# RISK ASSESSMENT FOR AUSTRALIA – Red Fox, (*Vulpes vulpes*) (Linnaeus, 1758)

Class - Mammalia, Order – Carnivora, Family - Canidae (Fischer, 1817), Genus - *Vulpes* (Frisch, 1775); (Wilson and Reeder 1993, ITIS Integrated Taxonomic Information System 2007, Catalogue of Life 2008)

GOVERNMENT OF WESTERN AUSTRALIA

Department of Agriculture and Food

**Score Sheet**

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| **SPECIES:** Red Fox (*Vulpes vulpes*)<br><br>**Subspecies:** 45 subspecies are listed on (ITIS Integrated Taxonomic Information System 2007). Examples include:<br><br>*V. v. fulvus* – North America<br><br>*V. v. beringiana* - NE Siberia<br><br>*V. v. dolichocrania* - Russian Far East<br><br>*V. v. vulpes* - Europe<br><br>The North American Red Fox (*V. v. fulvus*) has sometimes been designated a separate species, *Vulpes fulva*, but most authorities now consider it to be conspecific with the Palaearctic *Vulpes vulpes* (Nowak 1999). | | **Species Description** – The Red Fox is relatively small and slender, with an elongated muzzle, large pointed ears, long slender legs, and a round, bushy tail. Head and body length 455-900 mm, tail 300-555 mm (70% of head and body length), and weight 3-14 kg. Body size varies between individuals and geographically. Colouration can range from pale, yellowish-red to deep, reddish-brown on the upper parts, and white or off-white on the underparts. The typical colours are red, silver (ranging from silver to nearly black depending on the number of white-tipped guard hairs) and a mixture of the two (greyish-brown with long black guard hairs running down the back and across the shoulders). Completely black individuals have been recorded (pers comm. Nicky Marlow Sept, 08). The tips of the ears and lower parts of the legs and feet are usually black, and the long tail is usually tipped with white or black (Corbet and Harris 1991, Lariviere and Pasitschniak-Arts 1996, Nowak 1999, Macdonald and Reynolds 2004a).<br><br>**General information** – The Red Fox can run at speeds of up to 48 km/hr, leap fences or other obstacles 2 m high, and can swim well. It also has keen senses of sight, smell and hearing (Nowak 1999).<br><br>**Longevity –** Maximum longevity in captivity is 21.3 years (HAGR Human Ageing Genomic Resources 2006), but they generally live for 8-12 years; and probably only 1-4 years in the wild (Long 2003); it is estimated that only one in 10,000 will live up to nine years in the wild (Macdonald and Reynolds 2004a).<br><br>**Status –**<br><br>1. Red List Status – Least Concern (LC)<br><br>Rationale – The species has the widest geographical range of any member of the order Carnivora. Red Foxes are adaptable and opportunistic, and are capable of successfully occupying urban areas. The species currently is not under threat (Macdonald and Reynolds 2004b).<br><br>2. CITES listed Protection Status – Appendix III<br><br>Rationale: Not listed, except for three Indian subspecies; *V. v. griffithi*, *V. v. montana*, and *V. v. pusilla*, which are included in Appendix III. (Appendix III is a 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 (CITES 2007).) |
| **DATE OF ASSESSMENT: 11/09/2008**<br><br>**Model Used: (Bomford 2008) using PC CLIMATE (Brown et al 2006, Bureau of Rural Sciences 2006, Bomford 2008)** | | **The Risk Assessment Model**<br><br>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 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.<br>**Which models are being used for the assessments:**<br>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).<br>**Climate Matching Using PC CLIMATE**<br>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.<br>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.<br>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 30/10/2007 | | NOTE: Information about the red fox in Australia has been included in this assessment for interest alone, the assessment and the scoring of questions has been carried out using the information on the red fox from countries other than Australia. |
| **FACTOR** | **SCORE** | |
| **STAGE A: RISKS POSED BY CAPTIVE OR RELEASED INDIVIDUALS** | | |
| *A1. Risk to people from individual escapees (0–2)*<br>*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.* | 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* |

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| *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. Choose one:* | | An extremely shy species (Macdonald and Reynolds 2004b, a), foxes generally run away from people (Bradley 2004). They are widely kept in small wildlife parks and zoos (Macdonald and Reynolds 2004a).<br><br>One report of an urban, wild red fox attacking a child in West Denver, US, the child was bitten several times on her arm and face, she received treatment at a hospital and was then allowed home (Moreno and Coons 2007). |
| *A2. Risk to public safety from individual captive animals (0–2)*<br><br>*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**<br><br>**SUM A1 TO A2 (0–4)** | **1** | |

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| **STAGE B: PROBABILITY ESCAPED OR RELEASED INDIVIDUALS WILL ESTABLISH FREE-LIVING POPULATION** | | |
| **Model 1: Four-factor model for birds and mammals (BOMFORD 2008)** | | |
| *B1. Degree of climate match between species overseas range and Australia (1–6)* | 6 | *Climate Match Score = 2719 Extreme climate match with Australia* [See above information on climate matching.]<br><br>Climate data from 5128 locations (see species worldwide distribution map) were used to calculate the CMS; widely distributed across the northern hemisphere, with introduced populations in California, Canada and Australia (Long 2003) (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*<br><br>**Eurasia and North America**<br><br>There have been numerous introductions of the North American subspecies (*V. v. fulva*) throughout Eurasia (de Vos et al 1956, Long 2003). The European Red Fox (*V. vulpes*) was introduced into eastern United States and Canada in the 17$^{th}$ century (Long 2003, Macdonald and Reynolds 2004b). Range of the subspecies was considered as being part of the species natural range for this assessment which was done at the *species* level.<br><br>USA - Introduced populations of the red fox occur in the lowlands of California throughout the Sacramento Valley outside the species natural range in the Sierra Nevada and the southern Cascade Mountains. Introduction occurred in the 19$^{th}$ century, probably as a result of foxes escaping from fur-farms, fox hunt survivors, and/or intentional release of captive kept animals (Lewis et al 1993, Golightly et al 1994, Long 2003).<br><br>*Canada* - as a result of escapes from fur-farms the red fox has established on Vancouver Island, British Columbia, and in the Sayward forest north of the Campbell River; Baffin, Cornwallis and Ellesmere islands were colonised during the 1900s (Long 2003).<br><br>*Alaska* - the red fox has been introduced to some Aleutian Islands; also Unimak Island (Long 2003).<br><br>**New Zealand**<br><br>A pair of foxes were taken to Christchurch in 1864, but it is thought that they were not released. An Act passed in 1867 prohibited further importations (Lever 1985, Long 2003). |

