Advice to the Minister for the Environment and Heritage from the Threatened Species Scientific Committee (the Committee) on Amendments to the list of Threatened Species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

1. Scientific name (common name)

Phascolarctos cinereus (Koala)

Three 'races' or subspecies of *Phascolarctos cinereus* were proposed by early taxonomists, based on differences in the species' morphology across its geographic range: *Phascolarctos cinereus adjustus* (Thomas 1923) in Queensland, *P. c. cinereus* (Goldfuss 1817) in New South Wales and *P. c. victor* (Troughton 1935) in Victoria (Martin and Handasyde 1999). However, a genetic analysis of Koalas by Houlden et al. (1999) found relatively low levels of genetic differentiation between the proposed subspecies, which suggests that physical variations across the species' range may reflect adaptations to different climates, rather than separate subspecies.

2. Description

The Koala is a tree-dwelling, medium-sized marsupial with a stocky body, large rounded ears, sharp claws and grey-coloured fur. Males are larger than females and there is a gradient in body weight from north to south across their range, with larger individuals occurring in the south and smaller individuals occurring in the north. The average weight of males is 6.5 kg in Queensland, compared with 12 kg in Victoria. Koalas in the north also tend to have shorter, silver-grey fur, whereas individuals in the south have longer, thicker, brown-grey fur (Martin and Handasyde 1999).

Koalas reach sexual maturity at approximately 2 years of age and females can produce one offspring each year, with births occurring between October and May. The newly-born Koala lives in its mother's pouch for 6-8 months and after leaving the pouch remains dependent on the mother, riding on its back. Young Koalas are independent from 12 months of age and longevity in the wild is more than 15 years for females and more than 12 years for males (Martin and Handasyde 1999). Estimates of generation length range from 6 to 8 years (Phillips 2000).

The Koala is not territorial and the home ranges of individuals extensively overlap. Individuals tend to use the same set of trees, but generally not at the same time. They spend a lot of time alone and devote limited time to social interactions (Martin and Handasyde 1999).

Habitat and Food Requirements

Koalas inhabit a range of arid, temperate, sub-tropical and tropical forest and woodland communities dominated by species from the *Eucalyptus* genus (Martin and Handasyde 1999). They are also known to occupy vegetation communities dominated by other species, including *Corymbia*, *Callitris* and *Acacia* species, where *Eucalyptus* species are also present (Kavanagh and Barrott 2001; Sullivan et al. 2003). Koalas can also utilise isolated paddock trees (White 1999).

The Koala is a leaf-eating specialist. Its diet is restricted mainly to foliage of *Eucalyptus* species and related genera, including *Corymbia, Angophora* and *Lophostemon*. However, it is also known to supplement its diet with other species, including species from the genera *Leptospermum* and *Melaleuca* (Queensland EPA 2005; Martin and Handasyde 1999).

Across the Koala's geographic distribution, the species feeds on a wide range of *Eucalyptus* species. However, within a local area, Koalas preferentially feed on a small number of *Eucalyptus* species from the range available. The group of species that Koalas feed on at one

site may be different to what they feed on at another, and food preference can vary over a quite small geographic area (Martin and Handasyde 1999; Phillips 2000). There is also variation in food preference between individual Koalas at the same location, and Koalas often show preferences for particular trees within a species (Martin and Handasyde 1999). Food preferences can also vary on a seasonal basis (Ellis et al. 1995).

There are a number of factors, in addition to the abundance of preferred food species, that influence the quality of Koala habitat. Factors that contribute to natural variation in habitat quality include: the availability of seasonal or supplementary food species; the presence of suitable shelter and shade trees (particularly important in harsh climates); the structural diversity of the vegetation; and tree size (NPWS 2003). Research has found that Koalas tend to prefer larger trees (Hindell and Lee 1987; White 1999). There are other external factors that influence habitat quality, such as proximity to urban areas, and these are addressed under criterion 1.

It is difficult to identify preferred food species and preferred koala habitat as Koalas change the way in which they use their habitat in relation to climate, season and time of day. Koalas may use different trees by day and night, change food and vegetation community preferences seasonally or yearly, and may change the pattern of habitat use depending on temperature and rainfall (Ellis et al. 1995; Ellis et al. 1998; Hindell and Lee 1997; Melzer 1995).

3. National Context

National Distribution and Population Size

The Koala is endemic to Australia. It has a widespread distribution in coastal and inland areas of eastern Australia, from north-east Queensland to Eyre Peninsula in South Australia. The Koala's range extends over approximately 22^{o} of latitude and 18^{o} of longitude, and encompasses an area of around one million square kilometres (Martin and Handasyde 1999). The Koala's distribution is not continuous across this range and it occurs in a number of populations that are separated by cleared land or unsuitable habitat (Martin and Handasyde 1999; NPWS 2003).

The total number of Koalas in Australia is not known, although there are population size estimates for several local and regional Koala populations. The Queensland Government has estimated that there are between 100 000 and 300 000 Koalas in Queensland alone, based on total numbers estimated for the Mulga Lands and south-east Queensland, and density estimates across the rest of the species' Queensland distribution (Queensland EPA 2005). Therefore, the total number of Koalas in Australia is likely to be in the order of hundreds of thousands of mature individuals.

Natural Range

The natural range of the Koala, which can be inferred from the estimated distribution of the species prior to European settlement in Australia, extends from north-east Queensland to the south-east corner of South Australia (ANZECC 1998).

