# RISK ASSESSMENTS FOR EXOTIC REPTILES AND AMPHIBIANS INTRODUCED TO AUSTRALIA – Corn Snake (*Elaphe guttata*) (Linnaeus, 1766)

Class - Reptilia, Order - Squamata, Family - Colubridae (Oppel, 1811), Genus - *Elaphe* (Fitzinger, 1833); (The Reptile Database 2007, Catalogue of Life 2008)

GOVERNMENT OF WESTERN AUSTRALIA

Department of Agriculture and Food

**Score Sheet**

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| **SPECIES:** Corn Snake, Red Rat Snake (*Elaphe guttata*)<br><br>**Synonyms:** *Coluber guttatus*<br><br>**Subspecies:**<br><br>*E. g. emoryi* – Great Plains Rat Snake<br><br>*E. g. guttata* – Corn Snake<br><br>*E. g. intermontanus*<br><br>*E. g. meahllmorum*<br><br>*E. g. rosacea* – Rosy Rat Snake<br><br>No subspecies are currently recognised (Ernst and Ernst 2003). (Burbrink 2002) used cytochrome *b* sequences to examine phylogenetic relationships among *E. guttata* populations. He found no support for recognition of the nominal subspecies as distinct taxa. Burbrink recognised the three partitions as species using evolutionary species criteria (1) *Elaphe guttata*, (2) *Elaphe emoryi*, (3) *Elaphe slowinskii* (Hammerson 2007 , NatureServe 2008).<br><br>Following mitochondrial DNA examination, evidence was presented by (Utiger et al 2002) that North American (New World) Rat Snakes of the genus *Elaphe* are a monophyletic lineage, different from Old World members of the genus. The available genus *Pantherophis* was resurrected for all North American (north of Mexico) taxa. (Crother et al 2003) noted this proposal but did not adopt it, pending further review. (Burbrink and Lawson 2007) agreed that these species do not belong in *Elaphe*, but suggested that the genus *Pantherophis* might belong in *Pituophis*. | | **Species Description –** A slender, medium-sized snake, adults range in length from 76-152 cm, the record length is 182.8 cm. The species is orange, reddish-brown, brown or grey in colour, with black-margined brown or reddish blotches. On the belly, there are alternating rows of black and white marks, resembling a piano keyboard or a variety of multi-coloured corn. The underside of the tail has two black stripes, and there is a spear-shaped pattern on the head and neck. Considerable variation occurs in the colouration and patterns of individual snakes, depending on age and distribution. Juveniles are similar to adults in appearance, hatchlings range in size from 22-36 cm (Mehrtens 1987, Schwartz and Henderson 1991, Hudson 1998, Resmer 1999, Casler et al 2004, Huegel and Cook 2004, Florida Museum of Natural History 2006, Department of Primary Industries and Fisheries 2008, Virginia Department of Game and Inland Fisheries 2008).<br><br>**General Information –** The Corn Snake is a popular pet in both the US and in Europe (Mehrtens 1987).<br><br>**Longevity –** The average life span is 10 years, although one was documented to be 21 years old (Kaplan 1994, Ernst and Ernst 2003). The record longevity is 32.3 years (HAGR Human Ageing Genomic Resources 2006).<br><br>**Status** –<br><br>1. Red List Category – Least Concern (LC)<br><br>Rationale: Listed as 'Least Concern on the IUCN Red List of Threatened Species, in view of the large extent of occurrence, area of occupancy, number of subpopulations, and population size, and because the species is probably not declining fast enough to warrant listing in any of the threatened categories (Hammerson 2007 ). Adult population size is unknown but presumably exceeds 10,000 and probably exceeds 100,000 (NatureServe 2008).<br><br>2. CITES listed Protection Status – Not listed (CITES 2007). |
| **DATE OF ASSESSMENT: 06/11/2008**<br><br>**Bird and Mammal Model, and Reptile and Amphibian Model Used: (Bomford 2008) using PC CLIMATE (Brown et al 2006, Bureau of Rural Sciences 2006)** | | **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 |

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| | | http://www.daff.gov.au/brs/land/feral-animals/management/risk . This model used the Apple Mac application CLIMATE (Pheloung 1996) for climate matching.<br><br>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><br>**Which models are being used for the assessments:**<br><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><br>**Climate Matching Using PC CLIMATE**<br><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><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:**<br><br>NCBI, CAB Direct, MEDLINE, Science Direct, Web of Knowledge (Zoological Records, Biological Abstracts), SCIRUS, Google Search and Google Scholar 04/11/2008 | | |
| **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)* | 2 | *Climate Match Score = 367 Low climate match with Australia* [See above information on climate matching.]<br><br>Climate data from 405 locations (see species worldwide distribution map) were used to calculate the CMS. |

