RISK ASSESSMENTS FOR EXOTIC REPTILES AND AMPHIBIANS INTRODUCED TO AUSTRALIA – Cane Toad (*Bufo marinus*) (Linnaeus, 1758)

Class - Amphibia, Order - Anura, Family - Bufonidae (Gray, 1825), Genus - *Bufo* (Laurenti, 1768); (The Reptile Database 2007, Catalogue of Life 2008)

GOVERNMENT OF WESTERN AUSTRALIA

Department of Agriculture and Food

Score Sheet

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SPECIES: Cane Toad (*Bufo marinus*)

Other common names include: Marine Toad; Giant Toad.

Synonyms:

Rana marina

Chaunus marinus

(Christy et al 2007b, Catalogue of Life 2008).

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Species Description – Largest of the toads, short, squat body with short legs. Up to 15 cm snout-vent length, females are noticeably larger than the males. Grey, brown, olive-brown or reddish-brown above, adults rarely with any marked pattern other than dark brown caps to the wards, whereas juveniles have a series of narrow dark bars, dashes or lines on the head and back. Whitish or yellow below, usually speckled or mottled with dark brown. Skin very dry and warty above, granular below. A prominent pair of parotoid glands, located behind each eye. The supraocular region is warty and is separated from the smooth interorbital region by a high bony ridge, the ridge on each side continuing forward to meet on the snout between the nostrils. Fingers free, toes with a tough leather webbing. Tadpoles are less than 3.5 cm long, are jet black above and silvery white with black spots below (Cogger 2000, Lever 2001, Cameron 2002, Robinson 2002, Churchill 2003).

General Information – The species is very flexible in regards to breeding sites, with eggs and larvae developing in most slow or still shallow waters of ponds, ditches, temporary pools, reservoirs, canals and streams, and it can tolerate salinity levels of up to 15%. Clutch size is between 8,000-17,000 (Cameron 2002, Solis et al 2004).

Females can produce up to 20,000 black eggs, about 1 mm in diameter, in long jelly strings about 3 mm thick, which are usually attached to submergent or emergent aquatic vegetation. The number of eggs per female increases with body size (Gray and Massam 2005, Lannoo 2005).

Cane Toads can survive the loss of up to 50% of their body water, and can survive temperatures ranging from 5-40°C (Cameron 2002, Churchill 2003).

Longevity – Maximum longevity 24.8 years (HAGR Human Ageing Genomic Resources 2006). An ago of 40 years has been attributed to a similar species of Bufo in captivity (Lannoo 2005).

Status –

1. Red List Category – Least Concern (LC)

Rationale: Listed as 'Least Concern' on the IUCN Red List of Threatened Species, in view of its wide distribution, tolerance of a broad range of habitats, presumed large population, and because it is unlikely to be declining fast enough to qualify for listing in a more threatened category (Solis et al 2004).

CITES listed Protection Status – Not listed (CITES 2007).

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DATE OF ASSESSMENT: 21/07/2008

Bird and Mammal Model, and Reptile and Amphibian Model Used: (Bomford 2008) using PC CLIMATE (Brown et al 2006, Bureau of Rural Sciences 2006)

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The Risk Assessment Model

Models for assessing the risk that exotic vertebrates could establish in Australia have been developed for mammals, birds (Bomford 2003, Bomford 2006, 2008), reptiles and amphibians (Bomford et al 2005, Bomford 2006, 2008). Developed by Dr Mary Bomford of 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 was originally published in 'Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia' (Bomford 2003) available online http://www.daff.gov.au/brs/land/feral-animals/management/risk . This model used the Apple Mac application CLIMATE (Pheloung 1996) for climate matching.

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		The risk assessment model was revised and recalibrated 'Risk Assessment for the Establishment of Exotic Vertebrates in Australia: Recalibrated and Refinement of Models'(Bomford 2006) and the climate application changed to PC CLIMATE software (Bureau of Rural Sciences 2006), available online at http://affashop.gov.au/product.asp?prodid=13506. The most recent publication (Bomford 2008) includes updated instructions for using the exotic vertebrate risk assessment models and an additional model for freshwater fish. A bird and mammal model for New Zealand has also been included. **Which models are being used for the assessments:** Birds and mammals have been assessed using the Australian Bird and Mammal Model (Bomford 2008), pp 16-28, including both versions of stage B, models 1 (4 factors) and 2 (7 factors). All reptiles and amphibians were assessed using three models; the Australian Bird and Mammal Model (Bomford 2008), including Model A, using 3 factors from stage B (pp 54-55), and Model B, using 7 factors from stage B (pp 20), and the Australian Reptile and Amphibian Model (Bomford 2008), p 51-53. The rational for using additional models for reptiles and amphibians is to compare establishment risk ranks of the three models for a precautionary approach. If the models produce different outcomes for the establishment potential of any reptile or amphibian, the highest ranked outcome should be used (Bomford 2008). **Climate Matching Using PC CLIMATE** Sixteen climate parameters (variables) of temperature and rainfall are used to estimate the extent of similarity between data from meteorological stations located in the species' world distribution and in Australia. Worldwide, data (source; worlddata_all.txt CLIMATE database) from approximately 8000 locations are available for analysis. The number of locations used in an analysis will vary according to the size of the species' distribution. Data from approximately 762 Australian locations is used for analysis. To represent the climate match visually, the map of Australia has been divided into 2875 grid squares, each measured in 0.5 degrees in both longitude and latitude. CLIMATE calculates a match for each Australian grid by comparing it with all of the 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. These levels of climate match are used in the risk assessment for questions B1 (scores are summed to give a cumulative score), C6, and C8. For a grid square on the Australian map to score highly, it must match closely all 16 climatic variables of at least one meteorological station in the species' distribution for each level of climate match. [The score for each grid is based on the minimum Euclidian distance in the 16- dimensional variable space between it and all stations in the species' distribution. Each variable is normalized by dividing it by its worldwide standard deviation.]
LITERATURE SEARCH TYPE AND DATE: NCBI, CAB Direct, MEDLINE, Science Direct, Web of Knowledge (Zoological Records, Biological Abstracts), SCIRUS, Google Search and Google Scholar 16/05/2008		
FACTOR	**SCORE**	
PROBABILITY ESCAPED OR RELEASED INDIVIDUALS WILL ESTABLISH FREE-LIVING POPULATION		
Model A: Using the first three factors/questions from stage B of the Australian Bird and Mammal Model (Bomford 2008) pp 54-55)		
B1. Degree of climate match between species overseas range and Australia (1–6)	5	*Climate Match Score = 2041 Very high climate match with Australia* [See above for information on climate matching.] Climate data from 497 locations (see species' worldwide distribution map) were used to calculate the CMS. Overseas distribution Central and northern South America, with introduced populations occurring worldwide (Lever 2006) (see B2 and B3 for details).