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| | | **Australia**<br><br>Initial attempts to introduce the red fox into Australia were made before 1850 and during the 1860s and 1870s, first being released in southern Victoria (Strahan 1995). The first successful releases probably occurred in southern Victoria in 1871 (Lever 1985, Saunders et al 1995, Long 2003). The species rapidly spread across most of the southern half of the mainland by the 1930s; and the 1950s in the west. The fox failed to colonise the tropical north (Saunders et al 1995, Strahan 1995, Long 2003). Foxes are present on Benison Island, Victoria (Long 2003).<br><br>An attempt was made to introduce the fox to Tasmania in 1890, but the animals were destroyed by authorities before any releases took place. A single fox escaped from a ship at Hobart harbour in 1988, however it is believed this animal was also destroyed (Long 2003). It is now considered that the species has been introduced to Tasmania more recently, with evidence of its presence since 2000. Evidence includes positive scats, tracks, and fox carcasses and possible fox sightings. An eradication program has been initiated in an attempt to prevent the species from becoming firmly established in Tasmania (Saunders et al 2006, Department of Primary Industries and Water 2008).<br><br>One fox was recorded on Garden Island Western Australia in 1996, when it crossed the causeway to the island. It killed at least 25 Tammar Wallabies (*Macropus eugenii*) in one week before being destroyed (Long 2003). |
| *B3. Overseas range size (0–2)*<br><br>< 1 = 0; 1 – 70 = 1; >70 = 2 | 2 | *Overseas range between 1-70 million $km^2$, estimated at 145 million $km^2$. Includes current and past 1000 years, natural and introduced range.*<br><br>The red fox has the widest geographical range of any carnivore as it is distributed across the entire northern hemisphere from the Arctic Circle to North Africa, southern North America (northern Florida and New Mexico), and the Asiatic steppes. It occurs throughout Europe and Russia, including Afghanistan, Albania, Algeria, Arabia, Asia Minor, China, Indochina, Cyprus, Egypt, central India, Iraq, Japan, Libya, Manchuria, Mongolia, Morocco, Palestine, Persia, Tibet and Vietnam (Lever 1985, Lariviere and Pasitschniak-Arts 1996, Macdonald and Reynolds 2004b).<br><br>In North America, the species is found throughout Canada and the USA (including Alaska), except in parts of the arctic, the southern Atlantic coastal region, southwestern desert and Pacific coastal region, and areas of the south-central Great Plains (Samuel and Nelson 1982, Voight 1987) as cited in (Lariviere and Pasitschniak-Arts 1996). The European red fox was introduced into the eastern United States around 1790 and there is now some confusion regarding the original distribution of the native red fox before this time (Wilson and Ruff 1999).<br><br>During the early $20^{th}$ Century, the distribution of the red fox expanded the northern limits of its distribution into higher latitudes and altitudes (Hersteinsson and MacDonald 1992).<br><br>Fox density in Eurasia (average density measured at 0.21 individuals/$km^2$) is determined by winter climatic conditions and seasonality, not habitat productivity. Density decreases with declining winter and summer temperatures, an increasing degree of seasonality, and increased duration of snow cover (Barton and Zalewski 2007).<br><br>The city of Zurich (Switzerland) was colonized by red foxes around 1988 and the number of recorded individuals has increased steadily (Wandeler et al 2003).<br><br>Rapid increase in red fox densities during last decade in Western Poland; with changes in habitat preference – foxes expanded their habitat from mid-field afforested areas to adjacent open arable fields, often in the vicinity of human settlements; foxes adapted to anthropogenic conditions, learning to use garbage and poultry as major food items; extra food provided by people probably caused a rapid increase in fox densities in farmland areas (Goldyn et al 2003). |

