panicum, millet)	9	1	4	36
Fruit and nuts (includes wine grapes)	5			
Sheep (sheep and lamb slaughtering, live sheep exports, wool)	4	1	4	16
Other crops (hay, silage, pasture seed and grasses, nurseries, cut flowers, turf, coffee, spices, tea)	3			
Vegetables	3			
Poultry slaughtering and chicken egg production	3			
Oilseeds (canola, soybeans, sunflower, linseed, safflower, peanuts)	3	1	3	9
Pulses (chickpeas, lentils, field peas, lupins, faba beans, mung beans, navy beans)	2	1	3	6
Fisheries products	2			
Cotton lint	2			
Forestry (hardwood and softwood)	1	1	4	4
Pig slaughtering	1			
Sugarcane	1			
Other livestock slaughtering (goats, deer, crocodile, camels, rabbits, buffalo slaughtered at a commercial processing establishment)	0.1			
Other live animal exports (live breeding horses–excluding horses temporarily traded for racing or breeding purposes–and other live birds, mammals and insects not elsewhere specified)	0.1			
Honey and bee products (honey, beeswax, pollination services, package bees and queens)	0.1			
Total Commodity Damage Score (TCDS)				119

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:

4. *Nil (species does not have attributes to make it capable of damaging this commodity)*
5. *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*
6. *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)*
7. *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**		

Bibliography:

ABARES (Australian Bureau of Agricultural and Resource Economics). (2026). Catchment scale land use of Australia and commodities – Update December 2023 - DAFF. Available at: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-and-commodities-update-2023 (Accessed: 13 February 2026).

Agriculture.gov.au. (2026). Climatch. Available at: https://climatch.cp1.agriculture.gov.au/ (Accessed: 12 February 2026).

AnAge: The Animal Ageing and Longevity Database. (2026). AnAge entry for *Tragelaphus angasii*: Human Ageing Genomic Resources. Available at: https://genomics.senescence.info/species/entry.php?species=Tragelaphus_angasii (Accessed: 11 February 2026).

Bomford, M. (2003). *Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2006). *Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models - A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2008). *Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand - A report produced for the Invasive Animals Cooperative Research Centre*. Bureau of Rural Sciences, Canberra.

Catalogue of Life. (2026). *Tragelaphus angasii* Angas, 1849. Available at: https://www.catalogueoflife.org/data/taxon/57VQN (Accessed: 17 February 2026).

Ciszek, D. (1999). *Tragelaphus angasii*. Animal Diversity Web. University of Michigan. Available at: https://animaldiversity.org/accounts/Tragelaphus_angasii/ (Accessed: 16 February 2026).

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). (2026). Available at: https://cites.org/eng/search?search_api_fulltext=Tragelaphus+angasii (Accessed: 12 February 2026).

CMS. (2026). Convention on the Conservation of Migratory Species of Wild Animals: United Nations Environment Programme. Available at: https://www.cms.int/search?fulltext=Nyala+Tragelaphus (Accessed: 17 February 2026).

Furstenburg, D. (2015). NYALA *Tragelaphus angasii*. Available at: https://www.researchgate.net/profile/DeonFurstenburg/publication/312232086_NYALA_Tragelaphus_angasii/links/5877a9f308aebf17d3bb99ae/NYALA-Tragelaphus-angasii.pdf (Accessed: 12 February 2026).

GBIF (Global Biodiversity Information Facility). (2026). *Tragelaphus angasii* Angas, 1849. Available at: https://www.gbif.org/species/5220181 (Accessed: 13 February 2026).

Global Invasive Species Database. (2026). Invasive Species Specialist Group. Available at: https://www.iucngisd.org/gisd/search.php (Accessed: 16 February 2026).

Independent Online. (2013). Nyala kills elderly woman: report. Available at: https://www.iol.co.za/news/south-africa/limpopo/nyala-kills-elderly-woman-report-1454853 (Accessed: 17 February 2026).

ITIS (Integrated Taxonomic Information System). (2026). ITIS - Report: *Tragelaphus angasii* Angas, 1849. Available at: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=625128#null (Accessed: 16 February 2026).

IUCN SSC Antelope Specialist Group. (2016). Nyala *Tragelaphus angasii*. *The IUCN Red List of Threatened Species* 2016. International Union for Conservation of Nature and Natural Resources. Available at: https://www.iucnredlist.org/fr/species/22052/115165681 (Accessed: 12 February 2026).

Llewellyn, J. (2018). Nyala Incident. Ingewala Reserve. Available at: https://ingwelala.co.za/archives/news-archives/nyala-incident.html (Accessed: 17 February 2026).

Louw, A. (2023). Fochville farm owner killed by nyala. *Carletonville Herald*. Available at: https://www.citizen.co.za/carletonville-herhald/news/news-news/2023/08/31/fochville-farm-owner-killed-by-nyala/ (Accessed: 17 February 2026).

Mackie, V. (2017). A Close Animal Encounter with Nyala. Available at: https://viviennemackie.wordpress.com/2017/10/16/a-close-animal-encounter-with-nyala/ (Accessed: 17 February 2026).

Nowak, R.M. (1991). *Walker's Mammals of the World*. 5th edn. Vol. II. The Johns Hopkins University Press, Baltimore.

Opperman, J. (2022). Recipient Story: Surviving life by the horns. Western Cape Blood Service. Available at: https://www.wcbs.org.za/2022/05/27/recipient-story-surviving-life-by-the-horns/ (Accessed: 17 February 2026).

Pfitzer, S., Oosthuizen, M.C., Bosman, A.-M., Vorster, I. and Penzhorn, B.L. (2011). Tick-borne blood parasites in nyala (*Tragelaphus angasii*, Gray 1849) from KwaZulu-Natal, South Africa. *Veterinary Parasitology*, 176(2–3), pp.126–131. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0304401710006291#:~:text=In%20the%20only%20published%20paper,et%20al.%2C%202003 (Accessed: 16 February 2026).

Protected Matters Search Tool. (2026). Department of Climate Change, Energy, the Environment and Water. Available at: https://pmst.environment.gov.au/#/map?lng=131.52832031250003&lat=-28.671310915880834&zoom=5&baseLayers=Imagery (Accessed: 17 February 2026).

Roux, L., McCall, A.J. and Michel, A.L. (2019). Detection of native interferon-γ in nyala (*Tragelaphus angasii*): Towards diagnosing tuberculosis. *Onderstepoort Journal of Veterinary Research*, 86(1). Available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC6852497/#:~:text=Nyala%20(Tragelaphus%20angasii)%2C%20a,diagnosis%20of%20tuberculosis%20in%20nyala (Accessed: 17 February 2026).

Species+. (2026). Available at: https://www.speciesplus.net/species#/taxon_concepts?taxonomy=cites_eu&taxon_concept_query=Tragelaphus%20angasii&geo_entities_ids=&geo_entity_scope=cites&page=1 (Accessed: 17 February 2026).

Tello, J.L.P.L. and Van Gelder. R.G. (1975). *The Natural History of Nyala Tragelaphus angasii (Mammalia, Bovidae) in Mozambique*. American Museum of Natural History, New York.

Walker, J.F. (2015). Will Secret Wildlife Imports Doom Ultra-Rare Giant Sable? *National Geographic*. Available at: https://www.nationalgeographic.com/animals/article/150521-angola-giant-sable-antelope-operation-noahs-ark-south-africa (Accessed: 17 February 2026).