B2. Exotic population established overseas (0–4)	4	*Exotic population established on an island larger than 50 000 km^2 or anywhere on a continent* **Asia** • Japan – 10 Cane Toads were released in 1949 on Chichijima in the Ogasawara (Bonin Islands) by US army personnel. In the 1970s, the toads from Chichijima were transferred to Hahajima in the same archipelago, and are now found all over these two islands. At an unknown date, Cane Toads were introduced to Kita-Daitojima and Minami-Daitojima in the eastern Okinawa Islands of the Ryukyu Archipelago. Some toads were also transferred in 1978 to the town of Nakura on Ishigakijima, where they are now abundant throughout most of the island (Lever 2001, Lever 2006, Kidera et al 2008). • Philippines – A number of Cane Toads were imported to the island Luzon in 1934, to control insect pests in sugarcane plantations. Some escaped into the nearby countryside, where several years later the species had become established in large numbers. Around the same time, Cane Toads were deliberately released in Calauang and Pila in Laguna Province, and in the Central Luzon provinces. Within seven years they had become common in these areas. Other introductions to Philippine islands occurred between 1936-1950. By 1949, the toad had spread from Luzon to southern Mindanao, spreading both naturally and with human assistance. It has been suggested that Cane Toads are virtually ubiquitous throughout the archipelago, and they are known for certain to occur on at least 18 Philippine islands (Rabor 1952, Soriano 1965, Lever 2001, Solis et al 2004). • Taiwan – A number of attempts since the mid-1930s were made to introduce the species to Taiwan, but it has never become established (Lever 2001, 2006). • Thailand – Some Cane Toads escaped from a private collection in Bangkok in 1975; however the species never became established in the wild (Lever 2001, 2006). **Africa** • Egypt – In 1937, Cane Toads were introduced to Egypt, but they failed to become established (Lever 2001, 2006). **North America** • Bermuda – Cane Toads were introduced to the Bermuda Islands around 1885, or possibly as early as 1812.They are common on all the larger islands, and also occur on a few of the smaller islands (Lever 2001, 2006). • Florida **–** Around 100 toads were accidentally released at the Miami International Airport in 1955, and they successfully established in the wild. Previous attempts to deliberately introduce the species as a biological control agent for agricultural insect pests, as well as to help control rats and mice, had been unsuccessful. The species now occurs along the coast in south-eastern Dade County, north to the south-east of Broward County. An isolated population is established in West Palm Beach, Palm Beach County. It is limited by the Atlantic Cocean to the east, and by the Everglades to the west (Krakauer 1968, Lever 2001, Punzo and Lindstrom 2001, Churchill 2003, Lannoo 2005, Lever 2006, Meshaka et al 2006). • Louisiana – Several introductions have been made, however the species has not established (Lever 2001, 2006). **South America** • Antigua – The date of introduction is uncertain, however the species is now very common. It has become less abundant in recent years, probably the result of the small Indian Mongoose (*Herpestes javanicus*). Introduction probably occurred some time during 1934-1950 (Lever 2001, 2006). • Barbados – The species was introduced around 1833. While it has not flourished as well as in other places it

		was introduced, the Cane Toad is still abundant and widespread across the island (Lever 2006). • Carriacou – Cane Toads appear to have gained access to Carriacou in the Grenadines in 1999, where they were first seen near the principal town, Hillsborough. From here they soon spread across the forested hills to ponds 6.5 km away. It is believed they arrived in barges importing gravel from Grenada or Guyana (Lever 2001, 2006). • Cuba – Cane Toads were introduced to Cuba sometime prior to 1884 and again in 1946 to control plagues of small rodents that were ravaging the sugarcane plantations. However the species did not establish, possibly because of the frequent severe droughts on the island, and the paucity of permanent fresh water bodies for spawning (Lever 2001, 2006). • Cayman Islands – It is thought the species was introduced around 1994. The species has spread from George Town to the entire western half of Grand Cayman. No reports have come in from Cayman Brac or Little Cayman (Lever 2001, 2006). • Grenada – The species was introduced to Grenada before the 1870s, and have become established (Lever 2001, 2006). • Guadeloupe – The date of introduction is unknown, but was clearly prior to 1880, when specimens are known to have been collected in unspecified localities (Lever 2001, 2006). • Hispaniola (Haiti and Dominican Republic) – Cane Toads were reputedly introduced to Haiti in 1932, and to the Dominican Republic before 1938. The species is currently widespread in the lowlands throughout Hispaniola, especially in agricultural regions, but also in the arid Valle de Neiba in the south of the island (Lever 2001, 2006). • Jamaica – Cane Toads were introduced around 1844 and have become established (Lever 2001, 2006). • Marie Galante – It is uncertain whether the toad is or is not present on Marie Galante (Lever 2006). • Martinique – Cane Toads were introduced to Martinique sometime prior to 1844. The population appears to have declined in recent years (Lever 2001, 2006). • Montserrat – The species was introduced sometime prior to 1879. In 1995, it was noted that Cane Toads are established throughout the island, and are strongly associated with man-modified habitats (Lever 2001, 2006). • Nevis – Cane Toads were introduced to Nevis sometime prior to 1922. A survey carried out in 1999 revealed that below 500 m the toads are widely distributed on Nevis. Their status above 500 m is unknown (Lever 2001, 2006). • Puerto Rico – The species was introduced to Puerto Rico around 1920, in an attempt to control May Beetles (*Phyllophage portoricensis*), which were stripping the foliage from plants in the sugar cane fields and whose grubs were destroying the roots. In 1923-24, a second introduction of around 40 toads occurred. In 1926, it was reported that the toads had increased to such an extent that they could be found in considerable numbers at the western end of the island, and were spreading to other localities. By the 1930s, Cane Toads had become established throughout the littoral regions of Puerto Rico, and some had even penetrated the interior. Today, the toads occur mainly in the coastal lowlands of Puerto Rico (Lever 2001, Lannoo 2005, Lever 2006). • St Kitts (St Christopher) – Cane Toads were introduced to the island prior to 1904, with a second introduction occurring before 1914 (Lever 2001, 2006). • St Lucia – Cane Toads were introduced to St Lucia prior to 1879. The species is now widely distributed over the island (Lever 2001, 2006).

		• St Vincent – The date of introduction is uncertain. The Cane Toad population on St Vincent seemed to peak in the 1950s an d1960s; after that, numbers began to decline (Lever 2001, 2006). • US and British Virgin Islands – Cane Toads were introduced to St Croix in 1934, where within 2 years they had spread 6.4 km from their release site, and were described as 'well dispersed'. Toads on St Thomas had probably been introduced in the early or mid-1940s. Cane Toads also reportedly occur on St John in the US Virgin Islands (Lever 2001, 2006). • West Indies – The Cane Toad was introduced to the islands in the Caribbean between 1844-1946 as a biological control agent, where it is now firmly established (Lever 2001). **Oceania:** • Chagos Archipelago – It is thought that the toad was introduced between 1980-1989, but it is uncertain whether the introduction was deliberate or accidental. In 1996, Cane Toads were said to be widespread and abundant, and are continuing to expand their range (Lever 2001, 2006). • Mauritius – In the early 1930s and again in the 1940s, shipments of Cane Toads were despatched from Puerto Rico to Mauritius, where they were refused entry. Why the toads' entry was refused appears to be unknown (Lever 2001, 2006). • American Samoa – In 1953, several Cane Toads were imported to the island of Tutuila, where by 1976 they had multiplied to an estimated 2 million. The toads have also colonised neighbouring Aunu'u Island, but not elsewhere in American Samoa or in Western Samoa. On Tutuila, they are most abundant in lowland urban areas, and less common in upland regions (Lever 2001, 2006). • Cook Islands – The species is not established here. A single live Cane Toad was caught near the international airport in 1986 (Lever 2001, 2006). • Federated States of Micronesia – Cane Toads were introduced to Ponape (Pohnpei) by occupying Japanese forces during WWII to control grasshoppers and mosquitoes. The toads are also present on the Truk Islands and on Kusaie (Kosrae) Island. Some were also taken to Ulithi Atoll, where they were destroyed on arrival. The Cane Toad was introduced to Yap Island in 1939-40 (Lever 2001, 2006). • Fiji – The government first considered the possibility of introducing toads in 1933 to control pests of sugarcane, bananas, and other crops. Two years later the decision was made to proceed, and in the following year 67 toads were imported. Their offspring were released in various localities on Viti Levu, where breeding in the wild was reported in 1937. In the same year 50 tadpoles were shipped to Taveuni Island, and 200 to Rabi Island. Later, Cane Toads were planted in many parts of Viti Levu, and also on Vanua Levu, Taveuni and Rabi again, and Kadavu. The only large island on which it is not established is Gau, and probably most of the medium and smaller inhabited islands as well (Hinkley 1962, Pernetta and Watling 1978, Lever 2001, 2006). • Hawaiian Islands – In 1932, 149 toads were imported, and liberated in upper Manoa Valley, and at Waipio on the island of Oahu. Breeding was confirmed later that year, and the toads were considered to have become established. Two years later, it was reported that toads were multiplying on Oahu, where they had increased their numbers to many thousands. In late 1933, the number of toads and their range further increased, and translocations were made elsewhere in Oahu and to other islands. In early 1934, several thousand toads were despatched to every plantation in the Territory. Although there is no record of introductions to Molokai, it is known that at least 2 consignments of several dozen juveniles were made during the period. By the mid-1950s, Cane Toads were established in suitable habitats on all the main Hawaiian islands, where they became the most abundant amphibian, and where they still remain (Lever 2001, 2006). • Kiribati – Cane Toads were collected on Kuria Atoll in the Gilbert Islands in 1964, and on Cooper Island, off

Palmyra Island in the Line Islands in 1964 and 1966. Date of introduction is uncertain. The present status of the species on Kiribati is uncertain (Lever 2006).