As a consequence of Koala translocations, several existing Koala populations occur outside the species' natural range. These include the Kangaroo Island, Eyre Peninsula, Riverland, and Mount Lofty populations in South Australia. As there are no records of natural occurrences of Koalas on any Victorian Islands (ANZECC 1998), the Koala populations on Phillip Island, French Island, Snake Island and Raymond Island in Victoria also occur outside the species' natural range. Similarly, there are introduced Koala populations on several islands off the Queensland coast, including Brampton, St. Bees, Newry, Rabbit and Magnetic Islands (Melzer et al. 2000), which could be considered to occur outside the species' natural range.

Not all populations that have wholly or partly originated from translocations occur outside the species' natural range. There are several introduced populations, including populations in the Australian Capital Territory, mainland Victoria and the south-east of South Australia, which occur within the Koala's natural range.

Distribution in the States and Territories

Queensland

Koala populations are scattered throughout Queensland (Queensland EPA 2005). Koalas occur in moist forests along the coast, subhumid woodlands in southern and central Queensland, and in some eucalypt woodlands along watercourses in the semiarid environments of the western part of the State (Melzer et al. 2000). Koalas have also been found to occur in non-riverine communities in semiarid areas (Sullivan et al. 2003). Koalas also occur on several islands off the Queensland coast: populations on St. Bees, Newry, Rabbit and Magnetic Islands were introduced, whereas the population on north Stradbroke Island may be natural (Melzer et al. 2000).

Biogeographic regions of Queensland from which Koalas have been recorded include Einasleigh Uplands, Wet Tropics, Desert Uplands, Central Mackay Coast, Mitchell Grass Downs, Mulga Lands, Brigalow Belt, South Eastern Queensland and Channel Country (Patterson 1996). In addition, Koalas are present in the northern parts of several biogeographic regions that extend into New South Wales.

The greatest concentration of Koalas in the State occurs in south-east Queensland, and lower densities occur through central and eastern parts of Queensland (Queensland EPA 2005). For example, population densities range from moderately high in central and south-east Queensland (e.g. 1-3 Koalas per hectare) to low in other parts of central Queensland (0.01 Koalas per hectare) (Melzer et al. 2000 and references therein).

New South Wales

In New South Wales, Koalas inhabit a range of forest and woodland communities, including coastal forests, woodlands on the tablelands and western slopes, and woodland communities along watercourses in the western plains (NPWS 2003).

Koalas mainly occur on the Central and North Coasts, although large populations also exist on the Western Slopes and Plains, such as in the Pilliga region and Gunnedah and Walgett Local Government Areas. Koalas are known from a number of sites on the Central and Southern Tablelands and there are also records from the Northern Tablelands. Koalas occur in sparse, and possibly disjunct, populations on the South Coast (NPWS 1999b; NPWS 2003).

Population densities range from high (4-8 Koalas per hectare) on the NSW North Coast to low (0.006 Koalas per hectare) near Eden on the South Coast (Melzer et al. 2000 and references therein).

Australian Capital Territory

In the Australian Capital Territory, is it thought that there are currently relatively low density populations of Koalas through the Tidbinbilla and Brindabella Ranges, around Bushfold, and in Orroral Valley, Namadgi National Park (ANZECC 1998).

There have been several introductions of Koalas into the ACT, mainly from Victoria. It is likely that the current Koala population in the ACT is derived from these deliberate introductions, although it is possible that some Koalas originate from surviving local populations (ANZECC 1998).

Victoria

In Victoria, the Koala population was reduced to extremely low numbers by the 1920s, but a re-introduction program over 75 years has resulted in Koalas occupying most available suitable habitat in the State (DSE 2005). Koalas are widespread in the low altitude forests and woodlands across central and southern mainland Victoria, and also occur on four islands, including Raymond Island, Snake Island, French Island and Phillip Island (DSE 2004, 2005). Koalas are largely absent from the arid forests in the north-west and the high altitude areas of the north-east (Martin and Handasyde 1999).

In Victorian forests and woodlands, the population density of Koalas is generally less than 1 Koala per hectare (DSE 2004). However, there are several sites where Koalas can be readily located, including the Strathbogie Ranges, Otway Ranges, Mt Eccles National Park, Warrandyte State Park, French Island and Raymond Island (DSE 2004). In some areas, the density of Koalas is so high that they are putting unsustainable browsing pressure on tree species. These areas include Mt Eccles National Park, Snake Island, Raymond Island and parts of the Otway Ranges (DSE 2005).

In Victoria, large regional Koala populations occur in the Strathbogie Ranges, Otway Ranges, South Gippsland (including the Strezlecki Ranges), forests of the Naracoorte Coast Plain Bioregion, forests and woodlands on Mt Eccles lava flow (between Mt Eccles and Tyrendarra) and the Victorian Midlands Bioregion.

South Australia

The Koala was presumed extinct in South Australia in 1924 (Wood Jones 1924), but has subsequently been introduced to five locations in the State, including Kangaroo Island, the Riverland, Eyre Peninsula, Mount Lofty Ranges and the South East. Populations have expanded from release sites to occupy all suitable adjacent habitat (Melzer et al. 2000).

Koalas were introduced to Kangaroo Island from French Island (Victoria) in the 1920s and the Island now supports a large population of Koalas, which is putting unsustainable browsing pressure on tree species and is subject to a population-control program (Masters et al. 2004). Prior to this program, the population density in some areas exceeded 5.5 Koalas per hectare (Masters et al. 2004).

Koalas were translocated from Kangaroo Island to three sites in the Riverland between 1959 and 1965 (Robinson 1978). The current Riverland population is thought to be low in number and widely dispersed (Robinson et al. 1989). In 1969, Koalas from Kangaroo Island were also translocated to Mikkira on southern Eyre Peninsula, and this population has successfully established and dispersed into adjacent areas (Melzer et al. 2000; Robinson 1978).