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| | | Overseas distribution eastern North America, with introduced populations on Grand Cayman Island, St Thomas Island, and Grand Bahama Island (Ernst and Ernst 2003) (see B2 and B3 for details). |
| *B2. Exotic population established overseas (0–4)* | 2 | *Exotic population only established on small islands less than 50 000 km$^2$*<br>▪ Considered as naturalised on the Grand Cayman Island, West Indies. It is thought the species was probably introduced from Miami, Florida, around 1985 (Schwartz and Henderson 1991, Lever 2006, Hammerson 2007 , NatureServe 2008).<br>▪ Specimens have been collected from St Thomas, the Virgin Islands, United States of America. Evidence suggests they may have arrived in cargo containers originating in Florida. Repeated sightings, as well as the capture of juveniles at the site, suggest a population in the process of establishing. This is a first documented record for this part of the Caribbean (Perry et al 2003, Hammerson 2007 , NatureServe 2008).<br>▪ Introduced to Grand Bahama Island (arrival date uncertain) (Hayes et al 2004, Hammerson 2007 , NatureServe 2008).<br>Corn Snakes, including juveniles, have been reported from Curaco and Bonaire however, no specimens available. May also be present on Antigua, Anguilla, and St Barts (Perry et al 2003). (*Because it is uncertain whether the species is present, these locations have not been included in the distribution map and CLIMATE analysis.)* |
| *B3. Overseas range size score (0–2)*<br>< 1 = 0; 1 – 70 = 1; >70 = 2 | 1 | *Overseas range between 1-70 million km$^2$, estimated at 1.91 million km$^2$. Includes current and past 1000 years, natural and introduced range.*<br>The natural distribution extends from New Jersey to Delaware, Maryland, Virginia, southern Tennessee, North and South Carolina, Georgia, Florida, Alabama, Mississippi, southeastern Louisiana. Isolated populations occur in Kentucky, southern Arkansas, northwestern Louisiana, and southeastern Texas (Thompson 1982, Schwartz and Henderson 1991, Kaplan 1994, Vaughan et al 1996, Hudson 1998, Sontag 1998, Williams 1998, Ernst and Ernst 2003, Van Dyke and Grace 2005, Florida Museum of Natural History 2006, Lever 2006, Jackson and Lee 2007, NatureServe 2008, Woodland Park Zoo 2008).<br>The species occurs from sea level to around 1800 m elevation (Ernst and Ernst 2003, Virginia Department of Game and Inland Fisheries 2008, Woodland Park Zoo 2008).<br>Introduced populations occur on Grand Cayman Island *(no location available for CLIMATE analysis)*, St Thomas Island, and Grand Bahama Island (see B2 for details). |
| **ESTABLISHMENT RISK SCORE**<br>**SUM OF SCORE A (B1) + SCORE B (B2) + SCORE C (B3) (1-12)** | **5** | |
| **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 | *Reptile* (Catalogue of Life 2008). |
| *B5. Diet score (0–1)* | 1 | *Generalist with a broad diet of many food types*<br>Corn Snakes feeds mainly on rodents, but will prey upon a range of small mammals, including bats, as well as birds and their eggs, and lizards. Young hatchlings tend to feed on lizards and tree frogs, and also small insects such as crickets. Adults feed on larger prey (such as mammals and birds). Some southern Florida populations prey upon lizards almost exclusively (Mehrtens 1987, Kaplan 1994, Hudson 1998, Resmer 1999, Ernst and Ernst 2003, Casler et al 2004, Huegel and Cook 2004, Florida Museum of Natural History 2006, Department of Primary Industries and Fisheries 2008, NatureServe 2008). |
| *B6. Habitat score - undisturbed or disturbed habitat (0–1)* | 1 | *Can live in human-disturbed habitats*<br>Corn Snakes can be found in almost any habitat, including sandy pine or oak woods, rocky hillsides, meadowlands, brushy fields, mangrove thickets and inside caves. The species is relatively tolerant of human |