- Guam, Marianas Islands – The exact date and number of Cane Toads introduced to the island of Guam is uncertain. Some reports say that in 1937 some 19 toads were released at Agana Springs; others state that fewer than 39 individuals were introduced to Guam in 1937. Or, 19 toads may have been released at Agana Springs in 1937, followed by a further 41 in 1938. The Cane Toad is now established island-wide on Guam (Lever 2001, 2006, Christy et al 2007a, Christy et al 2007b). Cane Toads were introduced to Rota in 1944, and are now found throughout most habitats on the island (Reed et al 2007).
- Republic of the Marshall Islands – The only occurrences of Cane Toads in the Marshall Islands have been a few cases where individuals have been brought in from the nearby islands in the Federated States of Micronesia and Hawaii. Cane Toads have not been able to establish themselves in the Marshall Islands, as the narrow atolls and salty environment is too harsh for them to survive (Lever 2001, 2006).
- Republic of Palau (Belau) – The exact date of introduction is unrecorded, but as specimens were first collected in the early 1950s it seems likely that it was during or shortly after WWII, when the islands were occupied by the US military (Lever 2001, 2006).
- Solomon Islands – Cane Toads were introduced to Guadalcanal in 1940, 1943, and 1944; Banik Island in 1944; Gavutu Island in 1945; and at an unrecorded date to Banika Island in the Russell group (Lever 2001, 2006). The toad has also recently spread to San Cristobal (Makira) Island, at the eastern edge of the main chain of the Solomon Islands. The species probably reached the island as stowaways in vessels and cargo (Heinsohn 2006).
- Tuvalu – In 1939, 150 adult Cane Toads were imported to Funafuti Atoll in Tuvalu, from where they were later transferred to Vaitupu Atoll. It is not known whether this introduction was successful (Lever 2001, 2006).

Australasia:

- Australia – The Cane Toad was first introduced to Australia in 1935, when the Australian Bureau of Sugar Experimental Stations imported approximately 100 toads from Hawaii, bred them, and released more than 3000 in Queensland, in an attempt to control scarab beetles, that were pests of sugarcane.. It has rapidly spread, and today the Cane Toad occurs on the coast and hinterland of eastern Queensland, extending into the northern rivers region of NSW, and extending further west each year into western Queensland and the Northern Territory. In New South Wales they occur on the coast as far south as Yamba, and there is an isolated colony near Port Macquarie (Cogger 2000, Cameron 2002, Churchill 2003, Department of the Environment and Heritage. 2004, Lannoo 2005, Lever 2006).
- The Cane Toad also continues to expand its range southwards at about 1.3 km a year, and can be accidentally transported to new locations, for example in pot plants or loads of timber (Department of the Environment and Heritage. 2004). In 1974, shipments of the progeny of the stock introduced to Queensland, destined for dissection at schools, were accidently released at Darwin and at Perth. Intensive searches were mounted, and it is believed that all of the liberated animals were recaptured or probably perished (Tyler 1975).

A map of the current distribution of the Cane Toad in Australia, as well as predicted distribution in future years, is provided in (Urban et al 2007). Expanding its range west in the Northern Territory, the Cane Toad has been recorded in Western Australia at the Kununurra checkpoint (13/03/2009) (G.Gray/E.Kruger, pers. comm.).

- Papua New Guinea – Cane Toads were first introduced to New Guinea in 1937. This introduction was made on the Gazelle Peninsula of New Britain, and was followed by introductions on the mainland north and south of the mountain chain. In 1938 or 1948, Cane Toads were imported to Port Moresby for human pregnancy testing: when the toads were found unsuitable for this purpose, they either escaped or were deliberately released. Following these early introductions, Cane Toads were distributed to various localities throughout

		Papua New Guinea. During WWII, occupying Japanese troops, and later American liberators, are believed to have taken toads from New Britain to other islands in the archipelago. The toad is now abundant in urban areas, gardens, and plantations, and is less commonly seen in undisturbed forest localities (Lever 2001, Lever 2006). For further information regarding introduced range of the Cane Toad, see (Lever 2001).
B3. Overseas range size score (0–2) < 1 = 0; 1 – 70 = 1; >70 = 2	1	*Overseas range size between 1-70 million km^2, estimated at 12.25 million km^2. Includes current and past 1000 years, natural and introduced range.* The species is very abundant and increasing its range (Solis et al 2004). It naturally occurs from around 30°N in western Mexico and in the Lower Rio Grande Valley in extreme southern Texas, south through Mexico and Central America, to northern South America: central Brazil and Amazonian Peru, and northern parts of Amazonian Bolivia, Columbia, Venezuela, and the Guianas, as well as Trinidad and Tobago (Mattison 1993, Lever 2001, Lannoo 2005, IUCN et al 2006, Lever 2006). Occur at altitudes from sea level to 1,600 m (in Venezuela) (Lannoo 2005). Introduced populations occur worldwide (Lever 2006) (see B2 for details).
ESTABLISHMENT RISK SCORE **SUM OF SCORE A (B1) + SCORE B (B2) + SCORE C (B3) (1-12)**	**10**	
Model B: Using the seven factors/questions from stage B of the Australian Bird and Mammal Model (Bomford 2008) pp 20)		
B4. Taxonomic Class (0–1)	1	*Amphibian (Catalogue of Life 2008).*
B5. Diet score (0–1)	1	*Generalist with a broad diet of many food types* Cane Toads will eat almost anything they can swallow, including pet food, carrion and household scraps, but the majority of the diet consists mainly of living insects and other arthropods including beetles, honey bees, ants, termites, crickets, centipedes and bugs. Marine snails, scorpions, spiders, smaller toads and frogs, small snakes, and small mammals (e.g. mice) are occasionally consumed (Freeland 1986, Lever 2001, Robinson 2002, Churchill 2003, Solis et al 2004). Tadpoles eat algae and other aquatic plants and also filter organic matter from the water. Large tadpoles sometimes eat other Cane Toad eggs (Churchill 2003, Lannoo 2005). The diet of the Cane Toad within its natural habitat consists of a diversity of arthropod fauna, dominated by beetles and ants, as well as minor prey groups including Orthoptera, Lepidoptera, Diptera, Hymenoptera, as well as millipedes and spiders. Carrion (chicken and fish bones) is also taken by toads near villages (Evans and Lampo 1996). Cane Toads are considered to be non-specific and aggressive predators, and will occasionally consume native frogs and toads, even dog food and faeces. The size of prey is largely limited by the toad's jaw gape and the distension of its stomach (Lannoo 2005). A study of the diet of Cane Toads in Papua New Guinea revealed that ants composed 46%, snails 42%, and most of the remaining 12% were from 4 insect orders. Trace items (frequency of less than 1%) included 2 skinks and 2 small toads (Bailey 1976). Stomach contents of Cane Toads from Hawaii were 40% by weight plant material; and animal items found consisted by weight of Coleoptera (17.4%), Diplopoda (22.8%), Gastropoda (36.5%), and Lepidoptera larvae (9.6%); no other order was greater than 5%. It was thought that the Cane Toad was a predator of the invasive Puerto Rican Frog (*Eleutherodactylus coqui*), however non of the sample stomachs examined contained *E. coqui* (Beard and Pitt 2006).