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| | | Decline of red fox populations in Illinois has been attributed to altered habitats and the eastwards expansion of the coyote (*Canis latrans*) (Lavin et al 2003 ).<br><br>The species is not found in Iceland, the Arctic Islands, extreme northern parts of Siberia, or in extreme deserts (Lariviere and Pasitschniak-Arts 1996, Macdonald and Reynolds 2004b)<br><br>The species occurs from sea level to 4,500 m elevation (Nowak 1999, Macdonald and Reynolds 2004b). |
| *B4. Taxonomic Class (0–1)* | 1 | *Mammal* (Catalogue of Life 2008). |
| **B. ESTABLISHMENT RISK SCORE**<br><br>**SUM OF B1-4 (1–13)** | **13** | |
| **Model 2: Seven-factor model for birds and mammals (BOMFORD 2008)** | | |
| *B5. Diet (0–1)* | 1 | *Generalist with a broad diet of many food types*<br><br>The red fox is an opportunistic omnivore with a highly diverse diet, that includes small mammals (mainly rodents), birds, invertebrates, fruits and other vegetable material, carrion, and in urban areas compost heaps and general refuse (Nowak 1999, Macdonald and Reynolds 2004a, Basouny et al 2005) (Dell'Arte et al 2007); (Kozena 1988)..<br><br>The red fox can 'specialise', using an abundant local prey almost exclusively while available; as demonstrated in northwest Italy during 1998-200 with the introduction of the Eastern Cottontail (*Sylvilagus floridanus*) and its subsequent availability as prey for the Fox (Balciauskas et al 2005).<br><br>Nutrition of red fox (and predators in general) is seasonal in character, e.g. the summer diet of the red fox in Lithuania was dominated by small mammals – voles (Baltrunaite 2002).<br><br>The diet of foxes inhabiting the city of Oxford, England comprised the following: scavenged food (37%), earthworms (*Lumbricus terrestris*, 27%), mammals (16%), fruits (9%), birds (8%), other invertebrates (2%), domestic stock (1%); 81 types of food were identified including 5 orders of birds, 14 species of small mammals, and 14 species of fruits; composition of the diet varied monthly and seasonally (Doncaster et al 1990).<br><br>Diet composition did not differ significantly between three habitat types (grassland, cultivation and suburban) of a sub-arid island off North Africa, with insects comprising > 48% and fruits 25%, of the total prey items (Dell'Arte and Leonardi 2005). The main food source of foxes in Hungary consisted of small mammals (preferred *Microtus* voles) which were supplemented by brown hare and game-birds rarely (Lanszki 2005).<br><br>In Spain, the fox is a facultative predator feeding on rabbits when they are abundant and shifting to other prey (and hence a more divers diet) when rabbits become scarce (Delibes-Mateos et al 2008). In Scandinavia the red fox is considered a keystone predator (Smedshaug et al 1999).<br><br>Red foxes cache food for retrieval later (MacDonald et al 1994, Sklepkovych and Montevecchi 1996, Nowak 1999). In a study to determine the fate of dried meat baits taken by the red foxes in Australia, 25% of baits taken were cached, of these, 59% were later eaten by foxes (Thomson and Kok 2002). |
| *B6. Lives in disturbed habitat (0–1)* | 1 | *Can live in disturbed habitats*<br><br>The species is adaptable and opportunistic, and is capable of successfully occupying urban areas. In many habitats, the red fox appears to be closely associated with man, even thriving in intensive agricultural areas (Macdonald and Reynolds 2004b). The red fox is one of the best-documented |

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| | | examples of a species that has successfully occupied cities and suburbs during the last century (Saunders et al 1995, Wandeler et al 2003). It inhabits a diverse range of habitat types including deep forest, arctic tundra, open prairies, moorlands, deserts, sand dunes and farmland; areas with highly diverse vegetation are preferred (Saunders et al 1995, Nowak 1999, Macdonald and Reynolds 2004b).<br><br>Individual foxes utilise areas with low-density housing in suburban Toronto, Canada (Adkins and Stott 1998); and inhabit urbanised areas of most cities in Lithuania (Balciauskas et al 2005).<br><br>The red fox is common in many British urban areas (Harris and Smith 1987). Breeding populations of foxes were found within 5 km of London city centre, and foxes were recorded within the city centre (Harris 1977). In London, 211 family groups consisted of 578 adult foxes producing 904 cubs per annum; fox control operations did not significantly reduce the number of family groups but did reduced the number of adult foxes and cubs (Harris and Smith 1987).<br><br>The lack of specific habitat requirements is one of the keys to the success of the red fox (Corbet and Harris 1991). |
| *B7. Non-migratory behaviour (0–1)* | 1 | *Non-migratory or facultative migrant in its native range*<br><br>Non-migratory species (NatureServe 2008).<br><br>Home range size varies with habitat type and food availability but under natural conditions is usually 1-10 $km^2$, but ranges may be smaller in suburban areas (Nowak 1999). In suburban Toronto, Canada home range sizes of foxes was 52 ha, distances travelled by adults during the night ranged from 2 – 20 km (Adkins and Stott 1998). The young disperse from the parental home range during autumn to establish their own area, where they usually settle for life (Nowak 1999). |
| **B. Establishment Risk Score**<br><br>**Sum of B1-7 (1-16)** | **16** | |
| **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, AND mammal in one of the families that are particularly prone to cause agricultural damage*<br><br>Order Carnivora, Family Canidae (Wilson and Reeder 1993, ITIS Integrated Taxonomic Information System 2007, Catalogue of Life 2008). |
| *C2. Overseas range size including current and past 1000 years, natural and introduced range (0–2)* | 2 | *Overseas range greater than 30 million $km^2$. Estimated at 145 million $km^2$.*<br><br>Wide overseas distribution across the northern hemisphere, with introduced populations in California, Canada and Australia (Long 2003) (see B2 and B7 for details). |
| *C3. Diet and feeding (0–3)* | 1 | *Mammal that is a non-strict carnivore.*<br><br>Although predominantly carnivorous, the red fox is an opportunistic omnivore, consuming a variety of animal and plant matter including fruit, berries and legumes (Saunders et al 1995, Nowak 1999) (see B5 for details). |
| *C4. Competition with native fauna for tree hollows (0–2)* | 0 | *Does not use tree hollows*<br><br>Dens are used for the birth and early caring of cubs. Mean litter size is four, up to ten . (Saunders et al 1995).<br><br>Each individual or family group has a main earthen den, with one or more emergency burrows, within its |

