Australian Government
Department of the Environment

Key Threatening Process Nomination Form - For adding a threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

Nominated threatening process – summary of eligibility
6. Name of threatening process
Herbivory and environmental degradation caused by feral deer
7. Criteria under which the threatening process is eligible for listing
Identify which criteria the threatening process meets (one or more). Please note that the information you provide in this nomination form should support your claim. For further details on the criteria, please refer to Part A of the Threatened Species Scientific Committee guidelines attached to this form. X Criterion A - Evidence that the threatening process could cause a native species or ecological community to become eligible for listing in any category, other than conservation dependant. X Criterion B - Evidence that the threatening process could cause a listed threatened species or ecological community to become eligible for listing in another category representing a higher degree of endangerment. X Criterion C - Evidence that the threatening process adversely affects two or more listed threatened species (other than conservation dependant species) or two or more listed threatened ecological communities.

Section 1 - Name and Description

Conservation Theme

1. The conservation themes for the assessment period commencing 1 October 2010 (for which nominations close 25 March 2010) are **'heathlands and mallee woodlands', and 'terrestrial, estuarine and near–shore environments of Australia's coast'.** *How does this nomination relate to the **conservation themes**?*
Not applicable

Name

2. *Name of nominated threatening process. The name should accurately reflect the scope of the process based on the description and evidence provided in this form.*
Herbivory and environmental degradation caused by feral deer

Description

***3**. Description of the threatening process that distinguishes it from any other threatening process, by reference to:* *(i) its biological and non-biological components;* *1. (ii) the processes by which those components interact (if known).*

1. Feral deer in Australia - background

Deer are hard-hoofed mammals (ungulates) of family Cervidae distributed over Eurasia and the Americas. The first successful introductions into Australia were by acclimatisation societies in the 1800s. A history of their introduction can be found in Moriarty (2004). Of 18 species released, six species of three genera have established populations that currently survive and are the subject of this nomination (for a description see Van Dyck and Strahan 2008 and section 2 here):

- Chital (*Axis axis*)
- Hog Deer (*Axis porcinus*)
- Red Deer (*Cervus elaphus*)
- Rusa Deer (*Cervus timorensis*)
- Sambar (*Cervus unicolor*)
- Fallow Deer (*Dama dama*)

Feral populations have established due to release by acclimatisation societies (7% of 218 populations identified in 2002); escapes and releases from deer farms (35%); and translocation, presumably for hunting (58%) (Moriarty 2004). The rapid growth in deer farming in the 1970s-80s (an annual 25% increase in the number of farmed deer) has been the source for the recent expansion in wild deer populations (Jesser 2005). When the market for deer products crashed in the early 1990s some farmers released their deer or failed to maintain adequate fencing. Others were bought cheaply by hunters and released into new areas.

Collectively, ungulates have been implicated in significant adverse impacts on the environment, with goats and pigs recognised as key threatening processes under the EPBC Act and others such as camels the subject of substantial federally funded control programs. They have damaging impacts in common: consumption of rare species, competition with native herbivores, degradation of habitats by compaction, erosion and vegetation destruction, and weed spread. However, in contrast to most other feral ungulates, deer have had a reputation in Australia as environmentally benign. Deer have done 'no noticeable damage in Australia', said Rolls (1969) and Bentley (1998) claimed they 'are a benign presence in the Australian environment'. This reputation is due to relatively low populations, their low visibility in the environment and a lack of research. The deer hunting lobby has strongly promoted a positive image for deer, for they are regarded as premier game animals and highly sought-after trophy animals. Recent reports of rapid increases in deer numbers and deer damage in many areas increasingly undermine claims them ** the earlier benign reputation.

As Frith (1973) argues, the introduction of any large herbivore cannot fail to have an impact. Exotic deer elsewhere are known to cause substantial ecological damage (see Cotes et al. 2004 for a summary) and damage caused by exotic herbivores of comparable size – feral goats, for example – is substantial and typically related to population size (Parkes et al. 1996). With favourable climates in Australia, lack of predators and diseases, a large dietary range and adaptability to a wide range of habitats, deer could become one of Australia's most successful and damaging invaders (Low 2008).

Because of the strong hunting lobby in some states, feral deer have an unusual and variable legal status throughout Australia (see section 3 here). In some states they are accorded protection equivalent to that for native animals; in others they are declared pest species. In the three states in which deer are protected for hunting, spotlight hunting (usually the most effective method of ground shooting) is not permitted.

Interestingly, two of the states in which deer are protected (Victoria and NSW) have also listed one or more species as threatening processes, creating an apparent conflict in management goals. These declarations occurred only because there are independent scientific committees in these states to assess nominations for threatening processes. In Victoria, the Australian Deer Association attempted to have the 'Potentially Threatening Process' declaration overturned in court.

2. A brief description of feral deer species in Australia

Information from Strahan and van Dyck (2008); Jesser (2005). Population growth rates from Hone et al. (2010). Bioclimatic information from Moriarty (2004, with unpublished data from [redacted]).

Chital *(Axis axis)*
Native range: Indian subcontinent and Sri Lanka
Habitat: Strong preference for woodland, forests and clearings near waterways.
Size: Relatively small. Stags up to 100 kg and 101 cm at shoulder. Hinds up to 50 kg.
Behavour: Gregarious, mostly live in large herds of many females and young and 2-3 stags. Grazers

and browsers. Feed most actively at dawn and dusk.
Breeding: Often give birth to 2 or 3 young. Maximum annual population growth rate 0.76.
Bioclimatic (predicted) distribution: High habitat suitability across most of Australia.

Red Deer *(Cervus elaphus)*
Native range: Probably western China
Habitat: Preferred habitat of open, grassy glades in forests.
Size: Large. Stags up to 158 kg and 122 cm at shoulder. Hinds up to 92 kg.
Behavour: Gregarious. Sexes remain apart most of the year. Hinds and young form matriarchal herds. During the rut of 6-12 weeks, stags fight for females and form harems up to 50 hinds. Grazers and browsers. Diurnal. Peak activity at dawn and dusk.
Breeding: Usually give birth to a single calf.
Bioclimatic (predicted) distribution: High habitat suitability in southern Australia and eastern Australia (up to central Queensland).

Rusa Deer *(Cervus timorensis)*
Native range: Indonesia
Habitat: Preferred habitat is grassy plains bordered by dense brush or woodlands.
Size: Medium-sized. Stags up to 140 kg and 120 cm at shoulder. Hinds up to 75 kg.
Behavour: Gregarious. Stags 'plough' vegetation during the rut and drape antlers with plants to establish dominance. Semi-nocturnal. Preferential grazers of grass but also browse.
Breeding: Hinds can produce 3 calves in 2 years. Maximum annual population growth rate 0.7.
Bioclimatic (predicted) distribution: High habitat suitability in some coastal areas in northern Australia, eastern Australia, southern Australia (in the east) and Tasmania.

Fallow Deer *(Dama dama)*
Native range: Europe
Habitat: Open, glassy glades or forest margins for feeding; also marshes, agricultural lands, conifer plantations. Will retreat into forest with dense understorey.
Size: Relatively small. Stags up to 110 kg and 98 cm at shoulder. Hinds up to 56 kg.
Behavour: Gregarious. Mature bucks live apart from females until the rut. During rut, they herd females, and establish territories and rutting stands. Diurnal. Peak activity at dawn and dusk. Predominantly a grazer.
Breeding: Give birth to 1 young. Maximum annual population growth rate 0.45.
Bioclimatic (predicted) distribution: High habitat suitability across the southern third of Australia.

Hog deer *(Axis porcinus)*
Native range: Southeast Asia
Habitat: Coastal scrublands and swamps
Size: The smallest deer in Australia. Stags up to 45 kg and 72 cm at shoulder. Hinds up to 25 kg.
Behavour: Mostly solitary but often found in pairs. Large numbers can be observed in favoured foraging areas. Most active at dawn and dusk, occasionally during the day, but more nocturnal in areas subject to hunting. Mostly a grazer, also browses.
Breeding: Mostly 1 calf. Maximum annual population growth rate 0.85.
Bioclimatic (predicted) distribution: High habitat suitability across the top half of Australia.

Sambar *(Cervus unicolour)*
Native range: Southeast Asia
Habitat: Forests, woodlands.
Size: Largest species in Australia. Stags up to 300 kg and 140 cm at the shoulder. Hinds up to 230 kg.
Behavour: Stags generally solitary. Hinds and offspring may form small groups. Large numbers may congregate in productive foraging areas. Browser and grazer. Mostly nocturnal.
Breeding: Usually a single calf annually. Maximum annual population growth rate 0.55.
Bioclimatic (predicted) distribution: High habitat suitability across the top half of Australia, southeast Australia and Tasmania.

3. State-based information

Following is information about the deer species established in each state and the laws and policies that apply to feral deer.

Queensland
Information from Moriarty (2004); Jesser (2005); Pople et al. (2009); DEEDI (2010)

'More recently, wild deer populations have increased in density and range, due likely to a combination of natural spread, escapes from deer farms and deliberate releases for hunting. These new populations,

in particular, have the potential to adversely affect the environment, primary production and human safety…' (Pople et al. 2009)

'The possible impact of sambar in the wet tropics or hog deer in coastal wetlands, and the implications for some native species in those areas, gives cause for concern. The status quo could also be disturbed by the introduction of new genetic material if the effect was to increase the adaptability of deer species in Queensland.' (Jesser 2005)

Species established: Red, Fallow, Chital, Rusa

Distribution: Red Deer in southeast Queensland, near Rockhampton, around Roma, Injune and Mitchell. Chital in north Queensland, around Charters Towers and mouth of the Burdekin River. Rusa in Torres Stait Islands, Townsville, Rockhampton, Stanthorpe, Charters Towers. (Jesser 2005 notes anecdotal reports that 600 Rusa were released onto the Gulf Plains.) Fallow Deer around Warwick and elsewhere in southern Queensland. Large potential for greatly expanded range for all species.

Abundance: At least 20 populations, totaling about 30,000 (DEEDI 2010) but Moriarty (2004) reported 32 herds in 2002. Red Deer and Chital: number in the 10,000s. Fallow Deer: a few thousand. Rusa Deer: several hundred. Recent population increases attributed to natural spread, escapes and deliberate releases for hunting. 'Most populations of the four existing species outside the historic ranges are small and localised, suggesting they could be eradicated' (Pople et al. 2009).

Legal status: Since 2009, deer have been declared pest animals under the *Land Protection (Pest and Stock Route Management) Act 2002*. Class 1 (subject to eradication): Hog, White-tail, Sambar. Class 2 (control by landowners required): Rusa, Chital. Class 3 (control required if next to an environmentally sensitive area): Red, Fallow. (Deer were protected wildlife until 1994.)

Policy: A Feral Deer Management Strategy is under development (public consultation on the draft strategy recently closed). The draft included a goal to 'eradicate feral deer from defined areas where feasible and where eradication will have a long-term effect.'

NSW

Information from Moriarty (2004); NSW Scientific Committee (2004); West and Saunders (2007)

Species established: Rusa, Fallow, Red, Chital, Hog, Sambar

Distribution: Widely but patchily distributed on the Coast and Tablelands; at low densities in western NSW. Presence reported over about 50,000 km^2 (6% of the state) in 2005. Occur in many conservation reserves, including Bouddi, Deua, Guy Fawkes River, Royal, Blue Mountains, Kosciuszko, Morton, South East Forests, Wadbilliga and Towarri National Parks; Dharawal, Illawarra Escarpment and Mount Canobolas State Conservation Areas and Dharawal, Karuah, Lake Innes, Macquarie, Sea Acres and Wallaroo Nature Reserves. Bioclimatic modelling suggests all species could increase their ranges. Suitable climates exist over most of the state for Red, Chital and Fallow Deer.

Abundance: 96 herds reported in 2002. During 2004/05, wild deer were reported as occurring mainly at low densities in NSW. Areas reported to have medium to high densities covered 13,000km^2.

Legal status: Deer are protected under the *Game and Feral Animal Control Act 2002.* A hunting license must be obtained from the NSW Game Council (a few exceptions include farmers and government personnel) and hunting restrictions apply (a closed season for some species and spotlighting is not permitted). Hunting is permitted in most state forests.

'Herbivory and environmental degradation caused by feral deer' was listed as a Key Threatening Process under the *Threatened Species Conservation Act 1995* (TSC Act) in 2004.

Policy: No Threat Abatement Plan has been implemented. Deer are included in pest control plans for several national parks and there is a deer management program at Royal NP. Otherwise, deer are managed mostly for hunting and control is conducted mostly for economic or social/safety reasons.

ACT

Information from Moriarty (2004); Styles (2009).

'Despite initial control efforts being made, deer continued to disperse within the ACT, in particular along most of the length of the Murrumbidgee River, and also into mountain areas within Namadgi National Park, where few feasible control efforts were considered to be available.' (Styles 2009).

Species established: Fallow, Red, Sambar

Distribution: Along the Murrumbidgee River, into mountain areas within Namadgi National Park. Sambar and Red Deer in the south and Fallow Deer in the northeast.

Abundance: 8 herds reported in 2002. Mostly Fallow Deer (suspected of escaping/being released from a collapsed deer-farming venture). Deer sightings increased after the 2003 bushfires.

Legal status: Declared as pest animals under the *Pest Plants and Animals Act 2005*.

Policy: None known.

Victoria
Information from Moriarty (2004); Wright et al. (2009); State Government website.

'In limited instances, permits are issued to landholders for site-specific destruction where deer are having adverse impacts on agricultural, property or conservation values. However, while destruction permits may be issued, little work is currently undertaken to actively manage the abundance of deer or impacts they may have on natural values on public land.' (Wright et al. 2009)

Species established: Sambar, Hog, Red, Fallow

Distribution: Occur mostly in forests and woodlands in eastern Victoria; scattered populations in the west. Sambar are most widely distributed – throughout central and eastern Victoria. Hog Deer occur in low-lying coastal areas in eastern Victoria. Red Deer are mostly in the Grampians in western Victoria, but recent sightings in other areas suggest farm escapes or releases. Fallow Deer are patchily distributed due to releases since the 1990s.

Abundance: 51 herds reported in 2002. Sambar are most abundant, possibly numbering hundreds of thousands, and increasing. Fallow Deer may also be increasing.

Legal status: 'Protected wildlife' under the Victorian *Wildlife Act 1975*. No person may take or destroy protected wildlife, except where authorised. Classified as 'game' under the *Wildlife Act 1975* so may be taken by licensed hunters under regulations (bag limits and closed seasons apply to some species and spotlighting is not permitted). Deer hunting is permitted in some national parks.

'Reduction in biodiversity of native vegetation by Sambar (*Cervus unicolor*)' is listed as a Potentially Threatening Processes under Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act).

Policy: Most management is directed towards supporting recreational hunting. A draft Flora and Fauna Guarantee Action Statement in response to the threatening process listing has been developed.

Tasmania
Information from Moriarty (2004); Hall (2009); Tasmanian Government Website

'Tasmania boasts the potential to become one of the greatest fallow deer herds in the world.' (Hall [Tasmanian Government] 2009)

Species established: Fallow.

Distribution: Found on >30% of mainland Tasmania (2005) in an area roughly bounded by a line from Launceston to Derwent Bridge to Pontville to the east-coast to St. Helens and back to Launceston. In some areas there is recent range expansion.

Abundance: 4 herds reported in 2002. Estimated at 20,000 (Hall 2005) or 30,000 (Tasmanian Government).

Legal status: 'Partly-protected fauna' under the *Wildlife Regulations 1999*. An annual season is proclaimed for male and antlerless deer (about 2500 deer are hunted annually).

Policy: Deer are managed for the benefit of hunters. There is a Quality Deer Management program that 'involves the production of quality deer, quality habitat, quality hunting, and importantly, quality hunters' (Hall 2009). One landowner with a conservation covenant on his land was refused a permit to cull deer to prevent environmental damage to his property in spite of a legal agreement (which established the covenant) obliging the relevant Minister to provide support for the control of exotic

species that may impact the area's natural values ([redacted] [redacted] pers. comm.).

South Australia
Information mostly from Moriarty (2004); Williams (2009), State Government website.

Species established: Fallow, Red, Sambar, Rusa

Distribution: Fallow Deer in pockets in parts of the south east, mid north and Mt Lofty Ranges. Recent reports of small populations of fallow deer establishing in new areas (probably due to liberations by hunters or farm escapes). New herds of fallow deer at Burra, Southern Fleurieu Peninsula, Elliston and Kangaroo Island. Small herds of other species recently reported in the upper south east and around the Bundaleer forest in the mid north.

Abundance: 23 herds reported in 2002. Fallow Deer are the most abundant species; others are in low numbers but increasing.

Legal status: Under the *Natural Resources Management Regulations 2005*, landholders with wild deer on their land without their consent must control deer in accordance with Natural Resources Management (NRM) Board Regional Plans.

Policy: There is a State Policy on Wild Deer, requiring landowners to control deer. The goal is to eradicate new populations and control established populations to limit damage. There is an eradication program for Kangaroo Island (Masters 2009). Control programs are conducted in national parks and surrounding lands in the South East region, including with annual aerial shooting for the past 3 years.

Western Australia
Information from Moriarty (2004); Woolnough & Kirkpatrick (2009)

'In the last decade there has been increased concern about wild populations of these three species becoming more widely established in WA because of escapes from deer farms and deliberate releases for hunting (Long 2003). Currently, the agricultural and environmental impacts seem to be less than other populations of wild deer in eastern Australia and New Zealand, but this may be because of their low density and relatively restricted distribution in this state.' (Woolnough and Kirkpatrick 2009)

Species established: Red, Fallow, Rusa.

Distribution: Generally restricted to the southwest. Anecdotal evidence that recreational hunters have released breeding pairs obtained from farmed herds into bushland. Deer seem to persist and expand where 1080- bearing plants (*Gastrolobium* spp) occur.