World Life Expectancy. (2026). NYALA. Global Life Partners. Available at: https://www.worldlifeexpectancy.com/mammal-life-expectancy-nyala (Accessed: 12 February 2026).

DRAFT National Risk Assessment: EXTREME

RISK ASSESSMENT FOR AUSTRALIA: Barbary Sheep (*Ammotragus lervia*)

Class - Mammalia, **Order** - Artiodactyla, **Family** - Bovidae, **Genus** - *Ammotragus*.

SPECIES: *Ammotragus lervia* (Pallas, 1777) **Synonyms:** *Antilope lervia* (Pallas, 1777) *Ammotragus lervia barbatus* (Kerr, 1792) *Ammotragus tragelaphus* (Gray, 1850) *Antilope lervia* (Pallas, 1777) *Aries tragelaphus* (Lataste 1887) *Ovis lervia* (Anderson and de Winton 1902) *Ovis ornata* (Geoffroy Saint-Hilaire 1827) *Ovis tragelaphus* (Afzelius 1815) **Subspecies:** *Ammotragus lervia angusi* (Rothschild, 1921) *Ammotragus lervia blainei* (Rothschild, 1913) *Ammotragus lervia fassini* (Lepri, 1930) *Ammotragus lervia lervia* (Pallas, 1777)	**Species description:** The barbary sheep is not a true sheep but a caprine bovid. It is native to widespread areas of North Africa in rugged and mountainous terrain from deserts and semi-deserts to open forests (Cassinello et al 2022). Barbary sheep behaviour resembles that of sheep but morphologically, barbary sheep show intermediate characteristics of both sheep and goats (Cassinello 2015b). They more closely resemble a robust goat (Geist 1971). The body is slender yet tall, with a sloping croup. The tail extends to about halfway down the hocks and is bushy, although the underside at the base is hairless. The legs are strong and well built. The head is elongated, with small, pointed ears and a muzzle that shows only a narrow bare margin between the slanting nostrils (Haltenorth and Diller 1988). A distinctive feature is the mane that extends from under the throat down the front of the neck to the brisket, bifurcating then and continuing down the forelegs in mature animals, with the elbows concealed by long sleeves. Barbary sheep do not have goatees and, like some sheep species, they have a haired chin and a short erect fringe on the back (Cassinello 2015b). Females resemble males but have a less developed mane. Kids are light brown with paler undersides, darker foreheads, and a darker nasal stripe. Unlike sheep, they lack preorbital, interdigital and flank glands, but have subcaudal glands (Cassinello 2015b) . Males emit a strong scent during the rut. Females have two teats (Haltenorth and Diller 1988). There is a strong sexual dimorphism in mature individuals. Cassinello (1997) found the average body weight for males was 82 kg and 41 kg for females and the average body length was 147 cm for males and 128 cm for females. Significant size variability exists, with adult males weighing between 50 to 132 kg (Miranda et al. 2012) and as much as 145 kg (TISI 2014). Adult female weights range from 12 to 68 kilograms (Cassinello 2002 cited in Miranda et al. 2012), around 65 kg (TISI 2014). Sex and age classes can be identified by face and horn morphology; full details can be found in Cassinello (1997) (Cassinello 2015b). Both males and females possess horns, though those of males are larger and typically meet at the base. In cross-section, the horns are triangular, with a rear angle and a slightly rounded anterior surface that often displays a faint central ridge. The entire upper surface of the horns is marked by closely spaced transverse ridges at the front,

Ammotragus lervia ornatus (Saint-Hilaire, 1827) *Ammotragus lervia sahariensis* (Rothschild, 1913) **Common Names:** Barbary Sheep Aoudad Uaddan Arrui (Spanish) Kabsh arwi (Arabic)	which gradually wear away in older individuals (Cassinello 2015b). The horns curve in a circular arc and can be up to 50 cm long (QLD Gov 2021). As adults mature, the horns become a darker shade of yellow/brown (TISI 2014). Barbary sheep have a tawny-brown coat that becomes lighter toward a whitish underside, with darker brown shading around the head and forequarters. The chin, a stripe along the nose, parts of the chest mane, and a lateral stripe along the belly are often dark brown to black. In contrast, the mane, sleeves, belly, inner legs, and sometimes the nasal stripe may appear pale to white (Haltenorth and Diller 1988). Considerable variation in coat colour occurs among different populations, forming the basis for the currently recognised subspecies. Overall colouring ranges from isabelline to reddish-brown. The coat is coarse and bristly with a soft underwool, becoming shorter and smoother during summer. There are 6 subspecies recognised (Wacher et al. 2002). The International Union for Conservation of Nature (IUCN) (Cassinello et al 2022) notes there are several apparent zones of hybridisation and recommends a genetic study to determine the accuracy of the subspecies classification as they are currently based on morphological traits. The subspecies are (Wacher et al. 2002): ***A. l. angusi*** – body colour very deep rufous, darker than *A. l. ornata*, dorsal crest mixed with black, more strongly on front half, leg hair apparently sparse, no face stripe, beard colour cinnamon rufous on sides of lower jaw, horn shape much more upright on head and curving farther backwards and inwards. ***A. l. blainei*** – body colour 'brownish grey', less rufous than *A. l. sahariensis, A. l. ornata* and *A. l. lervia* with brownish mane, no face stripe but sides of head, face and mask dark owing to admixture of blackish hairs and contrast with body, beard colour black on lower jaw, horn shape strongly depressed in adult male but not bent backwards as much as *sahariensis, ornata* and *lervia.* ***A. l. fassini*** – body colour light tawny reddish, more rufous than *A. l. sahariensis* and *A. l. blainei*, spot below ear obscure, face colour face washed brownish by mixture of brownish and rufous hair contrasts with body, black chin, mixture of tawny and brown on jaw, horn shape horns more backward turned than *A. l. blainei*, less depressed than *A. l. sahariensis*. ***A. l. lervia*** – body colour mid tawny, indistinct dark median face stripe, beard colour is uniformly sandy and horn shape 'hardly' or not at all depressed. ***A. l. ornatus/ornata*** – body colour warm sandy rufous, deeper than *A. l. sahariensis*, no white patch below ear. No face stripe, beard colour uniformly sandy, horn shape strongly depressed.