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| | | home range. Preferred den sites are sheltered and situated on well-drained slopes with loose soil. The main entrance to the den is usually 40cm high with tunnels up to 22 m long leading to a chamber 1-3 m below the surface. Dens and other resting sites can be connected through a system of pathways. Foxes may rest during the day in thickets or other protected spots (Sheldon 1950) as cited in (Lariviere and Pasitschniak-Arts 1996), (Nowak 1999). Most red fox dens are in sandy soil (Sheldon 1950), in pastures(Sargeant 1972), or agricultural land (Hewson 1986), all three as cited in (Lariviere and Pasitschniak-Arts 1996). |
| *C5. Overseas environmental pest status (0–3)*<br><br>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*<br><br>The majority of environmental damage caused by the red fox is from predation on native wildlife. The red fox may also compete with similar-sized native carnivorous species:<br><br>**Birds:**<br><br>The red fox was the chief predator (along with raptors) in North Wales and the Scottish Highlands of Black Grouse (*Tetrao tetrix*) that declined severely between 1972-1991 (Baines et al 2007).<br><br>The red fox (along with Carrion Crows, *Corvus corone*) are considered to be among the most important predators of eggs of wader birds in Britain (Seymour et al 2003). It is an important predator of the lapwing (*Vanellus vanellus*), with nocturnal observations of lapwing nesting sites showing that 73% of disturbances were from foxes (Seymour et al 2003).<br><br>Increased predation pressure on remaining populations of California Clapper Rail (*Rallus longirostris obsoletus*), a United States endangered-listed marsh bird caused the invasion of the red fox coupled with habitat fragmentation (Foin et al 1997).<br><br>Introduced populations of the red fox in southern Californian, threaten endangered wildlife, including the Light-Footed Clapper Rail (*Rallus longriostris levipes*), California Clapper Rail (*R. l. obsoletus*), California Lest Tern (*Sterna antillarum browni*), Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*), Belding's Savannah Sparrow (*Passerculus sandwichensis beldingi*) (Lewis et al 1993, Golightly et al 1994)<br><br>Red fox predation on Ring-billed Gulls (*Larus delawarensis*) and Herring Gulls (*L. argentatus*) nesting on South Manitou Island in Lake Michigan reduce successful breeding by the gulls which are unlikely to produce any offspring at sites subjected to regular fox predation. During attacks, foxes kill small numbers of adult gulls, and cause severe loss of eggs and young. They also affect hatching rates and chick survival indirectly, by causing the adult gulls to abandon nests. (Southern et al 1985)<br><br>In southern Norway, the red fox may effect breeding density of the Goshawk (*Accipiter gentilits*) by limiting numbers of grouse the hawk's main food prey (Selas 1998).<br><br>Ring-billed Gulls (*Larus delawarensis*) and Herring Gulls (*L. argentatus*) nesting on South Manitou Island in Lake Michigan subject to at least 9 years of intense fox predation, had total or near total reproductive success (Southern et al 1985).<br><br>The red fox had negative impacts on successful breeding, in small-bird communities living in open farmland; a negative effect of the proximity of fox dens on the total bird density, the effect was recorded even for the most abundant bird species, the skylark (A*lauda arvensis*) (Tryjanowski et al 2002).<br><br>In North America, the red fox has a negative impact on many ground-nesting birds, such as ducks and grouse. In California, red foxes are controlled on an annual basis to protect the nesting grounds of several endangered species of birds (Global Invasive Species Database 2007). Predation on fledgling Tawny Owl (*Strix aluco*) by the red fox (Overskaug et al 1999).<br><br>In the West Carpathians from 1983-2001, clutch and chick losses were studied in Capercaillie (*Tetrao* |

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| | | *urogallus)* and from 1989-2001 in Hazel Grouse (*Bonasa bonasia)*; clutch losses were highest in ground breeders (66%) and lowest in tree-cavity breeders (24%); main mammalian predators of eggs and nestlings were martens (*Martes sp)*, mustelids (*Mustela sp)*, **Red Fox (*V. vulpes)*** and Lynx (*Lynx lynx*); altogether responsible for 19% of egg losses and 23% of chick losses (Saniga 2003).<br>**Mammals:**<br>Red foxes pose a potential threat to the endangered San Joaquin Kit Fox (*V. marcotis mutica*) through interference and exploitative competition between the two species(Clark et al 2005).<br>Red foxes compete with Arctic Foxes (*Alopex lagopus*) where the two species occur sympatrically in the Eurasian tundra. Red foxes are larger and generally out-compete Arctic Foxes, they kill both adult and young Arctic foxes (Hersteinsson and MacDonald 1992, Macdonald and Reynolds 2004a). Arctic Foxes have possibly retreated to higher altitudes on the mountain tundra because of increased competition by the red fox at the lower altitudes (Elmhagen et al 2002). Sterilised red foxes have been used as biological control agents for Arctic Foxes on the Aleutian Islands in Alaska. Arctic foxes were first introduced to the islands in the 1800s, and have had significant impact on endemic bird populations (Schmidt 1985).<br>Predation by red fox is the most important mortality cause for neonatal Roe Deer (*Capreolus capreolus*) (Jarnemo 2004); in Sweden, fox control usually results in increased fawn survival and a higher potential Roe Deer harvest (Jarnemo and Liberg 2005).<br>**Other species:**<br>Red foxes raid Loggerhead Turtles, (*Caretta caretta)* nests at Dalyan, Turkey; destruction of 89% of nests (28 surveyed) within the study site (Dalyan Beach) suggests a serious threat to the nests (MacDonald et al 1994).<br>**In Australia:**<br>The introduced red fox has eliminated remnant populations of some native rodent and marsupial species on the mainland, and evidence suggests they are the primary cause in the decline and extinction of many other small and medium-sized rodent and marsupial species (Global Invasive Species Database 2007).<br>Diet studies alone are not a reliable indication of the extent of damage to wildlife caused by the red fox; as some endangered native species may occur only rarely in the diet, but foxes may have a significant impact on the native species (Saunders et al 1995).<br>Some native species threatened by the red fox include the Brush-tailed Rock-wallaby (*Petrogale penicillata*), Numbat (*Myrmecobius fasciatus*), Brush-tailed Bettong (*Bettongia penicillata*), Burrowing Bettong (*Bettongia lesueur*), and Bilby (*Macrotis lagotis*) (Global Invasive Species Database 2007)<br>In Western Australia, nesting rookeries of four species of marine turtles – Green Turtle (*Chelonia mydas*), Flatback turtle (*Natator depressus*), Loggerhead Turtle (*Caretta caretta*) and Hawksbill Turtle (*Eretmochelys imbricate*) are threatened by predation of turtle eggs by red foxes (Global Invasive Species Database 2007).<br>Fox removal studies in Western Australia have shown substantial and consistent population increases by a variety of marsupial species [e.g. (Kinnear et al 1988, Friend 1990, Morris 1992)] (Saunders et al 1995). |
| *C6. Climate match to areas with susceptible native species or communities (0–5)* | 5 | *The species has 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 within the mapped area of the* |