Abundance: 3 herds reported in 2002. Low abundance reported in a 2005 survey of staff from DAFWA and DEC (but this may be a consequence of deer being difficult to detect and quantify). Red Deer are reportedly most common, followed by Fallow Deer. Present in Mount Frankland National Park, Fitzgerald River National Park, the Perth hills, Harvey hills and parts of the Greenough and Northampton Shires.

Legal status: All deer are on the List of Declared Pest Animals, under the *Agriculture and Related Resources Protection Act 1976* (Section 37). Red Deer & Fallow deer: categories A5 (numbers will be reduced/controlled) and A6 (keeping under Department of Agriculture and Food [DAFWA] permit and/or conditions). Other deer: categories A1 (entry prohibited), A2 (subject to eradication in the wild) and A3 (keeping prohibited).

Policy: There are no specific policies on wild deer management and no resources allocated. 'There is an urgent need for information on options for controlling deer at large in WA.'

Northern Territory
Information from Moriarty (2004); NT Government website.

Species established: Rusa, Sambar

Distribution: Rusa on Groote Eylandt and other smaller islands in the Gulf of Carpentaria; Coburg Peninsula and in Western Arnhem Land.

Abundance: 1 herd reported in 2002. Regarded as a 'minor pest'.

Legal status: Rusa and Sambar are declared feral pests under the *Territory Parks and Wildlife Conservation Act 2006*.

Policy: None known.

4. Deer abundance

Moriarty (2004) observes that feral deer in Australia have moved, relatively recently, 'from a minor component of the Australian biota to one that is now widespread'. Others also note recent population increases and range expansions (Jesser 2005; Peel et al. 2005; West and Saunders 2007). Moriarty's (2004) study was based on a comprehensive survey in 2002, with a very high return rate, of government land management agencies in each state and territory. The reported number of herds was 218. Although the majority of deer were in long-established acclimatisation-derived herds, the vast majority of herds were only recently established, with >90% established since about 1990 due to escapees/releases from deer farms and translocations by hunters.

The recent increase in feral deer populations can be partly attributed to a crash in prices for farmed deer in the early 1990s: 'Some animals escaped and were not recovered. Others were liberated as the cost of feeding them began to outweigh their value, even for slaughter. Some were purchased from farmers or trappers, to be released by those wishing to create their own populations for hunting or aesthetic reasons' (Jesser 2005). Moriarty (2007) also attributes the 'dramatic' increase in releases to the increased popularity of hunting, and the use of more effective control measures by land managers leading to less game species in some areas.

Almost half the total herds (44%) reported in 2002 were from NSW, a quarter from Victoria (23%), 15% in Queensland, 11% in South Australia and less than 5% each from the other states and territories (Moriarty 2004). Average population sizes were reported to be about 12,000 animals for herds deriving from acclimatisation (having had much longer to breed), about 140 animals per herd from farming releases/escapes and about 120 animals per translocated herd.

Table 1: Population and herd numbers estimated by Moriarty (2004)

	Fallow	Red	Sambar	Chital	Rusa	Hog	Total
Population (%)	55,000 (28)	32,500 (17)	70,700 (36)	13,000 (7)	15,000 (8)	9300 (5)	196,000
Herds (%)	85 (39)	65 (30)	8 (3)	28 (13)	23 (11)	9 (4)	218

Moriarty (2004) estimated total feral deer numbers at 200,000. However, this number is a considerable underestimate. In 2008-09 Victorian hunters reported killing 34,000 Sambar (Gormley and Turner 2009) – an impossible feat if the total Australian population size was not much more than the 71,000 reported for 2002 in Moriarty (2004).

However, Moriarty's 2002 estimate was a considerable increase on that for 1980 by the Standing Committee on Agriculture (1980, cited in Jesser 2005), with the difference between the two estimates suggesting that deer in acclimatisation herds (the longest-established and largest herds) had more than tripled in two decades, climbing from fewer than 50,000 (in 20 herds) in 1980 to about 170,000 in 2002. Jesser (2005) suggests that changes in management 'enabled some populations to increase beyond the critical threshold below which they previously had been held by hunting and natural predation.' That more than 90% of Australia's feral deer populations are only recently established due to farm releases/escapes and translocations implies a worryingly large potential for population expansion in the near future.

Numbers of Sambar, the most successful deer in Australia, have risen dramatically in Victoria. In 1995, they were estimated to number 8000 (Bentley 1995) and Moriarty (2004) estimated nine times that number (70,700) in 2002. In 2004 Victorian hunters were reportedly killing >8500 Sambar annually (Peel et al. citing DSE 2005) but just five years later they reportedly killed four times as many (34,000) (Gormley and Turnbull 2009) suggesting a total population numbering in the hundreds of thousands. The Victorian Government's website says hunting 'appears to have little noticeable effect on the success of the species', that Sambar have steadily extended their range into NSW and the ACT, and that their density is increasing. Modelling by Ray and Burgman (2006) based on analysis of suitable habitat suggests the potential Sambar population in Victoria could climb as high as 1 million.

Surveys of government land managers suggest that deer numbers in NSW are also rising rapidly. Deer presence was reported from 30 new NSW locations between 2002-2005, equivalent to an increase in range by >8000 km^2 (West and Saunders 2007). Areas with reported high deer density quadrupled.

Populations from other areas also are reported to be increasing although not as rapidly. Dryden (2009) calculates that the population of feral Red Deer in the Brisbane and Mary River valleys of southeast Queensland size has increased at about 6 percent per year over the past 130 years. The current population, estimated at 16-20,000, has probably been augmented by escapes and releases from deer

farms. They have been spreading out of the Brisbane River valley into surrounding areas.

Deer have a large potential for population increase. Hone et al. (2010) calculated maximum annual population growth rates for 5 of the 6 species feral in Australia (Table 2).

Table 2: Population growth rates for feral deer species (Hone et al. 2010)

	Female age at first reproduction (years)	Maximum annual population growth rate r_m	Maximum annual proportion to be removed to stop population growth
Axis axis	0.92	0.76	0.49
Axis porcinus	0.83	0.85	0.52
Cervus timorensis	1.00	0.70	0.46
Cervus unicolor	1.25	0.55	0.40
Dama dama	1.55	0.45	0.34

Forsyth and Caley (2006) propose that most large herbivores, particularly when introduced to a new environment, exhibit eruptive population dynamics: 'following introduction to new range or release from harvesting, the herbivore population increases to peak abundance, crashes to a lower abundance, and then increases to a carrying capacity lower than peak abundance'. The post-decline density is lower than the initial peak because the quantity and/or quality of food has been reduced, as preferred and browse-intolerant species decline and are replaced by unpalatable or more browse-tolerant species. Such a population dynamic has the potential to damage ecosystems and result in biodiversity losses, some of which are likely to be irreversible (Coomes et al. 2003). Current reports of rapid increases in deer populations in many areas are thus of considerable concern.

The greatest densities of feral ungulates occur in inland Australia west of the Great Divide. Deer, by contrast, are distributed throughout most of eastern and southern Australia where feral herbivore pest densities have been relatively low. Bioclimatic models show there is vast potential for expansion of all deer species into new areas (Moriarty 2004). For example, Sambar, Rusa and Hog Deer are tropical Asian deer that currently have their main Australian populations outside the tropics. As Moriarty (2009) says, 'If deer population trends in Australia continue to increase at their current rate, deer species are likely to rival both feral pigs and feral goats in distribution, abundance and impacts in the near future.'

5. Impacts of herbivory by feral deer

Decline of deer-preferred species

As selective feeders, deer can modify the relative abundance of species and alter the composition and dynamics of plant communities (Cote et al. 2004). Native plants in foraged habitats will fall into one of three categories defined by Forsyth et al. (2003): (1) preferred, (2) neither preferred nor avoided, (3) avoided. Those species that are preferred components of deer diet are at greatest risk of decline, particularly if they are rare. They may be at risk even if deer densities are low as 'even low levels of foraging could have impacts on the regeneration, growth and abundance of rare species' (Davis et al. 2008). As Cote et al. (2004) caution, it should not be assumed that deer impacts are simply proportional to deer density across sites; extirpations may accelerate once plant populations grow sparse (warranting a precautionary focus on potentially susceptible rare species).

Although it can be difficult to prove links between deer herbivory and species declines, particularly when there are co-existing herbivores, in some cases the link is obvious. (The height of browsing often indicates deer herbivory as large deer can reach much higher than native herbivores – up to 2.5 m for Sambar (Peel et al. 2005.) In East Gippsland Peel et al. (2005) recorded severe browsing pressure by Sambar and decline of several species (they list about 50 species 'severely and adversely affected' by browsing in East Gippsland). For example, saplings of the rainforest canopy species Black Wattle (*Acacia mearnsii*), Blackwood (*Acacia melanoxylon*), Lily Pily (*Acmena smithii*), Yellowwood (*Acronychia oblongifolia*), Sweet Pittosporum (*Pittosporum undulatum*) and Muttonwood (*Rapania howittania*) are being browsed to death, preventing regeneration, opening up rainforest margins and increasing the risk of fire entering rainforest. Browsing damage attributed to deer was recorded on 73-100% of the tree ferns *Cyathea australis* and *Dicksonia antarctica* in the Yarra Ranges (Forsyth 2007, citing Bennett 2002). [redacted] (pers. comm.) characterised *Gynatrix macrophylla*, a rare Victorian species now critically endangered according to IUCN criteria, as 'ice-cream' for Sambar (see under Q5). Similarly, Keith and Pellow (2005) concluded that *Syzygium paniculatum* was a particularly palatable species for Rusa Deer after finding that more than 75% of foliage and branchlets were consumed on most of the 93 individuals to which deer had access for 3 months (see under Q9).

Plants likely to be least tolerant of browsing are those that grow slowly (such as understorey plants in shady forests) and small ephemeral herbs such as orchirds that lose all their leaves or flowers in a single bite (Cote et al. 2004). Species browsed or grazed by deer that are not typically eaten by native

herbivores could be highly susceptible to herbivory (as anti-herbivore defenses are costly for plants) (Gomez and Zamora 2002). The dietary overlap between Rusa Deer and Swamp Wallabies (*Wallabia bicolor*) in Royal NP ranged from only 24% in autumn in a heath habitat to 60% in winter in a cleared/mosaic habitat (Moriarty 2004b). Deer tended to consume more trees, shrubs and introduced grasses while wallabies tended to consume more herbs, orchids, sedges, grasses, rushes and fungi. In contrast there was substantial overlap in the diet of Hog Deer and Swamp Wallabies foraging in Coastal Grassy Woodland at Yanakie Isthmus, Wilsons Promontory (Davis et al. 2008).

Selective herbivory can strongly affect competitive relationships among plants, facilitating increase in browse-tolerant and unpalatable species. Although not a definitive example, because other factors are likely to be involved, the encroachment of *Leptospermum laevigatum* at Yanakie Isthmus may be assisted because it is mostly avoided by herbivores, exotic and native (Davis et al. 2008).

Loss of plant biomass

As medium to large herbivores, feral deer eat large volumes of plant matter. The sheer volume of herbivory can have substantial impacts on ecosystem structure and processes, with implications for birds and other wildlife that depend on particular vegetation structure. This is the case whether herbivores are exotic or native, as overabundant deer populations in their native ranges in North America and Europe have demonstrated (Cote et al. 2004).

Assessing volumes in the rumen of Rusa Deer in Royal National Park, Moriarty (2004b) found they ate an 'alarming' amount of native vegetation, likely to have 'profound consequences' for the NP, a relatively small area with high habitat diversity. He estimated the deer population (from 2500-2900 in 1999-2001) ate a total of 47 million litres of material per year, of which about three-quarters was native. Deer in different habitats consumed different amounts, with an average deer in:

- cleared/mosaic areas consuming ~ 280 litres of food/season (160 litres native)
- forest/rainforest ~ 430 litres (210 litres native)
- woodland ~ 380 litres (346 litres native)
- heath ~ 244 litres (220 litres native).

Moriarty (2004b) concluded that Swamp Wallaby numbers in Royal NP are depressed by Rusa Deer. In most of their range, the wallabies are at densities of 8-19 animals/km^2 but densities in Royal NP are an estimated 2.2-2.7 animals/km^2, and the highest wallaby densities were recorded where deer densities were lowest. Modelling by Moriarty suggested that Royal NP was inhabited by almost three times the number of medium-sized herbivores than other areas along the east coast of Australia. An average Rusa Deer consumed about 3.9 times the volume of food eaten by a Swamp Wallaby but less diversity.

Bennett (2008) found that Sambar were consuming almost all available forage at a favoured feeding location in Yarra Ranges National Park. Sambar eat about 3–4 kg dry weight/day, compared with 400 g eaten by swamp wallabies (*Wallabia bicolor*) and 700-1450 g by common wombats (*Vombatus ursinus*). Bennett calculated that Sambar consumed 5.8–30.0 tonnes (dry weight) per month. Using selective exclosures that permitted differentiation between Sambar and native herbivores, Bennett (2008) recorded significantly reduced biomass in forest understorey in areas with high Sambar densities. Most browsing occurred on branches above 60 cm in height, and prevented the vertical growth of plants in the understorey. Three species were browsed to a significantly greater extent than by native herbivores: Hazel Pomaderris (*Pomaderris aspera*), Prickly Tea-tree (*Leptospermum continentale*) and Prickly Bush-pea (*Pultenaea juniperina*).

Large numbers of Chital around Charters Towers have caused significant damage in grazing vegetation to bare ground (Jesser 2005 citing Peterson 2004). Some sensitive or low-productivity ecosystems, such as in alpine areas where the growing season is short or forest understoreys, may be particularly sensitive to the loss of plant biomass through deer herbivory.

Most of the native herbivores currently competing with feral deer for forage are widespread and abundant so not threatened by deer. However, deer expansion into the habitat of threatened native herbivores could be a problem. Dawson and Ellis (1979) found that feral goats competed with endangered yellow-footed rock wallabies for water and food particularly during drought. Feral deer could be a problem for Malleefowl for this reason; sheep grazing reduces their breeding density by up to 90% (Benshemesh 2007).

Declines in plant diversity

In the one Australian study assessing the impacts of deer on plant diversity, Moriarty (2004b) found that Rusa Deer in high densities substantially reduced diversity in three vegetation communities in Royal NP, implicating them as 'gross habitat changers'. Moriarty assessed species diversity in littoral rainforest (wet forest), sandstone gully forest (dry forest) and sandstone heath, each of which contains

rare and threatened plant species. Using fenced exclosure plots, he compared no deer, low deer density (<5/km^2) and high deer density (>20/km^2). Few differences were recorded for no deer versus low deer density, probably because of the short experimental duration (3 years compared to the 10-30 years it usually takes for significant changes to be detected). But there were substantial (and significant) differences between plots with low deer density and high deer density. Plant diversity was reduced by 27 to 54% in the three habitats (see Table 3). For example, in littoral rainforest plots subject to high deer density the mean number of species was 17 compared to 37 in plots subject to low deer density.

Table 3: Percentage reduction in plant species diversity in three habitats in Royal NP in areas with high deer density compared to low deer density (recorded by Moriarty 2004b).

	Saplings	Understorey spp	Ground cover spp	Plant spp total
Littoral rainforest	58%	28%	65%	54%
Sandstone gully forest	49%	28%	37%	33%
Sandstone heath	-	21%	29%	27%

Rusa eat a wide range of native plants, with Moriarty identifying material from 155 species (18 genera) in the rumen of deer in Royal NP. About one-third of species could not be identified. The majority were shrubs (43%) or trees (26%).

In opportunistic observations of bushland in Royal NP, Keith and Pellow (2005) recorded that deer ate 60-66 of 70 plant species within 1km of the Bundeena township. Shoot removal was particularly conspicuous for leguminous species, with complete defoliation of some species. Bark removed from some species may also have been eaten. Nine species, most prevalently orchids, had flowers consumed or damaged.

About 15% of the identified species in the Rusa Deer rumens were listed as threatened species (2 listed as endangered and 9 as vulnerable under the TSC Act) or regionally rare (13 species). They were present mostly in deer from low-density areas implying they had already been eradicated or almost so from high-density areas. NSW's Scientific Committee (2004) accepted that some of these species were threatened or potentially threatened by deer herbivory. A number of species listed under Victoria's *Flora and Fauna Guarantee Act* (FFG Act) and browsed by Sambar were recognised by Victoria's Scientific Advisory Committee (SAC 2007) as threatened by Sambar.

Some mycological experts are also concerned about the impact of feral deer on fungi. Rare fungi species in the wet forests of central and southern Victoria inhabited by Sambar are no longer recorded at former known locations and are being replaced by common species (David Cameron, DSE pers. comm.). Some mosses and liverworts may also be susceptible (Peel et al. 2005).

Compromised regeneration

Deer herbivory is known to compromise multiple stages of plant life cycles – consumption of seedlings preventing establishment, consumption of shoots of juvenile plants reducing survival and growth, consumption of shoots of adult plants reducing seed production, and consumption of seeds preventing regeneration. Keith and Pellow (2005) propose that the greatest influence of deer on population viability of species is in preventing the establishment of seedlings and reducing seed production.

Destruction of seedlings: Deer often target seedlings and saplings and tree species are most vulnerable at this stage. Peel et al. (2005) list 13 tree and shrub species in East Gippsland for which regeneration is prevented by saplings being 'browsed to death'. Deer herbivory may be of particular concern after fire: 'bushfires expose more seedlings to browsing by deer because they release seeds of many species from dormancy or canopy storages' (Keith and Pellow 2005). Deer densities in Royal NP escalated after a fire burned 90% of the park in 1994, rising from <500 just after the fire to 2500 by 1999 (Keith and Pellow 2005). Peel et al. (2005) observed that Sambar can devastate regrowth after fire or logging.