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| | | disturbance and can often be found in suburban and agricultural areas, including barnyards, cultivated fields, abandoned buildings, trash piles, along abandoned railroads. It will readily enter buildings in search of prey or hiding places (Mehrtens 1987, Obst et al 1988, Kaplan 1994, Resmer 1999, Ernst and Ernst 2003, Casler et al 2004, Huegel and Cook 2004, Florida Museum of Natural History 2006, NatureServe 2008, Virginia Department of Game and Inland Fisheries 2008, Woodland Park Zoo 2008). |
| *B7. Non-migratory behaviour (0–1)* | 1 | *Non-migratory or facultative migrant in its native range*<br>Is non-migratory (NatureServe 2008). |
| **ESTABLISHMENT RISK SCORE**<br>**SUM OF B1-7 (1–16)** | **9** | |
| **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)* | 4 | *CMRS = 100 (119/2785)*<br>Overseas distribution eastern North America, with introduced populations on Grand Cayman Island, St Thomas Island, and Grand Bahama Island (Ernst and Ernst 2003) (see B3 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 exotic population in another country*<br>Exotic population established on islands (See B2 for details) (Lever 2006). |
| **Score C.** *Taxonomic Family risk score (0–30)* | 10 | *Moderate risk family (Bomford 2006)*<br>Family - Colubridae (Catalogue of Life 2008). |
| **ESTABLISHMENT RISK SCORE**<br>**SUM OF SCORE A + SCORE B + SCORE C (0 – ≥116)** | **44** | |
| **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)*<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. Question C11 addresses the risk of harm from aggressive behaviour if the species establishes a wild population).*<br>*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 (will not make unprovoked attacks causing injury requiring medical attention, and which, even if cornered or handled, are unlikely to cause injury requiring hospitalisation)*<br>The species is shy and secretive and often kept as pets because of their docile temperament. They tame easily, but will defend themselves aggressively when cornered. When threatened, they may also vibrate their tails rapidly, and although being relatively small in body mass are quite strong. Bites from captive animals are rare and usually associated with feeding. Bites result in little more than a scratch Damage (Mehrtens 1987, Kaplan 1994, Resmer 1999, Huegel and Cook 2004, New England Herpetological Society 2008).<br>R. Reed (pers comm. 2008) suggests that this species does bite fairly often, and juveniles are especially prone to biting, however bites cause little damage. |
| *A2. Risk to public safety from individual captive animals (0–2)*<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)*<br>Corn Snakes are a non-venomous species; prey is killed by constriction (Obst et al 1988, Kaplan 1994, Casler et al 2004, Deufel and Cundall 2006, Florida Museum of Natural History 2006, Department of Primary Industries and Fisheries 2008). |
| **PUBLIC SAFETY RISK SCORE**<br>**SUM OF A1 + A2 (0-4)** | **0** | |

**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 | |
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| *1. Has adverse impacts elsewhere*<br>*Impacts can be economic, environmental or social; impacts can be significant or subtle.* | ✓ | *Reported to be a minor environmental pest in any country or region [score = 1, using scoring from Australian Bird and Mammal Model Q C5 (0-3)].*<br>The Brown-headed Nuthatch (*Sitta pusilla*) occurs in southeastern United States, and on Grand Bahama Island in the Bahamas. The subspecies (*S. p. insularis*) is endemic to the island and the rarest bird in the Bahamas. While not threatened on the mainland, the island subspecies is endangered, and currently threatened by a number of factors, including habitat loss and invasive species. The Corn Snake is one of many exotic species currently threatening the survival of the nuthatch (other invasive vertebrates present on the island include the House Sparrow, Starling, feral cat, and raccoon) (Hayes et al 2004).<br>Corn Snakes may have a beneficial environmental effect, as they feed on mice and rats, helping to control rodent populations that may otherwise spread disease (Resmer 1999).<br>*Can nest or shelter in tree hollows [score = 2, using scoring from Australian Bird and Mammal Model Q C4 (0, 2)].*<br>A secretive species, the Corn Snake will spend much of the time underground moving through rodent burrows, or hidden under or in rotted logs, uprooted trees, loose bark, rocks, and other debris (Mehrtens 1987, Hudson 1998, Resmer 1999, Huegel and Cook 2004, Florida Museum of Natural History 2006, NatureServe 2008, Virginia Department of Game and Inland Fisheries 2008).<br>In the north of its range the Corn Snake hibernates during winter in rodent burrows, old stumps, hollow logs, caves, rock crevices, and old stone walls and building foundations. In the southern states, individuals may be active all year (Ernst and Ernst 2003).<br>Corn Snakes are oviparous, depositing a clutch of 10-30 eggs. The number of eggs laid per clutch is correlated with the size of the female. Eggs are laid where there is sufficient heat and humidity for incubagtion; in mammal burrows, sawdust piles, in rotting logs and stumps, or other similar locations (Resmer 1999, Ernst and Ernst 2003).<br>*No reports of damage to crops or other primary production in any country or region [score = 0, using scoring from Australian Bird and Mammal Model Q C7 (0-3)].*<br>Corn Snakes are useful in controlling rats and mice, and are helpful to farmers in keeping down these rodent populations in corn fields (Kaplan 1994, Huegel and Cook 2004).<br>*Very low risk of harm or annoyance to the public posed by a wild population [score = 1, using scoring from Australian Bird and Mammal Model Q C11 (0-5)].*<br>The Corn Snake is a non-venomous and usually does not bite. Bites are little more than a scratch (Casler et al 2004, New England Herpetological Society 2008). Corn Snakes are harmless to humans, but will strike if disturbed to scare off predators (Department of Primary Industries and Fisheries 2008). Defensive behaviour observed in a wild caught female included vertical head bobbing followed by a defensive strike; between strikes, the snake maintained an S-shaped coil posture (Van Dyke and Grace 2005). |