	A. l. sahariensis – body colour uniform pale sandy rufous with a white patch below and somewhat behind ear, lighter than *A. l. fassini*, no trace of a median facial stripe, face colour uniform with body, beard colour uniformly sandy, horn shape strongly depressed in adult male turning sharply down before bending backwards. **General information:** Distribution: The barbary sheep is resident in Algeria, northern Chad, Egypt, Libya, northern Mali, Mauritania, Morocco, Niger, Sudan (west of Nile and east of Nile in Red Sea Hills) and Tunisia (Grub 2005; Cassinello et al. 2018, 2022). Cassinello et al (2022) states barbary sheep may be present in low numbers in Western Sahara, but Species+ (2026) lists them as extinct in that region. The barbary sheep has been introduced and established populations in Croatia, Italy, north Mexico, Spain (the Canary Islands, La Palma Island, southeastern mainland and Tenerife), on the Iberian Peninsula (Spain and Portugal) and the United States (mainly Texas, New Mexico and California) (Cassinello et al. 2018, 2022; CITES 2026; GISD 2026). CITES (2026) also states that the barbary sheep can be found in Czech Republic and South Africa. ***A. l. angusi*** - 'Aïr Aoudad' inhabit both the Aïr Massif in norther Niger and the Termit Massifs in south-eastern Niger. ***A. l. blainei*** - 'Kordofan Aoudad' was once relatively widespread from west Sudan to the Red Sea coast, but, although no recent reports have been obtained, it is still probably restricted to the Red Sea hills of east Sudan (Nimir 1997 as cited in Cassinello et al 2022). It is not clear whether other Aoudad populations present further west correspond to this subspecies (Cassinello et al 2022). ***A. l. fassini*** - 'Libyan Aoudad' is only found in extreme southern Tunisia (Ben Mimoun et al. 2016) and in Libya. In Libya barbary sheep inhabit the Hamada el Homra, the region south of Gatroun in the Fezzan, near Socna, Uaddan and Murzuq and some around Ghadames and Kufra (Shackleton 1997). ***A. l. lervia*** - 'Atlas Aoudad' occur along the whole Atlas Mountain Range from Morocco (Shackleton 1997) to north Algeria and Northern Tunisia ((Shackleton 1997; Ben Mimoun et al. 2016; Cassinello et al 2022). ***A. l. ornatus*** - 'Egyptian Aoudad' was formerly quite widespread throughout the Eastern and Western Deserts of Egypt and was thought to be extinct in 1996 (Amer 1997 cited in Cassinello et al 2022). However, Wacher et al. (2002) (cited in Cassinello et al 2022) reported evidence of its presence in both the Elba Protected Area and the Western Desert between 1997 and 2000. A population currently inhabits the Djebel Uweinat, probably reaching the Djebel Kissu in Sudan and could also be expected to inhabit some areas of the Gilf Kebir and the Djebel Nazar, in Egypt (A. Zboray, pers. Comm cited in Cassinello et al 2022). ***A. l. sahariensis*** - 'Saharan Aoudad' has the largest range of the subspecies, including southern Morocco, the Western Sahara, Mauritania, the mountains of the Adrar des Ifoghas, the Hoggar mountains in southern

	Algeria, south-west Libya, the Tibesti Massif, the Ennedi Massif in Chad and western Sudan (Cassinello et al 2022). Populations have been reported in Arkenu, Gebel Uwainat and Dallani at Tierko and Tousside in the Tibesti (Hufnagl 1972) and in the south of Tunisia (Ben Mimoun et al. 2016). Barbary sheep live in family groups, including male or bachelor groups (adult males only), female groups (adult females only), nursery groups (adult females and their calves/juveniles) and mixed groups (adults of both sexes with or without calves) (Ben Mimoun and Nouira 2013). They are sociable and commonly occur in family parties of one adult male with several females and young. During the dry season several groups may congregate together (Haltenorth and Diller 1988). Ben Mimoun and Nouira (2012) most commonly saw small herds of less than 10 animals. Habitat: In their native range, barbary sheep occupy arid and semi-arid environments, favouring rocky outcrops, rugged terrain, hills in deserts, desert mountains and mountainous areas and chains (Ben Mimoun and Nouira 2015; Ben Mimoun et al. 2016; Bounaceur et al. 2016). Barbary sheep are agile climbers and jumpers (QLD Gov 2021). They inhabit rocky, steep terrains and steppe mountains from near sea level (200 metres) up to elevations of approximately 4,100 metres, utilising sparse tree cover for shade (Cassinello et al 2022). Barbary sheep do not tolerate humidity or snow and prefer open lands to forests (Cassinello 1998 cited in Cassinello 2015b). They are primarily crepuscular, with peak activity during early morning and late afternoon hours, sheltering during the middle of the day in overhanging rocks or holes. Diet: Barbary sheep require vegetation cover made up of grasses (Ben Mimoun et al. 2016). They are extremely resilient animals that manage to survive in some of Africa's most arid regions, receiving little or no rainfall for several years at a time, if the plants they are eating are sufficient to satisfy their water requirements (CMS 2026). They also drink from water holes (Haltenorth and Diller 1988). Barbary sheep are generalist herbivores whose diet consists of grasses, browse, forbs, shrubs, trees (Mimoun and Nouira 2015) and primarily graze at dusk, dawn and during the night (Qld Govt 2021). Through scat analysis it has been confirmed that they have a seasonal variation in diet depending on the plant species available (Miranda et al. 2012). (Ben Mimoun and Nouira (2015) found that in Tunisia barbary sheep were eating 19 plant species – 8 grasses, 6 browse types and 5 forbs. Reproduction: Barbary sheep have a relatively long breeding season, typically occurring in the autumn (September to November), with a gestation period of between 150-165 days. Lambs are usually born in late spring (March to April) and are nursed for 3 to 4 months (Haltenorth and Diller 1988; QLD Gov 2021). Females generally give birth to

	a single offspring, although twins can occur. Females reach sexual maturity at about 18 months and produce 1-3 offspring per year (Haltenorth and Diller 1988; QLD Gov 2021). Males often exhibit territorial behaviour during the breeding season. (Haltenorth and Diller 1988). Longevity: The maximum recorded longevity for this species in captivity is 21.7 years (AnAge 2023). Life expectancy estimates in the wild vary - World Life Expectancy (2026) estimates 10 years and the Queensland Government (2021) estimates 15 to 20 years. **Conservation status:** **IUCN:** Vulnerable: considered to be facing a high risk of extinction in the wild (IUCN 2022). **CITES:** Appendix II: not currently threatened with extinction but may become so if international trade is not regulated (CITES 2026).
DATE OF ORIGINAL ASSESSMENT: February 2026 Aimee Carter and Emily Strong PIRSA **Reviewer:** Kristen Petrov, DCCEEW **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 2006, 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 matching:** Matching similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia is an important step for Bomford models. Climatch v3.0, a new version of the Climatch released by the Australian Bureau of Agricultural Resource Economics and Sciences in 2025 is used for climate matching. Climatch v3.0 uses WorldClim v2.1 datasets with the algorithm updated to use global variances specific to each source dataset. Climatch v3.0 can be accessed on the ABARES website, agriculture.gov.au/abares. The direct URL is https://climatch.cp1.agriculture.gov.au/. 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. Climatch v3.0 also includes an additional 3 bioclimatic variables (Diurnal temperature range, Isothermality and Temperature Seasonality) that are not included in the Bomford models. 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 19235 grid squares, each measured at a spatial resolution of 10 arcminutes (approximately 20 km) in both longitude and latitude. ABARES recalibration thresholds applied in Climatch v3.0 are similar to those used in Climatch v2.0 (at ~20 km resolution) (Table 1).

	Climatch v3.0 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.