B6. Habitat score - undisturbed or disturbed habitat (0–1)	1	*Can live in disturbed habitats* A nocturnal and terrestrial toad that inhabits humid areas with adequate cover, including moist forest and woodlands, open forest, grasslands and savannah, and beach dunes. It thrives in degraded habitats and man-made environments, and is occasionally found in pristine lowland and montane rainforests, but generally prefers open or disturbed habitat such as tracks, roads, low grassland, and areas that are near human settlement, such as grazing land, suburban parks and gardens. It tends to avoid more densely vegetated areas, such as wet sclerophyll and rainforest, which can then act as a barrier to their dispersal (Cogger 2000, Lever 2001, Solis et al 2004). Where introduced, Cane Toads are found mainly in disturbed areas, such as around buildings, in yards, on roads, in suburban gardens, and near canals and ponds (Churchill 2003, Lever 2006). Cane Toads are also found in a variety of agricultural habitats, including sugarcane fields, pastures, banana plantations, coconut plantations, and rice fields (Hinkley 1962, Lever 2006).
B7. Non-migratory behaviour (0–1)	1	*Non-migratory or facultative migrant in its native range OR unknown* The only 'migrations' made by marine toads are to and from breeding sites at the onset and the closure of the wet/breeding season (Lannoo 2005). In Australia, male toads begin to move toward breeding sites from aestivation sites with rise in temperature after winter (usually around August-September). Females appear at the sites only when they are ready to breed and have mature oocytes (Lannoo 2005). Newly metamorphosed toads require easy access to water to facilitate gas exchange and to prevent desiccation and often stay within 1-5 m of the water. Within 3-4 days following metamorphosis, juveniles (less than 30 mm) disperse and do not return until they are about 90 mm. As toads get older and larger, they are found at greater distances from water (Lannoo 2005). Home range size is variable, dependent on size of water bodies and feeding sites. Displaced animals will return to their capture site (using visual cues) (Lannoo 2005).
ESTABLISHMENT RISK SCORE **SUM OF B1-7 (1–16)**	**14**	
Australian Reptile and Amphibian Model (Bomford 2008, pp 51-53)		
Score A. *Climate Match Risk Score Degree (Sum of species 4 scores for Euclidian match classes 7 – 10)*	54.9	*CMRS = 100(1531/2785)* Overseas distribution Central and northern South America, with introduced populations occurring worldwide (Lever 2006) (see Score C of Bird and Mammal Model for details).
Score B. *Has the species established an exotic population in another country? (0–30)*	30	*The species has established a breeding self-sustaining population in another country* Introduced populations occur worldwide (Lever 2006) (see Score B2 of Bird and Mammal Model for details).
Score C. *Taxonomic Family risk score (0–30)*	20	*Very high risk family (Bomford 2006)* Family Bufonidae (Catalogue of Life 2008).
ESTABLISHMENT RISK SCORE **SUM OF SCORE A + SCORE B + SCORE C (0 – ≥116)**	**104.9**	
PUBLIC SAFETY RISK RANK		

Risks to public safety posed by captive or released individuals (using the questions from stage A of the Australian Bird and Mammal Model (Bomford 2008, pp 17)		
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.*	0	*All other animals posing a lower risk of harm to people (i.e. animals that will not make unprovoked attacks causing injury requiring medical attention, and which, even if cornered or handled, are unlikely to cause injury requiring hospitalisation.* A threatened Cane Toad will usually hop rapidly away. If escape is impossible, it will face its enemy and inflate its body with air to appear larger. Occasionally the toad under threat will actually lunge at its attacker (Lever 2001). When a Cane Toad is attacked, it exudes a milky liquid (bufotoxin), which acts as an irritant to the mucous membranes of the attacker. The poisonous glands, known as parotid glands, occur in two concentrations behind each eye. Additional poison glands are present on the thighs (Mattison 1993, Churchill 2003). The bufotoxin is a mixture of bufotenine and epinephrine, a steroid-like substance that is toxic to most animals (Lannoo 2005). This secretion can be sprayed up to a metre, however Cane Toads will spray only in reaction to severe mental or physical stress (Lever 2001). The poison can irritate human skin, but it is fatal to small animals including domestic cats and dogs (Roberts et al 2000, Reeves 2004). It has been reported, though not always confirmed, that humans have died from eating Cane Toads and/or its eggs (Churchill 2003). The greatest risk to man is the injection of venom into the eyes, which can cause pain. There is also the threat of the venom entering the blood stream through a break in the skin (Lever 2001).
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)*	2	*High risk (feasible and consequences could be fatal)* The secretions from the parotid glands of Cane Toad is highly toxic, all stages of the Cane Toad's lifecycle are poisonous. The venom acts principally on the heart. Overseas, people have died after eating toads. A Cane Toad responds to a threat by turning side-on so its parotid glands are directed towards the attacker. The venom usually oozes out of the glands, but the toads can squirt a fine spray a short distance if they are handled roughly. The venom is absorbed through mucous membranes of the eyes, mouth and nose. In humans, it may cause irritation of the skin and burning of the eyes, intense pain, temporary blindness and inflammation (Cameron 2002, Robinson 2002). It is uncertain whether any human deaths from Cane Toad poisoning have occurred in Australia – (Cameron 2002) states that no humans have died in Australia from Cane Toad poison, however (Lever 2001) mentions that in Australia, there have been reports of illness and death from the deliberate licking of Cane Toads by youths in search of an hallucinatory experience. Dried toad venom is used in China as a tradition medicine known as *chan su* and is a major component of *kyushin*, another popular medication in Asia. Toad venom poisoning may predominantly manifest as gastrointestinal, mental, and cardiac disturbances. A healthy 40 year old man developed gastrointestinal symptoms after ingesting three pills of an unknown aphrodisiac. He rapidly developed severe life threatening cardiac arrhythmias and died after a few hours. Toad venom, a constituent of the aphrodisiac, was considered responsible death (Gowda et al 2003). In the Philippines, one case of human fatality in 1941 when the Chief of Detectives of a municipality of Iloilo Province, Panay, died after a meal of 3 toads (mistaken for edible frogs), testing of the remains of the meal identified them as Cane Toads (Rabor 1952). In Peru, a woman and her four year old daughter are thought to have died following the consumption of water in which Cane Toad eggs were boiled by her son. The nine year old boy had earlier that morning gathered numerous strings of Cane Toad eggs from a nearby marsh and then boiled them in water, which the family drank (Lever 2001).
PUBLIC SAFETY RISK SCORE	**2**	

SUM OF A1 + A2 (0-2)		

OTHER INFORMATION TO ASSESS PEST RISKS

Checklist of factors associated with increased risks of adverse impacts of established species (Bomford 2008, pp 90-91)

NB – an asterisk (*) denotes factors that have not been researched to the same degree as other factors, and were generally addressed using standard textbooks only

FACTOR	TICK IF YES	
1. Has adverse impacts elsewhere *Impacts can be economic, environmental or social; impacts can be significant or subtle.*	✓	*Reported to be a moderate environmental pest in any country or region [score = 2, using scoring from Australian Bird and Mammal Model Q C5 (0-3)].* **Caribbean:** It has been suggested that Cane Toads may outcompete the Mountain Chicken (*Leptodactylus fallax*) (a frog) on both Martinique and Montserrat, however these suggestions have been rejected (Lever 2006). **Japan:** Introduced to Chichijima and Hahajima, the Cane Toad has had a negative impact on the islands' terrestrial fauna, in particular endemic snails and insects. It has also polluted the freshwater supply through the deposition of eggs in dams and the subsequent emergence of tadpoles (Lever 2006). **Florida:** The Cane Toad has become an additional food source for a variety of predators in Florida, including birds, snakes, and fish. Because Florida has two native species of *Bufo*, native predators have an evolutionary exposure to bufotoxin, and are therefore not harmed by it. However, the Cane Toad may be competing and preying on the native Southern Toad *Bufo terrestris*. The extent of competition and predation have yet to been assessed, however it is thought that the presence of the Cane Toad has at least contributed to the relative scarcity of the Southern Toad in parts of Dade County (Lever 2006). One study found that Cane Toad tadpoles did not significantly impact the growth, development or survivorship of tadpoles of two native anurans, the Southern Toad (*Bufo terrestris*) and the Green Treefrog (*Hyla cinerea*) (Smith 2005). **American Samoa:** The Cane Toad may compete with the native insectivorous Sheath-tailed Bat (*Emballonura semicaudata*) on American Samoa (Knowles 1988) as cited in (Grant 1995). While prey of the bat on American Samoa has not been studied, it has been observed that most prey taken by toads are ground-dwelling. However, over 60% of prey items taken by the toads studied in suburban/park habitat, and over 40% of prey items taken in forest habitat, have wings in the adult life-history stage. Because bat populations have also declined on islands lacking toads, it is unlikely toads would compete for food resources with the bat (Grant 1995). **Philippines:** It has been claimed that following the initial introduction of the Cane Toad in the Philippines, so many cats died from eating the species that there was a plague of rats (which had previously been kept under control by the cats) (Tyler 1975). **Papua New Guinea:** Papua New Guinea has no ecological native anuran equivalent to the Cane Toad, and adult native frogs are unlikely to come into competition for food, shelter, or refuges with the species, and only to a limited extent for spawning sites (Herington 1977, Lever 2006). **Australia:** Cane Toads eat some native vertebrates, including young snakes, frogs, and small marsupials. Although vertebrates comprise a relatively small percentage of the toads' diet, such predation could have a significant effect on some prey populations (Lever 2006), particularly those already threatened or endangered (Department of the Environment and Heritage. 2004). Cane Toad toxin kills some native vertebrates, mainly predatory species. Large lizards, some snakes, and endemic *Dasyurus* spp. seem especially vulnerable to Cane Toad toxin, and there are numerous reports of such species virtually disappearing locally following colonisation by toads (Lever 2006). Adult Cane Toads may also compete for food with some native vertebrates, such as native frogs *Limnodynastes*