Koalas were introduced to the Mount Lofty Ranges in the 1930s and 1960s from Queensland, Victoria, South Australia (Kangaroo Island and possibly the South East) and possibly New South Wales, and the population has since expanded throughout the Adelaide Hills region (Bryan 1996). A preliminary survey in 2003 indicated that there are areas with high population densities in the Mount Lofty Ranges (2.4 to 8.9 Koalas per hectare) (SA Govt, 18 January 2005).

The Koala population in South Australia's South East includes individuals that naturally dispersed into the region from Victoria, and individuals that were introduced from Kangaroo Island. Non-sterilised Koalas were introduced prior to 1997 and approximately 1500 sterilised Koalas have been introduced since 1997 as part of the Kangaroo Island population-control program. Population densities range up to 1 Koala per hectare in the South East (SA Govt, 18 January 2005).

Conservation Status in the States and Territories

Under the Queensland *Nature Conservation Act 1992*, the Koala is listed as vulnerable in the South Eastern Queensland Bioregion and common elsewhere in the State.

In New South Wales, the Koala is listed as vulnerable, and both the 'Hawks Nest and Tea Gardens' population, and the 'Pittwater Local Government Area' population are listed as endangered under the New South Wales *Threatened Species Conservation Act 1995*.

In South Australia, the Koala is listed as rare under the South Australian *National Parks and Wildlife Act 1972*.

The Koala is not listed under the Australian Capital Territory *Nature Conservation Act 1980* or the Victorian *Flora and Fauna Guarantee Act 1988.*

4. How judged by the Committee in relation to the EPBC Act criteria.

The Committee acknowledges that, notwithstanding the large amount of information available on the Koala, there are still information gaps regarding the species' conservation status. However, in assessing the Koala's eligibility for listing against each criterion, the Committee has considered, assessed and interpreted all available information and agrees it is in a position to make an informed recommendation.

The Committee judges the species to be ineligible for listing under the EPBC Act. The justification against the criteria is as follows:

Criterion 1 – It has undergone, is suspected to have undergone or is likely to undergo in the immediate future a very severe, severe or substantial reduction in numbers.

Past and Current Threats to Koalas

There is a range of historic and current threats to Koalas, which may have contributed to past declines, and could cause future declines, in Koala numbers.

Major historical threats to Koalas included hunting for the fur trade and habitat clearance (ANZECC 1998). The fur trade ceased in the late 1930s, however habitat loss, fragmentation and degradation remain a threat to Koalas today. Other current threats to Koalas include vehicle collision, predation by dogs, disease, starvation due to over-browsing, fires, drought and reduced genetic variation. The Koala has a wide distribution and consequently, the presence and severity of these threats varies across the species' range. A brief discussion of threats to Koalas is provided below.

Fur Trade

Large numbers of Koalas were hunted in the late 19th and early 20th centuries for the fur and skin trade. In Queensland, the annual commercial harvest of Koalas ranged from approximately 450 000 animals to nearly one million between 1906 and 1927 (Hrdina and Gordon 2004). Hunting for the fur trade is one of the major reasons proposed for the decline in Koala populations that took place in many parts of its range in the early 20th century, although habitat clearance, infectious disease, and bushfires have also been put forward as contributors to the decline (Martin and Handasyde 1999). In the late 1930s, State Governments started to introduce protection measures for Koalas and the fur trade ceased (ANZECC 1998).

The high number of Koala skins exported during the fur trade indicates that Koalas were much more abundant in the late 19th and early 20th centuries than they are today.

Habitat loss, fragmentation and degradation

Habitat loss has been a significant threat to Koalas across the species' range since European settlement, and remains the major threat (ANZECC 1998; NPWS 2003). The Australian Koala Foundation has analysed past change in extent of *Eucalyptus*, *Callitris* and *Acacia* forests and woodlands within the Koala's approximate geographic distribution and suggests that approximately 50% of potential Koala habitat has been cleared in the 200+ years since European settlement.

Habitat loss has resulted from the clearing of forests and woodlands for agriculture, urban development, roads and other infrastructure (ANZECC 1998; NPWS 2003). Clearing for urban development occurs mainly in coastal and adjacent hinterland areas, and is currently a particular threat to Koalas in northern New South Wales and south-east Queensland. Broad scale clearing for agricultural and pastoral activities occurs mainly in inland areas, and is currently a particular threat to Koalas in central and south-west Queensland (ANZECC 1998; Martin and Handasyde 1999).

Vegetation clearance not only causes habitat loss, but can also result in fragmentation of the remaining habitat. The Australian Koala Foundation undertook habitat fragmentation analyses to assess the degree of Koala habitat fragmentation over the past 200+ years since European settlement. These analyses suggest that the degree of Koala habitat fragmentation varies across the species' range. Habitat fragmentation hinders dispersal, which may reduce gene flow and prevent the recolonisation of suitable habitat (NPWS 1999b; NPWS 2003). In a fragmented landscape, Koalas may be required to travel across cleared areas between habitat patches, where they are more vulnerable to other threats such as dog attacks (NPWS 2003). A recent analysis of Koalas in a rural-urban landscape in south-east Queensland indicated that habitat loss and fragmentation are major determinants of Koala occurrence (McAlpine et al. in review). However, there is also evidence that Koalas can be resilient to the impact of habitat fragmentation, as Koala populations have successfully persisted in some fragmented habitats for long periods of time (Gordon et al. 1990).