The Australian 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 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.* Barbary sheep are known to be aggressive and territorial with the ability to climb and evade predators successfully (TISI 2014). Male barbary sheep charge each other head-on, making contact with their horns and also butt heads and hook their horns then twist and make gouging movements (Steinway 2000). No record has been found of barbary sheep injuring or killing humans.
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: RISK OF ESTABLISHMENT **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 v2.1 (Version 3.0), Value X = sum of classes 6 – 10, see Table 1.*	5	*Very High climate match to Australia* Value X = 14,732 Climate Match Score = 5
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.*	4	*Exotic population established on a larger island (> 50,000km^2) or anywhere on a continent.* The barbary sheep has established exotic populations in the United States – primarily in Texas, New Mexico and California, and also in Croatia, Italy, north Mexico, Spain (the Canary Islands, La Palma Island, southeastern mainland and Tenerife), and on the Iberian Peninsula (Spain and Portugal).
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 between 1 to 70 million square kilometres.* Climatch using IUCN and GBIF data estimates the range as 4,591,866 km^2 The IUCN Red List (Cassinello et al 2022) states the estimated extent of occurrence at 6,624,571 km^2
B4. Taxonomic Class (0–1) *Bird = 0; mammal = 1*	1	*Mammal*
B. ESTABLISHMENT RISK SCORE **SUM OF B1- B4 (1–13)**	11	**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.* Primarily a grazer, actively selecting grasses and forbs of many different species and varying due to seasonal availability (Ben Mimoun & Nouira 2015; Miranda et al. 2012).
B6. Habitat score (0–1)	0	*Requires access to undisturbed (natural) habitats to survive and breed.*

Undisturbed or disturbed habitat		Barbary sheep primarily occupy reserves or protected areas. During the day they take refuge in steep rocky slopes to avoid human disturbance or predation (Irzagh et al. 2020 cited in Cassinello et al 2022).
B7. Migratory score (0–1) *Always migratory = 0; non-migratory = 1*	1	*Facultative migrant in its native range.* They probably make small migratory movements in relation to food availability (Cassinello et al 2022). The species is migratory throughout its native range (CMS 2026a). They might wander far from water sources for long periods of time, even years, if they manage to find succulent forbs that supply water requirements (Poilecot 1991 cited in Cassinello et al 2022). The species is listed in CMS Appendix II (migratory species that have an unfavourable conservation status and that require international agreements for their conservation and management) (CMS 2026).
B. ESTABLISHMENT RISK SCORE **SUM OF B1- B7 (1–16)**	13	**SERIOUS establishment risk**
STAGE C: RISK OF BECOMING A PEST **Probability an established species will become a pest**		
C1. Taxonomic group (0–4)	4	*Mammal in one of the orders that have been demonstrated to have detrimental effects on prey abundance and/or habitat degradation (Artiodactyla) = 2.* *Mammal in one of the families that are particularly prone to cause agricultural damage (Bovidae) = 2.* Barbary sheep are category 2, 3, 4, 5 and 6 restricted invasive animals under the Queensland Biosecurity Act 2014 (Qld Govt 2021).
C2. Overseas range size including current and past 1000 years, natural and introduced range (0–2)	0	*Overseas geographic range less than 10 million square kilometres.*

Estimate the species overseas range size (including current and past 1000 years, natural and introduced range) in millions of square kilometres		The IUCN Red List (Cassinello et al 2022) states the estimated extent of occurrence at 6,624,571 km^2 Climatch using IUCN and GBIF data estimates the range as 4,591,866 km^2
C3. Diet and feeding (0–3)	3	*Mammal that is primarily a grazer or browser.* Barbary sheep are herbivorous, feeding on a variety of vegetation such as grasses, forbs, and shrubs. Seasonal variation plays a role in determining their diet. In the winter, grass makes up the majority of food intake, while shrubs are the more common food the rest of the year (The Mammals of Texas 1994 as citied in Steinway 2000).
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.* Reported as outcompeting native fauna in areas where it has been introduced (CMS 2023). Competes with cattle, goats and sheep for food (QLD Gov 2021). Barnaby sheep were introduced into Spain and labelled invasive by Spanish authorities. In the Canary Islands the barbary sheep is reported to have a negative economic impact on agricultural lands as it feeds on the native Macaronesian flora which includes several threatened and vulnerable species (Cassinello 2015b). In the United States, barbary sheep are a threat to mule deer and bighorn sheep because of direct competition for food and habitat resources. Mule deer and Barbary sheep feed on similar vegetation (TISI 2014). Barbary sheep live in packs comprised of mature and immature members allowing a pack size advantage over native bighorn sheep. Efforts to reintroduce big horn sheep populations are at risk because of habitat competition (TISI 2014). Can spread weeds and damage grassland ecosystems (QLD Gov 2021).

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 138 grid squares within the highest two climate match classes that overlap the distribution of any susceptible native species or ecological communities = 5.* Sum of Climatch classes 9 and 10 = 2,400. Examples of susceptible native species or ecological communities include (DCCEEW Protected Matters Search Tool 2026): *Zyzomys pedunculatus* (Central Rock-rat) – Critically Endangered *Petrogale lateralis centralis* (Central Australian Rock-wallaby) - Vulnerable *Acacia undoolyana* (Sickle-leaf Wattle) – Vulnerable Barnaby sheep would disturb habitat and compete for food resources of the Central Rock-rats and Central Australian Rock-wallaby. They would be likely to browse on the Sickle-leaf Wattle and other vulnerable desert plants.
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?*	2	*Moderate pest of primary production in any country or region.* Competes with livestock for grazing. Overgrazing effects, resource competitions and potential source of infections and parasitic diseases (Ben Mimoun et al. 2016). Crops affected sorghum, millet, pasture, various cereal and pulse crops (QLD Gov 2021). Barbary sheep are a threat to wheat farmers with several observations of the invasive sheep feeding on winter wheat crops (TISI 2014).
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*	5	*Total Commodity Damage Score = 162 (see Table 2)* Queensland Government (2021) states barbary sheep could affect sorghum, millet, pasture, various cereal and pulse 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 mammals (likely or unknown effect on native species and on livestock and other domestic animals).* Barbary sheep have been found to carry three distinct strains of *Mycoplasma ovipneumoniae* (Movi), a respiratory pathogen detrimental to bighorn populations in the United States. Barbary sheep have been shown to carry strains associated with domestic sheep, domestic goats along with a newly discovered aoudad strain (Moore 2025). All species can play a role in the spread of diseases or parasites to other animals (native species and on livestock and other domestic animals) or to humans (zoonotic). For further information on the impacts of zoonotic diseases, the following links are available: Department of Agriculture, Fisheries and Forestry - Animal Import Risk Analysis Department of Agriculture, Fisheries and Forestry - Exotic Environmental Pest List Wildlife Health Australia - Fact Sheets
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* Barbary sheep can be a traffic hazard and damage fences (QLD Gov 2021).
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).*	3	*Injuries or harm moderate but unlikely to be fatal and few people at risk.* Barbary sheep could potentially injure people by knocking them over and/or goring with their horns.

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*	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*	11	EXTREME establishment risk A wild population has developed in the southwestern United States as a result of surplus zoo stock being sold and then released into the wild in New Mexico in 1950 and in Texas in 1957 (Gray & Simpson 1980 cited in Steinway 2000).
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*	13	SERIOUS 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**

IUCN Red List world distribution map (Cassinello 2022) indicating where meteorological data was sourced for the climate analysis (see B1):
From the IUCN website: "Free ranging introduced barbary sheep populations can be found in the United States of America, Mexico, Spain, Croatia and probably Italy (Gray 1985, Cassinello 2015, Mori et al. 2017, Sprem et al. in press). These introduced populations are not included in this assessment and their range is not mapped here" (Cassinello 2022).
Note: while the IUCN map does not include those introduced populations, the GBIF does, so they have been included in the Climatch analysis (see Figures 2 and 3).