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| | | The species does not display aggressive behaviour protecting young and does not demonstrate parental care; newly hatched Corn Snakes must fend for themselves (Woodland Park Zoo 2008).<br>**Zoonoses**:<br>Corn Snakes can be carriers of the parasite *Cryptosporidium*, which can also affect humans (Cimon et al 1996). People at risk may include backpackers, hikers, and campers who drink unfiltered, untreated water, including swimmers, who swallow water from contaminated sources. Symptoms in humans include diarrhoea, stomach cramps or pain, dehydration, nausea, vomiting, fever, and weight loss. Symptoms last for two to 14 days. The illness is usually self-limiting in healthy individuals, but is more severe in immunocompromised persons. The illness may be persistent or remittent, lasting for months, possibly ending in death (Stevenson and Hughes 1988).<br>Many reptiles carry *Salmonella* bacteria in their intestinal tract that are easily spread to humans however transmission from reptiles 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). Risk of disease transmission from populations of the Corn Snake established in the wild is very low. |
| *2. Has close relatives with similar behavioural and ecological strategies that have had adverse impacts elsewhere ** | ✓ | Several members of the genus *Elaphe* have established exotic populations, however there are no reports of adverse impacts for these other species (Lever 2006).<br>The Beauty Snake (*Elaphe taeniura*) may have a negative impact on the indigenous mammals and birds of Okinawa Island, and its impact through predation on indigenous species is of great conservation concern (Murakami and Washitani 2002) as cited in (Ota et al 2004). This is because many of the vertebrates present on Okinawa are endemic to the island, and most are endangered or near extinction (Ito et al 2000). |
| *3. Is dietary generalist* | ✓ | Corn Snakes feeds mainly on rodents, but will prey upon a range of small mammals, including bats, as well as birds and their eggs, and lizards (Ernst and Ernst 2003) (see B5 for details). |
| *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 ** | | No information regarding density found; although females will lay a clutch of 10-30 eggs (Resmer 1999, Ernst and Ernst 2003). Very limited data on populations is available; at a study site in Florida, the Corn snake made up only 4.6% of 1,782 snakes caught or observed (Ernst and Ernst 2003). |
| *6. Harbours or transmits diseases or parasites that are present in Australia ** | ✓ | Exotic snakes can harbour diseases that could harm native snake species, such as Inclusion Body Disease or Ophidian Paramyxo Virus (Schumacher 2006). |
| *7. Has close relatives among Australia's endemic reptiles and amphibians* | ✓ | Australian snakes in the family Colubridae but not in the genus *Elaphe* (Catalogue of Life 2008; Cogger 2000). |
| *8. Is known to have spread rapidly following their release into new environments ** | | No information found (Lever 2006). |
| *9. Is predatory* | ✓ | Corn Snakes feeds mainly on rodents, but will prey upon a range of small mammals, including bats, as well as birds and their eggs, and lizards. Young hatchlings tend to feed on lizards and tree frogs, and also small insects such as crickets. Adults feed on larger prey (such as mammals and birds). Some southern Florida populations prey upon lizards almost exclusively (Mehrtens 1987, Kaplan 1994, Hudson 1998, Resmer 1999, Ernst and Ernst 2003, Casler et al 2004, Huegel and Cook 2004, Florida Museum of Natural History 2006, Department of Primary Industries and Fisheries 2008, NatureServe 2008) |