		terraereginae and *Litoria caerulea* (Lever 2006). Adult Cane Toads compete with some native vertebrates for shelter and refuges, and compete with native amphibians for breeding sites. The species may compete successfully with the native Common Green Tree Frog *Litoria caerulea* for spawning sites in Australia. The Cane Toad is more prolific than most northern Australian frogs, and its tadpoles tend to assemble in huge congregations, which may help them to outcompete tadpoles of native species (Department of the Environment and Heritage. 2004, Lever 2006). An investigation as to whether the Cane Toad was a predator of native anuran eggs, hatchlings and larvae found that Cane Toad tadpoles were not significant predators of native anuran eggs, hatchlings or tadpoles, and that native tadpoles, such as *Limnodynastes ornatus*, had a greater impact on the survival of early life history stages of native anurans (Crossland 1998). A study to determine within-habitat competitive relationships between the Cane Toad and dry season communities of native frog species around waterholes in the Gulf of Carpentaria lowlands also revealed that the Cane Toad had no observable impact on habitat and food use by the native frog species, or on the species compositions and population sizes of native frog communities active during the dry season It is acknowledged that the Cane Toad could possibly have a negative impact on the native frogs by eating them; however in the course of this study and a previous one by the author, over 550 Cane Toad stomachs were examined, and the remains of native frogs were found in only 3 (Freeland and Kerin 1988). It has been estimated that Cane Toads threaten populations of approximately 30% of terrestrial Australian snake species. In one particular study, most snake species tested exhibited low tolerance to the toxins of the Cane Toad (Phillips et al 2003). Alternatively, Australian Black Snakes (*Pseudechis porphyriacus*) appear to have developed a physiological resistance to Cane Toad toxins, and have learnt to avoid this species as prey (Phillips and Shine 2006). The recent arrival of Cane Toads in Kakadu National Park has been linked to a marked decline in native predators in the park, especially Northern Quolls *Dasyurus hallucatus* and large Goannas (*Varanus* spp.) (Department of the Environment and Heritage. 2004). Along the Daly River in the Northern Territory, the Yellow-spotted Monitor Lizard (*Varanus panoptes*) has experienced a marked decline in relative population numbers as a result of predation on the Cane Toad. The species has been reduced to such low numbers that it is currently no longer a significant predator of Pig-nosed Turtle (*Carettochelys insculpta*) eggs (Doody et al 2006). Experimental trials conducted on the invertebrate fauna of a tropical floodplain near Darwin, found that Cane Toad presence significantly reduced invertebrate abundance and species richness, but only to about the same degree as did an equivalent biomass of native frog species. It was concluded that, if Cane Toads simply replaced native anurans, the offtake of invertebrates might not be substantially different from that due to native anurans before toad invasion (Greenlees et al 2006). Cane Toads have been identified as active nest predators and competitors of Rainbow Bee-eaters (*Merops ornatus*). During a three-year study, Cane Toads ruined one-third of nest attempts of ground-nesting Rainbow Bee-eaters, by invading and taking over their nest burrows and preying upon their eggs and young nestlings. Cane Toads are having a significant negative effect on the population level: at present, Rainbow Bee-eaters produce 0.8 fledglings per nest; however, in the absence of Cane Toads, each nest would produce 1.2 fledglings. Nests that were deep, and those built on steep slopes were still preyed upon by the toads. Cane Toads were significantly more likely to prey upon nests containing hatchlings rather than eggs. Rainbow Bee-eaters have little defence against the Cane Toads, as the diurnal birds were not able to mob the nocturnal toads, nor were they able to eject Cane Toads from the nest (Boland 2004). Though everything adds up to the conclusion that Cane Toads could outcompete native fauna, this has yet to be established. It is suspected that there is a reasonable correlation between the reduction of some frog/skink populations and the invasion of the Cane Toad in Australia, and the CSIRO (Commonwealth Scientific and Industrial Research Organisation) have labelled them a “pest”. There is much cause for concern in Australia,

because Cane Toads poison pets with their toxins, poison many native animals whose diet includes frogs, tadpoles and frogs' eggs, prey on native fauna, compete for food with vertebrate insectivores such as small skinks, and may carry diseases that can be transmitted to native frogs and fishes (Churchill 2003).

Further information on the impact of the Cane Toad in Australia can be found in (Lever 2001).

Does not use tree hollows [score = 0, using scoring from Australian Bird and Mammal Model Q C4 (0, 2)].

The species uses hollow trees rather than tree hollow and would not be able to gain access to hollows above ground level.

Adults are nocturnal and during the day and in cold or dry weather shelter in crevices and hollows (Churchill 2003). During the day or during periods of aestivation it can be found beneath fallen trees, boulders, leaf litter, loose boards, matted coconut leaves, in hollow logs, old burrows of other animals, and similar cover (Solis et al 2004, Lannoo 2005).

Cane Toads may use hollow trees for shelter during the dry season, and dense vegetation during the wet season, in addition to rock crevices which are used throughout the year (Seebacher and Alford 1999, Robinson 2002). Shelters often contain more than one toad (Cohen and Alford 1996).

Minor pest of primary production in any country or region/ Moderate pest of primary production in any country or region [score = 1, using scoring from Australian Bird and Mammal Model Q C7 (0-3)].

Cane Toads can be beneficial in reducing the number of insects where infestation is a problem (Churchill 2003), such as in Puerto Rico, where the Cane Toad has been successfully introduced as a biological control agent of destructive pests of sugarcane. In 1932, a study of the diet and impact of the Cane Toad in the sugarcane plantations of Puerto Rico determined that Scarabeid beetles comprised 43.3% of the toad's diet, more than 25% was the destructive May Beetle (*Phyllophaga portoricensis*), and a further 12.5% was composed of large leaf-cutting Curculionid weevils, whose grubs were important destroyers of sugar-cane roots (Lever 2006).

Cane Toads were also successfully introduced to control the larvae of the Sweet Potato Hawk Moth (*Hippotion celerio*). Cane Toads also reportedly help to control outbreaks of caterpillars at Laloki. The species is said to have also been successful in reducing the numbers of the Pentatomid (*Megymenum papuense*), a minor pest of cucurbits in the Northern District. One study found that of the invertebrate prey consumed by 800 toads, a total of 351 were beneficial, 1943 were neutral, and 2198 were harmful (Lever 2006).

It is understood that when the Cane Toad was first introduced, many Fijians believed that the species was preying on prawns, and feared that as a result, prawns would disappear from the creeks. However belief was false, as the toads feed on land, and do not enter the water to take their food (Turbett 1938).

In Australia, the species consumes large numbers of honey bees, creating a management problem for bee-keepers (Churchill 2003). Toads tend to congregate around the entrance to hives, and a single toad has been known to consume over 100 bees in a day. To combat this predation, hives have to be placed on moveable wooden stands, which is a labour intensive and expensive procedure (Lever 2001, Lever 2006).

Moderate risk – injuries, harm or annoyance minor but many people at risk [score = 3, using scoring from Australian Bird and Mammal Model Q C11 (0-5)].