Koala habitat can be degraded by the removal of important habitat trees and other disturbances, such as regular burning, feral animals and weed invasion (ANZECC 1998; NPWS 2003; Queensland EPA 2005). Tree dieback and senescence, which is particularly evident in agricultural areas, also degrades the quality of Koala habitat (NPWS 2003). Koalas may use modified vegetation, such as grazed, disturbed or thinned forest (Queensland EPA 2005); but highly degraded habitats are likely to support fewer Koalas than less degraded habitats (ANZECC 1998).

Vehicle collisions and predation by dogs

Vehicle collisions can cause trauma, injury or death to Koalas, and a high frequency of collisions can reduce population viability. Vehicle collisions can be a threat to Koalas in urban and semi-urban areas, and where highways intersect Koala habitat (ANZECC 1998). Vehicle collisions are more frequent in areas where Koala populations occur close to roads that are poorly lit or obscured by vegetation, have high speed limits, and carry high volumes of traffic (ANZECC 1998).

Domestic dog attacks can result in stress, injury or death to Koalas, and a high frequency of attacks can reduce population viability. Dog attacks mainly occur in urban and semi-urban areas, and on rural properties (ANZECC 1998).

In South Eastern Queensland, more than 6000 Koalas were confirmed dead at the Moggill Koala Hospital between 1995 and 2001 (Australian Koala Foundation 2005). One third of all admissions to the Moggill Koala Hospital result from vehicle related incidents, making it the most significant threat to Koalas in South Eastern Queensland after habitat clearing and fragmentation (Queensland EPA 2005). Based on admissions to the Moggill Koala Hospital, at

least 1000 Koalas have been killed or injured by dogs in the last seven years (Queensland EPA 2005).

The number of Koala admissions and deaths at the Moggill Koala Hospital and other Koala carer organisations indicates that vehicles and dogs are threats to Koalas. However, documented increases in Koala mortalities from Koala hospital and carer data cannot be used to quantify declines in local Koala populations without additional information, such as information on the total population size, population parameters such as fecundity rates, and the level of community participation in Koala rescues.

Disease

The most significant disease present in Koala populations is associated with the organism *Chlamydia* (ANZECC 1998). Many Koalas carry *Chlamydia*, but do not always show clinical symptoms (known as chlamydiosis). The symptoms include eye, urinary tract, respiratory tract and reproductive tract infections, and the latter can lead to infertility in female Koalas (ANZECC 1998). There is circumstantial evidence that chlamydiosis might increase in response to environmental stresses such as overcrowding and poor nutrition (Melzer et al. 2000 and references therein), although the epidemiology of chlamydiosis is not well understood.

Reduced female fertility caused by *Chlamydia* infection may limit the reproductive potential of Koala populations (Phillips 2000; Queensland EPA 2005). Chlamydiosis may contribute to local declines or extinctions in small, isolated populations, where recruitment rates between populations are low and mortalities from other threats are high (NPWS 2003). However, through reducing female fertility, chlamydiosis may also prevent some Koala populations from reaching very high densities and over-browsing their food trees (NPWS 2003). The South Australian and French Island (Victoria) populations are thought to be *Chlamydia*-free, but the disease is present throughout the remainder of the species' range (Martin and Handasyde 1999; SA Govt, 18 January 2005).

Starvation due to over-browsing

Koala populations can increase rapidly in the absence of disease and predators and reach very high densities. Where rapidly increasing Koala populations occupy islands or isolated habitats, and there is limited opportunity for dispersal, over-browsing can occur. Over-browsing causes defoliation of food trees and the severe depletion of food resources, which can lead to starvation and death of Koalas (ANZECC 1998; Martin and Handasyde 1999; NPWS 2003). There are several examples of local Koala populations that have increased in size and subsequently rapidly declined, or 'crashed', as a result of over-browsing of food trees. These populations include Framlingham, Sandy Point and Snake Island in Victoria (Martin and Handasyde 1999). Over-browsing is also of concern in parts of South Australia such as Kangaroo Island, but has not been recorded as a problem in New South Wales or Queensland (ANZECC 1998; NPWS 2003).

Fires and Drought

Bushfires can cause substantial Koala mortalities, destroy and fragment Koala habitat and reduce food availability for the surviving population (ANZECC 1998; Melzer et al.2000). Inappropriate fire regimes can also change the plant composition of Koala habitat, by depleting some plant species and favouring other species that are fire tolerant (Queensland EPA 2005; NPWS 2003). The capacity for Koalas to repopulate fire-affected habitat depends on the intensity of the fire, the extent of habitat fragmentation, the proximity of other Koala populations, and the presence of other threats (NPWS 2003).

Severe, prolonged drought can also cause significant Koala mortalities and can result in the acute reduction of local or regional Koala populations (ANZECC 1998; Gordon et al. 1988). However, Koala populations can recover from droughts and recolonise former habitat (Martin

and Handasyde 1999). Koalas have been observed to move away from drier areas to areas along rivers and creeks during droughts, and the presence of nearby refuge habitat influences the capacity for Koalas to survive prolonged drought (NPWS 2003).

Low genetic variation

Habitat fragmentation, translocations and population crashes may have reduced genetic variation between and within Koala populations, particularly in the southern part of the species' range. There is some evidence to suggest that reduced genetic variation might reduce the fitness of Koala populations (Sherwin et al. 2000).

Estimating past declines in population size

To establish the current impact of threats on the size of the national Koala population, it is necessary to examine population trends over an appropriate timeframe. An appropriate period for examining past declines in the number of Koalas is three generations, or 18-24 years. This is consistent with current best practice for assessing the conservation status of species (IUCN 2001).

There have been no direct measurements of change in the size of the national Koala population over the past three generations. Consequently, it is necessary to *estimate* past change in the total population size using available data and information. Available information includes: 1) changes in the extent of Koala habitat; and 2) measured (or modelled) changes in the size of local Koala populations.