| Factors | **1**,2,3,6,7,9 | |
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| **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)*<br>*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.*<br><br>*[score = 5, using scoring from Australian Bird and Mammal Model Q C6 (0-5)].*<br><br>Reference for all vulnerable or endangered species (status noted in bold) (Department of the Environment Water Heritage and the Arts 2007, 2008).<br><br>Susceptible Australian native species or natural communities that could be threatened include:<br><br>**Small mammals: Critically endangered –** Bare-rumped Sheathtail Bat *(Saccolaimus saccolaimus nudicluniatus)*; **Endangered –** Red-tailed Phascogale (*Phascogale calura*), Sandhill Dunnart (*Sminthopsis psammophila)*, Mountain Pygmy-possum (*Burramys parvus*), Smoky Mouse (*P. fumeus*), Hastings River Mouse (*Pseudomys oralis*); **Vulnerable –** Southern Brown Bandicoot *(Isoodon obesulus*), Northern Hopping-mouse (*Notomys aquilo*), Plains Rat (*Pseudomys australis*), Pilliga Mouse (*Pseudomys pilligaensis*), Heath Rat (*Pseudomys shortridgei*) (Strahan 1995).<br><br>**Birds: Critically endangered** – Spotted Quail-thrush (*Cinclosoma punctatum*); **Endangered** – Buff-breasted Button-quail (*Turnix olivii*), Golden-shouldered Parrot (*Psephotus chrysopterygius*), Ground Parrot (*Pezoporus wallicus*), Eastern Bristlebird (*Dasyornis brachypterus*), Chestnut-rumped Heathwren (*Hylacola pyrrhopygia*), Western Whipbird (*Psophodes nigrogularis*); **Vulnerable** – Partridge Pigeon (*Geophaps smithii*), Squatter Pigeon (*G. scripta*), Black-breasted Button-quail (*T. melanogaster*), Mallee Emu-wren (*Stipiturus mallee*), Slender-billed Thornbill (*Acanthiza iredalei*), Red-lored Whistler (*Pachycephala rufogularis*) (Barrett et al 2003, Christidis and Boles 2008).<br><br>**Small lizards:** Allan's Lerista (*Lerista allanae*) **(endangered)**, Pernatty Knob-tail (*Nephrurus deleani)* **(vulnerable)** (Cogger 2000).<br><br>**Frogs: Critically endangered** – Armoured Mistfrog (*L. lorica*), Mountain Mistfrog (*L. nyakalensis*); **Vulnerable** – Southern Barred Frog (*Mixophyes balbus*), Magnificent Brood Frog (*Pseudophryne covacevichae*), Northern Corroboree Frog (*P. pengilleyi*), Kroombit Tinker Frog (*Taudactylus pleione*), Green and Golden Bell Frog (*Litoria aurea*), Littlejohn's Tree Frog (*L. littlejohni*), Wallum Sedge Frog (*L. olongburensis*), Peppered Tree Frog (*L. piperata*), Bell Frog (*L. raniformis*), Alpine Tree Frog (*L. verreauxii*) (Cogger 2000).<br><br>***AND,*** *The species has 30 - 100 grid squares within the highest four climate match classes that overlap the distribution of any susceptible species or communities*<br><br>**Small mammals:** Kultarr (*Antechinomys laniger*), Fat-tailed Dunnart (*Sminthopsis crassicaudata*), Little Long-tailed Dunnart (*S. dolichura*), Greater Long-eared Bat (*Nyctophilus timoriensis*), Gould's Wattled Bat (*Chalinolobus gouldii*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Spinifex Hopping-mouse (*Notomys alexis*) (Strahan 1995).<br><br>**Birds:** Little Button-quail (*Turnix velox*), Common Bronzewing (*Phaps chalcoptera*), Crested Pigeon (*Ocyphaps lophotes*), Mulga Parrot (*Psephotus varius*), Budgerigar (*Melopsittacus undulatus*), Pallid Cuckoo (*Cacomantis pallidus*), Black-eared Cuckoo (*Chalcites osculans*), Horsfield's Bronze-cuckoo (*C. basalis*), Spotted Nightjar (*Eurostopodus argus*), Australian Owlet-nightjar (*Aegotheles cristatus*), Rainbow Bee-eater (*Merops ornatus*), Variegated Fairy-wren (*Malurus lamberti*), White-winged Fairy-wren (*M. leucopterus*), Weebill (*Smicrornis bevirostris*), Inland Thornbill (*Acanthiza apicalis*), Chestnut-rumped Thornbill (*A. uropygialis*), Yellow-rumped Thornbill (*A. chrysorrhoa*), Southern Whiteface (*Aphelocephala leucopsis*), Spiny-cheeked Honeyeater |