Cane Toad venom is an irritant to the skin of humans (Churchill 2003). The venom is absorbed through mucous membranes such as eyes, mouth and nose, and in humans may cause irritation of the skin and burning of the eyes, intense pain, temporary blindness and inflammation (Cameron 2002, Robinson 2002). Reports of human

		deaths resulting from consuming Cane Toad or their eggs (Rabor 1952, Lever 2001, Gowda et al 2003) (see A2 for details). **Zoonoses:** There are suggestions that Cane Toads may be beneficial to human health, in that the species consumes mosquitos, a major vector of human disease throughout the world. The presence of Cane Toad tadpoles in waterbodies appears to discourage oviposition by mosquitoes. In the laboratory, the presence of Cane Toad tadpoles significantly reduced the sizes of adult mosquitoes at emergence, and also reduced survival rates of the larvae of one mosquitoe species (Hagman and Shine 2007). It is known that Cane Toads feed on human faeces and where there is inadequate sewage disposal facilities, toads may spread the eggs of human parasites *Ascaris lumbricoides, Trichuris trichiura*, and *Schistoma mansoni*, as well as the eggs of *Uncinaria* canine hookworm*;* parasite eggs passed in toad faeces are viable; water supplies could be polluted (Lever 2006). In Grenada, Cane Toads have been implicated as being reservoirs for the bacteria *Leptospira interrogans*, which causes Weils disease (infectious jaundice) in humans (Global Invasive Species Database 2006). Some symptoms include intense headache, chills, fever, and possibly meningitis. The fatality rate is less than 1% (Stevenson and Hughes 1988). Toads readily eat faeces and can carry *Septicaemia*, *Salmonellosis*, and *Leptospirosis* (Speare 1990), and reportred to transmit Salmonella especially in areas where human hygiene is poor (O'Shea et al 1990, Department of the Environment and Heritage. 2004). Many amphibians carry *Salmonella* bacteria in their intestinal tract that are easily spread to humans however transmission from amphibians to humans occurs through ingestion of the bacteria; simply touching or handling an infected animal will not result in transmission. Overall, reptile and amphibian contacts are estimated to account for around 74,000 (6%) of the approximately 1.2 million *Salmonella* infections that occur each year in the United States (Mermin et al 2004).
*2. Has close relatives with similar behavioural and ecological strategies that have had adverse impacts elsewhere **	✓	The Black-spined Toad (*Bufo melanostictus*) is reported to be a minor environmental pest. Possible effect by the introduced black-spined toad on the number of native amphibian species around Manokwari in Papua, as native species numbers appear limited, e.g. *Platymantis papuensis*, the black-spined toad could compete with it and may also prey on its eggs and young (Lever 2006). Other members of the genus *Bufo* have also established exotic populations (Lever 2006).
3. Is dietary generalist	✓	Cane Toads will eat almost anything they can swallow, including pet food, carrion and household scraps, but the majority of the diet consists mainly of living insects and other arthropods including beetles, honey bees, ants, termites, crickets, centipedes and bugs. Marine snails, scorpions, spiders, smaller toads and frogs, small snakes, and small mammals (e.g. mice) are occasionally consumed (Freeland 1986, Lever 2001, Robinson 2002, Churchill 2003, Solis et al 2004).
*4. Stirs up sediments to increase turbidity in aquatic habitats **		No information found (Lever 2006).
*5. Occurs in high densities in their native or introduced range **	✓	In Australia, cane toad populations have been observed to increase dramatically within a short period, and the density of adult toads here exceeds that than in their natural range (Lannoo 2005). In the natural range, population density is 50-150 toads per hectare (NatureServe 2007).
*6. Harbours or transmits diseases or parasites that are present in Australia **	✓	Potential carrier of Chytridiomycosis (Schumacher 2006).

7. Has close relatives among Australia's endemic reptiles and amphibians		No Australian species in the family Bufonidae or genus Bufo (Catalogue of Life 2008; Cogger 2000).
*8. Is known to have spread rapidly following their release into new environments **	✓	Cane Toads appear to have gained access to Carriacou in the Grenadines in 1999, where they were first seen near the principal town, Hillsborough. From here they soon spread across the forested hills to ponds 6.5 km away. It is believed they arrived in barges importing gravel from Grenada or Guyana (Lever 2001, 2006). On the US and British Virgin Islands, Cane Toads were introduced to St Croix in 1934, where within 2 years they had spread 6.4 km from their release site, and were described as 'well dispersed'. Toads on St Thomas had probably been introduced in the early or mid-1940s. Cane Toads also reportedly occur on St John in the US Virgin Islands (Lever 2001, 2006). In 1953, several Cane Toads were imported to the island of Tutuila, American Samoa, where by 1976 they had multiplied to an estimated 2 million. The toads have also colonised neighbouring Aunu'u Island, but not elsewhere in American Samoa or in Western Samoa. On Tutuila, they are most abundant in lowland urban areas, and less common in upland regions (Lever 2001, 2006). In Oahu, Hawaii, the number of individuals increased from 148 to more than 100,000 within a two year period (Lannoo 2005). In Australia, the cane toad continues its northwesterly advance at a rate of 27-40 km/yr (Lannoo 2005).
9. Is predatory	✓	Cane Toads will eat almost anything they can swallow, including pet food, carrion and household scraps, but the majority of the diet consists mainly of living insects and other arthropods including beetles, honey bees, ants, termites, crickets, centipedes and bugs. Marine snails, scorpions, spiders, smaller toads and frogs, small snakes, and small mammals (e.g. mice) are occasionally consumed (Freeland 1986, Lever 2001, Robinson 2002, Churchill 2003, Solis et al 2004). Tadpoles eat algae and other aquatic plants and also filter organic matter from the water. Large tadpoles sometimes eat other Cane Toad eggs (Churchill 2003, Lannoo 2005). The diet of the Cane Toad within its natural habitat consists of a diversity of arthropod fauna, dominated by beetles and ants, as well as minor prey groups including Orthoptera, Lepidoptera, Diptera, Hymenoptera, as well as millipedes and spiders. Carrion (chicken and fish bones) is also taken by toads near villages (Evans and Lampo 1996). Cane Toads are considered to be non-specific and aggressive predators, and will occasionally consume native frogs and toads, even dog food and faeces. The size of prey is largely limited by the toad's jaw gape and the distension of its stomach (Lannoo 2005). A study of the diet of Cane Toads in Papua New Guinea revealed that ants composed 46%, snails 42%, and most of the remaining 12% were from 4 insect orders. Trace items (frequency of less than 1%) included 2 skinks and 2 small toads (Bailey 1976). Stomach contents of Cane Toads from Hawaii were 40% by weight plant material; and animal items found consisted by weight of Coleoptera (17.4%), Diplopoda (22.8%), Gastropoda (36.5%), and Lepidoptera larvae (9.6%); no other order was greater than 5%. It was thought that the Cane Toad was a predator of the invasive Puerto Rican Frog (*Eleutherodactylus coqui*), however non of the sample stomachs examined contained *E. coqui* (Beard and Pitt 2006).
Factors	**1**,2,3,**5**,6,8, 9	

Susceptible native Australian species (using question C6 from the Australian Bird and Mammal Model, Bomford 2008, pp 22-23)