Deer can also prevent seedling establishment by destroying thickets that act as nursery sites or regeneration refuges, as Peel et al. (2005) documented for Sambar. Regeneration refuges provide physical barriers against other browsers, such as Black Wallabies in Victorian rainforests, within which palatable species can survive. Barriers may consist of fallen trees, thorny or stinging species such as *Bursaria spinosa* and *Urtica incisa* and plants unpalatable to most herbivores but they do not deter Sambar. They also eat vines that would normally protect regenerating plants around tree falls and remove protective branches of fallen trees. Destruction of these refuges exposes seedlings and saplings to grazing/browsing by wallabies, rabbits and Hog Deer.

Deer browsing on seedlings can also compromise revegetation projects. Browsing by Fallow Deer necessitated the erection of deer-proof fencing around areas revegetated in Yellingbo Nature Conservation Reserve in Victoria's Central Highlands (Wright et al. 2009). In South Australia, deer are

compromising regeneration of *Allocasuarina verticillata*, the main foodplant of an endangered subspecies of Glossy Black-cockatoos (see under Q9).

Reduced seed production and seed consumption: Peel et al. (2005) observed that Sambar reduced the reproductive output of species such as Yellow Milk Vine (*Marsdenia flavescens*), Prickly Currant-bush (*Coprosma quadrifida*) and Muttonwood (*Rapania howittana*) in East Gippsland by consuming flowers and fruits as well as seeds and seedlings. Deer may consume all reproductive material of orchids or lilies in a single visit (Keith and Pellow 2005). In Queensland, Red Deer have recently started consuming the seeds of Bunya Nuts leading to concerns about the future viability of *Araucaria bidwillii* (see box). Experimental caches of *Telopea speciossima* seeds were eaten by Rusa Deer in Royal NP (Keith and Pellow 2005, citing Auld and Denham).

Red Deer and *Araucaria bidwillii* (Bunya Pine)

Bunya Pines occur in two widely disjunct and relictual populations in north and south Queensland, with a gap of ~1000 km. There is 'extreme' genetic differentiation between the northern and southern populations and also between some of the sub-populations in southern Queensland (Pye and Gadek 2004).

Red Deer have recently been observed eating the seeds of Bunya Pines, leading to concerns that deer expansion in Queensland could compromise regeneration and genetic diversity of this species (Smith et al. in prep.). Deer predation of Bunya Pine seeds was observed initially just around the Barambah Education Centre in Wratten State Forest (the Jimna population of Bunya Pines). As the deer have spread – over an approximate 3 km radius out from the Education Centre during the past 3 years – they have eaten most of the bunya cones before they open on the ground.

The dry rainforest areas containing *A. bidwillii* extend between Yarraman, through Jimna, Wratten and the Mary River. Much of the area was cleared for plantations, and only steep areas and firebreaks retained (Smith and Butler, 2009). Although southern populations are considered secure, its long-term future may be compromised because of poor seed dispersal (it is possible that its former animal dispersers are now extinct). Deer predation of cones add to predation by rats and further reduces recruitment potential (Smith et al. in prep.).

Based on observations of the extent of seed predation in the area currently occupied by Red Deer, if their expansion into forests with *A. bidwillii* continues, they could eventually threaten the species by preventing regeneration and reducing genetic variation ([redacted] pers. comm.)

6. Physical damage caused by trampling, wallowing, thrashing and rubbing

As large animals with hard hoofs and antlers and damaging (from a plant perspective) breeding rituals deer can have a physically destructive impact on the environment.

Deer hoofs can damage delicate plants, sensitive environments such as wetlands and mossbeds, and nests (including Malleefowl mounds). Keith and Pellow (2005) found that the margin of wetlands used by Rusa Deer in Royal NP were 'exposed, compacted and deformed' by deer footprints. Three sites subject to high deer use were denuded of vegetation and had lost up to 0.6 m of topsoil. Tree and shrub roots were exposed and broken. Peel et al (2005) observed that erosion is becoming a significantly greater issue as Sambar gradually move from higher country into lower elevation country and begin to graze wetlands, sometimes along with Hog Deer. Being very large Sambar can wade further out into wetlands and damage vegetation in mud or deeper water, altering vegetative and hydrological structures and destroying fish and crustacean habitat. While fencing around some wetlands has helped to restrict access by domestic stock grazing, Sambar deer are capable of jumping standard stock fences (Peel et al. 2005).

Deer are attracted to raised patches of bare dirt in the form of Malleefowl mounds in the South East region of South Australia, leading sometimes to their collapse and abandonment (James Darling pers. comm.; see under Q9). Deer trampling of plants is a particular concern where rare plants occupy a very small area frequented by deer, such as the threatened Summer Leek-orchid (*Prasophyllum canaliculatum*) occupying only about 0.5 ha in the South East Forests NP ([redacted] pers. Comm..) Some deer create bare scrapes for rutting purposes, trampling the ground and removing vegetation. Sambar rutting areas have been observed along floodplains of small creeks in East Gippsland, where vegetation over an area up 15 x 7 m has been completely cleared (Peel et al. 2005). Such areas become sites for weed invasion. Sambar also create wallows in areas with shallow water and a muddy base – in swamp scrub, warm temperate rainforest, salt marsh and estuarine wetlands. Physical

damage to plants in the vicinity can be severe, and wallows are vulnerable to gully erosion (Peel et al. 2005). Sambar wallows (and trampling) have been observed in Alpine mossbeds, which are particularly sensitive to damage (Tolsma 2009; see under Q9). Sambar signs have recently been observed at a substantial number of breeding sites for the critically endangered Northern Corroboree Frog (*Pseudophryne pengilleyi*) ([redacted] pers. comm).

Deer also create 'rub trees', scraping away the surface bark with their antlers. This is a major problem for the critically endangered (based on IUCN criteria) Shiny Nematolepis (*Nematolepis wilsonii*) (see under Q7). It can ringbark and kill trees, exposes them to wood borers and fungal pathogens, reduce foliage and compromise the health of the tree (Bennett and Coulson 2011). Sambar had rubbed 61% of 92 Cherry Ballarts (*Exocarpus cupressiformis*) in Mount Buffalo National Park (Forsyth 2007 citing Millington 1991). Peel et al. (2005) list several species adversely affected by antler rubbing: 'So widespread and ubiquitous is the damage that at the current rate of attrition, several species are under threat just from antler rubbing alone.' They found over 100 rub trees of the rare Yellowwood (*Acronychia oblongifolia*) in one patch within East Gippsland Coastal Warm Temperate Rainforest. Sambar rub marks go as high as 2.1 m.

Thrashing of saplings during rutting is also very damaging, such as recorded for Shiny Nematolepis (Bennett and Coulson 2011).

7. Facilitating other invaders

Exotic invaders sometimes cause damage by facilitating other biotic invasions (Simberloff and Von Holle 1999) – in the case of deer by weed spread, pathogen spread, and facilitating exotic predators.

Weed spread

Feral deer (and other feral herbivores) can facilitate weed spread by creating gaps in vegetation for weed germination and by dispersing weed seeds, and this is recognised as part of the threatening process for one critically endangered habitat (see littoral rainforest under Q9). Davis et al. (2010) recommend that the potential for endozoochory 'be considered more widely in studies assessing the impacts of exotic mammals on plant communities'. They assessed seed germination from the faeces of Hog Deer in Victoria's Wilsons Promontory National Park as a case study of the role of exotic mammalian herbivores as seed dispersers in weedy ecosystems. They estimated the total number of viable seeds dispersed daily by the hog deer population (on the Greater Yanaki Isthmus) as 133,000, of which about one-quarter were of exotic species. Each Hog Deer on average was depositing 494 seeds a day. With some Hog Deer moving more than 2 km to feeding areas and occasionally undertaking much longer trips, they can facilitate weed spread across landscapes and accelerate plant invasions. They can also facilitate spread of native species. *Acacia longifolia*, an encroaching native shrub, germinated from Hog Deer faeces. Moriarty (2004b) found 11 weed species and several garden plant species in the rumen of Rusa Deer in Royal NP.

Sambar are implicated in the spread of the weed Himalayan Honeysuckle (*Leycesteria formosa*) in alpine areas (Wright et al. 2009, citing Eyles 2002). Deer are also spreading Senegal Tea (*Gymnocoronis spilanthoides*) and Ludwigia (*Ludwigia peruviana*) (NSW Scientific Committee 2004). (In some cases deer could control weeds by browsing them.) In Queensland pest plants such as Rubber Vine (*Cryptostegia grandiflora*), Chinee Apple (*Ziziphus mauritania*) and Parthenium (*Parthenium hysterophorus*) are flourishing in areas around Charters Towers where chital are removing pastures and native vegetation (Jesser 2005).

One of the threatening processes identified in the listing of the critically endangered *Littoral Rainforest and Coastal Vine Thickets of Eastern Australia* is weed invasion following vegetation damage by Sambar. One area severely affected is near Genoa River, in Victoria, where vegetation gaps created by deer have been colonised by Cape Ivy (*Delairea odorata*) and Madeira Winter-cherry (*Solanum pseudocapsicum*), contributing to the collapse of rainforest patches by smothering shrubs and young trees (EPBC Listing Advice 2008).

Pathogen spread

There is concern about spread of pathogens and parasites by deer, focused mostly on the risk to domestic livestock (Jesser 2005). One environmental concern is that deer could spread the dieback pathogen *Phytophthora cinnamomi* (Masters 2009), which is listed as a key threatening process.

Benefiting predators

Another example of a facilitative interaction between exotic species occurs when deer fragment and create pathways through thick vegetation that permit easy access to exotic predators. Sambar create paths through dense scrub that normally serves as refuge for ground nesting birds and small native mammals. Sambar paths 'essentially become highways through the bush for introduced predators'

(Peel et al. 2005). Exotic predators also benefit when hunters discard deer carcasses. Peel et al. (2005) observed that recreational deer hunters who seek just a trophy head are leaving hundreds of tonnes of meat for a rapidly increasing feral dog population. The height of the hunting season corresponds with the birth and weaning of wild dogs. The peak in Sambar calving during winter provides another source of food for feral dogs when prey is likely to be limiting (ibid.). The impact on native mammals and livestock is likely to be high: Faecal pellet counts in the Upper Yarra Catchment suggest that Sambar are approximately 100 times more abundant there than Black Wallabies (Peel et al. 2005 citing Houston 2003 and Stockwell 2003), which may be due to both competition and wild dog predation on wallabies (Ibid.)

8. Ecosystem impacts

By altering interactions among competitive plants, compromising regeneration, affecting community structure, facilitating weed invasion, among other impacts on plants, deer can have cascade effects on biodiversity with research overseas documenting impacts on songbird abundance and species composition, nest predation rates, the abundance and density of invertebrates and the abundance and seed predation activity of small mammals (Dolman and Waber 2008). They are widely regarded as 'ecosystem engineers' (Cote et al. 2004). In temperate and boreal forests, large herbivores can act as 'biological switches' that move forest communities toward alternative successional pathways and stable states that are not reversible (ibid). The changes observed by Peel et al. (2005) in East Gippsland due to Sambar suggest the potential for this fate: Sambar are capable of 'significant, severe and possibly lasting alteration to vegetation structure, including negative feedback loops that lead to destruction of particular vegetation types such as rainforest and wetlands'. Sambar alter and deflect rainforest successional dynamics with the plants either being killed or prevented from regenerating. Regeneration failure and gap openings expose soils and lead to disruption of internal rainforest moisture homeostasis through the loss of vine thickets and curtains, canopy tree curtains, destruction and loss of understory shrubs, increasing the risk of fire.

Although deer impacts on some preferred and declining species are reversible if deer densities are controlled, as shown by exclosure studies, others may not be: 'the drivers of resilience in relation to deer impacts are far more complex than any simple correlation with deer density alone' (Forsyth et al. 2003). Coomes et al. (2003) gave several examples where deer impacts may not be reversible, where:

- control reduces the number of deer browsing on some species but the per capita intake of more preferred species increases;
- the spread of less-browsed species prevents the re-establishment of more preferred species;
- the course of succession has been altered;
- there are no longer seed sources of some species;
- deer have altered ecosystem properties – litter quality, soil microbial properties, microfauna;
- other feral species benefit from control;
- other factors such as weeds prevent re-establishment.

9. Threatened species and communities

Feral herbivores together constitute one of the most severe threats to Australian biodiversity. In NSW, they are known to pose a threat to >23% of threatened species and when domesticated herbivores are included, 45% (Coutts-Smith et al. 2007). Deer share many of the attributes of other threatening herbivores and are likely to substantially increase the number of threatened species as they increase and spread. Unfortunately, their range overlaps with that of numerous rare plant species with tiny distributions, and some of the coastal areas they inhabit have a high density of threatened species and are not substantially invaded by other ungulates. Deer have the potential to spread over much larger areas of Australia, increasing their potential to threaten rare plants.

Experts consulted for this nomination said they strongly suspected feral deer were a threatening process for vastly more species than identified to date. In Victoria, where there tends to be more awareness of deer impacts than elsewhere, [redacted] [redacted] (pers. comm.) said the species identified as threatened by Sambar to date represent the 'tip of the iceberg'.

There is limited published information about several plant species which have been identified as being at risk from deer (eg. by inclusion in the NSW listing of feral deer as a KTP) so they are not included in the following sections. Several were found in the rumen of Rusa Deer by Moriarty (2004b) – mostly in areas with low deer density rather than high deer density. That they are palatable to deer suggests, as Moriarty says, that 'their populations are at risk, particularly if poor climatic conditions prevail for any length of time and deer are forced to search for different foods in more marginal areas.' Table 4 shows a list of species in this category potentially at risk as determined by the NSW Scientific Committee (2004). There are also several plants known to be regionally threatened by deer that are likely to become universally threatened if deer become more widespread. There is a large list of Victorian plant

species threatened by Sambar (5 for which Sambar are the principal threat, 17 for which Sambar are a major threat and 27 for which Sambar are a secondary threat)([redacted] pers. comm.) but which are probably not nationally threatened because their range extends beyond that of Sambar into other states.

Table 4: Species identified by NSW Scientific Committee (2004) at risk from deer (in addition to species listed under Q4, Q8).

Species	EPBC status	Threat
Acacia bynoeana	Endangered	Threatened species eaten by deer
Persoonia hirsuta	Endangered	Ditto
Eucalyptus camfieldii	Vulnerable	Ditto
Leucopogon exolasius	Vulnerable	Ditto
Melaleuca deanei	Vulnerable	Ditto
Pultenaea aristata	Vulnerable	Ditto
Darwinia diminuta	Not listed	Could become threatened by grazing and environmental degradation caused by feral deer
Darwinia grandiflora	Not listed	Ditto
Epacris coriacea	Not listed	Ditto
Eucalyptus luehmanniana	Not listed	Ditto
Genoplesium baueri	Nominated CE	Ditto
Gonocarpus salsoloides	Not listed	Ditto
Grevillea longifolia	Not listed	Ditto
Lomandra fluviatilis	Not listed	Ditto
Monotoca ledifolia	Not listed	Ditto
Platysace stephensonii	Not listed	Ditto
Rulingia hermanniifolia	Not listed	Ditto
Tetratheca neglecta	Not listed	Ditto
Thysanotus virgatus	Not listed	Ditto
Isoodon obesulus	Endangered	Grazing and trampling could alter the composition and structure of their habitats
Potorous longipes	Endangered	Ditto

The case for a collective listing of deer

We propose here that all feral deer established in Australia be included in a KTP listing. The majority of adverse impacts are attributed to Sambar, the largest and most populous species, but the examples in this nomination (see Table 5) show other deer species also have adverse impacts and all have the potential to threaten species and ecological communities if they spread and increase. Most types of adverse impact – browsing/grazing and trampling on rare plants, damaging sensitive vegetation communities, causing erosion, facilitating weed invasion – are potentially caused by any deer species.

Table 5: Species/ecological communities threatened by this KTP and the deer species implicated

Species/EC	EPBC Status	Deer species & behaviours implicated
Gynatrix macrophylla	Not listed	Sambar. Browsing & antler rubbing.
Pultenaea weindorferi	Not listed	Sambar (mainly), Fallow. Browsing.
Pomaderris vacciniifolia	Not listed	Sambar (mainly), Red, Fallow. Browsing.
Tetratheca stenocarpa	Not listed	Sambar (mainly), Fallow. Browsing.
Ozothamnus rogersianus	Not listed	Sambar. Browsing & antler rubbing.
Acacia daviesii	Not listed	Sambar.
Prasophyllum canaliculatum	Not listed	Red, Fallow, Sambar. Grazing & trampling.
Nematolepis wilsonii	Vulnerable	Sambar. Antler rubbing, thrashing, trampling.
Pseudophryne pengilleyi	Vulnerable	Sambar. Trampling.
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Sambar (major), Rusa (major), Hog. Browsing, antler rubbing, trampling, wallowing.
Alpine Sphagnum Bogs and Associated Fens ecological community	Endangered	Sambar (mainly), Fallow. Wallowing, trampling, browsing.
White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Sambar, Fallow. Browsing, trampling.

Eucalyptus gunnii ssp. *Divaricata*	Endangered	Fallow. Browsing.
Syzygium paniculatum	Vulnerable	Rusa. Browsing.
Xerochrysum palustre	Vulnerable	Hog, Sambar, Red, Fallow. Grazing, trampling.
Prostanthera densa	Vulnerable	Rusa. Browsing.
Calyptorhynchus lathami halmaturinus	Endangered	Fallow. Browsing.
Leipoa ocellata	Vulnerable	Fallow (mainly), Red, Sambar, Rusa, Chital. Trampling.