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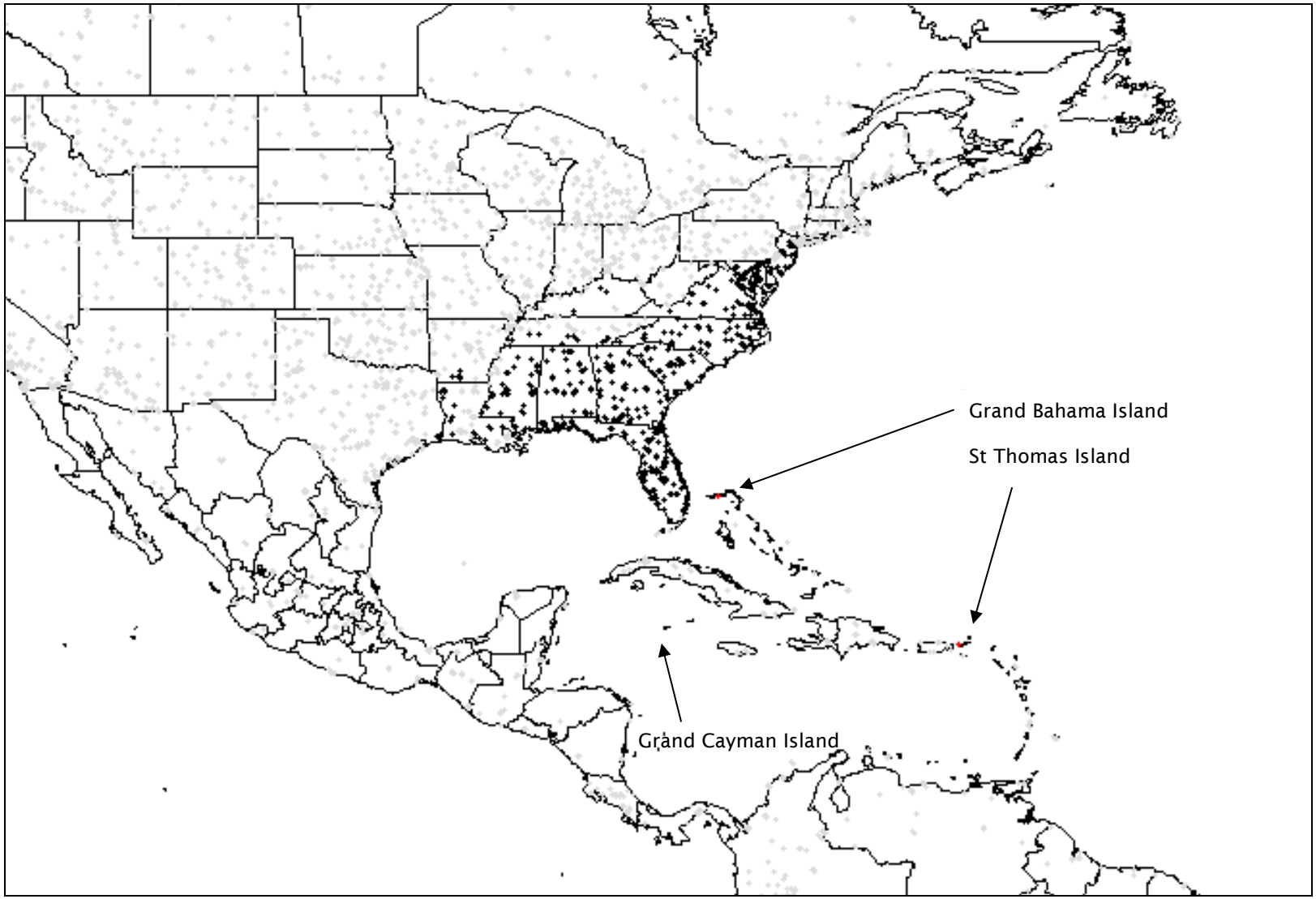
| | | (*Acanthagenys rufogularis*), Yellow-throated Miner (*Manorina flavigula*), Singing Honeyeater (*Lichenostomus virescens*), White-fronted Honeyeater (*Purnella albifrons*), Crimson Chat (*Epthianura tricolor*), Red-capped Robin (*Petroica goodenovii*), Hooded Robin (*Melanodryas cucullata*), White-browed Babbler (*Pomatostomus superciliosus*), Crested Bellbird (*Oreoica gutturalis*), Rufous Whistler (*Pachycephala rufiventris*), Grey Shrike-thrush (*Colluricincla harmonica*), Willie Wagtail (*Rhipidura leucophrys*), Black-faced Cuckoo-shrike (*Coracina novaehollandiae*), Black-faced Woodswallow (*Artamus cinereus*), Richard's Pipit (*Anthus novaeseelandiae*) (Barrett et al 2003, Christidis and Boles 2008).<br><br>**Small lizards:** Clawless Gecko (*Crenadactylus ocellatus*), Western Stone Gecko (*Diplodactylus granariensis*), Tree Dtella (*Gehyra variegata*), Bynoe's Gecko (*Heteronotia binoei*), Western Netted Dragon (*Ctenophorus reticulatus*), Barred Wedge-snout Ctenotus (*Ctenotus schomburgkii*), Spotted Ctenotus (*C. uber)*, Broad-banded Sand Swimmer (*Eremiascincus richardsonii*), Common Dwarf Skink (*Menetia greyii*) (Cogger 2000).<br><br>**Frogs:** Trilling Frog (*Neobatrachus centralis*), Kunapalari Frog (*N. kunapalari*), Shoemaker Frog (*N. sutor*) (Cogger 2000).<br><br>**Communities:** No listed vulnerable or endangered ecological communities likely to be at risk. |
| **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)*<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 elsewhere.* | 1 | *Score = 6 (Bomford 2008) [score = 1, using scoring from Australian Bird and Mammal Model Q C8 (0-5)].*<br><br>See Commodity Scores Table – species has attributes making it capable of damaging poultry and egg industries. |
| ***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)<br><br>≤ 4 = LOW ESTABLISHMENT RISK; 5-7 = MODERATE ESTABLISHMENT RISK; 8-9 = SERIOUS ESTABLISHMENT RISK; 10-12 = EXTREME ESTABLISHMENT RISK | **5** | **MODERATE** |
| MODEL B: USING THE SEVEN FACTORS/QUESTIONS FROM STAGE B OF THE AUSTRALIAN BIRD AND MAMMAL MODEL (BOMFORD 2008) PP 20)<br><br>≤ 6 = LOW ESTABLISHMENT RISK; 7-11 = MODERATE ESTABLISHMENT RISK; 12-13 = SERIOUS ESTABLISHMENT RISK; ≥ 14 = EXTREME ESTABLISHMENT RISK | **9** | **MODERATE** |
| AUSTRALIAN REPTILE AND AMPHIBIAN MODEL (BOMFORD 2008, PP 51-53)<br><br>≤ 22 = LOW ESTABLISHMENT RISK; 23-60 = MODERATE | **44** | **MODERATE** |