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| 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. | | *highest six climate match classes for the exotic species being assessed.*<br><br>Reference for all vulnerable or endangered species and communities (status noted in bold) (Dept of the Environment Water Heritage and the Arts 2007, 2008)<br><br>Foxes typically kill birds and mammals up to about 3.5 kg (equivalent to an adult brown hare) (Macdonald and Reynolds 2004a), therefore many Australian native species would be vulnerable to fox predation. Examples of susceptible Australian native species or natural communities that could be threatened include, but are not limited to:<br><br>**Mammals: Critically endangered –** Gilbert's Potoroo (*Potorous gilbertii*); **Endangered –** Northern Bettong (*Bettongia tropica*), Ampurta (*Dasycercus hillieri*), Southern Brown Bandicoot (*Isoodon obesulus*), Dibbler (*Parantechinus apicalis*), Eastern Barred Bandicoot (*Perameles gunnii*), Long-footed Potoroo (*Potorous longipes*), Smoky Mouse (*Pseudomys fumeus*), Hastings River Mouse (*Pseudomys oralis*), Sandhill Dunnart (*Sminthopsis psammophila*), Carpentarian Rock-rat (*Zyzomys palatalis*); **Vulnerable** – Kowari (*Dasyuroides byrnei*), Golden Bandicoot (*Isoodon auratus*), Southern Brown Bandicoot (*Isoodon obesulus*), Numbat (*Myrmecobius fasciatus*), Northern Hopping-mouse (*Notomys aquilo*), Dusky Hopping-mouse (*N. fuscus*), Pilliga Mouse (*Pseudomys pilligaensis*), Quokka (*Setonix brachyurus*) (Strahan 1995).<br><br>**Birds: Critically endangered –** Spotted Quail-thrush (*Cinclosoma punctatum*); **Endangered –** Eastern Bristlebird (*Dasyornis brachypterus*), Western Ground Parrot (*Pezoporus wallicus*), Southern Emu-wren (*Stipiturus malachurus*), Mallee Emu-wren (*Stipiturus mallee*), Buff-breasted Button-quail (*Turnix olivii*); **Vulnerable** – Grey Grasswren (*Amytornis barbatus*), Noisy Scrub-bird (*Atrichornis clamosus*), Western Bristlebird (*Dasyornis longirostris*), Partridge Pigeon (*Geophaps smithii*) (Pizzey and Knight 1997, Barrett et al 2003).<br><br>**Reptiles and Amphibian** – the eggs of Green Turtle (*Chelonia mydas*), Flatback turtle (*Natator depressus*), Loggerhead Turtle (*Caretta caretta*) and Hawksbill Turtle (*Eretmochelys imbricate*). Numerous other small reptiles and amphibians could be predated upon by the red fox.<br><br>**Invertebrates: Vulnerable** – Giant Gippsland Earthworm (*Megascolides australis*).<br><br>**Communities:** No listed vulnerable or endangered communities likely to be threatened. |
| *C7. Overseas primary production pest status (0–3)*<br><br>*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*<br><br>The red fox is a threat to livestock, as they prey on poultry, lambs and kids (Global Invasive Species Database 2007).<br><br>The red fox is considered to be a major predator of livestock and game animals throughout its range, and large numbers of foxes are culled annually in an attempt to reduce damage caused by predation; i agricultural landscapes, red foxes have been observed to feed mainly on rabbits, as well as wild pheasants and domestic poultry; and larger prey is usually taken as road kill scavenging, although deer fawns are predated. (Baker et al 2006a)<br><br>In the US, the red fox is a predator of poultry, small pigs, and lambs, however only poultry losses reach significant proportions (Scott 1955, Long 2003).<br><br>The red fox is often considered to be a threat to poultry, but depredations are generally localised, and many of the birds eaten are taken in the form of carrion (Nowak 1999).<br><br>In Britain, fox predation has a direct economic cost to agriculture of approximately £12 million per year. However, the red fox is beneficial to agriculture, by controlling rabbit numbers, which cause in excess of £100 million damage to agriculture each year (Baker et al 2006b). |