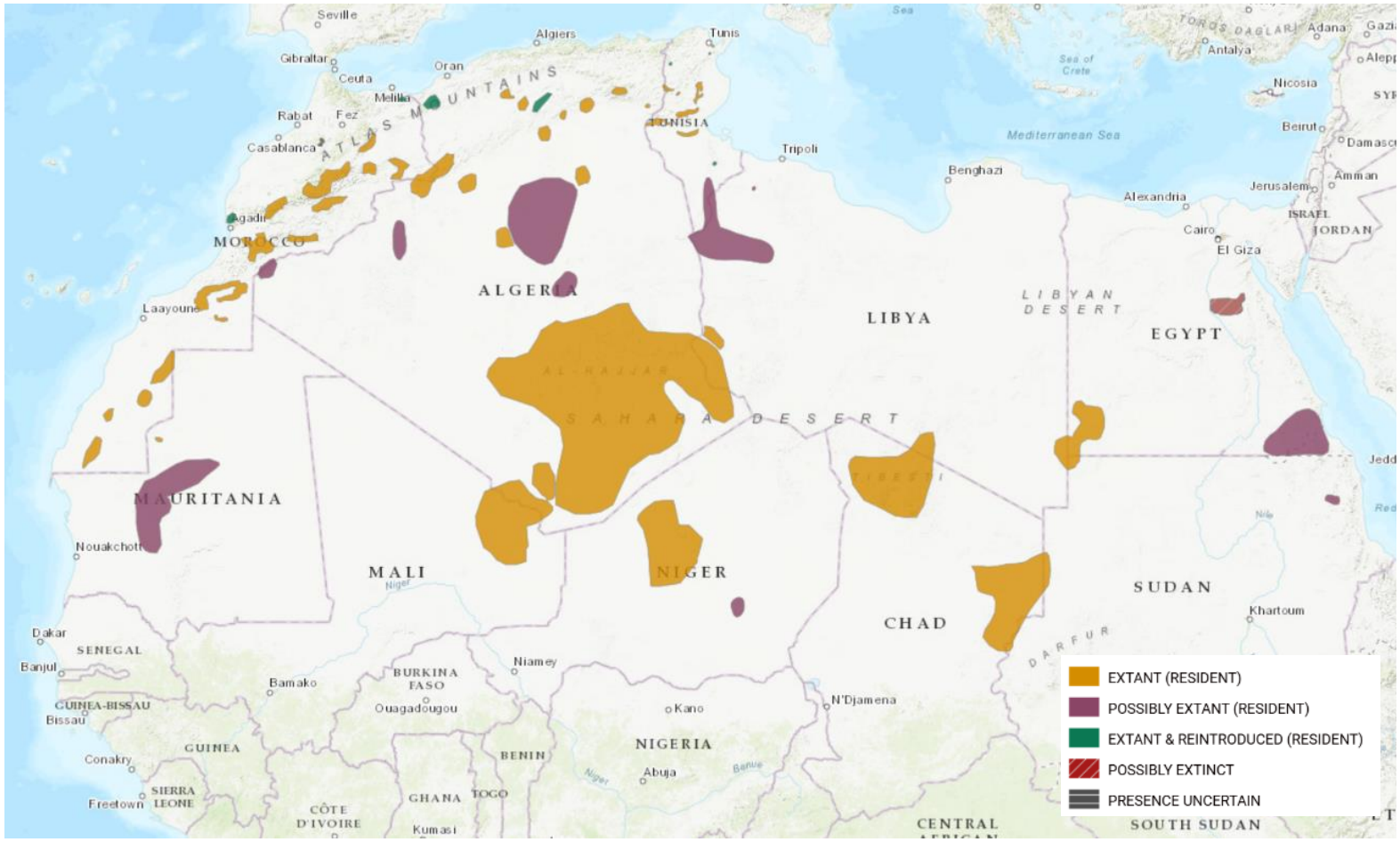


Figure 1- World Distribution Map - IUCN Red List

Global Biodiversity Information Facility (GBIF)world distribution map indicating where meteorological data was sourced for the climate analysis (see B1):