1. Koala Habitat Loss

Habitat loss has been identified as the major threat to Koalas (ANZECC 1998). Consequently, past declines in the area of Koala habitat may provide an indication of the magnitude of past declines in the size of the Koala population.

Detailed information is not available on the distribution and relative abundance of Koalas within vegetation communities that have been mapped across the species' wide distribution. Therefore, the use of habitat loss as a surrogate for population decline requires several assumptions. If habitat clearance is used as a surrogate for population decline, the assumptions include: that all cleared habitat was previously occupied by Koalas; that the cleared habitat supported an average density of Koalas; and that the density of Koalas in uncleared habitat did not change as a result of habitat clearance. If net habitat loss (i.e. the balance of clearance, revegetation and regrowth) is used as a surrogate for population decline, then the following additional assumptions apply: that Koalas occupy all restored habitat; that the restored habitat supports an average density of Koalas; and that the density of Koalas in existing habitat did not change as a result of habitat restoration.

In addition, the use of habitat loss as a surrogate for population decline does not account for other threats to Koalas, such as habitat fragmentation and vehicle collisions, which may have contributed to population declines.

Different types of vegetation data are available to assess past changes in the area of Koala habitat, including: a) changes in forest extent; b) changes in the extent of major vegetation groups that potentially support Koala populations; and c) changes in the extent of vegetation in Koala Habitat Atlas areas. There are advantages and disadvantages to using each type of vegetation information.

a) Forest extent

The extent of forest in Australia has been mapped using Landsat satellite imagery as part of the National Carbon Accounting System (National Carbon Accounting System 2005). Forest is defined as vegetation with a minimum of 20 per cent canopy cover, which has the potential to reach 2 metres in height, and which covers a minimum area of 0.2 hectares. Net change in

forest extent over the past 24 years can be calculated by comparing forest extent in 1980 with forest extent in 2004.

The advantage of using change in forest extent to assess Koala habitat loss is that the information is available across the species' wide distribution over an appropriate timeframe. The disadvantage of using this information is that 'forest' is only defined by the vegetation structure, and not by species composition. Therefore, it may include some vegetation communities that do not support Koalas.

Past changes in extent of forest across Queensland, New South Wales and Victoria provides a coarse indication of habitat loss over the Koala's approximate distribution. In recent years, there has been a decline in the forest extent across New South Wales, Queensland and Victoria, from 71 147 000 hectares in 1980 to 69 505 000 hectares in 2004. This represents a 2% decline in forest extent over 24 years, or three Koala generations. Assuming that the decline in forest extent can be used as a surrogate for a decline in the national Koala population size, this analysis indicates that the total number of Koalas may have declined by 2% over the past three generations.

Across the Koala's distribution in NSW, Queensland and Victoria, there is large variation in forest extent change, with some biogeographic regions (IBRA 6.1 2004) experiencing an increase in forest extent and some biogeographic regions experiencing a decline. For example, over the past 24 years, forest extent increased by approximately 8% in South Eastern Queensland and 3% in the New South Wales North Coast, whereas forest extent declined by approximately 3.5% in the Mulga Lands and 13.5% in the Brigalow Belt South Bioregion. The largest decline in forest extent occurred in the Brigalow Belt North Bioregion of Queensland, where there was a 24.6% decline over the past 24 years.

b) 'Potential Koala Habitat'- Assessment of Major Vegetation Groups

Koalas inhabit a range of arid, temperate, sub-tropical and tropical forest and woodland communities dominated by species from the *Eucalyptus* genus (Martin and Handasyde 1999). They are also known to occupy vegetation communities dominated by other species, including *Corymbia*, *Callitris* and *Acacia* species, where *Eucalyptus* species are also present (Kavanagh and Barrott 2001; Sullivan et al. 2003). Major vegetation groups, defined by the Native Vegetation Information System (NVIS) framework (NVIS in prep.), which fit the description of Koala habitat include Eucalypt tall open forest, Eucalypt open forest, Eucalypt low open forest, Eucalypt woodlands, Eucalypt open woodlands, Callitris forest and woodlands, and Acacia forest and woodlands.

Net changes in the extent of major vegetation groups that comprise potential Koala habitat can be calculated by overlaying the National Carbon Accounting System forest extent data for 1980-2004 with the NVIS major vegetation group data. The advantage of combining the forest extent and NVIS major vegetation group data to define Koala habitat is that both vegetation structure and species composition are taken into account. Therefore, vegetation communities that do not support Koalas are more likely to be excluded from the assessment[1].

The disadvantage of using this information is that it is not currently available across the species' wide distribution over the past 24 years, or three Koala generations. However, changes to the extent of major vegetation groups have been examined over this timeframe for a number of biogeographic regions in which Koalas occur. The biogeographic regions that were examined included two coastal biogeographic regions known to support high-density Koala

[1] The assessment is based on modelled data of the pre-European extent of NVIS major vegetation groups and assumes that there has been no change in vegetation type since European settlement. For example, if an area of 'forest type A' (e.g. Eucalypt woodland) is replaced with 'forest type B' (e.g. pine plantation) in 1950, the assessment assumes that the area still contains 'forest type A' in 1980. Consequently, some vegetation communities that do not support Koalas may still be included in the assessment.

populations (South Eastern Queensland and New South Wales North Coast) and two biogeographic regions known to have experienced high rates of decline in forest extent in recent years (Brigalow Belt South and Brigalow Belt North).