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| | | In Britain, lamb losses to fox predation are small in relation to other causes of lamb mortality, and in most cases there is no benefit to farmers carrying out fox control. Fox predation of piglets is also generally low, and again it is not considered worthwhile for farmers to control fox numbers (Baker et al 2006b). Poultry losses from fox predation is highest for free-range egg producers, and negligible for table chicken producers. Losses of poultry to fox predation can be reduced most effectively through improved husbandry practices and preventative measures such as secure fencing and housing (Baker et al 2006b).<br><br>Culling of foxes occurs in the rural regions of Britain, motivation for the culling and methods used reflect regional variation in agricultural and game-shooting interests (Heydon and Reynolds 2000).<br><br>There are currently bounties on the subspecies *V. v. pusilla* in Pakistan to protect game birds such as Houbara Bustards (*Chlamydotis undulate macqueenii*), that have a high hunting value (Macdonald and Reynolds 2004b).<br><br>Farming of foxes for fur exceeds that of any other fur species, except possibly the Mink (*Mustela vison*); worldwide trade in ranched red fox pelts was 700,000 in 1988-89, excluding internal consumption in the USSR (Macdonald and Reynolds 2004b)<br><br>**Australia**<br><br>In Australia, the red fox is recognised as an agricultural pest, especially as predators to newborn lambs and goat kids. Foxes will chase and harass lambs and kids, biting and chewing on the hindquarters and around the neck. Poultry are also at risk, however losses to commercial poultry enterprises are usually insignificant since the majority keep their poultry well protected (Gentle 2006).<br><br>The economic significance of red foxes as predators of livestock is uncertain and subject to debate, but lamb losses attributable to foxes can be as high as 30% in some areas (Saunders et al 1995, Gentle 2006, Global Invasive Species Database 2007).<br><br>Foxes are known to cause damage to horticultural industries, by damaging infrastructure, such as irrigation systems in orchards, as well as consuming or chewing on items, such as rockmelon fruit or stems. Stone-fruit producers have also reported damage to fruit and chewing of infrastructure such as watering systems. Foxes will also consume grapes, as evidenced by missing bunches from vines and scats containing grape seeds (Gentle 2006). |
| *C8. Climate match to susceptible primary production (0–5)*<br><br>*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.* | 5 | Score = 159.5 (Bomford 2003, 2006)<br><br>See Commodity Scores Table – Species has attributes making it capable of damaging sheep, poultry , grape, fruit and other livestock commodities. |
| *C9. Spread disease (1–2)* | 2 | *All birds and mammals (likely or unknown effect on native species and on livestock and other domestic animals).* |
| *C10. Harm to property (0–3)* | 1 | *$1.00 – 10 million*<br><br>Potential of loss of domestic pets to red fox, and damage to household gardens by foxes digging or damaging garden plants (Baker et al 2006b). |
| *C11. Harm to people (0–5)*<br><br>*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,* | 3 | *Moderate risk – injuries or harm moderate but unlikely to be fatal and few people at risk*<br><br>The risk of foxes attacking children is extremely low, and negligible when compared to the risks posed by companion animals. There is no evidence to suggest that foxes pose a significant risk of attack on people, and none of the occasional press reports that foxes have bitten babies appear to be typical fox bites (Baker et al 2006b). However, there are several reports of foxes entering houses and attacking |

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| *Score A1).* | | young children, e.g. (Sapsted 2002, McNeil 2003), and an elderly woman in her garden (Bradley 2004). (Note – these sources do not state the type of fox involved in the attack, however given the location, it is possible that it involved a red fox).<br><br>In urban areas in Britain, the red fox is generally welcomed by most residents (Corbet and Harris 1991, Baker et al 2006b).<br><br>Contrary to popular belief, only about half of all foxes show aggression normally associated with rabies (Smith and Harris 1989). Reports exist of rabid fox attacks on people, e.g. (Floyd 2000, Brown Hackney 2008) (note – the first of these sources does not state the type of fox involved in the attack; the second states that a red fox was involved).<br><br>**Zoonoses:** Constant proximity and frequent use of residential habitats give foxes ample opportunity to transmit diseases to domestic pets and humans (Adkins and Stott 1998).<br><br>The fox is a vector for and carrier of rabies, the tapeworm *Alveolar echinococcoses* and sarcoptic mange; and a concern for public health especially in areas with high human density (Wandeler et al 2003).<br><br>Giardia and Cryptosporidium present in faecal samples from 269 Norwegian wild red foxes (Hamnes et al).<br><br>Leptospirosis, caused by *Leptospira interrogans* serovar *spmona* was isolated from the kidneys of three of eight red foxes tested in Ontario, Canada (Kingscote 1986).<br><br>In the northern hemisphere, the red fox is the main carrier and vector species of the most important endemic zoonoses, such as fox tapeworm *Echinococcus multilocularis*, *Toxocara canis* and nematode *Trichinella spp*. (Letkova et al 2006).<br><br>High densities of the red fox pose a health threat to humans through transmission of diseases, including distemper, parvo virus, and mange, but especially rabies (Global Invasive Species Database 2007). In Europe, the red fox is responsible for spreading and maintaining the rabies virus (Smith and Harris 1989), and the red fox is the main vector of the virus in southern Ontario, Canada (MacInnes et al 2001) Worldwide, an estimated 40,000-100,000 people die from rabies each year (Rupprecht et al 1995). |
| **C. Pest Risk Score**<br><br>**Sum C 1 to 11 (1–37)** | **27** | |
| **Stage A. Public Safety Risk Rank – risk to public safety posed by captive or released individuals**<br><br>0 = Not dangerous; 1 = Moderately dangerous; ≥ 2 = Highly dangerous | **1** | **Moderately Dangerous** |
| **Stage B. Establishment Risk Rank – risk of establishing a wild population**<br><br>**Model 1: Four-factor model for birds and mammals (Bomford 2008)**<br><br>≤ 5 = low establishment risk; 6-8 = moderate establishment risk; 9-10 = serious establishment risk; ≥11-13 = extreme establishment risk | **13** | **Extreme Establishment Risk** |

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| **STAGE B. ESTABLISHMENT RISK RANK – RISK OF ESTABLISHING A WILD POPULATION**<br><br>**MODEL 2: SEVEN-FACTOR MODEL FOR BIRDS AND MAMMALS (BOMFORD 2008)**<br><br>≤ 6 = low establishment risk; 7-11 = moderate establishment risk; 12-13 = serious establishment risk; ≥14 = extreme establishment risk | **16** | **EXTREME ESTABLISHMENT RISK** |
| **STAGE C. PEST RISK RANK - RISK OF BECOMING A PEST FOLLOWING ESTABLISHMENT**<br><br>< 9 = low pest risk; 9-14 = moderate pest risk; 15-19 = serious pest risk; > 19 = extreme pest risk | **27** | **EXTREME PEST RISK** |

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| **VERTEBRATE PESTS COMMITTEE THREAT CATEGORY** | **EXTREME – ENDORSED BY VPC** |