| | | |
|---|---|---|
| ESTABLISHMENT RISK; 61-115 = SERIOUS ESTABLISHMENT RISK; ≥116 = EXTREME ESTABLISHMENT RISK | | |
| ***HIGHEST ESTABLISHMENT RISK RANK***<br>(When establishment risk ranks differ between the models, the highest ranked outcome is used, (Bomford 2008). | - | **ON HOLD** |
| **PUBLIC SAFETY RISK RANK**<br>AUSTRALIAN BIRD & MAMMAL MODEL, STAGE A (BOMFORD 2008, PP 17)<br>A = 0 = NOT DANGEROUS; A = 1 = MODERATELY DANGEROUS; A ≥ 2 = HIGHLY DANGEROUS | **0** | NOT DANGEROUS |
| Median number of references for Establishment Risk and Public Safety Risk, for all reptiles assessed by (Massam et al 2010) (n=11)<br><br>Total number of references for this species | | 15, 2<br><br>25 – more than the median number of reptile references were used for this aspect of the assessment, indicating a decreased level of uncertainty.<br>5 - 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**<br>**(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<br>(BOMFORD 2008, PP 90-91) (0-9) | **1**,2,3,6,7,9 | |
| AUSTRALIAN SPECIES POTENTIALLY AT RISK<br>AUSTRALIAN BIRD & MAMMAL MODEL, Q. C6 (BOMFORD 2008, PP 22-23) (0-5) | **5** | |
| AUSTRALIAN PRIMARY PRODUCTION POTENTIALLY AT RISK<br>AUSTRALIAN BIRD & MAMMAL MODEL, Q. C8 (BOMFORD 2008, PP 23-25) (0-5) | 1 | |

| **ALTERNATIVE THREAT CATEGORY - assigned for this study**<br><br>**(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)** | | **SERIOUS – NOT ENDORSED BY VPC** |
|---|---|---|
| Median number of references for Establishment Risk, Public Safety Risk and Overseas Environmental and Agricultural Adverse Impacts, for all reptiles assessed by (Massam et al 2010) (n=11)<br><br>Total number of references for this species | | 20<br><br>31 – more than the median number of reptile references were used for this assessment, indicating a decreased level of uncertainty. |