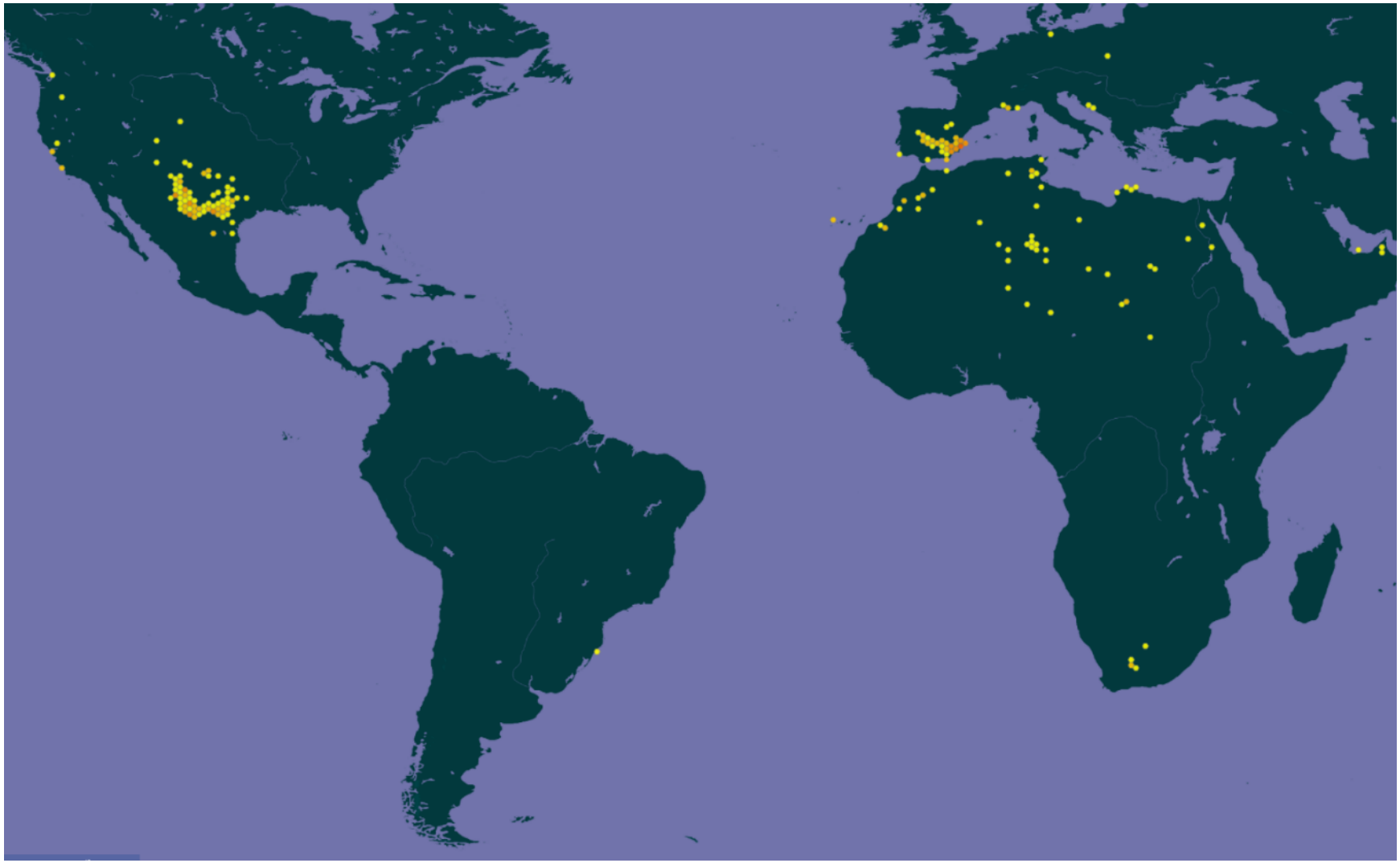


Figure 2- GBIF Map

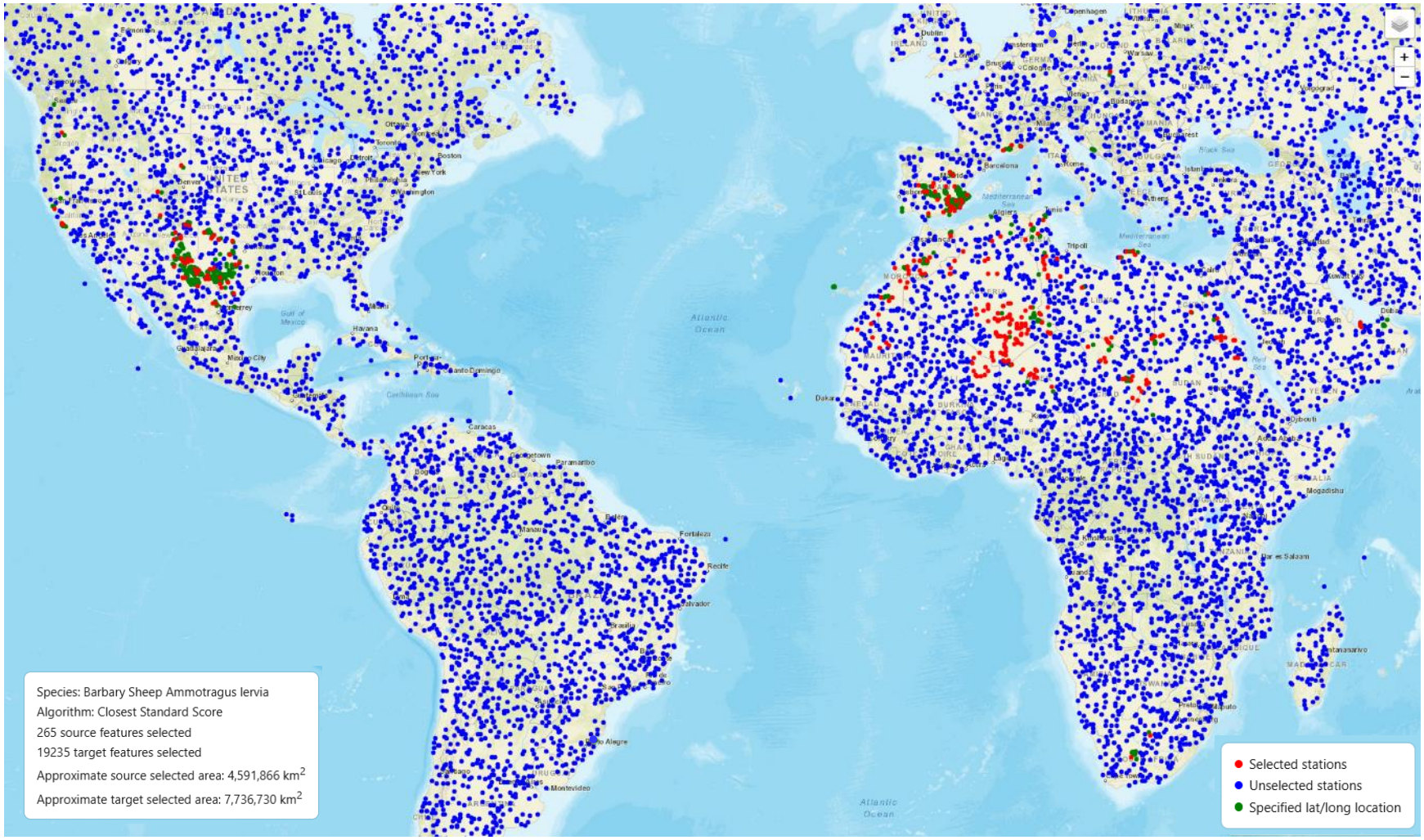


Figure 3 - World Distribution Map – Climatch.

Climate match between world distribution of species and Australia:

Areas of Australia where the climate appears suitable for *Ammotragus lervia*

Value X = 14,732

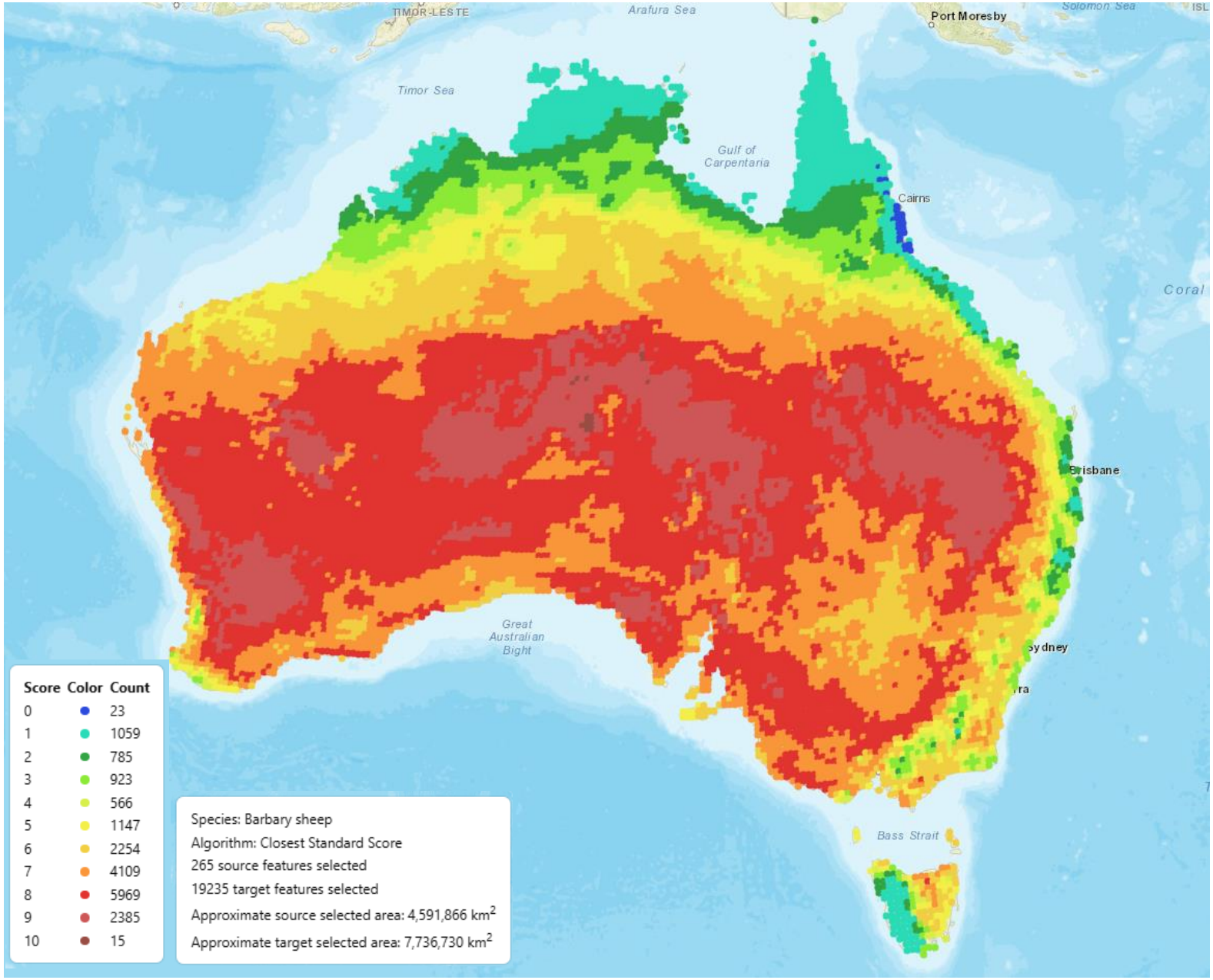


Table 1: ABARES recalibration thresholds

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 and Australian Bureau of Agricultural and Resource Economics and Sciences 2024 – 2025 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 data)	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 (cattle and calf slaughtering, live bovine exports, milk)	12	1	4	48
Cereal grains (wheat, barley, sorghum, corn, oats, rice, triticale, rye, canary seed, panicum, millet)	9	2	4	72
Fruit and nuts (includes wine grapes)	5			
Sheep (sheep and lamb slaughtering, live sheep exports, wool)	4	2	4	32
Other crops (hay, silage, pasture seed and grasses, nurseries, cut flowers, turf, coffee, spices, tea)	3			
Vegetables	3			
Poultry slaughtering and chicken egg production	3			
Oilseeds (canola, soybeans, sunflower, linseed, safflower, peanuts)	3	1	2	6
Pulses (chickpeas, lentils, field peas, lupins, faba beans, mung beans, navy beans)	2	1	2	4
Fisheries products	2			
Cotton lint	2			
Forestry (hardwood and softwood)	1			
Pig slaughtering	1			
Sugarcane	1			
Other livestock slaughtering (goats, deer, crocodile, camels, rabbits, buffalo slaughtered at a commercial processing establishment)	0.1			
Other live animal exports (live breeding horses–excluding horses temporarily traded for racing or breeding purposes–and other live birds, mammals and insects not elsewhere specified)	0.1			
Honey and bee products (honey, beeswax, pollination services, package bees and queens)	0.1			
Total Commodity Damage Score (TCDS)				162

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:

8. *Nil (species does not have attributes to make it capable of damaging this commodity)*
9. *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*
10. *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)*
11. *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**		

Bibliography:

ABARES (Australian Bureau of Agricultural and Resource Economics). (2024). Catchment scale land use of Australia and commodities – Update December 2023. Department of Agriculture, Fisheries and Forestry. Available at: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-and-commodities-update-2023 (Accessed: 23 February 2026).

Acevedo, P., Cassinello, J., Hortal, J. and Gortázar, C. (2007). Invasive exotic aoudad (*Ammotragus lervia*) as a major threat to native Iberian ibex (*Capra pyrenaica*): A habitat suitability model approach. *Diversity and Distributions*, 13(5), pp.587–597. Available at: https://digital.csic.es/bitstream/10261/118202/1/Invasive%20exotic%20aoudad%20%28Ammotragus%201%20lervia%29%20as%20a%20major.pdf (Accessed: 23 February 2026).

Agriculture.gov.au. (2026). Climatch. Available at: https://climatch.cp1.agriculture.gov.au/ (Accessed: 19 February 2026).

AnAge. (2026). AnAge entry for *Ammotragus lervia*. AnAge, The Animal Ageing and Longevity Database: Human Ageing Genomic Resources. Available at: https://genomics.senescence.info/species/entry.php?species=Ammotragus_lervia (Accessed: 23 February 2026).

Aulagnier, S. and Thevenot, M. (1997). Morocco. In: D.M. Shackleton (ed.), *Wild Sheep and Goats and their Relatives: Status Survey and Conservation Action Plan for Caprinae*, pp.34–38. IUCN/SSC Caprinae Specialist Group, Gland, Switzerland and Cambridge.

Ben Mimoun, J., Cassinello, J. and Nouira, S. (2016). Update of the distribution and status of the aoudad *Ammotragus lervia* (Bovidae, Caprini) in Tunisia. *Mammalia*, 81(2), pp.181–187. Available at: https://www.degruyterbrill.com/document/doi/10.1515/mammalia-2015-0069/html (Accessed: 19 February 2026).

Ben Mimoun, J. and Nouira, S. (2013). Social organization of Barbary Sheep (*Ammotragus lervia*) population in the Chambi National Park, Tunisia. *International Journal of Biodiversity and Conservation*, 5, pp.15–19. Available at: https://academicjournals.org/article/article1380037823_Ben%20Mimoun%20and%20Nouira.pdf (Accessed: 19 February 2026).

Ben Mimoun, J. and Nouira, S. (2015). Food habits of the aoudad *Ammotragus lervia* in the Bou Hedma mountains, Tunisia. *South African Journal of Science*, 111(11/12), pp.1–5. Available at: https://doi.org/10.17159/sajs.2015/20140448

Bomford, M. (2003). *Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2006). *Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models - A report produced for the Department of Environment and Heritage*. Bureau of Rural Sciences, Canberra.

Bomford, M. (2008). *Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand - A report produced for the Invasive Animals Cooperative Research Centre*. Bureau of Rural Sciences, Canberra.

Bounaceur, F., Benamor, N., Bissaad, F.Z., Abdi, A. and Aulagnier, S. (2016). Is there a future for the last populations of Aoudad (*Ammotragus lervia*) in northern Algeria? *Pakistan Journal of Zoology*, 48(6), pp.1727–1731. Available at: https://www.researchgate.net/publication/310620315_Is_there_a_future_for_the_last_populations_of_Aoudad_Ammotragus_lervia_in_northern_Algeria (Accessed: 23 February 2026).

Cassinello, J. (1997). Sex and age classes in Spanish populations of arrui (*Ammotragus lervia*). Relationship with the management of free-ranging populations. *Boletín del Instituto de Estudios Almerienses, Ciencias*, 14, pp.171–178. Almeria.

Cassinello, J. (2015a). *Ammotragus lervia* (aoudad). CABI Compendium. Available at: https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.94507 (Accessed: 26 February 2026).

Cassinello, J. (2015b). *Ammotragus lervia* (Aoudad). *Invasive Species Compendium*. CAB International, Wallingford.

Cassinello, J. (2017). Barbary sheep – *Ammotragus lervia*. In: Salvador, A. and Barja, I. (eds.), *Virtual Encyclopedia of Spanish Vertebrates*. National Museum of Natural Sciences, Madrid. Available at: https://www.vertebradosibericos.org/mamiferos/ammler.html (Accessed: 23 February 2026).

Cassinello, J. (2018). Misconception and mismanagement of invasive species: The paradoxical case of an alien ungulate in Spain. *Conservation Letters*, 11(5). Available at: https://conbio.onlinelibrary.wiley.com/doi/epdf/10.1111/conl.12440 (Accessed: 23 February 2026).