In the South Eastern Queensland biogeographic region, there was a 7.9% increase in the extent of major vegetation groups that comprise potential Koala habitat, from 3 255 730 hectares in 1980 to 3 512 020 hectares in 2004. Eucalypt tall open forest, which is approximately 3% of all potential Koala habitat in South Eastern Queensland, was the only major vegetation group that declined. Eucalypt tall open forest declined in extent by approximately 2.5% over the 24-year period. In the New South Wales North Coast biogeographic region, there was a 3.5% increase in the extent of major vegetation groups that comprise potential Koala habitat, from 2 396 360 hectares in 1980 to 2 479 980 hectares in 2004.

The Brigalow Belt North biogeographic region experienced a 26.4% decline in the extent of major vegetation groups that comprise potential Koala habitat, from 4 673 200 hectares in 1980 to 3 438 360 hectares in 2004. In the Brigalow Belt South biogeographic region, there was an 18.6% decline in the extent of potential Koala habitat, from 13 957 510 hectares in 1980 to 11 365 490 hectares in 2004.

Clearly there is variation in the rate of change of major vegetation groups that comprise potential Koala habitat between biogeographic regions. However, even in the biogeographic region subject to the highest rate of decline in forest extent in recent years (Brigalow Belt North), the loss of potential Koala habitat, used as a surrogate for population decline, was still less than 30% over three generations.

c) 'Potential Koala Habitat' – Assessment of Koala Habitat Atlas Vegetation Maps

The Koala Habitat Atlas, based on research undertaken by the Australian Koala Foundation, provides a local-scale indication of the extent of vegetation decline for a range of project areas that currently support Koalas. Koala Habitat Atlas project areas include: the Brisbane/Logan/Redland/ Redcliffe/ Pine Rivers Local Government Areas (LGA) and Noosa LGA in Queensland; the East Tweed LGA, Port Stephens LGA, Campbelltown LGA, Greater Taree LGA, Walgett LGA and the Pilliga region in New South Wales; and the Ballarat LGA in Victoria.

The Koala Habitat Atlas maps present a current snapshot of the amount of cleared and uncleared land in a project area, and define the quality of Koala habitat in the uncleared areas. The maps indicate that there has been a significant amount of vegetation loss in these project areas, and that the extent of vegetation loss varies considerably across the species' range. However, it is not known how much of the cleared vegetation previously provided habitat for Koalas.

The Koala Habitat Atlas maps can be used to infer potential Koala habitat loss within project areas over the 200+ years since European settlement, however the maps do not provide information on the extent of potential Koala habitat loss over past 18-24 years. Therefore, it is not possible to use the Koala Habitat Atlas information to estimate declines in size of Koala populations over the past three generations.

Summary

Forest extent, albeit a coarse indicator of Koala habitat, is the only vegetation information available across the species' wide distribution over a timeframe relevant to this assessment. There has been a 2% net decline in forest extent across New South Wales, Queensland and Victoria over the past 24 years.

The forest extent and NVIS major vegetation group data revealed large variation in the magnitude of past change in vegetation extent between biogeographic regions. There are some biogeographic regions, including regions known to support high Koala densities, which have

not experienced a net decline in the major vegetation groups that comprise potential Koala habitat over the past 24 years. In the biogeographic region subject to the highest rate of net forest decline in recent years (Brigalow Belt North), the loss of potential Koala habitat was less than 30% over the past 24 years.

If Koala habitat loss is used as a surrogate for population decline, it suggests that there has been a decline in the number of Koalas across the species' range. However, the magnitude of this population decline is likely to be considerably less than 30% over 3 generations. The use of Koala habitat loss as a surrogate for population decline indicates that the Koala is not eligible for listing as threatened under criterion 1.

2. Measured (or modelled) changes in local Koala populations

One model suggests that past change in the total population size may be assessed by examining measured (or modelled) changes in the size of local Koala populations, and determining whether they are representative of changes at a broader scale.

Recent declines in population size have been observed for several local Koala populations in Queensland, New South Wales and Victoria (Callaghan et al. in review; Lunney et al. 2002; NPWS 1998; NPWS 1999a; Phillips 2000; Sullivan et al. 2004). However, it is difficult to extrapolate from these local declines to conclude that the Koala population has declined in numbers on a national scale, as there are some local Koala populations in Queensland, New South Wales, Victoria and South Australia that have been stable, fluctuating or increasing in recent years (Bryan 1996; Gordon et al. 1990; Kavanagh and Barrott 2001; Masters et al. 2004). Local population trends are clearly variable across the Koala's range, such that it is very difficult to deduce national trends from observed declines or increases in some local populations.

Furthermore, extrapolating from local population declines to determine national population declines is particularly difficult for a species as widespread as the Koala. The Koala occurs in a wide variety of habitats, climates and land use types, and the presence and severity of threats varies across the species' range. The observed local population declines are likely to be representative of population trends at a regional scale, within areas where Koalas are subject to similar threats. However, the local population declines are not likely to be representative of population trends at a national scale, given that threats to Koalas are not uniform across the species' range.

Large recent declines in local Koala populations have been observed in urban or rapidly urbanising areas, including at Pittwater (NPWS 1998), Hawks Nest/Tea Gardens (NPWS 1999a) and Iluka (Lunney et al. 2002) in New South Wales, which are subject to the threats of habitat loss and fragmentation, vehicle collisions and dog attacks. These local declines could be representative of population trends at a regional scale, within habitat areas of similar size that are subject to similar threats. These regions include the Sydney basin and central coast of New South Wales (NPWS 2003), the north coast of New South Wales (NPWS 2003) and coastal and adjacent hinterland areas between Noosa and the Gold Coast in south-east Queensland (Queensland EPA 2005). However, it is not appropriate to conclude that these local declines are representative of population trends at a national scale, given that there are large areas of occupied Koala habitat in Queensland, New South Wales, Victoria and South Australia that are not subject to urban development and its associated impacts.