A note about the evidence

Information about the environmental impacts of feral deer in Australia is inadequate. The lack of peer-reviewed research is highlighted by Forsyth (2009): Till 1960, there were two papers; and from 1960 until the 2000s there were no papers published in peer-reviewed science journals. There have been articles published in *Australian Deer*, the magazine of the Australian Deer Association but they are not peer-reviewed and most of the work is conducted by ADA members focused on improving the status of deer as a game animal. Some contend the lack of published information is reason to maintain the status quo for deer: of predominantly hunting-focused management (in three states) with patchy control efforts in some conservation areas and where deer threaten economic assets and safety (they cause vehicle accidents). However, the fact of deer as large exotic ungulates introduced into a country that previously had no ungulates, the weight of evidence from overseas about damaging deer impacts, and the growing accumulation of threats documented by biologists in Australia as deer populations increase lead to the conclusion that to delay more concerted action on feral deer is to guarantee biodiversity losses and environmental degradation.

It is obvious that as deer become more populous in Australia they are going to cause serious damage to the environment – as medium to large animals with hard hoofs that eat a lot of vegetation from diverse sources in diverse habitats and have destructive habits. As with other ungulates, their potential to cause damage will be related to population levels and depend on the sensitivity of the environment they inhabit. Moriarty (2009) rightly says that 'If deer population trends in Australia continue to increase at their current rate, deer species are likely to rival both feral pigs and feral goats in distribution, abundance and impacts in the near future'. There is evidence from many places that deer populations are increasing and establishing in new areas, due to escapes and releases from farms and releases by hunters. Even a limited application of the precautionary principle warrants taking the deer problem seriously while there is still opportunity to eradicate some of these new populations, limit expansion of others and protect particular high conservation value areas from damage.

Deer are amongst the best-studied species globally and evidence from multiple countries demonstrates the damage they cause as 'ecosystem engineers' and 'keystone herbivores' (Cote et al. 2004). Evidence comes from regions where deer are indigenous but have increased in numbers (Europe and North America) and from where they have been introduced (New Zealand, in particular). Some of this evidence is applicable to Australia because it is based on deer population dynamics, behaviours and impacts that occur universally. Deer are causing problems in much of their native range because predation rates are inadequate to limit their numbers, which also applies in Australia.

Finally, there is mounting evidence of specific damage in Australian environments caused by deer, some of which is summarised here. Most of it is very recent evidence, observed by field biologists and not yet published in the peer-reviewed literature, due to the lack of research previously and because of the rapid expansion in deer populations within the past decade or two following the rise and fall of the farmed deer industry. As an example of the rapid evolution of the feral deer threat, when Shiny Nematolepis (*Nematolepis wilsonii*) was listed as Vulnerable under the EPBC Act in 2000 there was no deer damage observed on the one population then known. Sambar numbers then escalated in the Yarra Ranges National Park and within just a few years have rendered this species Critically Endangered (despite discovery of a second population, also affected by Sambar). Sambar were recognised as the principal threat to this species in the 2006 recovery plan (Murphy et al. 2006).

Section 2 - Impacts on Native Species and Ecological Communities

Notes:

- General information on the mechanism of impact should not be included in this section - this is part of the description.
- In this section only one pair of questions 4/5, 6/7 or 8/9 need to be answered. However, providing all available evidence against each question will aid in assessment on the nomination.

- The criteria for listing a species (Part B) or ecological community (Part D) under the EPBC Act are and the Threatened Species Scientific Committee guidelines at the end of this form. It is important to refer to these criteria when answering questions in this section.
- The EPBC Act lists of threatened species and ecological communities are available on the Department of Sustainability, Environment, Water, Population and Communities website at: www.environment.gov.au/biodiversity/threatened/index.html

Non-EPBC Act Listed Species/Ecological Communities

***4**. Provide a summary of those species or ecological communities, other than those that are listed under the EPBC Act, that could become eligible for listing in any category, other than conservation dependent. Please include:*

a. *For each species: the scientific name, common name (if appropriate), category it could become eligible for listing in;*
b. *For each ecological community: the complete title (published or otherwise generally accepted), category it could become eligible for listing in.*

Species/Ecological Community	**Category**
Gynatrix macrophylla (Gippsland Hemp Bush)	Endangered
Pultenaea weindorferi (Swamp Bush-pea)	Critically Endangered
Pomaderris vacciniifolia (Round-leaf Pomaderris)	Endangered
Tetratheca stenocarpa (Long Pink-bells)	Critically Endangered
Ozothamnus rogersianus (Nunniong Everlasting)	Endangered
Acacia daviesii (Timbertop Wattle)	Critically Endangered
Prasophyllum canaliculatum (Summer Leek-orchid)	Critically Endangered

***5.** Provide justification that the species or ecological communities detailed at question 3 could become eligible for listing in any category, other than conservation dependent. For each species/ecological community please include:*

a. *data on the current status in relation to the criteria for listing;*
b. *specific information on how the threatening process threatens this species/community;*
c. *information on the extent to which the threat could change the status of the species/community in relation to the criteria for listing.*

Note: The six Victorian endemic species described here have all been assessed against IUCN criteria by the Victorian Government, so further information about how they meet EPBC criteria is available. Because there is only need to meet one criterion, I have not provided information to inform a thorough assessment against all listing criteria.

Gynatrix macrophylla (Gippsland Hemp Bush)
A shrub from eastern Victoria (Gippsland). Described only recently (Walsh 1996). Very rare. Highly fragmented and with only localised dispersal.

Status: Not listed under any legislation. Endemic to Victoria.

Threats: Sambar are rated the 'principal' threat to this species ([redacted] [redacted] pers. comm.). Blackberry invasion is also a threat. SAC (2007) found that Sambar are or potentially are 'a significant threat' to the species. Their ranges substantially overlap, and observations of Sambar damage at Licola and Mitchell River locations suggest the species is likely to be in 'deep trouble' across its range ([redacted] [redacted] pers. comm.). Observations at Mitchell River NP found that saplings were browsed to death by Sambar with consequent lack of regeneration and plants were also damaged by antler rubbing (Peel et al. 2005). Observations at Licola, where Sambar are in very high numbers, showed the species as highly palatable to Sambar (preferentially browsed), as indicated by the height of the browse line observed, and it now survives mainly in places inaccessible to Sambar ([redacted] [redacted] pers. comm.). It is likely to be most vulnerable after fire because it recruits from seed and seedlings are likely to be targeted by deer. A recent re-survey at a site at Licola after a fire found only one plant where previously there had been a few (which is typical for this species), and deer browsing was suspected as the major contributing factor ([redacted] [redacted] pers. comm.). Goats are also a problem for this species in some locations but Sambar numbers are much higher and they are also much larger than goats.

EPBC Listing Criteria: Assessed as Endangered against IUCN criteria A3ce; B2ab(ii,iii,iv,v) in the DSE review of the conservation status of all Victorian plant taxa ([redacted] [redacted] pers. comm.). It meets criterion 2 for Endangered: severely fragmented, continuing decline, and area of occupancy <500km^2.

***Pultenaea weindorferi* (Swamp Bush-pea)**

Erect shrub 1–2 m high. Occurs in four populations in Victoria's Dandenong Range: Mt Evelyn/Wandinn area, Wombat Ranges, Kinglake and Gembrook/Bunyip State Parks (SAC 1997), over 10-20 ha across 2700km^2.

Status: Not listed under any legislation. Note that *P. glabra* (into which de Kok and West 2002 place P. *weindorferi*) is listed as vulnerable under the EPBC Act but see taxonomic note below.

Taxonomic note: There has been debate about whether the *Pultenaea glabra* species complex is one widespread species with geographic variants (de Kok and West 2002) or whether some variants warrant recognition as separate species. Victorian botanists dispute the revision by de Kok and West (2002), which placed *P. weindorferi* in *P. glabra*, and the Census of Victorian Plants (Walsh and Stasjic 2007) lists *P. weindorferi* as a species endemic to Victoria. The EPBC listing advice for *P. glabra* says it is located in NSW Central and Northern Tablelands and in central-eastern Queensland (but it is not listed by the Queensland Herbarium as a Queensland species). *P. glabra* is listed as vulnerable under the EPBC Act. If the TSSC does not recognise *P. weindorferi* as a separate species, it would still be part of this nomination as an existing threatened species threatened by feral deer.

Threats: Sambar are the principal threat to this species due to heavy browsing ([redacted] pers. comm.). Other threats are thought to be inappropriate fire regimes and other herbivores (such as goats, which are in much lower densities). There has been a recent increase in Sambar density in 3 of the 4 locations of this species, rendering more likely the prospect of local extinction at any one of the locations (ibid.). The core population is in Kinglake NP. An environmental burn in 1990 was successful in increasing the population to about 1000 plants, which was maintained for 5-10 years ([redacted] pers. comm.). However, from 2000-05 as Sambar densities greatly increased in the NP (goat populations had been controlled and remained stable), numbers declined to a 'few dozen' due to browsing and senescence. There was complete recruitment failure as all mature plants were being browsed and the flowers consumed, and seedlings were eaten to ground level. The browsing impacts were magnified by drought allowing deer to move further into the forest interior. Since the 2009 fires, there has been 'reasonable' germination in Kinglake NP (because their seeds are long-lived there were seeds in the soil from prior to deer preventing seed production), and the population currently numbers about 500 (Ibid.). Fences have been erected around the main population to protect them from deer, which have dispersed since the fire to the perimeters of the NP. Deer control is also conducted in the NP but re-invasion from surrounding areas where deer are not controlled is a major challenge. The population in Bunyip State Park is also substantially affected by deer (ibid.), which includes both Sambar and Fallow Deer.

EPBC listing criterion: Assessed as Critically Endangered against IUCN criteria B2ab(i,ii,iii,iv,v) in the DSE review of the conservation status of all Victorian plant taxa ([redacted] pers. comm.). Meets criterion 2 for Critically Endangered: severely fragmented, continuing decline, and area of occupancy <10km^2 (10-20 ha).

***Pomaderris vacciniifolia* (Round-leaf Pomaderris)**
A slender shrub 1-8 m high. Found in the middle and upper catchments of the Yarra River in central Victoria. The current area of occupancy is estimated at 2-5 ha and extent 4300 km^2 (Steve Meacher, Healesville Environment Watch pers. comm.). In 2006 no more than 140 mature plants could be found. Current estimates are 100-300 (prob. ~200) in 30 populations/subpopulations ([redacted] pers. comm.). The February 2009 fires destroyed all known specimens at one site and most at another. It has a severely fragmented distribution, with 100 km separating populations around Melbourne with those in the La Trobe Valley and subpopulations within the core area separated by many kilometers ([redacted] pers. comm.).

Status: Not listed under EPBC Act (nominated as Critically Endangered in May 2009). Listed under the FFG Act (in 2009). Endemic to Victoria.

Threats: Sambar are a 'major' threat to the species ([redacted] pers. comm.). Major causes of mortality are thought to be browsing by herbivores (including deer, rabbits and wallabies), insect predation and senescence in the absence of fire. Browsing by deer (mostly Sambar but also Red and Fallow Deer) and rabbits are the major factors limiting survival of juvenile plants ([redacted] pers. comm.). The species has poor ability to recover from browsing at all ages. Deer are a particular problem in the Kinglake area, where significant remnant populations exist, as well as in 3 other locations. Damage caused by antler rubbing was observed in one population ([redacted] pers. comm.).

EPBC Listing Criteria: Assessed as Critically Endangered, against IUCN criteria B2ab(ii-v) in the DSE review of the conservation status of all Victorian plant taxa (David Cameron DSE pers. comm.). Also nominated as Critically Endangered. Meets Criterion 2: severely fragmented, with continuing declines

eg. in individuals, and an area of occupancy 2-5 ha (+ extent 4300km^2). (For more detail please refer to the 2009 nomination of this species.)

***Tetratheca stenocarpa* (Long Pink-bells)**
A slender almost leafless shrub 1-1.5 m high. Grows in damp forests with tall trees and a dense and species-rich understorey of small-leafed shrubs, herbs, grasses and sedges. Severely fragmented and diffuse populations in restricted distribution, in damp forests in hilly country east of Melbourne, on French Island and in Gisborne.

Status: Not listed under any legislation. Endemic to Victoria.

Threats: Sambar are the principal threat to this species ([redacted] pers. comm.). Populations coincide with high and increasing Sambar density. Observations of heavy browsing of this species in Bunyip State Park ([redacted] pers. comm.), where the majority of site records occur and where there are 20-30 plants in each of about 6 sites, occupying ~1 ha. Deer impacts observed here likely to be general across range ([redacted] pers. comm.). Also likely to be threatened by other herbivores (Fallow Deer and wallabies) and fire ([redacted] pers. comm.). Because plants are scattered and uncommon it is difficult to quantify impacts. It is also impossible to fence off populations to protect them from deer.

EPBC Listing Criteria: Assessed as Critically Endangered against IUCN criteria B2ab(v) in the DSE review of the conservation status of all Victorian plant taxa ([redacted] pers. comm). Meets criterion 2 for Critically Endangered: severely fragmented, continuing decline in number of individuals, and area of occupancy <10km^2 (10-20 ha).

***Ozothamnus rogersianus* (Nunniong Everlasting)**
An erect shrub to 2.5 m tall. Known from 4 disjunct populations on the Nunniong Platau, Western Otways (Great Otway NP) and Central Highlands. Very rare.

Status: Not listed under any legislation. Endemic to Victoria.

Threats: Sambar browsing and antler rubbing are the principal threat to this species ([redacted] pers. comm.) Its brittle stems are easily damaged. It recruits after fire and is susceptible to loss of seedlings. There is substantial geographic overlap with Sambar and increasing Samber density in its range.

EPBC Listing Criteria: Assessed as Endangered against IUCN criteria A3ce; B2ab(v) in the DSE review of the conservation status of all Victorian plant taxa ([redacted] pers. comm.). Meets Criterion 2 for Endangered: severely fragmented, continuing decline in number of mature individuals, and area of occupancy <500km^2.

***Acacia daviesii* (Timbertop Wattle)**
Discovered in 1998 near Mt Timbertop in northeast Victoria. Occupies <1.5 ha over an area <5km^2 in 10 clonal populations – each population is a root-suckering clone with 9 to >1000 rametes (SAC 2004). Each population is important as there are just 9 distinct genotypes and the loss of any one could seriously deplete the gene pool (Bartolome 2002).

Status: Not listed under EPBC Act. Listed under FFG Act. Endemic to Victoria.

Threats: Recognised by SAC (2007) that Sambar are, or potentially are, 'a significant threat' to this species. Sambar are a secondary threat to probably fire and climate change. ([redacted] pers. comm.).

EPBC Listing Criteria: Assessed as Critically Endangered against IUCN criteria 1ab(i-v)+2ab(i-v);D in the DSE review of the conservation status of all Victorian plant taxa ([redacted] pers. comm). Meets Criterion 4: number of mature individuals <50 (n=10).

***Prasophyllum canaliculatum* (Summer Leek-orchid)**
Orchid 30-50 cm high. Grows singly or in groups of 2-4 plants in dense low grass tussocks in *Eucalyptus pauciflora* open woodland. 2 known surviving populations: 1 in NSW and 1 in ACT. The NSW population in South East Forests NP (Nimmitabel site) was reported to number about 190 plants in January 2004 (NSW Scientific Committee 2007, citing McPherson 2004) but now numbers about 40 ([redacted] pers. comm.). A previous population at Kybeyan, NSW, containing about 30 plants in 1996 (NSW Scientific Committee 2007, citing Jones 1997), no longer exists ([redacted] pers. comm.). There is an ACT population in one site that recently numbered about 200 individuals (NSW Scientific Committee 2007; [redacted] pers. comm.). This year, there were 20-30 flowering (Ibid.)

Status: Not listed under EPBC Act. Listed as Critically Endangered under TSC Act. Endemic to NSW (Southern Tablelands) and ACT.

Threats: Threats reported by the NSW Scientific Committee (2007) for the remaining NSW site are grazing by feral deer, rooting by feral pigs, weed invasion and illegal off-road vehicle traffic (the latter now prevented by a gate, [redacted] pers. comm.). Due to small area and population size, it is also threatened by environmental and demographic stochasticity. Trampling by feral deer is an additional threat because the species occupies such a small area (<0.5 ha) frequented by deer ([redacted] pers. comm.) Deer in the area include Red Deer, Fallow Deer and Sambar. The ACT population is threatened by feral pig rooting ([redacted] pers. comm.).

EPBC Listing Criteria: Meets Criterion 2 for Critically Endangered: severely fragmented, continuing decline in number of mature individuals, and area of occupancy <10 km^2 (a few hectares). Meets Criterion 4 for Endangered: Estimated population as low as 70 and likely no more than ~250.

EPBC Act Listed Species/Ecological Communities

6. *Provide a summary of those listed threatened species or ecological communities that, due to the impacts of the threatening process, could become eligible for listing in another category representing a higher degree of endangerment. Please include:*

a. For each species: the scientific name, common name (if appropriate), category it could become eligible for listing in;
d. For each ecological community: the complete title (published or otherwise generally accepted), category it could become eligible for listing in.

Species/Ecological Community	**Category**
Nematolepis wilsonii (Shiny Nematolepis) *Pseudophryne pengilleyi* (Northern Corroboree Frog)	Critically Endangered Critically Endangered

7. *Provide justification that the species or ecological communities detailed at question 6 could become eligible for listing in another category representing a higher degree of endangerment due to the impacts of the threatening process. Please include:*

a. data on the current status in relation to the criteria for listing (at least one criterion for the current listed category has been previously met);
b. specific information on how the threatening process significantly threatens this species/community;
e. information on the extent to which the threat could change the status of the species/community in relation to the criteria for listing. This does not have to be the same criterion under which the species/community was previously listed.