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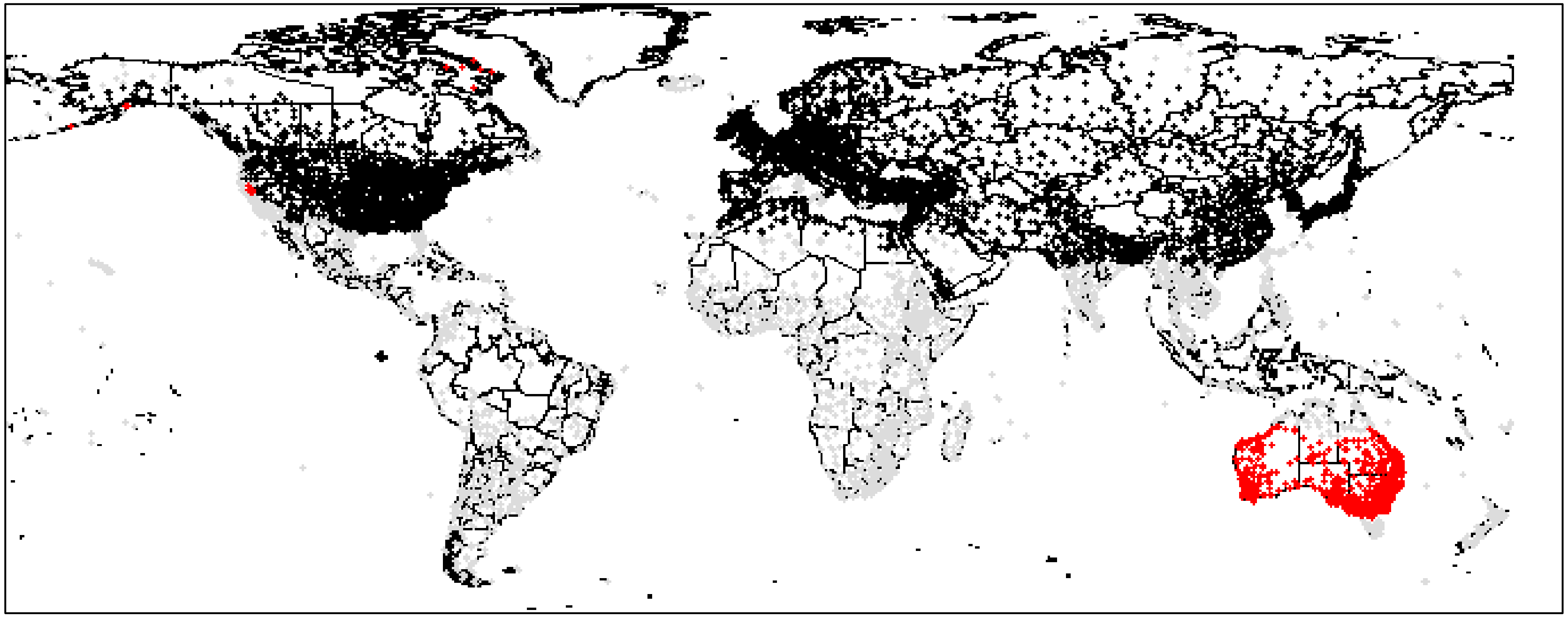
| Median number of references per mammal, for all mammals assessed by (Massam et al 2010) (n=17)<br><br>Total number of references for this species<br><br>*(median number for references for Public Safety Risk, Establishment Risk and Overseas Environmental and Agricultural Adverse Impacts)* | 37<br><br>57 – more than the median number of mammal references were used for this assessment, indicating a decreased level of uncertainty. |

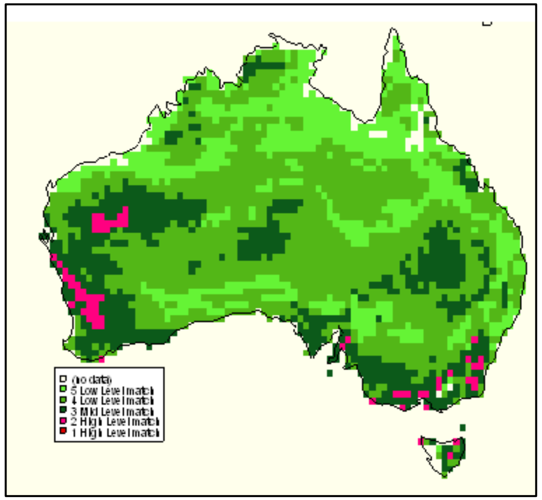
**WORLDWIDE DISTRIBUTION – Red Fox (*Vulpes vulpes*), includes current and past 1000 years; including natural populations (black) and introduced populations (red).**

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.
[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 14.]



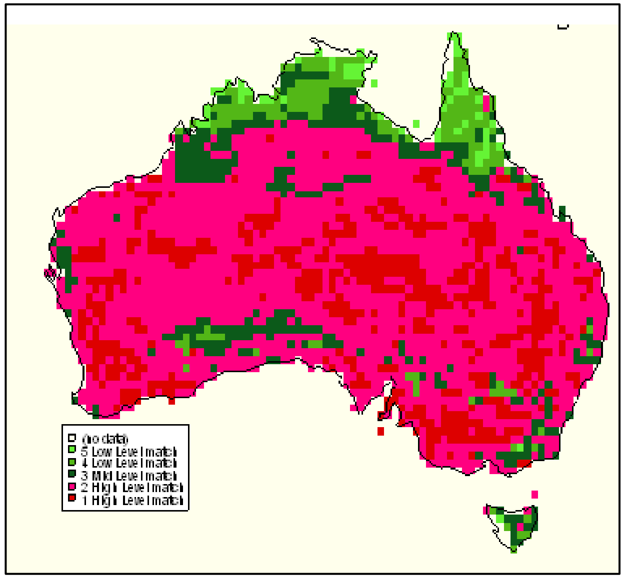
**Map 1. Climate match between the world distribution of Red Fox (*Vulpes vulpes*) and Australia for five match classes.**

| 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 | 64 |
| Dark Green | 8 MODERATE MATCH | 601 |
| Mid Green | 7 MODERATE MATCH | 1394 |
| Lime Green | 6 LOW MATCH | 660 |
| | | **CMS = 2719** |