Recent declines in local Koala populations have also been modelled for some rural areas, such as the Mulga Lands biogeographic region of south-west Queensland (Sullivan et al. 2004). The decline in the Mulga Lands Koala population was less severe than the declines observed for several populations in rapidly urbanising coastal areas, and may be representative of population trends in rural regions that have experienced broadscale clearing in recent years. However, as discussed previously, the rate of loss of forest extent in recent years is variable

across the Koala's range and not all biogeographic regions have experienced declines in forest extent. The variation in population trends in rural regions is demonstrated by the fact that several rural Koala populations, including the Springsure (Queensland), Pilliga region (New South Wales) and Otway Ranges (Victoria) populations, have remained stable, fluctuated or increased in numbers in recent years (Gordon et al. 1990; Kavanagh and Barrott 2001).

Summary

Recent declines in population size have been measured for a number of local Koala populations in Queensland, New South Wales and Victoria. However, it is not possible to extrapolate from these local declines to conclude that the Koala population has experienced a similar decline in numbers on a national scale. The threats to Koalas are not uniform across the species' wide distribution and consequently, the declines observed in one area are not likely to represent trends in other areas that are subject to different or fewer threats. Furthermore, there are some local Koala populations that have been stable, fluctuating or increasing in recent years. This confirms that local population trends are variable across the Koala's range, and reinforces that it is not possible to quantify national trends from observed declines in some local populations.

Conclusion

Recent declines in population size have been measured (or modelled) for a number of local Koala populations, although it is not possible to extrapolate from these local declines to conclude that the Koala population has experienced a similar decline in numbers on a national scale. Available information on Koala habitat loss, used as a surrogate for population decline, does suggest that the national Koala population has experienced a reduction in numbers in recent years. However, it is not likely that there has been a substantial (≥30%) reduction in the Koala population size across its national range over the past three generations (18-24 years).

Even if the conservation status assessment is restricted to the Koala's natural range, thereby excluding populations such as Kangaroo Island, there is still variation in local population trends. Several populations within the species' natural range have been observed to be stable or increasing in numbers, including populations in Queensland, New South Wales and mainland Victoria. Therefore, it is unlikely that there has been a substantial (≥30%) reduction in the Koala population size across its natural range over the past three generations (18-24 years).

Estimating future declines in population size

Predicting future declines in the national Koala population is extremely difficult, given the complexity of natural processes and human developments that may impact on Koala populations over time.

A preliminary population viability analysis (PVA) using VORTEX software was undertaken by the Australian Koala Foundation (AKF), in order to estimate potential rates of decline in Koala populations of the South Eastern Queensland and New South Wales North Coast biogeographic regions. The models were based on Koala population estimates of 25 000 for the South Eastern Queensland biogeographic region and 8200 for the New South Wales North Coast biogeographic region, and the different modelling scenarios accommodated variations in female fertility, mortality rates, and the probability and severity of catastrophic events.

The models predicted that the Koala population in each biogeographic region would decline. The models also predicted that the South Eastern Queensland population would become extinct within 12.7 to 53.7 years, and the New South Wales North Coast population would become extinct within 9.9 to 43.8 years.

Many parameter values used in the AKF's population viability analysis (e.g. mortality rates) were based on values derived from a small Koala population at Iluka in north-east New South Wales (Lunney et al. 2002). It is not appropriate to use parameters derived from a small

population in an urban area, which was subject to severe localised threats, to predict future population declines across a broader scale. Consequently, the results of AKF's population viability analysis cannot be extrapolated to predict future declines across the species' natural or national range.

Koala populations in urban and rapidly urbanising areas, which are subject to severe localised threats, are highly likely to continue to decline. However, this is not indicative of future trends across the species' national or natural range. Koala populations subject to fewer threats are likely to decline at a smaller rate, remain stable or continue to increase.

Across the Koala's national or natural range, the rate of population decline over the next three generations is likely to be lower than the rate of population decline over the past three generations, given that there are a number of new initiatives that increase protection for Koalas. The Queensland Government's Draft Koala Conservation Plan 2005-2015 is likely to provide improved protection for Koalas in areas subject to urban development. In addition, changes made to Queensland's *Vegetation Management Act 1999* in 2004, which will see broad scale land clearing of remnant vegetation in Queensland phased out by December 2006, should mean that Koala habitat loss, particularly in inland areas, is significantly reduced in the coming years (Queensland EPA 2005).

Conclusion

There is little doubt that the national Koala population has undergone a very large reduction in numbers since European settlement in Australia. Given that approximately 50% of potential Koala habitat has been cleared in the past 200+ years, the current population size is likely to be much smaller than it was at European settlement. Furthermore, the high number of Koala skins exported during the fur trade provides evidence that Koalas were much more abundant in the late 19^{th} and early 20^{th} centuries that they are today.

However, in order to assess the present conservation status of the Koala, it is necessary to establish the contemporary level of threat and more recent decline in the population. Available evidence indicates that the Koala has not undergone a substantial reduction in numbers, equivalent to ≥30% of the total population, across its national or natural range over the past three generations. Given that it is unlikely that the rate of population decline will increase in the near future, it is not expected that there will be a substantial reduction in numbers, equivalent to ≥30% of the total population, across its national or natural range over the next three generations. Therefore, the species is **not eligible** for listing under this criterion.

Criterion 2 –Its geographic distribution is precarious for the survival of the species and is very restricted, restricted or limited.