Nematolepis wilsonii (*Shiny Nematolepis*)
A shrub or small tree to 10 m high growing in the understorey of Cool Temperate Mixed Forest between old-growth wet forest, dominated by Mountain Ash, and Cool Temperate Rainforest dominated by Myrtle Beech (Murphy et al. 2006). Known from two populations in the Yarra Ranges National Park, with only 12 mature individuals remaining. >400 mature trees were destroyed in the February 2009 fires in one site and an unknown number in the other site (only discovered in 2010). Seedlings have emerged since the fires (Bennett and Coulson 2011) numbering in the tens of thousands.

Status: Vulnerable under EPBC Act (based on a 2000 assessment). Listed under the FFG Act. Endemic to Victoria.

Threats: Damage caused by Sambar is identified in the recovery plan as the greatest threat (Murphy et al. 2006) and this remains the case. Other lesser threats are weed invasion and road maintenance. Deer rub their antlers on this species to remove velvet, thrash saplings as part of rutting and trample seedlings. Antler rubbing can result in ringbarking and death. Otherwise, stem wounding creates access for wood boring insects or fungal infections (Bennett and Coulson 2011). Antler rubbing damage was recorded on 27% of individuals in May 2005, with the population then consisting of an estimated 400 mature trees and 1000 saplings (Bennett and Coulson 2011, citing Lorimer and Lorimer 2005). Rubbed trees that don't die from ringbarking have significantly poorer health and less foliage (on average 19% less) than non-rubbed trees (Bennett & Coulson 2011). Deer are known to favour particular species for antler rubbing. The threat has emerged only in the past few years as Sambar numbers have increased in the Central Highlands. There was no evidence of damage to the one known stand in 1995 ([redacted] pers. comm.) and deer damage was first identified as a threat in 2003 (after it was listed as Vulnerable under the EPBC Act).

EPBC Listing Criteria: DSE's review of the conservation status of Victorian plants has assessed it as Critically Endangered against IUCN criteria A3ce; B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v) ([redacted] pers.

comm.). Consisting only of 2 populations in a limited location, with recent severe reduction in number of mature individuals (from >400 to 12), and occurrence and occupancy (just over 5 ha) both very restricted, it meets criterion 2 for Critically Endangered. With only 12 mature individuals known to exist in the wild it meets criterion 4 for Critically Endangered.

Pseudophryne pengilleyi **(Northern Corroboree Frog)**
A small, colourful frog growing to 2.5–3 cm. Restricted to montane and sub-alpine woodlands, heathland and grassland above ~1000 m. Known from 3 disjunct regions: the Fiery Ranges, the Northern Brindabella Ranges and the Southern Brindabella Ranges. Each region contains a genetically distinct subpopulation (Morgan et al. 2008). During the summer breeding season the frog inhabits sphagnum bogs, wet tussock grasslands, and wet heath. In other seasons it inhabits the litter, logs and dense ground cover in the understorey of snow gum woodland and heath forest usually about 10-30 m away from the breeding area (NSW Scientific Committee 2010). Surveys of calling males and egg counts suggested a 2008 population of 2000-3000 (Ibid.). Since 1988 (about 3 generations) there has been an estimated >95% decline in the population occupying the Bridabella Ranges (2 subpopulations) and an estimated 86% decline in the Fiery Ranges population (Ibid.).

Status: Vulnerable under EPBC Act. Critically Endangered under TSC Act. Endangered under the ACT *Nature Conservation Act 1980*. Endemic to NSW and ACT.

Threats: Population decline has been rapid and precipitous since the early 1990s due primarily to disease caused by Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*). Climate change is considered a serious threat (NSW Scientific Committee 2010). Fire – by causing direct mortality and altering habitat - and weed invasion of breeding sites are also threats (Ibid). A further threat is damage by pigs and horses to breeding and overwintering habitats. Horse trampling has caused considerable disturbance to breeding sites in the Fiery Range (Ibid.)

Sambar have recently increased in distribution and abundance in southern NSW particularly since the 2002-03 fires, are now 'omnipresent' throughout the species' range, and are most prolific in the last known stronghold of the frog in the Fiery Ranges ([redacted] [redacted] pers. comm.). Sambar presence has recently been documented in the frog's breeding habitat, in 17 of 23 breeding sites in the north of Kosciuszko NP (Ibid.) Sambar damage observed includes trampling of vegetation at the bogs and in the habitat linking bogs and the formation of trails. They have the potential to cause serious damage to breeding sites, and are cause for 'great concern' (ibid.)

EPBC Listing Criteria: In 2010 the NSW Scientific Committee reassessed the species' status as Critically Endangered (see http://environmentaltrust.nsw.gov.au/determinations/northerncorroboreefrogPD.htm and also NSW Scientific Committee 2010). The species meets Criterion 1 (A1) and (A2) for Critically Endangered: a reduction of >90% in population size over 3 generations (A1) as well as a reduction of >80% in population size with the causes of decline ongoing (A2), as assessed by the NSW Scientific Committee:

> 'Populations of the Northern Corroboree Frog in NSW have experienced significant decline in recent years. For example, in 1988 the number of adult males in the Brindabella Ranges (northern and southern subpopulations combined) was estimated to be 2 000-3 000 (Osborne 1988), yet in 2009 just 25-75 adult males were thought to be present ([redacted] [redacted] pers. comm. 2009). This represents a decline of between 96 and 99% over 21 years (or three generations). Similarly, tens of thousands of adult males were believed to be in the Fiery Range subpopulation in 1988 (Osborne 1988), and although this estimate is very broad, assuming a minimum historic population of 10 000 males and based on the 2009 estimate of between 1 000 – 1 400 males ([redacted] [redacted] pers. comm. 2009), this subpopulation has experienced a decline of between 86 and 90%. In addition, many of the previously known breeding sites in the Brindabella Ranges no longer contain the species, or contain extremely low numbers of individuals (Hunter *et al.* 2006).'

The species meets Criterion 2 for Endangered: there is severe population fragmentation; ongoing decline in populations; and the area of occupancy is <500 km^2 (estimated to be no more than 340 km^2) and extent of occurrence is <5000 km^2 (estimated to be <2000 km^2).

8. *Provide a summary of those species or ecological communities, listed as threatened under the EPBC Act, that are considered to be adversely affected by the threatening process. Please include:*

f. For species: the scientific name, common name (if appropriate) and category of listing under the EPBC Act;
g. For ecological communities: the complete title (exactly as listed) and category of listing under the EPBC Act.

Littoral Rainforest and Coastal Vine Thickets of Eastern Australia. Critically Endangered.
Alpine Sphagnum Bogs and Associated Fens ecological community. Endangered.
White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland. Critically Endangered.
Eucalyptus gunnii ssp. *divaricata* (Miena Cider Gum). Endangered.
Syzygium paniculatum (Magenta lilly pilly). Vulnerable.
Xerochrysum palustre (Swamp Everlasting). Vulnerable.
Prostanthera densa (Villous Mintbush). Vulnerable.
Calyptorhynchus lathami halmaturinus (Glossy Black-Cockatoo). Endangered.
Leipoa ocellata (Malleefowl). Vulnerable.

9. *Provide justification that the species or ecological communities detailed at question 8 are affected adversely by the threatening process.*

Littoral Rainforest and Coastal Vine Thickets of Eastern Australia
Represents a complex of rainforest and coastal vine thickets on the east coast of Australia, typically within 2 km of the coast or adjacent to a large salt water body, such as an estuary.

Status: Critically endangered under EPBC Act. Includes 'Littoral Rainforest in NSW North Coast, Sydney Basin and South East Corner Bioregions' which is endangered under the NSW TSC Act. Many of the Regional Ecosystems included within the EC in Queensland are 'of concern'.

Threats: Deer species damaging this ecological community include Sambar, Rusa and Hog Deer.
The Threatened Species Scientific Committee has already recognised feral deer as a significant threat to this EC, with the 2008 EPBC listing advice stating:

> 'Grazing and browsing by feral deer {Sambar deer *(Cervus unicolor)* and Hog deer *(C. porcinus)*} has been shown to detrimentally impact the ecological community on both a local and landscape level. Browsing prevents regeneration of littoral rainforest canopy and understorey species and creates gaps in the vegetation which allows colonisation by weeds. This has occurred in the area near Genoa River, in Victoria, where the vegetation gaps have been colonised by Cape Ivy (*Delairea odorata*) and dense thickets of Madeira Winter-cherry (*Solanum pseudocapsicum*). These weeds are seriously contributing to the collapse of the existing littoral rainforest patches through the smothering of shrubs and young trees. Severe damage to littoral rainforest has also been observed from Twofold Bay in NSW to the Gippsland Lakes in Victoria. Persistent infestations are documented as causing the local loss of rainforest species and whole sections of mature rainforest in Victoria (Peel et al. 2005). The coastal expansion of feral deer has reached at least as far north as Bermagui ([redacted] in prep.). Where the ranges of the two deer overlap, patches of littoral rainforest (e.g. Marl Island) have been destroyed ([redacted] in prep.).'

The NSW Scientific Committee (2004) found that grazing and trampling by feral deer could alter the composition and structure of this ecological community. Moriarty (2004b) found that where Rusa Deer exist in high densities they substantially reduced diversity in littoral rainforest in Royal NP (see section 5 under Q3). In plots subject to high deer density the mean number of plant species was 17 compared to 37 in plots subject to low deer density. Sapling diversity was reduced by 58% understorey species diversity by 28%, groundcover diversity by 65%, and the total plant diversity by 54%.

Peel et al. (2005) documented severe damage to littoral rainforest communities in East Gippsland. Sambar damage was observed in 74 sites surveyed during 2002-2005. Several species were suffering high rates of morality from Sambar browsing. Those species subject to heavy browsing during drought have reduced capacity to recover. Destruction of regeneration refuges is of particular concern (see section 5 under Q3) as it exposes palatable seedlings to browsing by native and exotic herbivores and undermines species' capacity for regeneration. Peel et al. (2005) rated this impact of browsing as perhaps causing the most severe damage. Wallowing, antler rubbing and rutting behaviours also cause considerable damage. Damage to rainforest can facilitate weed invasion and increase the risk of fire. Sambar trails into thick forest provides pathways for exotic predators and carcasses left by deer hunters provide feral dogs with a reliable food source during breeding.

Alpine Sphagnum Bogs and Associated Fens ecological community
Alpine vegetation community occurring in fragmented remnants in Tasmania, Victoria, NSW, ACT.

Status: Alpine Sphagnum Bogs and Associated Fens ecological community listed as endangered under the EPBC Act. Alpine Bog and Fen (Bog Pool) communities listed under the FFG Act. Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South

Eastern Highlands and Australian Alps bioregions listed as endangered under the TSC Act.

Threats: Grazing and trampling by exotic ungulates is well recognised as a threat, particularly by cattle and horses, and also by deer, goats and pigs (EPBC Listing Advice 2008):

> 'Even though alpine cattle grazing has ceased in the national parks, its impact remains, and is now perpetuated by the habits of other (largely feral) non-native animals, primarily horses, deer, goats and pigs. These animals also trample delicate vegetation and wallow in pools and waterways, making them an ongoing threat to the structural integrity of the Alpine *Sphagnum* Bogs and Associated Fens ecological community. The threat of damage is substantially increased following a fire, due to improved access into bogs for animals, and the presence of burnt, highly-erodible peat.'

In Victoria, both Fallow Deer and Sambar inhabit alpine country. Sambar are of greatest concern (Tolsma 2009). They create tracks from the treeline into mossbeds and scrape out wallows. Tolsma (2009) assessed the condition of 424 individual mossbeds (or sub-sections of larger mossbed systems) across alpine Victoria between 2004 and 2009. Signs of deer activity (scats, tracks or prints) were found at 17% (n=72) and wallows were found at 7% (n=28) of the mossbeds assessed. Lake Mountain and the Wonnangatta-Moroka Unit of the Alpine National Park were assessed to have the highest rates of deer activity overall (58% and 47% respectively of mossbeds assessed), and the latter contained most of the wallows observed (n=20). Deer damage tends to be localised (in contrast to extensive pugging by horses and cattle). Deer activity is likely to increase as the vegetation recovers from fires, as Sambar are drawn to regenerating areas, and the extent of damage will depend on deer numbers.

In NSW, deer have increased in distribution and abundance in southern NSW since the 2002-03 fires, and Sambar are now 'omnipresent' ([redacted] pers. comm.). Some damage has been observed, including at one bog site 'severely trampled and wallowed' along the Burrungubugee River in Kosciuszko NP ([redacted] pers. comm.) Of ~33 sites examined recently (for feral horse damage), there was deer sign at 3, with impacts including grazing and trampling ([redacted] pers. comm.). Sambar presence recently documented in the breeding habitat of the critically endangered Northern Corroboree Frog (*Pseudophryne pengilleyi*) is of great concern; they have been recorded in 17 of 23 breeding sites in the north of Kosciuszko NP ([redacted] pers. comm.) (see under Q5, Q6). Feral deer have been noted as a likely threat also to alpine wetland habitats of the Alpine Tree Frog (*Litoria verreauxii alpina*) (vulnerable under the EPBC Act) (Clemann and Gillespie 2010).

White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland
Characterised by 'a species-rich understorey of native tussock grasses, herbs and scattered shrubs, and the dominance, or prior dominance, of White Box, Yellow Box or Blakely's Red Gum trees' (EPBC Listing Advice 2006). Occurs along the western slopes and tablelands of the Great Dividing Range in highly fragmented patches, with >95% having been cleared or degraded (ibid.).

Status: Critically endangered under EPBC Act. White Box Yellow Box Blakely's Red Gum Woodland endangered under TSC Act. Yellow Box – Red Gum Grassy Woodland endangered under ACT NC Act. Some component regional ecosystems are of concern or endangered in Queensland. Some component Ecological Vegetation Classes are threatened in Victoria. Only portions of the state-listed areas with a predominantly native understorey are part of the EPBC listing.

Threats: Much of this ecological community has been cleared for agriculture (EPBC Listing Advice). In uncleared areas, most of the characteristic understorey has been removed due to grazing and pasture improvement, and grazing also prevents the regeneration of overstorey species (ibid.). Weed invasion and inappropriate fire regimes are also major threats.

Increasing deer populations are an additional threat to this EC. For example, observations in the Byadbo Wilderness component of this EC are that Sambar and Fallow Deer are 'causing severe disruption to the understorey shrub layer, browsing and trampling and causing soil erosion' ([redacted] pers. comm.) In addition, deer inhabit creeklines once dominated by evidence of nationally threatened species such as the Spotted-tailed Quoll (*Dasyurus maculatus*), where they are likely to be damaging latrine sites vital for quoll breeding and communication (ibid.).

Eucalyptus gunnii ssp. divaricata (*Miena Cider Gum*)
Small-medium woodland tree to 12-15 high. Part of a continuum between *Eucalyptus gunnii* and *Eucalyptus archeri*. Restricted to frost hollows in open woodland around the Great Lake region on Tasmania's Central Plateau in an area 40 x 40 km.

Status: Endangered under the EPBC Act. Endangered under the Tasmanian Threatened Species Protection Act 1995. Endemic to the Tasmanian Central Plateau.

Threats: Threats identified in the EPBC listing advice (2003) are 'frequent burning; grazing sheep, rabbits and native marsupials (e.g. brushtail possums); clearing for roadwork; flooding; seed collection; and drought'. Brushtail Possums, which have increased in the area, intensively browse new growth and may hasten the death of mature trees and prevent establishment (Potts et al. 2001). They are regarded as a major threat. Browsing of saplings by Fallow Deer is a more recently recognised threat (Tasmanian Threatened Species Listing Statement), which may be just as severe as that due to possum browsing ([redacted] pers. comm.). *E. gunni* ssp. *divaricata* is probably the most palatable eucalypt in Tasmania, and landholders with it on their land have observed that deer are browsing the plant and having a major impact. This is consistent with recent observations of damage to *E. gunni* ssp. *divaricata* saplings within an exclosure that excludes herbivores other than deer ([redacted] pers. comm.).

Syzygium paniculatum (*Magenta Lilly Pilly*)
A rainforest tree 3-8m high. Grows in subtropical and littoral rainforest on sandy soils or stabilized dunes near the sea; widely separated localities between Bulahdelah and Jervis Bay.

Status: Vulnerable under EPBC Act. Vulnerable under TSC Act. Endemic to NSW: South Coast, Central Coast & North Coast.

Threats: Highly palatable to Rusa Deer (Keith & Pellow 2005). The NSW Scientific Committee (2004) identified it as a threatened species known to be eaten by deer. Keith and Pellow (2005) assessed the impacts of Rusa Deer on this species in Royal NP. They planted 93 individual *S. paniculatum* and protected them behind fencing until they were 1-1.4 m tall. Rusa were given access to the plants for 3 months then excluded. 5 plants in an adjacent fenced area were used as a qualitative control with deer excluded. The only other herbivore, brush-tailed possums, had access to both areas. All 93 plants exposed to deer suffered loss of foliage and 84% had <25% of foliage remaining. About 15% had their bark stripped or their main stem broken near the ground. About 90% started to recover when deer were again excluded. None of the 5 control plants suffered damage. The experiment showed that deer 'may have very substantial impacts on at least some plant species over a relatively short time frame'.

Xerochrysum palustre (*Swamp everlasting*)
Perennial erect herb to 30–100 cm high. Distributed from central eastern New South Wales through Victoria to north-eastern Tasmania. ~ 35 populations known, with total abundance estimated at >10,000 plants (rhizomatous habit and dense clumps with large numbers of stems within clumps makes counting difficult) (Carter and Walsh 2010). Grows in wetlands including sedge-swamps and shallow freshwater marshes, often on heavy black clay soils. In Victoria estimated 5,000–10,000 plants; incomplete information from NSW; distribution & abundance in Tasmania poorly known.

Status: Vulnerable under EPBC Act. Listed under FFG Act. Not listed in NSW (rare in scattered locations in Central & Southern Tablelands). Not listed in Tasmania. Endemic to south-eastern Australia.