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**	*One or more susceptible native species or ecological communities that are listed as vulnerable or endangered under the Australian Government* Environment Protection and Biodiversity Conservation Act 1999 *has a restricted geographical range that lies with the mapped area of the highest six climate match classes for the exotic species being assessed.* *[score = 5, using scoring from Australian Bird and Mammal Model Q C6 (0-5)].* Reference for all vulnerable or endangered species and communities (status noted in bold) (Dept of the Environment Water Heritage and the Arts 2007, 2008). Susceptible Australian native species or natural communities that could be threatened due to predation by the Cane Toad (small mammals, ground-nesting birds, frogs, small snakes, invertebrates), predation on the Cane Toad, and consequential death due to poisoning (carnivorous mammals, predatory birds, snakes, monitor lizards), or competition for food or breeding sites (frogs), include (but are not limited to): **Mammals:** **Vulnerable** – Western Quoll (*Dasyurus geoffroii*) **(vulnerable)** (Strahan 1995). **Birds:** **Endangered** – Buff-breasted Button-quail (*Turnix olivii*); **Vulnerable** – Black-breasted Button-quail (*Turnix melanogaster*) (Pizzey and Knight 1997, Barrett et al 2003). Cane Toads have been identified as a threat to the survival of Rainbow Bee-eaters (*Merops ornatus*) (Boland 2004). **Reptiles:** **Vulnerable** – Ornamental Snake (*Denisonia maculata*, Krefft's Tiger Snake (*Notechis scutatus ater*) (Cogger 2000). The Cane Toad has indirectly caused a marked decline in Yellow-spotted Monitor Lizard (*Varanus panoptes*) population numbers in the Northern Territory (Doody et al 2006). **Frogs:** **Critically endangered –** Armoured Mistfrog (*Litoria lorica*), Mountain Mistfrog (*L. nyakalensis*); **Endangered –** Yellow-spotted Tree Frog (*Litoria castanea*), Waterfall Frog (*L. nannotis*), Common Mistfrog (*L. rheocola*), Fleay's Frog (*Mixophyes fleayi*), Southern Barred Frog (*M. iteratus*), Lace-eyed Tree Frog (*Nyctimystes dayi*), Eungella Day Frog (*Taudactylus eungellensis*), Tinkling Frog (*Taudactylus rheophilus*); **Vulnerable** – Wallum Sedge Frog (*Litoria olongburensis*), Magnificent Brood Frog (*Pseudophryne covacevichae*), Kroombit Tinker Frog (*Taudactylus pleione*) (Cogger 2000). Cane Toads are known to compete for food and spawning sites with the Northern Banjo Frog *(Limnodynastes terraereginae)* and the Common Green Tree Frog (*Litoria caerulea*). **Invertebrates:** **Critically endangered –**Boggomoss Snail (*Adclarkia dawsonensis*), Golden Sun Moth (*Synemon plana)*, Mitchell's Rainforest Snail (*Thersites mitchellae*); **Endangered** – Gove Crow Butterfly (*Euploea alcathoe enastri*), land snails (*Mesodontrachia fitzroyana* and *Semotrachia euzyga*), Bednall's Land Snail (*Sinumelon bednalli*), moth (*Phyllodes imperialis*); **Vulnerable** – Bathurst Copper Butterfly (*Paralucia spinifera*). **Communities:** Assemblages of plants and invertebrate animals of tumulus (organic mound) springs of the Swan Coastal Plain **(endangered)**.
Susceptible Australian primary production (using question C8 from the Australian Bird and Mammal model; Bomford 2008 pp 23-25)		
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 elsewhere.*	**1**	*Score = 2* See Commodity Scores Table – species has attributes making it capable of damaging bee commodities.

SUMMARY OF RESULTS

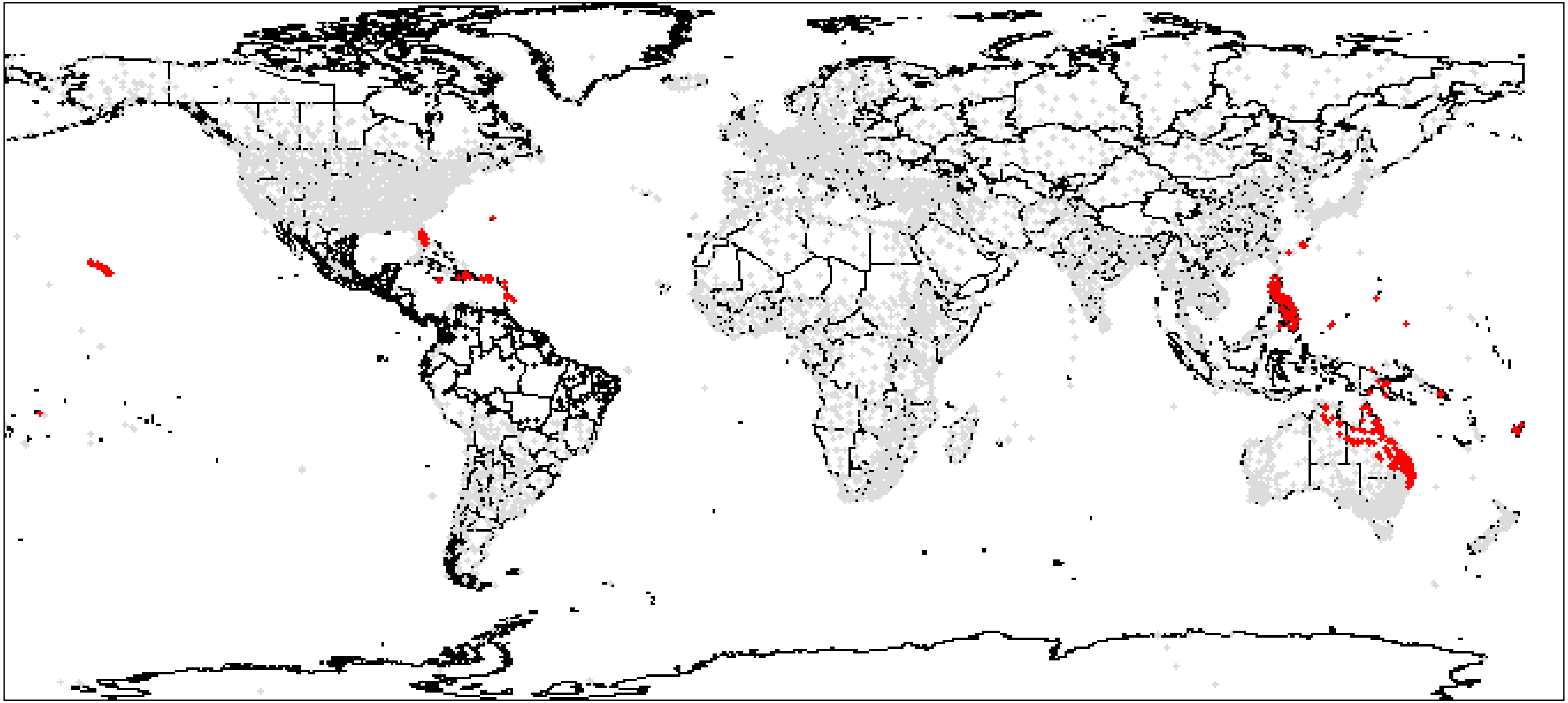
ESTABLISHMENT RISK RANKS – RISK OF ESTABLISHING A WILD POPULATION		
MODEL A: USING THE FIRST THREE FACTORS/QUESTIONS FROM STAGE B OF THE AUSTRALIAN BIRD AND MAMMAL MODEL (BOMFORD 2008) PP 54-55) ≤ 4 = LOW ESTABLISHMENT RISK; 5-7 = MODERATE ESTABLISHMENT RISK; 8-9 = SERIOUS ESTABLISHMENT RISK; 10-12 = EXTREME ESTABLISHMENT RISK	**10**	**EXTREME**
MODEL B: USING THE SEVEN FACTORS/QUESTIONS FROM STAGE B OF THE AUSTRALIAN BIRD AND MAMMAL MODEL (BOMFORD 2008) PP 20) ≤ 6 = LOW ESTABLISHMENT RISK; 7-11 = MODERATE ESTABLISHMENT RISK; 12-13 = SERIOUS ESTABLISHMENT RISK; ≥ 14 = EXTREME ESTABLISHMENT RISK	**14**	**EXTREME**
AUSTRALIAN REPTILE AND AMPHIBIAN MODEL (BOMFORD 2008, PP 51-53) ≤ 22 = LOW ESTABLISHMENT RISK; 23-60 = MODERATE ESTABLISHMENT RISK; 61-115 = SERIOUS ESTABLISHMENT RISK; ≥116 = EXTREME ESTABLISHMENT RISK	**104.9**	**SERIOUS**
HIGHEST ESTABLISHMENT RISK RANK (When establishment risk ranks differ between the models, the highest ranked outcome is used, (Bomford 2008).	**-**	**EXTREME – ENDORSED BY VPC**
PUBLIC SAFETY RISK RANK **AUSTRALIAN BIRD & MAMMAL MODEL, STAGE A (BOMFORD 2008, PP 17)** A = 0 = NOT DANGEROUS; A = 1 = MODERATELY DANGEROUS; A ≥ 2 = HIGHLY DANGEROUS	**2**	**HIGHLY DANGEROUS**
Median number of references per amphibians for Establishment Risk and Public Safety Risk, for all amphibians assessed by (Massam et al 2010) (n=11) Total number of references for this species		15, 1 26 – more than the median number of reptile references were used for this aspect of the assessment, indicating a decreased level of uncertainty. 11 - more than the median number of reptile references were used for this aspect of the assessment, indicating a