Cassinello, J., Bounaceur, F., Brito, J.C., Bussière, E., Cuzin, F., Gil-Sánchez, J., Herrera-Sánchez, F.J. and Wacher, T. (2022). Aoudad *Ammotragus lervia* (amended version of 2021 assessment). *The IUCN Red List of Threatened Species*. Available at: https://www.iucnredlist.org/species/1151/214430287 (Accessed: 24 February 2026).

Catalogue of Life. (2026). *Ammotragus lervia* (Pallas, 1777). Global Core Biodata Resource. Available at: https://www.catalogueoflife.org/data/taxon/CVNG (Accessed: 24 February 2026).

CITES (Conservation on International Trade in Endangered Species). (2026). Checklist of CITES species. Available at: https://checklist.cites.org/#/en/search/output_layout=alphabetical&level_of_listing=0&show_synonyms=1&show_author=1&show_english=1&show_spanish=1&show_french=1&scientific_name=Ammotragus+lervia&page=1&per_page=20 (Accessed: 24 February 2026).

CMS (Convention on the Conservation of Migratory Species of Wild Animals). (2023). Third Regional Seminar on the Conservation and Restoration of Sahelo-Saharan Megafauna. Available at: https://www.cms.int/en/meeting/third-regional-seminar-conservation-and-restoration-sahelo-saharan-megafauna (Accessed: 24 February 2026).

CMS (Convention on the Conservation of Migratory Species of Wild Animals). (2026). United Nations Environment Programme. Available at: https://www.cms.int/species/appendix-i-ii-cms (Accessed: 17 February 2026).

DCCEEW Protected Matters Search Tool (Department of Climate Change, Energy, the Environment and Water). (2026). Protected Matters Search Tool: Interactive Map. Available at: https://pmst.environment.gov.au/#/map?lng=131.52832031250003&lat=-28.6905876542507&zoom=5&baseLayers=Imagery (Accessed: 19 February 2026).

De Smet, K. (1997a). Algeria. In: D.M. Shackleton (ed.), *Wild Sheep and Goats and their Relatives: Status Survey and Conservation Action Plan for Caprinae*, pp.17–19. IUCN/SSC Caprinae Specialist Group, Gland, Switzerland and Cambridge.

De Smet, K. (1997b). Tunisia. In: D.M. Shackleton (ed.), *Wild Sheep and Goats and their Relatives: Status Survey and Conservation Action Plan for Caprinae*, pp.45–47. IUCN/SSC Caprinae Specialist Group, Gland, Switzerland and Cambridge.

EDDMapS. (2026). barbary sheep (*Ammotragus lervia* (Pallas, 1777)) – Early Detection and Distribution Mapping System, Centre for Invasive Species and Ecosystem Health, University of Georgia. Available at: https://www.eddmaps.org/distribution/uscounty.cfm?sub=59184 (Accessed: 19 February 2026).

GBIF (Global Biodiversity Information Facility). (2026). *Ammotragus lervia* (Pallas, 1777). Available at: https://www.gbif.org/species/2441005 (Accessed: 19 February 2026).

Geist, V. (1971). *Mountain sheep: A study in behavior and evolution*. Wildlife Behaviour and Ecology. University of Chicago Press.

Gharaibeh, M.B. (1997). *Systematics, distribution, and zoogeography of mammals of Tunisia*. Texas Tech University. Available at: https://ttu-ir.tdl.org/items/93778b6d-a009-4501-881f-3216c8050ada (Accessed: 23 February 2026).

GISD (Global Invasive Species Database). (2026). *Ammotragus lervia*. Invasive Species Specialist Group. Available at: https://www.iucngisd.org/gisd/speciesname/Ammotragus+lervia (Accessed: 24 February 2026).

Grubb, P. (2005). Artiodactyla. In: D.E. Wilson and D.M. Reeder (eds.), *Mammal Species of the World. A Taxonomic and Geographic Reference* (3rd ed.), pp.637–722. Johns Hopkins University Press, Baltimore.

Haltenorth, T. and Diller, H. (1988). *The Collins Field Guide to the Mammals of Africa including Madagascar*. The Stephen Green Press, Lexington, Massachusetts.

Hufnagl, E. (1972). *Libyan Mammals*. The Oleander Press, New York.

ITIS (Integrated Taxonomic Information System). (2024). ITIS - Report: *Ammotragus lervia*. Available at: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=180719#null (Accessed: 24 February 2026).

Lamarche, B. (1997). Mali. In: D.M. Shackleton (ed.), *Wild Sheep and Goats and their Relatives: Status Survey and Conservation Action Plan for Caprinae*, pp.32–33. IUCN/SSC Caprinae Specialist Group, Gland, Switzerland and Cambridge.

Miranda, M., Sicilia, M., Bartolomé, J., Molina-Alcaide, E., Gálvez-Bravo, L. and Cassinello, J. (2012). Contrasting feeding patterns of native red deer and two exotic ungulates in a Mediterranean ecosystem. *Wildlife Research*, 39(2), p.171. Available at: https://connectsci.au/wr/article-abstract/39/2/171/40434/Contrasting-feeding-patterns-of-native-red-deer?redirectedFrom=fulltext (Accessed: 19 February 2026).

Moore, C. (2025). 10 Things Hunters Need To Know About Aoudad. Wild Sheep Foundation. Available at: https://www.wildsheepfoundation.org/The-Latest/10-things-hunters-need-to-know-about-aoudad (Accessed: 27 February 2026).

QLD Gov (Queensland Government). (2021). Barbary sheep. Business Queensland. Available at: https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/biosecurity/animals/invasive/restricted/barbary-sheep (Accessed: 19 February 2026).

Species+. (2026). Available at: https://www.speciesplus.net/species#/taxon_concepts/3905/distribution (Accessed: 24 February 2026).

Steinway, M. (2000). *Ammotragus lervia* (aoudad). Animal Diversity Web. University of Michigan. Available at: https://animaldiversity.org/accounts/Ammotragus_lervia/ (Accessed: 24 February 2026).

TISI (Texas Invasive Species Institute). (2014). Barbary Sheep. Available at: https://tsusinvasives.org/home/database/ammotragus-lervia#:~:text=Barbary%20sheep%20are%20known%20to,over%20the%20native%20bighorn%20sheep (Accessed: 19 February 2026).

Wacher, T., Baha el Din, S., Mikhail, G. and Baha del Din, M. (2002). New observations of the 'extinct' Barbary sheep *Ammotragus lervia ornata* in Egypt. *Oryx*, 36(3), pp.301–304. Available at: https://www.cambridge.org/core/journals/oryx/article/new-observations-of-the-extinct-barbary-sheep-ammotragus-lervia-ornata-in-egypt/A4D384AEADF72DFF2DED1395663A3B29 (Accessed: 23 February 2026).

Wilson, D.E. and Reeder, D.M. (eds.) (2005). *Mammal Species of the World. A Taxonomic and Geographic Reference*. Third Edition. Johns Hopkins University Press, Baltimore.

World Life Expectancy. (2026). Aoudad life expectancy. Available at: https://www.worldlifeexpectancy.com/mammal-life-expectancy-aoudad (Accessed: 19 February 2026).