Threats: Recognised threats in the draft recovery plan (Carter & Walsh 2010) include grazing and damage by deer particularly in dry seasons. Trampling by deer is of concern, for example in South East Forests NP where it is in a small area (<0.5 ha) potentially frequented by Sambar, Red Deer and Fallow Deer ([redacted] pers. comm.). Other threats identified in the recovery plan are wetland drainage/modification (major threat), weed invasion, maintenance, ploughing, mining, climate change and grazing by kangaroos, rabbits, cattle, feral horses, pigs.

Deer are recorded as a threat to the species in the following locations (Carter & Walsh 2010):

- NSW South East Forests National Park: Packers Swamp, Nunnock Swamp, NSW: Damage by deer (Sambar, Red Deer & Fallow Deer); deer (& pig) presence attracts shooters, who drive their vehicles across the drier parts of the swamps [this is now prevented by a gate].
- NSW Wadbilliga National Park: Damage and grazing by feral animals including deer
- NSW Tantawangalo State Forest: Deer grazing.
- Victoria Blond Bay Wildlife Reserve: Grazing by Hog Deer. This population has been 'severely damaged' by Hog Deer ([redacted] pers. comm.).

The NSW Scientific Committee (2004) identified it as an unlisted species (for NSW) that could become threatened due to deer.

Prostanthera densa (*Villous Mintbush*)
Erect shrub to 2 m high. Grows in sclerophyll forest and shrubland, on coastal headlands and near-coastal ranges, on sandstone; from Nelson Bay to Beecroft Peninsula.

Status: Listed as vulnerable under EPBC Act. Listed as vulnerable under TSC Act. Endemic to NSW.

Threats: Fairley (2004) lists development, fire and deer grazing as the main threats. The EPBC Act Conservation Advice (2008) identifies clearing as the main threat. Deer grazing, inappropriate fire and phytophthora dieback are identified as potential threats. The NSW Scientific Committee (2004) listed in the feral deer KTP advice as a threatened species known to be eaten by deer. The population at Royal NP had been thought for many years to be extinct due to deer, as the species was reportedly 'quite common' on Marley Beach prior to deer ([redacted] pers. comm.). A remnant of this population was recently discovered in scree on a cliff face inaccessible to deer (ibid.).

Calyptorhynchus lathami halmaturinus (*Glossy Black-Cockatoo*)
A South Australian subspecies that has disappeared from the SA mainland and is currently restricted to Kangaroo Island.

Status: Endangered under EPBC Act. Endangered under SA *National Parks and Wildlife Act.* Endemic to South Australia.

Threats: The cockatoo feeds almost exclusively on the seeds of Drooping Sheoak (*Allocasuarina verticillata*) (Garnett and Crowley 2000) and requires highly quality sheoak woodland for foraging. The recovery plan (Mooney & Pedler 2005) identifies habitat destruction as the primary cause of decline and grazing – including by deer – as a threat to regenerating habitat on Kangaroo Island. Fallow Deer are also present on the Fleurieu Peninsula, where it is proposed to protect and expand suitable habitat to re-introduce the cockatoo in future. Other threats include nest predation by Brushtail Possums and grazing by domestic stock, native wildlife and feral goats.

Fallow Deer have been causing substantial damage in Coorong National Park ([redacted] pers comm.), which they invaded from a neighbouring pastoral property after feral goats had been eradicated from the NP. At the time researchers were conducting a rabbit exclusion experiment using tree guards to protect regenerating clusters of *Allocasuarina verticillata*. Surviving seedlings at ~ 2 m high and ~ 3 years of age and well above rabbit browse height were destroyed by Fallow Deer, implicated by the height of the browse line. There remain 3-4 exclusion plots where there is continuous and healthy recruitment of *A. verticillata* but in non-protected areas it is generally unable to escape browse height and recruitment is very poor ([redacted] pers. comm.). This shows that Fallow Deer are a major threat to regenerating habitat for the Glossy Black-Cockatoo. Drooping Sheoak woodland is an endangered vegetation association in southeast South Australia.

Leipoa ocellata (*Malleefowl*)
A large ground-dwelling bird inhabiting semi-arid regions of southern Australia. Found in semi-arid to arid shrublands and low woodlands, especially those dominated by mallee and/or acacias. Populations severely fragmented (Benshemesh 2007).

Status: Vulnerable under the EPBC Act. Vulnerable under the SA National Parks and Wildlife Act 1972. Endangered under the NSW TSC Act. Critically Endangered under the Territory Parks and Wildlife Conservation Act 2000. Listed under the FFG Act. Classified as 'rare' or 'likely to become extinct' under the WA Wildlife Conservation Act 1950.

Threats: Major identified threats in the recovery plan are clearing, habitat fragmentation, grazing (sheep grazing can reduce breeding densities by 90% and deer are noted as a potential problem in this respect), predation (particularly by foxes) and fire (Benshemesh 2007). Deer trampling of malleefowl mounds is an additional recently observed problem (escalating over the past decade) in the South East region of South Australia. It has been observed in all 5 grids being monitored in the South East, especially from 2006-2008 ([redacted] pers. comm.). It was most evident in the 2 monitoring grids in Gum Lagoon Conservation Park (25 mounds affected in 2007 and 17 in 2008), where the 'surrounding bush was also trampled, bashed and criss-crossed with well used pads' (ibid). Gum Lagoon Conservation Park and Duck Island (which are jointly managed by the SA Government and landowner James Darling, who is also a member of the South East Deer Advisory Committee) is a stronghold for Malleefowl, one of the most densely populated areas in their range ([redacted] pers. comm.) Feral deer – mainly Red Deer and Fallow Deer, sometimes Rusa, occasional Sambar and Chital – have been a major problem in the area for the past decade. Most have escaped from a nearby, poorly fenced deer farm. Aerial shooting in the upper South East region on conservation reserves and some private properties has been conducted for the past 3 years and has been successful in 'containing' deer numbers, but farm escapes continue to replenish numbers (ibid.). Deer are attracted to Malleefowl mounds (as they are to sandy banks) seemingly for play 'like children in a sandpit' (ibid.). Their trampling damages the mound, sometimes collapsing the egg chamber. Although malleefowl are tenacious about maintaining mounds (some mounds are >100 years old) deer damage can result in abandonment, and otherwise requires extra maintenance efforts. James Darling and other landholders have fenced some mounds to protect them (while deer occasionally breach the fences, it prevents

groups gathering on the mound). He considers that the entire malleefowl population in the South East would be threatened by mound trampling if deer were not controlled (>800 were killed last year by helicopter shooting and >800 by ground shooting).

Other feral deer threats probably include grazing/browsing impacts that deny food to Malleefowl and change the structure and floristic diversity of habitats; Malleefowl are highly sensitive to grazing (Benshemesh 2007). Deer browsing can be particularly damaging for regeneration after fire. In the Gum Lagoon and Duck Island area, 70% of which was burnt in 2006, seedling consumption by feral deer has been extensive, including in revegetation projects ([redacted] [redacted] pers. comm.). There has also been damage to saplings and trees caused by antler rubbing (ibid.).

Section 3 – Threat Abatement Plan

10. Threat Abatement

10. *Give an overview of how threats posed by this process are being abated by current (or proposed) activities. Identify who is undertaking these activities and how successful the activities have been to date.*

There are currently only patchy and limited attempts to abate the threat of feral deer. A summary of the legislative status and relevant policies applying to feral deer in each state/territory are provided in the 'Description'. They vary widely.

In at least 3 states (NSW, Victoria, Tasmania) deer are protected wildlife and most management is for the benefit of recreational hunters. Managers of individual conservation reserves in NSW and Victoria conduct deer control but are hampered by lack of control beyond their perimeters. Some also fence off threatened plant populations to protect them from deer. Feral deer have been listed as a key threatening process in NSW and Sambar a potentially threatening process in Victoria but no threat abatement plans are in place.

Queensland is currently prepared a deer management strategy after recently declaring deer pest species. The draft strategy includes a goal to eradicate new populations. South Australia seems to be making the most concerted effort to control deer, including an eradication program on Kangaroo Island, and aerial and ground shooting in conservation reserves and some private properties in the South East region.

The recent (and presumably ongoing) establishment of new deer populations due to farm escapes or releases and hunter releases demonstrate major flaws in the management of deer farms in most states.

11. *Would the development of a threat abatement plan be a feasible, effective and efficient way to abate the process? What other measures could be undertaken?*

Abating the threat of feral deer will be very challenging due to the conflicting goals evident in current approaches, the technical difficulties of deer control, the ongoing release or escape of deer and the limited awareness about their environmental impacts. For these reasons we think it is vital to have a national management plan. It could assist by:

- increasing awareness and acceptance of the environmental threats of deer
- promoting consistency between states and territories
- promoting research into the environmental impacts and management options
- identifying eradication, control and other management priorities based on biodiversity criteria (outside national parks the focus has been mostly on agricultural and safety issues).

12. *Should the threatening process be recommended for listing under the EPBC Act, what elements could a threat abatement plan include?*

The threat: Summary of the evidence for environmental threats
Management priorities: Including eradication of new populations to prevent future threats, control in areas of high conservation value or to protect threatened biodiversity; and better implementation of laws to prevent the escape and release of deer.
Control options: The most effective and practicable methods for different circumstances need to be identified.
Research priorities: Including about environmental impacts and management and control options.

The human dimensions: Address the ways in which hunting contributes to the deer problem and could contribute to solutions (eg. as part of professionally run control programs). Address animal welfare concerns.
Education: Outline what is needed to increase awareness and acceptance that deer are an environmental threat.

***13**. Is there other information that relates to threat abatement that you would like to provide?*

11. Major Studies

***14.** Identify major studies that might assist in the assessment of the nominated threatening process.*

Peel B, Bilney RJ and Bilney RJ. (2005) Observations of the ecological impacts of Sambar *Cervus unicolor* in East Gippsland, Victoria, with reference to destruction of rainforest communities. *Victorian Naturalist* 122:189–200.

Moriarty A. (2004b) *Ecology and environmental impact of Javan rusa deer (Cervus timorensis russa) in the Royal National Park*. PhD Thesis. University of Western Sydney, Sydney.

Section 3 – References and Reviewers

12.

Notes:

- The opinion of appropriate scientific experts may be cited (with their approval) in support of a nomination. If this is done the names of the experts, their qualifications and full contact details must also be provided in the reference list below.
- Please provide copies of key documentation/references used in the nomination.

***15.** Reference list*

References

Bennett A and Coulson G. (2011) The impacts of Sambar (Cervus unicolor) on the threatened Shiny Nematolepis (Nematolepis wilsonii). *Pacific Conservation Biology* 16: 251-60.

Bennett A. (2008) *The impacts of sambar (Cervus unicolor) in the Yarra Ranges National Park*. PhD Thesis. Department of Zoology, The University of Melbourne.

Benshemesh J. (2007) *National Recovery Plan for Malleefowl 2006-2010*. Department of Environment and Heritage, Adelaide, South Australia.

Bentley A. (1995) Sambar Cervus unicolor. In Strahan R (ed.) *The Mammals of Australia*, 2nd edition. Reed Books. Chatswood.

Bentley A. (1998) *An introduction to the deer of Australia with special reference to Victoria*. The Koetong trust fund and the Forest Commission of Victoria, Melbourne.

Carter O and Walsh N. (2010) *National Recovery Plan for the Swamp Everlasting Xerochrysum palustre*. Department of Sustainability and Environment, Melbourne.

Clemann N and Gillespie GR. (2010). *National Recovery Plan for the Alpine Tree Frog Litoria verreauxii alpina.* Department of Sustainability and Environment, Melbourne.

Coomes DA, Allen R, Forsyth DM and Lee WG. (2003) How reversible are the impacts of introduced deer in New Zealand forests? *Conservation Biology* 17: 450-459.

Côté SD, Rooney, TP, Tremblay J, Dussault C and Waller DM. (2004) Ecological impacts of deer overabundance. *Annual Review of Ecology Evolution and Systematic*s 35, 113–147.

Coutts-Smith A, Mahon P, Letnic M and Downey P. (2007*) The threat posed by pest animals to biodiversity in NSW*. Invasive Animals Cooperative Research Centre, Canberra/NSW Department of Environment and Climate Change joint report.

Danell K, Niemela P, Varvikko T, Vuorisalo T. 1991. Moose browsing on Scots pine along a gradient of plant productivity. *Ecology* 72:1624–33.

Davis N, Forsyth D and Coulson G. (2010) Facilitative interactions between an exotic mammal and native and exotic plants: hog deer (Axis porcinus) as seed dispersers in south-eastern Australia. *Biological Invasions* 12:1079–1092.

Davis, N, Forsyth D and Coulson G. (2008) Diets of native and introduced mammalian herbivores in shrub-encroached grassy woodland, south-eastern Australia. *Wildlife Research* 35: 684–694.

Dawson TJ and Ellis BA. (1979) Comparison of the diets of Yellow-footed Rock-wallabies and sympatric herbivores in western New South Wales. *Australian Wildlife Research* 6: 245-254.

de Kok R and West J. (2002) A revision of *Pultenaea* Sm. (Fabaceae) 1. Species with ovaries glabrous and/or with tufted hairs. *Australian Systematic Botany* 15: 81-113.

DEEDI (2010). *Feral Deer Management Strategy 2010-2015*. Consultation Draft. Department of Employment, Economic Development and Innovation, Queensland Government.

Dolman PM and Wäber K. (2008) Ecosystem and competition impacts of introduced deer*. Wildlife Research* 35: 202-214.

Dryden G. (2009) Wild deer in SE Queensland – graziers' pest or charismatic megafauna? In McLeod S (ed.) *Workshop Proceedings: What are the issues for the management of wild deer in Australia?* November 2005, Canberra. Invasive Animals CRC. pp. 97-105.

Fairly A. (2004) *Seldom seen: rare plants of greater Sydney*. Reed New Holland, Frenchs Forest*.*

Forsyth D. (2007) Deer impacts on the natural environment: what are they and how should they be monitored? In *Deer Best Practice Management in the Australian Alps National Parks*. Workshop Lake Hume, Albury, NSW 14-16 August 2007.

Forsyth D. (2009) How can research contribute to the management of wild deer in Australia? In McLeod S (ed.) *Workshop Proceedings: What are the issues for the management of wild deer in Australia?* November 2005, Canberra. Invasive Animals CRC. pp. 7-20.

Forsyth DM, Coomes DA, and Nugent G. (2003) Framework for assessing the susceptibility of management areas to deer impacts. *Science for Conservation* 213, New Zealand Department of Conservation, Wellington, <http://wwwdocgovtnz/Publications/004~Science-and-Research/Science-for-Conservation/091~2003asp>.

Forsyth D and Caley P. (2006) Testing the irruptive paradigm of large-herbivore dynamics', *Ecology* 87: 297- 303.

Frith HJ. (1973) *Wildlife Conservation*. Angus and Robertson, Sydney.

Garnett S and Crowley G. (2000) *The Action Plan for Australian Birds*. Environment Australia, Canberra.

Gomez JM and Zamora R. (2002) Thorns as mechanical defense in a long-lived shrub (*Hormathophylla spinosa*, Cruciferae). *Ecology* 83:885–90.

Gormley AM, Turnbull JD. 2009. *Estimates of harvest for deer, duck and quail in Victoria: Results from surveys of Victorian game licence holders in 2009*. Arthur Rylah Institute for Environmental Research, DSE Victoria.

Hall G. (2009) Wild deer in Tasmania – exotic pest or valued resource? In McLeod S (ed.) Workshop Proceedings: What are the issues for the management of wild deer in Australia? November 2005, Canberra. Invasive Animals CRC. pp. 58-65.

Hone J, Duncan R, Forsyth D. 2010. Estimates of maximum annual population growth rates (r_m) of mammals and their application in wildlife management. *Journal of Applied Ecology* 47: 507-514.

Jesser P. (2005) *Deer in Queensland: Pest Status Review Series - Land Protection*, Department of Natural Resources and Mines, Brisbane.

Keith D and Pellow B. (2005) Effects of Javan rusa deer (*Cervus timorensis*) on native plant species in the Jibbon- Bundeena Area, Royal National Park, New South Wales. *Proceedings of the Linnean Society of New South Wales* 126: 99-110.

Low T. (2008) Family Cervidae: Deer. In Van Dyck SM and Strahan *R*. (eds). *The Mammals of Australia*, 3rd edition. New Holland, Sydney.

Masters P. (2009) Management of Fallow Deer on Kangaroo Island. In McLeod S (ed.) *Workshop Proceedings: What are the issues for the management of wild deer in Australia?* November 2005, Canberra. Invasive Animals CRC. pp. 70-75.

Mooney PA and Pedler LP. (2005) *Recovery Plan for the South Australian subspecies of the Glossy Black-Cockatoo* (*Calyptorhynchus lathami halmaturinus*): *2005-2010*. South Australian Department for Environment and Heritage. Adelaide.

Morgan MJ, Hunter D, Pietsch R, Osborne W and Keogh JS. (2008) Assessment of genetic diversity in the critically endangered Australian corroboree frogs, *Pseudophryne corroboree* and *Pseudophryne pengilleyi*, identifies four evolutionarily significant units for conservation. *Molecular Ecology* 17:

3448–3463.

Moriarty A. (2004) The liberation, distribution, abundance and management of wild deer in Australia. *Wildlife Research* 31:291–299.

Moriarty A. (2004b) *Ecology and environmental impact of Javan rusa deer (Cervus timorensis russa) in the Royal National Park*. PhD Thesis. University of Western Sydney, Sydney.

Moriarty A. (2009) Science based management of wild deer in Australia: A case study – rusa deer in the Royal National Park. In McLeod S (ed.) *Workshop Proceedings: What are the issues for the management of wild deer in Australia?* November 2005, Canberra, Invasive Animals CRC. pp. 112-118.