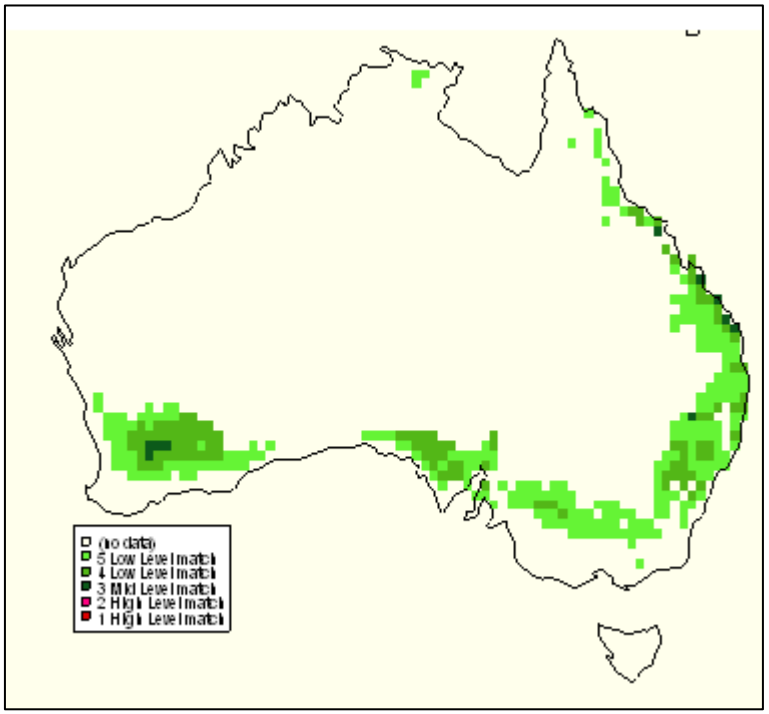
**World Distribution – Corn Snake (*Elaphe guttata*) including natural populations (black) and introduced populations (red), includes current and past 1000 years**

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.



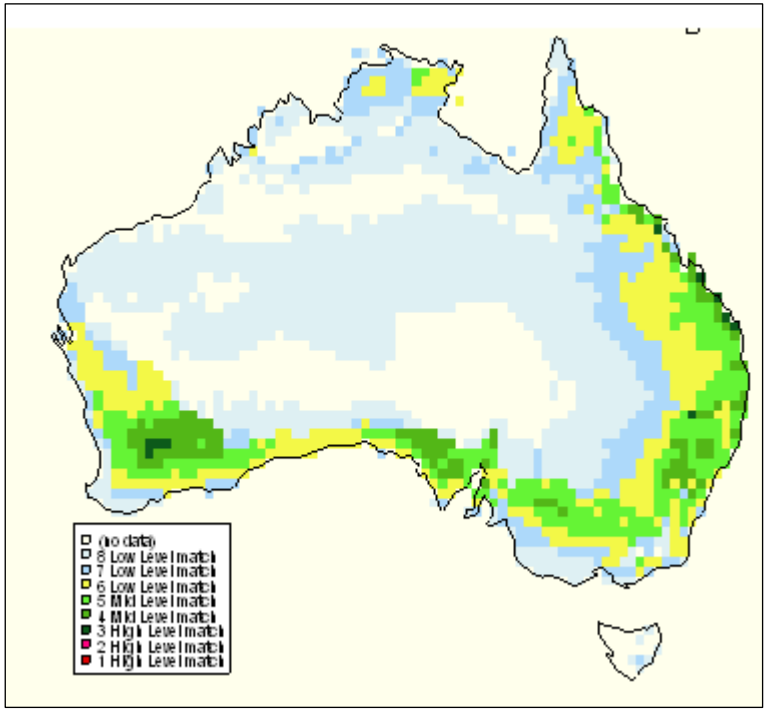
**Map 1. Climate match between the world distribution of Corn Snake (*Elaphe guttata*) and Australia for five match classes.**

| 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 | 0 |
| Dark Green | 8 MOD MATCH | 10 |
| Mid Green | 7 MOD MATCH | 109 |
| Lime Green | 6 LOW MATCH | 248 |
| | | **CMS = 367** |



**Map 2. Climate match between the world distribution of Corn Snake *(Elaphe guttata)* 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 | 0 |
| Dark Green | 8 HIGH MATCH | 10 |
| Mid Green | 7 MOD MATCH | 109 |
| Lime Green | 6 MOD MATCH | 248 |
| Yellow | 5 MOD MATCH | 335 |
| Blue | 4 LOW MATCH | 306 |
| Light blue | 3 LOW MATCH | 1136 |



## Corn Snake (*Elaphe guttata*) 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** | **1** | **3** | **6** |
| 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) | 1 | 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 | 0 | 0 | 0 |
| **Total Commodity Damage Score (TCDS)** | | | | **6** |

*[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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