		decreased level of uncertainty
DAFWA THREAT CATEGORY - assigned for this study **(Public Safety + ERR) + use of the precautionary approach (when Prelim. Threat Ranking Low or Moderate)**		**EXTREME – NOT ENDORSED BY VPC**
OTHER INFORMATION TO ASSESS PEST RISKS		
CHECKLIST OF FACTORS ASSOCIATED WITH INCREASED RISKS OF ADVERSE IMPACTS OF ESTABLISHED SPECIES (BOMFORD 2008, PP 90-91) (0-9)	**1**,2,3,**5**,6,8, 9	
AUSTRALIAN SPECIES POTENTIALLY AT RISK AUSTRALIAN BIRD & MAMMAL MODEL, Q. C6 (BOMFORD 2008, PP 22-23) (0-5)	**5**	
AUSTRALIAN PRIMARY PRODUCTION POTENTIALLY AT RISK AUSTRALIAN BIRD & MAMMAL MODEL, Q. C8 (BOMFORD 2008, PP 23-25) (0-5)	**1**	
ALTERNATIVE THREAT CATEGORY - assigned for this study **(Public Safety + ERR) + arbitrary increase of one rank (based on presence of adverse impact factors 1 or 5, or maximum scoring for predicted effects on Australian species or primary production)**		**EXTREME – NOT ENDORSED BY VPC**
Median number of references for Establishment Risk, Public Safety Risk and Overseas Environmental and Agricultural Adverse Impacts, for all amphibians assessed by (Massam et al 2010) (n=11) Total number of references for this species		19 42 – more than the median number of amphibian references were used for this assessment, indicating a decreased level of uncertainty.

World Distribution – Cane Toad (*Bufo marinus*), includes current and past 1000 years; including natural populations (black) and introduced populations (red).

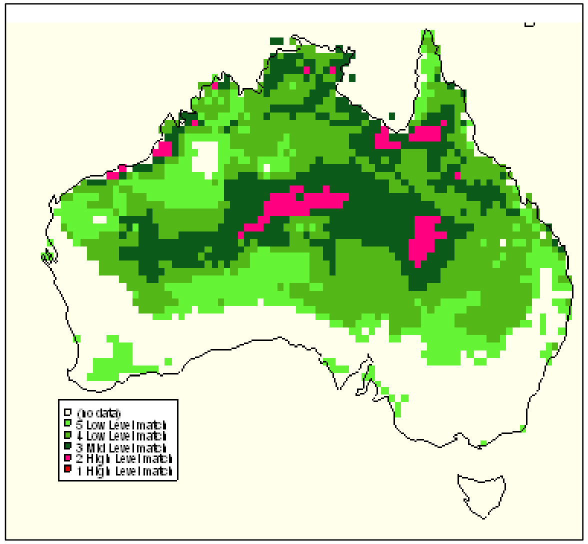
[Note: Australian distribution was not included in the climate analysis for this assessment. However, to assist predictions of further spread within Australia, an analysis that includes the Australian distribution has been included on page 11.]

Each black or red dot is a location where meteorological data was sourced for the climate analysis (see B1), faint grey dots are locations available for CLIMATE analysis but are not within the species' distribution therefore not used.



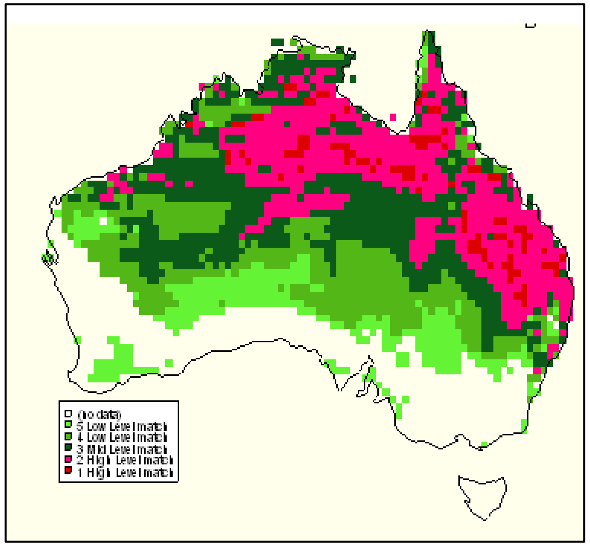
Map 1. Climate match between the world distribution of Cane Toad (*Bufo marinus*) and Australia for five match classes.

Colour on Map	Level of Match from Highest (10) to Lowest (6)	No. Grid Squares on Map
Red	10 HIGH MATCH	0
Pink	9 HIGH MATCH	93
Dark Green	8 MOD MATCH	559
Mid Green	7 MOD MATCH	879
Lime Green	6 LOW MATCH	510
		CMS = 2041



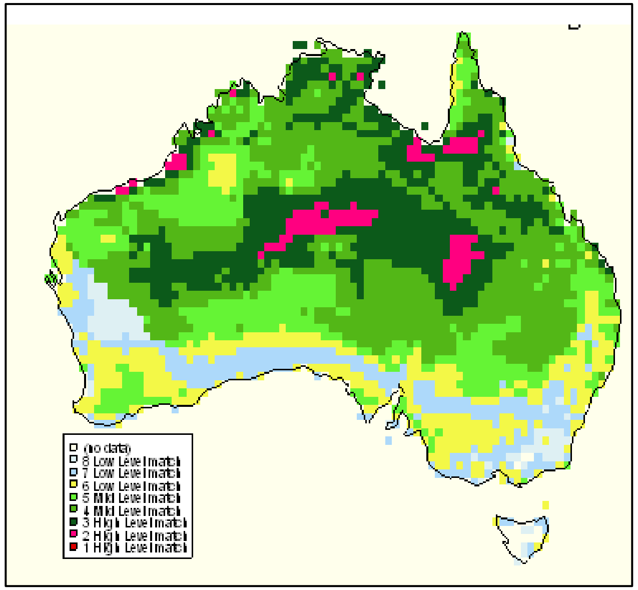
Map 2. Climate match between the world distribution (including Australian distribution) of Cane Toad (*Bufo marinus*) and Australia for five match classes.

Colour on Map	Level of Match from Highest (10) to Lowest (6)	No. Grid Squares on Map
Red	10 HIGH MATCH	100
Pink	9 HIGH MATCH	591
Dark Green	8 MOD MATCH	651
Mid Green	7 MOD MATCH	520
Lime Green	6 LOW MATCH	311
		CMS = 2173



Map 3. Climate match between the world distribution of Cane Toad (Bufo marinus) and Australia for eight match classes.

Colour on Map	Level of Match from Highest (10) to Lowest (3)	No. Grid Squares on Map
Red	10 HIGH MATCH	0
Pink	9 HIGH MATCH	93
Dark Green	8 HIGH MATCH	559
Mid Green	7 MOD MATCH	879
Lime Green	6 MOD MATCH	510
Yellow	5 MOD MATCH	383
Blue	4 LOW MATCH	267
Light blue	3 LOW MATCH	77



Cane Toad *(Bufo marinus)* Susceptible Australian Primary Production – Calculating Total Commodity Damage Score.

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

Industry	Commodity Value Index (based on 2005-2006 data)	Potential Commodity Impact Score (0-3)	Climate Match to Commodity Score (0–5)	Commodity Damage Score (columns 2 X 3 X 4)
Cattle (includes dairy and beef)	11	0	0	0
Timber (includes native and plantation forests)	10	0	0	0
Cereal grain (includes wheat, barley sorghum etc)	8	0	0	0
Sheep (includes wool and sheep meat)	5	0	0	0
Fruit (includes wine grapes)	4	0	0	0
Vegetables	3	0	0	0
Poultry and eggs	2	0	0	0
Aquaculture (includes coastal mariculture)	2	0	0	0
Oilseeds (includes canola, sunflower etc)	1	0	0	0
Grain legumes (includes soybeans)	1	0	0	0
Sugarcane	1	0	0	0
Cotton	1	0	0	0
Other crops and horticulture (includes nuts, tobacco and flowers)		0	0	0
Pigs	1	0	0	0
Other livestock (includes goats, deer, camels, rabbits)	0.5	0	0	0
Bees (includes honey, beeswax and pollination)	**0.5**	**2**	**2**	**2**
Total Commodity Damage Score (TCDS)				**2**

[Table 9 Rational
Potential Commodity Impact Score (0-3)
Assess Potential Commodity Impact Scores for each primary production commodity listed in Table 9, based on species' attributes (diet, behaviour, ecology), excluding risk of spreading disease which is addressed in Question C9, and pest status worldwide as:

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

Climate Match to Commodity Score (0–5)

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

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