Murphy AH, White M and Downe J. (2006) *National Recovery Plan for the Shiny Nematolepis Nematolepis wilsonii*. Department of Sustainability and Environment, Melbourne.

NSW Scientific Committee (2004) *Herbivory and environmental degradation caused by feral deer — key threatening process declaration*. < http://www.environment.nsw.gov.au/determinations/FeralDeerKtp.htm>.

NSW Scientific Committee (2007) *Prasophyllum canaliculatum D.L. Jones - critically endangered species listing*. <http://www.environment.nsw.gov.au/determinations/PrasophyllumCanaliculatumCritEndSpListing.htm>

NSW Scientific Committee (2010) *Northern Corroboree Frog Pseudophryne pengilleyi: Review of Current Information in NSW*. www.environment.nsw.gov.au/resources/nature/schedules/nthcorrofrog.pdf.

Parkes JP, Henzell R and Pickles G. (1996) *Managing Vertebrate Pests: Feral Goats*. Bureau of Resource Sciences. Australian Government Publishing Service, Canberra.

Peel B, Bilney RJ and Bilney RJ. (2005) Observations of the ecological impacts of Sambar *Cervus unicolor* in East Gippsland, Victoria, with reference to destruction of rainforest communities. *Victorian Naturalist* 122:189–200.

Pople T, Paroz G and Wilke A. (2009). Deer management in Queensland. In McLeod S (ed.) *Workshop Proceedings: What are the issues for the management of wild deer in Australia?* November 2005, Canberra. Invasive Animals CRC. pp. 50-57.

Potts BM, Potts WC and Kantvilas G. (2001) The Miena Cider Gum, *Eucalyptus gunnii* subsp. *divaricata* (Myrtaceae): a taxon in rapid decline. *Papers & Proceedings of the Royal Society of Tasmania* 135: 57-61.

Pye MG and Gadek PA. (2004) Genetic diversity, differentiation and conservation in Araucaria bidwillii (Araucariaceae), Australia's Bunya pine. *Conservation Genetics* 5: 619-629

Ray N and Burgman MA (2006) Subjective uncertainties in habitat suitability maps. *Ecological Modeling* 195:172-186.

Rolls EC. (1969) *They all ran wild*. Angus and Robertson, Sydney.

SAC (2007) *Final recommendation on a nomination for listing: 'Reduction in biodiversity of native vegetation by Sambar (Cervus unicolor)'.* Flora and Fauna Guarantee Act Scientific Advisory Committee. Department of Sustainability & Environment, Melbourne.

Simberloff D and Von Holle B. (1999) Positive interactions of nonindigenous species: Invasional meltdown? *Biological Invasions* 1: 21-32.

Smith IR and Butler D. (2009) The Bunya Pine the Ecology of Australia's Other 'Living Fossil' Araucarian- Dandabah Area-Bunya Mountains South East Queensland, Australia. In *Proceedings of the 2002 International Araucariaceae Symposium Araucaria-Agathis-Wollemi, International Dendrology Society*. Touchwood Books, NZ.

Smith IR, Withers K, Blomberg S, Billingsley J. (in prep.) Maintaining the ancient Bunya Tree (*Araucaria bidwillii* Hook.) - Dispersal and mast years.

Styles K. (2009) Feral deer situation in the ACT. In McLeod S (ed.) *Workshop Proceedings: What are the issues for the management of wild deer in Australia?* November 2005, Canberra. Invasive Animals CRC. pp. 76-77.

Tolsma A. (2009) *An Assessment of Mossbeds Across the Victorian Alps, 2004-2009*. Report to Parks Victoria. Victorian Department for Sustainability and Environment.

Van Dyck SM and Strahan R. (ed) (2008) *The Mammals of Australia, 3rd edition*. New Holland: Sydney.

Walsh NG and Stajsic V. (2007) *A census of the vascular plants of Victoria*, 8th edn. Royal Botanic Gardens Melbourne, South Yarra. <http://www.rbg.vic.gov.au/viclist/index.htm>

Walsh NG. (1996) A new species of Gynatrix (Willd.) Alef. (Malvaceae) from eastern Victoria. *Muelleria* 9:191-93

West P and Saunders G. (2007) *Pest Animal Survey: A review of the distribution, impacts and control of invasive animals throughout NSW and the ACT*. NSW Department of Primary Industries.

Williams M. (2009) Wild deer in South Australia: position paper for National Deer Workshop. In McLeod S (ed.) *Workshop Proceedings: What are the issues for the management of wild deer in Australia?* November 2005, Canberra. Invasive Animals CRC. pp. 66-69.

Woolnough A and Kirkpatrick W. (2009) Wild deer in Western Australia: A review of the current issues. In McLeod S (ed.) *Workshop Proceedings: What are the issues for the management of wild deer in Australia?* Invasive Animals CRC. November 2005, Canberra. pp. 32-38.

Wright W, Varcoe T and Toop S. (2009) Management of Deer in Victoria. In McLeod S (ed.) *Workshop Proceedings: What are the issues for the management of wild deer in Australia?* November 2005, Canberra. Invasive Animals CRC. pp. 45-49.

Guidelines for assessing key threatening process nominations according to the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) and *EPBC Regulations 2000*

Threatened Species Scientific Committee (TSSC)

Part A – Guidelines for key threatening process nominations

Introduction

The listing of a key threatening process under the EPBC Act is designed to prevent native species or ecological communities from becoming threatened or prevent threatened species and ecological communities from becoming more threatened.

There is a difference between identifying a process as threatening or potentially threatening and listing it as a Key Threatening Process under the EPBC Act. The TSSC is of the view that while many processes that occur in the landscape are or could be threatening processes, there is a lesser number that should be regarded as key threatening processes and receive the appropriate legislative status and hence regulatory recognition.

These guidelines designed to assist in the preparation of nominations of threatening processes consistent with the Regulations and Act.

Naming the threatening process

The name provided should accurately reflect the scope of the process based on the description and evidence provided in this form. The name nominated may not necessarily be the name adopted by the TSSC for a successful nomination.

Describing the threatening process

Nominators need to provide a description of the threatening process that distinguishes it from any other threatening process, by reference to

(i) its biological and non-biological components.

Nominators need to carefully consider all the components which make up the threatening process. Each biological and non-biological component of the process nominated should be defined as accurately and concisely as possible. If appropriate, in order to distinguish the nominated threatening process from other processes, components which are specifically excluded from the nominated process can be listed.

While not wishing to restrict the generality of nominations, the TSSC would prefer that threatening processes were identified as operating in particular landscape or ecological or seascape contexts.

(ii) the processes by which those components interact (if known).

In relation to the biological and non-biological components defined above, nominators should attempt to identify the interactions that occur between these components, ie. to describe the actual process. All terms used to name the interactions making up the process should be defined as accurately and as concisely as possible.

It would also be useful if the linkage between components demonstrated how the process threatens native species or ecological communities. For example, it is conceivable that a change in vegetation cover could be threatening to downstream aquatic species, but this linkage would need to be established before it could be understood as a threatening process. Specific examples or data demonstrating impact on named native species or ecological communities should not be included in the description (these are included in the justification section).

Justification for why the threatening process is eligible to be treated as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999*

Nominators need to include reasons for their nomination and provide evidence against the criteria for listing key threatening processes. Although there are three criteria for listing, meeting any **one** of the criteria means a threatening process is eligible for listing as a key threatening process. However, provision of all available evidence against each criterion aids in assessment by the TSSC.

The EPBC Act lists of threatened species and ecological communities are available on the Department of Sustainability, Environment, Water, Population and Communities website at: www.environment.gov.au/biodiversity/threatened/index.html

Criterion A - evidence that the threatening process could cause a native species or an ecological community to become eligible for listing in any category, other than conservation dependent.

This criterion refers to species or ecological communities not currently included in the EPBC Act lists, but which could become eligible for listing due to the impacts of the nominated threatening process. To meet this criterion there must a high likelihood of a significant effect, to the extent that the species or ecological community will meet at least one of the criteria for listing, within an indicated timeframe, should the threat continue.

The conservation status categories of listing relevant to this criterion are:

- for species- Extinct, Extinct in the wild, Critically Endangered, Endangered, Vulnerable.
- for ecological communities- Critically Endangered, Endangered, Vulnerable.

The criteria for listing species and ecological communities in each of these categories can be found in the Part B and Part D of these guidelines.

Criterion B - evidence that the threatening process could cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment.

This criterion refers to species or ecological communities which are currently included in the EPBC Act lists. In order to cause a species or ecological community to become eligible for listing in a category representing a higher degree of endangerment, there must be a high likelihood of a significant effect, to the extent that the species or ecological community will meet at least one criterion for the higher category, within an indicated timeframe, should the threat continue.

The conservation status categories of listing relevant to this criterion are:

- for species- Extinct in the wild, Critically Endangered, Endangered, Vulnerable or Conservation Dependant.
- for ecological communities- Endangered or Vulnerable.

The categories Extinct for species and Critically Endangered for ecological communities are not relevant, since there are no categories representing a higher degree of endangerment. The criteria for listing species and ecological communities in each of these status categories can be found in Part B and Part D of these guidelines.

Criterion C - evidence that the threatening process adversely affects two or more listed threatened species (other than conservation dependent species) or two or more listed threatened ecological communities.

This criterion refers to species or ecological communities which are currently included in the EPBC Act lists. In order to be adversely affecting a species or ecological community, the threatening process must currently occur where the species or ecological community occurs, and there must be evidence of a current effect.

An adverse effect can include mortality, injury, spread of disease, disturbance to breeding, feeding or roosting habits, habitat alteration or habitat destruction. The extent of impact which can be considered to be an adverse effect depends on the attributes of the population, ecological characteristics, and category in which the species/ecological community is listed. For example, if a species listed as Critically Endangered has less than 50 individuals remaining, then the death of a few individuals would probably constitute an adverse effect. Conversely, the same impact in a species listed as Vulnerable, which has a population of over 9000, would not constitute an adverse impact for the purpose of this criterion.

The conservation status categories relevant to this criterion are:

- for species- Extinct in the wild, Critically Endangered, Endangered, Vulnerable
- for ecological communities- Critically Endangered, Endangered, Vulnerable

The category Extinct for species is not included since there cannot be a current adverse effect on this species. However, if there is evidence of a previous adverse impact before the species became extinct, and this is highly relevant to current impacts of the threatening process, this evidence can also be included.

Some of the information provided in criterion B will also be relevant here. In this case, it should be provided again in the context of this criterion ie. relating to adverse effects rather than population-level impacts.

Providing information on threat abatement

If a decision is made to list the threatening process being nominated as a key threatening process, the Minister must then make a decision on whether to have a threat abatement plan.

This section is not required for the nomination to be eligible for listing as a key threatening process under the EPBC Act. However any additional information provided by nominators can be used by the TSSC in preparing its advice to the Minister on the feasibility, effectiveness and efficiency of developing a threat abatement plan, should the threatening process be listed.

Part B – Criteria for listing species under the *Environment Protection and Biodiversity Conservation Act 1999* and *Environment Protection and Biodiversity Conservation Regulations 2000*

For section 179 of the EPBC Act (which provides general eligibility for inclusion in a category of the list of threatened species), a native species is in the critically endangered, endangered or vulnerable category if it meets any of the criteria for the category mentioned in the following table:

	Criterion	Category Critically Endangered	Endangered	Vulnerable
1	It has undergone, is suspected to have undergone or is likely to undergo in the immediate future:	a very severe reduction in numbers	a severe reduction in numbers	a substantial reduction in numbers
2	Its geographic distribution is precarious for the survival of the species and is:	very restricted	restricted	limited
3	The estimated total number of mature individuals is: and either of (a) or (b) is true: (a) evidence suggests that the number will continue to decline at: or (b) the number is likely to continue to decline and its geographic distribution is:	very low a very high rate precarious for its survival	low a high rate precarious for its survival	limited a substantial rate precarious for its survival
4	The estimated total number of mature individuals is:	extremely low	very low	low
5	The probability of its extinction in the wild is at least:	50% in the immediate future	20% in the near future	10% in the medium-term future

These criteria define situations in which a risk of extinction in the wild, some time in the future, is deemed to exist for a species (for the purposes of section 179 of the EPBC Act). It is not necessary to identify a quantitative risk of extinction, but it is important to ensure that judgements about the criteria (for example, whether a reduction in numbers represents a severe decline), are made in the context of risk of extinction. For example, the Committee's consideration of whether a reduction in numbers of a species is 'severe' takes into account the relationship between the reduction in numbers and the biological and other factors that are relevant to the species' risk of extinction in the wild (or, alternatively, the factors relevant to the species' prospects of survival in the wild).

The table above includes hyperlinks that, when clicked, will take you to indicative thresholds (Part C) that may be used by the Committee to judge the subjective terms given above. While these are modified from the "IUCN Red List Categories and Criteria Version 3.1, 2001", it should be noted that the Committee does not strictly apply these, but has regard to them when making judgments about species in terms of their biological contexts, and on a case-by-case basis.

Part C – Indicative thresholds that may be used by the Committee to judge the subjective terms provided by the criteria for listing (as presented at Part B)

When assessing a species' eligibility against the listing criteria (see Part B), the Committee exercises its judgement to give practical meaning to the subjective terms of the criteria. The Committee does this by considering the information provided to it via the nomination form in the context of the species' biology and relevant ecological factors, and having regard to the degree of complexity and uncertainty associated with that context and the information provided.

The Committee is also informed by, but not bound by, indicative thresholds, which have been adapted from "IUCN Red List Categories and Criteria Version 3.1, 2001". When considering whether to use these thresholds, the Committee judges whether they are appropriate to the species in question. For example, a relatively long-lived species with slow reproduction and relative population stability (such as most mammals) might be more impacted by, for example, a 30% decline in numbers than might a relatively short-lived species with fast reproduction and naturally fluctuating populations (such as most insects). This consideration of biological attributes is placed in the context of matters such as the relative population size so as to judge whether, for the species in question, a decline is substantial, severe or very severe, for the purposes of the criteria for listing.

When considering thresholds for assessing commercially harvested marine fish, the Committee refers to the Commonwealth Government Harvest Strategy Policy. This policy allows that declines of up to 60% (from pre-fishing biomass levels) are acceptable for commercially harvested fish species where depletion is a managed outcome. Variations in the extent of acceptable decline depend on the biology of the individual species. The Committee is informed, but not bound, by a series of biological reference trigger points (commonly referred to as BLIM and BTARG) provided in the policy for management intervention for species that decline below 60% of their pre-fishing biomass. These interventions include listing assessments.

EPBC	Matters considered	Indicative Thresholds		
	Reduction in numbers (based on any of A1 – A4)	**Very severe**	**Severe**	**Substantial**
Criterion One	A1. An observed, estimated, inferred or suspected population size reduction over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following: (a) direct observation (b) an index of abundance appropriate to the taxon (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat (d) actual or potential levels of exploitation (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.	≥90%	≥70%	≥50%
	A2. An observed, estimated, inferred or suspected population size reduction over the last 10 years or three generations, whichever is the longer**,** where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible**,** based on (and specifying) any of (a) to (e) under A1.	≥80%	≥50%	≥30%
	A3. A population size reduction, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.	≥80%	≥50%	≥30%
	A4. An observed, estimated, inferred, projected or suspected population size reduction over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.	≥80%	≥50%	≥30%

EPBC	Matters considered	Indicative Thresholds		
Criterion Two	**Geographic distribution is precarious** for the survival of the species, based on at least two of a – c: a. Severely fragmented or known to exist at a limited location. b. Continuing decline, observed, inferred or projected, in any of the following: (i) extent of occurrence (ii) area of occupancy (iii) area, extent and/or quality of habitat (iv) number of locations or subpopulations (v) number of mature individuals. c. Extreme fluctuations in any of the following: (i) extent of occurrence (ii) area of occupancy (iii) number of locations or subpopulations (iv) number of mature individuals	**Precariousness** is judged on a case-by-case basis, having regard to the degree of threat operating on the species		
	Geographic distribution (based on either of B1 or B2)	**Very restricted**	**Restricted**	**Limited**
	B1. Extent of occurrence estimated to be less than	100 km^2	5,000 km^2	20,000 km^2
	B2. Area of occupancy estimated to be less than	10 km^2	500 km^2	2,000 km^2
Criterion Three	Estimated **total number** of mature individuals	**Very low**	**Low**	**Limited**
	And either of (A) or (B) is true	<250	<2,500	<10,000
	(A) **Rate** of continued decline	**Very high**	**High**	**Substantial**
		25% in 3 years or 1 generation (up to 100 years), whichever is longer	20% in 5 years or 2 generations (up to 100 years), whichever is longer	10% in 10 years or 3 generations (up to 100 years), whichever is longer
	OR (B) **Continued decline** and **geographic distribution is precarious**, based on at least two of a – c: a. Severely fragmented or known to exist at a limited location. b. Continuing decline, observed, inferred or projected, in any of the following: (i) extent of occurrence (ii) area of occupancy (iii) area, extent and/or quality of habitat (iv) number of locations or subpopulations (v) number of mature individuals. c. Extreme fluctuations in any of the following: (i) extent of occurrence (ii) area of occupancy (iii) number of locations or subpopulations (iv) number of mature individuals	**Precariousness** is judged on a case-by-case basis, having regard to the degree of threat operating on the species		

Criterion Four	Estimated **total number of mature individuals**, based on the following: a. Number of mature individuals only	**Extremely low** < 50	**Very low** < 250	**Low** < 1,000

Criterion Five	**Probability of extinction** in the wild within a period, based on the following: a. Quantitative analysis (Note: probability must be at least 50% for critically endangered, 20% for endangered, 10% for vulnerable)	**Immediate future** 10 years or three generations, whichever is the longer (up to a maximum of 100 years)	**Near future** 20 years or five generations, whichever is the longer (up to a maximum of 100 years)	**Medium-term future** Within 100 years

Part D – Criteria for listing ecological communities under the *Environment Protection and Biodiversity Conservation Act 1999* and *Environment Protection and Biodiversity Conservation Regulations 2000*

Item	Criterion	Category		
		Critically Endangered	**Endangered**	**Vulnerable**
1	Its decline in geographic distribution is:	very severe	severe	substantial
2	Its geographic distribution is: and the nature of its distribution makes it likely that the action of a threatening process could cause it to be lost in:	very restricted	restricted	limited
		the immediate future	the near future	medium term future
3	For a population of a native species that is likely to play a major role in the community, there is a:	very severe decline	severe decline	substantial decline
	to the extent that restoration of the community is not likely to be possible in:	the immediate future	the near future	the medium-term future
4	The reduction in its integrity across most of its geographic distribution is:	very severe	severe	substantial
	as indicated by degradation of the community or its habitat, or disruption of important community processes, that is:	very severe	severe	substantial
5	Its rate of continuing detrimental change is:	very severe	severe	substantial
	as indicated by: a rate of continuing decline in its geographic distribution, or a population of a native species that is believed to play a major role in the community, that is:	very severe	severe	serious
	or (b) intensification, across most of its geographic distribution, in degradation, or disruption of important community processes, that is:	very severe	severe	serious
6	A quantitative analysis shows that its probability of extinction, or extreme degradation over all of its geographic distribution, is:	at least 50% in the immediate future	at least 20% in the near future	at least 10% in the medium-term future

Applying criteria to assess the level of threat to ecological communities - Interpreting specific criteria

13. Criterion 1. Decline in geographic distribution

14. This criterion can refer to a decrease in the total area of the community without a contraction in range, a decrease in the range over the whole or part of the area in which the community originally existed, or fragmentation of the community through a decrease in the size of patches. A decrease sufficient to meet the criterion is considered to be a measurable change whereby: the ecological community has contracted to less than some threshold proportion of its former range; or the total area occupied by the community is less than the threshold proportion of its former area; or where less than the threshold proportion of the former area of the community is in patches of a size sufficiently large or well connected with other patches for them to be likely to persist beyond the *near future.*

Indicative decline thresholds for terrestrial vegetation communities are:

- Critically Endangered = a very severe decline ≅ 95% or more
- Endangered = a severe decline ≅ 90% or more
- Vulnerable = a substantial decline ≅ 70% or more

These thresholds are indicative only; other thresholds might be more appropriate for other kinds of communities (e.g. invertebrate or aquatic communities) or for terrestrial vegetation communities that originally covered a relatively large or a particularly small area.