**Map 2. Climate match between the world distribution (including Australian distribution) of Red Fox (*Vulpes vulpes*) 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 | 60 |
| Pink | 9 HIGH MATCH | 180 |
| Dark Green | 8 MOD MATCH | 324 |
| Mid Green | 7 MOD MATCH | 1635 |
| Lime Green | 6 LOW MATCH | 564 |
| | | **CMS = 2763** |



## Red Fox *(Vulpes vulpes)* 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).

Table 9

| Industry | Commodity Value Index 1 (CVI based on 2005- 06 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) |
|---|---|---|---|---|
| **Sheep (includes wool and sheep meat)** | **5** | **3** | **5** | **75** |
| 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 |
| **Pigs** | **1** | **3** | **5** | **15** |
| **Poultry and eggs** | **2** | **3** | **5** | **30** |
| Aquaculture (includes coastal mariculture) | 2 | 0 | 0 | 0 |
| Cotton | 1 | 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 |
| **Fruit (includes wine grapes)** | **4** | **2** | **4** | **32** |
| Vegetables | 3 | 0 | 0 | 0 |
| **Other livestock (includes goats, deer, camels, rabbits)** | **0.5** | **3** | **5** | **7.5** |
| Bees (included honey, beeswax and pollination) | 0.5 | 0 | 0 | 0 |
| **Other crops and horticulture (includes nuts, tobacco and flowers etc)** | **1** | **0** | **0** | **0** |
| **Total Commodity Damage Score (TCDS)** | | | | **159.5** |

*[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:*

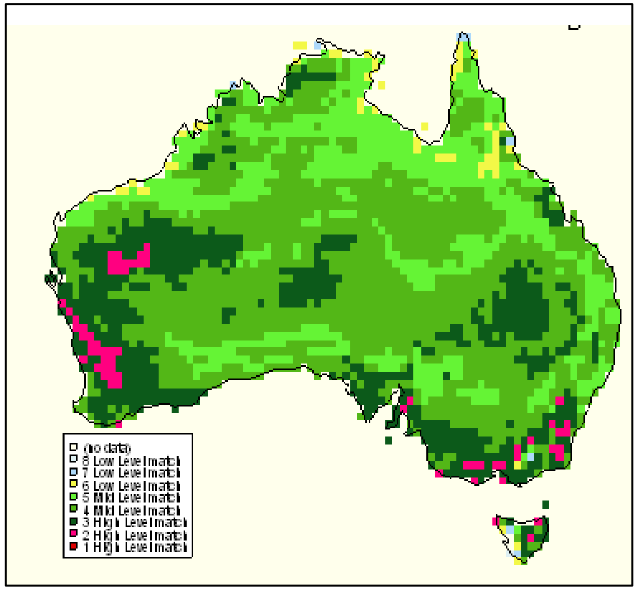
0. *Nil (species does not have attributes to make it capable of damaging this commodity)*
1. *Low (species has attributes making it capable of damaging this or similar commodities and has had the opportunity but no reports or other evidence that it has caused damage in any country or region*
2. *Moderate–serious (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.]*

**Map 2. Climate match between the world distribution of Red Fox *(Vulpes vulpes)* 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 | 64 |
| Dark Green | 8 HIGH MATCH | 601 |
| Mid Green | 7 MOD MATCH | 1394 |
| Lime Green | 6 MOD MATCH | 660 |
| Yellow | 5 MOD MATCH | 55 |
| Blue | 4 LOW MATCH | 8 |
| Light blue | 3 LOW MATCH | 1 |



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**Vertebrate Pests Committee Threat Categories (Natural Resource Management Standing Committee 2004)**

**VPC Threat Category**

A species' VPC Threat Category is determined from the various combinations of its three risk ranks; (A) Public safety risk rank, (B) Establishment risk rank, (C) Pest risk rank.

| B. Establishment Risk Rank[1] | C. Pest Risk Rank[1] | A. Public Safety Risk Rank | Threat Category |
|---|---|---|---|
| Extreme | Extreme | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Extreme** |
| Extreme | High | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Extreme** |
| Extreme | Moderate | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Extreme** |
| Extreme | Low | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Extreme** |
| High | Extreme | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Extreme** |
| High | High | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Extreme** |
| High | Moderate | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Serious** |
| High | Low | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Serious** |
| Moderate | Extreme | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Extreme** |
| Moderate | High | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Serious** |
| Moderate | Moderate | Highly Dangerous | **Serious** |
| Moderate | Moderate | Moderately Dangerous or Not Dangerous | **Moderate** |
| Moderate | Low | Highly Dangerous | **Serious** |
| Moderate | Low | Moderately Dangerous or Not Dangerous | **Moderate** |
| Low | Extreme | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Serious** |
| Low | High | Highly Dangerous, Moderately Dangerous or Not Dangerous | **Serious** |
| Low | Moderate | Highly Dangerous | **Serious** |
| Low | Moderate | Moderately Dangerous or Not Dangerous | **Moderate** |
| Low | Low | Highly Dangerous | **Serious** |
| Low | Low | Moderately Dangerous | **Moderate** |
| Low | Low | Not Dangerous | **Low** |

[1] 'Establishment Risk' is referred to as the 'Establishment Likelihood' and 'Pest Risk' is referred to as the 'Establishment Consequences' by the Natural Resource Management Standing Committee (2004).