The application of a specific time frame (such as since 1750) is not considered critical. However, it is important to demonstrate that the ecological community has declined to its present state from some convincingly defined former state.

Where possible, a measurable contraction in distribution should be demonstrated by an appropriate scale of mapping. Where it is not possible to provide precise spatial information on the distribution of an ecological community, particularly at the map scale available (e.g. a very narrow riparian ecosystem), other supporting evidence demonstrating a contraction in distribution may be considered, provided it is supported by independent scientific assessment.

15. Criterion 2. Small geographic distribution coupled with demonstrable threat

The categories under this criterion provide for the listing of ecological communities that have a small geographic distribution and for which a threatening process exists within an understood or predicted time-frame. The general thrust is to recognise that an ecological community with a distribution that is currently small has an inherently higher risk of extinction if it is subject to a threatening process. This criterion is not likely to be considered for an ecological community which has a naturally small distribution but is not currently subject to any threatening process or likely to be subject to such processes in the foreseeable future. It applies only to ecological communities with distributions that are small on a national scale, taking into account all bioregional occurrences regardless of State boundaries.

Indicative thresholds for identifying terrestrial vegetation communities with small distributions are:

- Very restricted: Total area of occupancy of < 10 km^2 (1,000 ha) or total extent of occurrence < 100 km^2 (10,000 ha) or patch sizes of generally < 0.1 km^2 (10 ha), depending on the particular community. (Communities tend to have a typical range of patch size that reflects the nature of the habitat and is relevant to their assessment.)
- Restricted: Total area of occupancy of <100 km^2 (10,000 ha) or total extent of occurrence <1,000 km^2 (100,000 ha), or patch sizes of generally < 1 km^2 (100 ha), depending on the particular community.
- Limited: Total area of occupancy of <1,000 km^2 (100,000 ha) or total extent of occurrence <10,000 km^2 (1,000,000 ha).

The categories are nested: very restricted is a subset of restricted and limited. The thresholds between categories are indicative only; other thresholds might be more appropriate for particular vegetation communities or communities defined by other attributes.

16. Criterion 3. Loss or decline of functionally important species

17. This criterion refers to native species that are critically important in the processes that sustain or play a major role in the ecological community, and whose removal has the potential to precipitate change in community structure or function sufficient to lead to the community's eventual extinction (functionally important species). Examples of species that are functionally important in some ecological communities include the dominant seagrass species in a seagrass community or a keystone disperser of fruits, such as the cassowary, in some rainforest communities.

To determine the eligibility of an ecological community under this criterion, there are two linked, inseparable components:

1. the decline of a population of native species that is likely to play a major role in the community; and
2. based on that decline, the specified threshold within which restoration of the community is **not likely** to be possible.

The category for which the ecological community may be eligible for listing under this criterion (Critically Endangered, Endangered or Vulnerable) is dependent on the level of decline of a functionally important species. The community as a whole is only eligible for listing under the appropriate category if it also meets the appropriate timeframe threshold for restoration. If the timeframe threshold is not met, the ecological community is not eligible for listing under any category using this criterion.

In simple terms, this criterion provides timeframes, linked with the severity of decline, in which the decline of the functionally important species must be halted, or reversed, to ensure the continuation of the ecological community.

Basically, if an ecological community had only one key seed disperser, and that key seed disperser was undergoing a very severe decline, then if the species could not be recovered within ten years (the timeframe for critically endangered), the ecological community would be

considered critically endangered. If that same key seed disperser was suffering from a substantial decline, instead of a very severe decline, then the species would need to be able to be recovered within 50 years, otherwise it would meet the timeframe for classification as a vulnerable ecological community.

In making an assessment against the criterion, the following steps are followed:

Step 1: determine the level of decline experienced by a population of a functionally important species of that community.

Based on the IUCN species criteria, the TSSC provides the following thresholds as guidance:

- very severe decline: an estimated decline of at least 80% over the last 10 years or three generations, whichever is longer;
- severe decline: an estimated decline of at least 50% over the last 10 years or three generations, whichever is longer; and
- substantial decline: an estimated decline of at least 20% over the last 10 years or three generations, whichever is longer.

Step 2: determine in which category the community **may** be eligible for listing, according to the level of decline determined in step 1:

Level of decline	**Category**
very severe	Critically Endangered
severe	Endangered
substantial	Vulnerable

Step 3: predict whether restoration of the community is **not likely** to be possible within a certain timeframe. Restoration is defined as the near complete or complete recovery of species composition, structure and ecological processes, with or without active intervention.

The timeframe threshold used to determine eligibility depends on the level of decline of the functionally important species:

If the decline is **very severe:**

the threshold is **immediate future**- the next 10 years, or three generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 60 years.

If the decline is **severe**:

the threshold is **near future**- the next 20 years, or five generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 100 years.

If the decline is **substantial**:

the threshold is **medium-term future**- the next 50 years, or ten generations of any long-lived species believed to play a major role in sustaining the community, whichever is the longer up to a maximum of 100 years.

The criterion is met if the time within which restoration of the ecological community is **not likely** to be possible is longer than the relevant threshold.

In summary, under this criterion a community is eligible for listing:

- as **Critically Endangered** if, for a population of functionally important species there is a very severe decline, to the extent that restoration of the community is not likely to be possible in the immediate future; or

- as **Endangered** if, for a population of functionally important species there is a severe decline, to the extent that restoration of the community is not likely to be possible in the near future; or
- as **Vulnerable** if, for a population of functionally important species there is a substantial decline, to the extent that restoration of the community is not likely to be possible in the medium-term future.

Example 1, to assess an ecological community for which it is known that a functionally important species has declined by 85% over the past 10 years; and restoration of the community is likely to be possible in 100 years:

Step 1: the level of decline is over 80%, which is a **very severe decline**;

Step 2: based on this decline the community **may be eligible for listing as Critically Endangered**;

Step 3: based on the decline, the timeframe threshold is **immediate future**. Since restoration may be possible in 100 years, it is not likely to be possible in the immediate future (10 years), so the community meets the threshold.

The community therefore meets this criterion for listing as Critically Endangered.

Example 2, to assess an ecological community for which it is known that a functionally important species has declined by 53% over the past 10 years; and restoration is likely to be possible in 17 years.

Step 1: the level of decline is at least 50% and less than 80%, which is a **severe decline**;

Step 2: based on this decline the community **may be eligible for listing as Endangered**;

Step 3: based on the decline, the timeframe threshold is **near future**. Since restoration is likely to be possible in 17 years, it does not meet the threshold, as restoration is likely to be possible in the near future (20 years).

The ecological community therefore does not meet this criterion under any category.

18. Criterion 4. Reduction in community integrity

19. This criterion recognises that an ecological community can be threatened with extinction through on-going modifications that do not necessarily lead to total destruction of all elements of the community. Changes in integrity can be measured by comparison with a benchmark state that reflects, as closely as possible, the natural condition of the community with respect to the composition and arrangement of its abiotic and biotic elements and the processes that sustain them.

The following guidelines apply to particular risk categories:

- Critically Endangered = change in integrity such that *regeneration* is unlikely within the *immediate future*, even with positive human intervention
- Endangered = change in integrity such that *regeneration* is unlikely within the *near future*, even with positive human intervention
- Vulnerable = change in integrity such that *regeneration* is unlikely within the *medium-term future*, even with positive human intervention

[Where *regeneration* is defined as the re-establishment of ecological processes, species composition and community structure within the range of variability exhibited by the original community; and *indicative time frames* associated with extinction risk are as discussed on page 4.]

The first part of this criterion is intended to capture detrimental changes in the identity and number of component species, the relative and absolute abundances of those species and the state of the abiotic environment that supports them. It includes irretrievable loss of native species and invasion by non-native species, as well as changes in the physical environment sufficient to lead to ongoing change in biota.

It may be helpful to assess the level of degradation using non-biological factors known to support the community and the species most significant in its description. For example, if the species of invertebrates that characterise a cave community have no mechanism to survive desiccation, the complete drying out of the cave could be considered sufficient to cause the extinction of that community.

The second part of this criterion recognises that ecological processes are important to maintain an ecological community (e.g. fire regimes or flooding) and that disruption to those processes can lead to the decline in integrity of the ecological community. This criterion could apply where disruption of processes is evident or imminent (e.g. altered hydrology leading to rising water tables and/or dryland salinity) prior to a measurable decline in integrity of the ecological community. It could also apply where recruitment to the community is known to be disrupted but where long lived species mask immediate community breakdown (e.g. when seedlings of a dominant tree species are not able to persist in the face of grazing by exotic herbivores). Such a criterion allows for recognition of a problem at an early stage.

20. Criterion 5. Rate of continuing detrimental change

A continuing change refers to a recent, current or projected future change whose causes are either not known or not adequately controlled, and so is liable to continue unless remedial measures are taken. Natural fluctuations will not normally count as a continuing change, but an observed change should not be considered to be part of a natural fluctuation unless there is evidence for this.

This criterion has been divided into an expression of change with two alternative expressions of the indication of that change. In doing this, the TSSC has recognised that the rate of continuing detrimental change occurring in a community is relevant to its risk of extinction independently of any pre-European data. It is difficult to quantify because detrimental change can be manifest in many different ways and adequate data for monitoring change may not be available. The TSSC will have to exercise "ecological judgement" in applying these criteria, nominations should therefore provide as much evidence as possible of the factors affecting decline and how these factors act on the community.

The following rates drawn from the updated IUCN Red List Criteria for species are intended to provide guidance only:

- Critically Endangered ≅ an observed, estimated, inferred or suspected *detrimental change* of at least 80% over the immediate past or projected for the immediate future
- Endangered ≅ an observed, estimated, inferred or suspected *detrimental change* of at least 50% over the immediate past or projected for the immediate future
- Vulnerable ≅ an observed, estimated, inferred or suspected *detrimental change* of at least 30% over the immediate past or projected for the immediate future

Where *detrimental change* may refer to any one of the components of this criterion, i.e. to (a) geographic distribution or populations of critically important species, or (b) degradation or disruption of important processes.

Data to demonstrate this criterion must be documented. They can be in the form of direct measurements of any of the components, actual or potential levels of exploitation, or the known effects of introduced biotic or abiotic elements on any of the components.

21. Criterion 6. Quantitative analysis showing probability of extinction

This criterion is intended to include any form of analysis that estimates the extinction probability of an ecological community based on known characteristics of important species or other components, habitat requirements, ecological processes, threats and any specified management options. The TSSC has recognised that this is an emerging area of science and will examine any acceptable modelling that may be provided to it. The Committee will use peer review as part of its process for this criterion.

Population Viability Analysis (PVA) is an example of such a technique appropriate for species, but no formal equivalent has been developed for ecological communities. Regardless of their form, quantitative analyses should make full use of all relevant available data. In a situation in which there is limited information, such data as are available can be used to provide an estimate of extinction risk (for example, estimating the impact of stochastic events on habitat). In presenting the results of quantitative analyses, the assumptions (which must be explicitly stated) and the data used must be documented.

22. Part E – Area of occupancy and extent of occurrence

Extent of occurrence

Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon/ecological community, excluding cases of vagrancy (see Figure 1). This measure may exclude discontinuities or disjunctions within the overall distributions of taxa/ecological communities (e.g. large areas of obviously unsuitable habitat, see 'area of occupancy' below). Extent of occurrence can often be measured by a minimum convex polygon (the smallest polygon in which no internal angle exceeds 180 degrees and which contains all the sites of occurrence).

Area of occupancy

Area of occupancy is defined as the area within its 'extent of occurrence' (see above) which is occupied by a taxon/ecological community, excluding cases of vagrancy. The measure reflects the fact that a taxon/ecological community will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats. In some cases (e.g. irreplaceable colonial nesting sites, crucial feeding sites for migratory taxa) the area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon/ecological community. The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon/ecological community, the nature of threats and the available data. To avoid inconsistencies and bias in assessments caused by estimating area of occupancy at different scales, it may be necessary to standardize estimates by applying a scale-correction factor. It is difficult to give strict guidance on how standardization should be done because different types of taxa/ecological communities have different scale-area relationships.

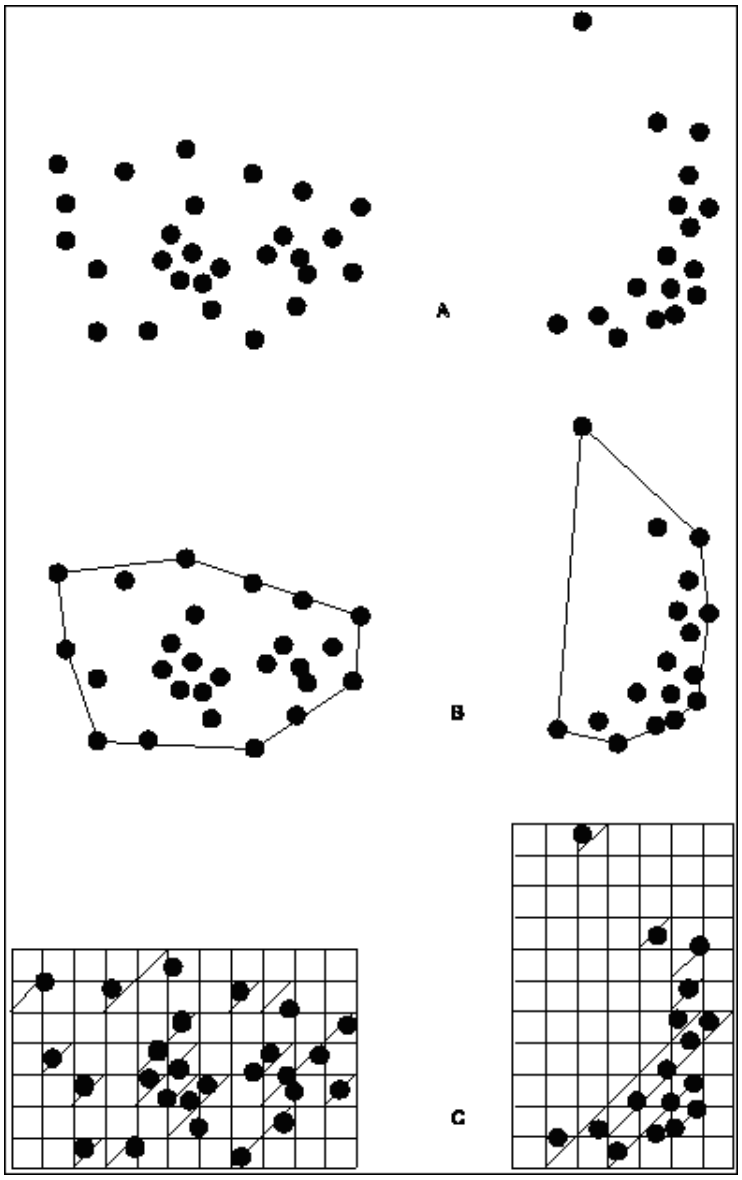

Figure 1. *Two examples of the distinction between extent of occurrence and area of occupancy. (A) is the spatial distribution of known, inferred or projected sites of present occurrence. (B) shows one possible boundary to the extent of occurrence, which is the measured area within this boundary. (C) shows one measure of area of occupancy which can be achieved by the sum of the occupied grid squares.*