The Koala has a widespread distribution in coastal and inland areas of eastern Australia. The Koala's range extends over approximately 22^{o} of latitude and 18^{o} of longitude and the extent of occurrence is estimated to be around 1 million square kilometres (Martin and Handasyde 1999).

The Koala's distribution is not continuous across this range, and it occurs in a number of populations that are separated by cleared land or unsuitable habitat (Martin and Handasyde 1999; NPWS 2003). Consequently, the Koala's total area of occupancy is lower than its extent of occurrence. The total area of occupancy is not known, but it would not be low enough to be considered very restricted, restricted or limited.

The Koala's distribution is not very restricted, restricted or limited and therefore the species is **not eligible** for listing under this criterion.

Criterion 3 – The estimated total number of mature individuals is limited to a particular degree and: (a) evidence suggests that the number will continue to decline at a particular rate; or (b) the number is likely to continue to decline and its geographic distribution is precarious for its survival.

There are population estimates for several local and regional Koala populations, but the total population size is not known. It is difficult to accurately estimate the total population size, as the Koala has a very widespread distribution and the population density is not uniform across its range.

The Queensland Government has estimated that there are between 100 000 and 300 000 Koalas in Queensland alone, based on total estimated numbers in the Mulga Lands and south-east Queensland and density estimates across the rest of the species' Queensland distribution (Queensland EPA 2005). Therefore, it is reasonable to conclude that the total number of Koalas in Australia is in the order of hundreds of thousands of mature individuals.

As the estimated total number of mature individuals is not limited to a particular degree, the species is **not eligible** for listing under this criterion.

Criterion 4 – The estimated total number of mature individuals is extremely low, very low or low.

As discussed under criterion 3, it is estimated that the total Koala population consists of hundreds of thousands of mature individuals. As the estimated total number of mature individuals is not extremely low, very low or low, the species is **not eligible** for listing under this criterion.

Criterion 5 - Probability of extinction in the wild

The Australian Koala Foundation undertook a preliminary population viability analysis using VORTEX software, in order to estimate future rates of decline in the Koala populations of the South Eastern Queensland and New South Wales North Coast biogeographic regions. While these models predicted that both populations would become extinct in the near future, these results cannot be extrapolated to determine the probability of extinction across the Koala's national or natural range. There are no other modelling data available to assess the species against this criterion.

5. Conclusion

The Koala has a widespread distribution in coastal and inland areas of eastern Australia and the total population size is estimated to be in the order of hundreds of thousands of individuals. Current available evidence indicates that the Koala population has declined in numbers in recent years. However, it is not likely that the decline in Koala numbers across the species' national or natural range has been substantial. Therefore, the Koala is not eligible for listing under any of the EPBC Act criteria.

There are clearly some local Koala populations, subject to severe localised threats, which have undergone large declines in numbers in recent years. These populations are likely to continue to decline if the threats to the populations are not appropriately managed. It is important that there are adequate management regimes and conservation initiatives in place at a local and regional level, to ensure the long-term survival of these populations.

6. Recommendation

The Committee recommends that the species ***Phascolarctos cinereus*** **(Koala)** is **not eligible** for inclusion in the list referred to in section 178 of the EPBC Act.

Publications cited in the advice

Australian Koala Foundation (2005). Moggill Koala Hospital Statistics. Accessed from: http://www.savethekoala.com/nom-moggill.pdf on 18 August 2005.

ANZECC (1998). National Koala Conservation Strategy. Environment Australia, Canberra.

Bryan, B.A. (1996). Koala ecology in the Mt Lofty Ranges: another Kangaroo Island? *in* South Australian Geographic Journal 95: 36-49.

Callaghan J., C. De Jong and R. Sternberg (in review). Population decline of the Koala *Phascolarctos cinereus* in South East Queensland (Australia): preliminary modeling using mortality data. In review: Environmental Management.

DSE (The State of Victoria Department of Sustainability and Environment) (2004). Victoria's Koala Management Strategy. Accessed from http://dse.vic.gov.au (plants and animals) on 18 August 2005.

DSE (The State of Victoria Department of Sustainability and Environment) (2005). Koalas in Victoria. Accessed from http://dse.vic.gov .au (plants and animals) on 12 May 2005.

Ellis, W.A.H., A. Melzer, B. Green, K. Newgrain, M.A. Hindell and F.N. Carrick (1995). Seasonal variation in water flux, field metabolic rate and food consumption of free-ranging Koala (*Phascolarctos cinereus*) *in* Australian Journal of Zoology 43: 59-68.

Ellis, W.A.H., B.J. Sullivan, A.T. Lisle and F.N. Carrick (1998). The spatial and temporal distribution of koala faecal pellets *in* Wildlife Research 25: 663-668.

Gordon, G, A.S. Brown and T. Pulsford (1988). A koala (*Phascolarctos cinereus* Goldfuss) population crash during drought and heatwave conditions in south-western Queensland *in* Australian Journal of Ecology 13:451-461.

Gordon, G., D. McGreevy and B. Lawrie (1990). Koala populations in Queensland: major limiting factors in Biology of the Koala, A. Lee, K.A. Handasyde and G.D. Sanson (eds). Surrey Beatty and Sons.

Hindell, M. and A.K. Lee (1987). Habitat use and tree preferences of koalas in a mixed eucalypt forest *in* Australian Wildlife Research 14:349-360.

Houlden, B.A, B.H. Costello, D. Sharkey, E.V. Fowler, A. Melzer, W. Ellis, F. Carrick, P.R Baverstock and M.S. Elphinstone (1999). Phylogeographic differentiation in the mitochondrial control region in the Koala, *Phascolarctos cinereus* (Goldfuss, 1817) *in* Molecular Ecology 8: 999-1011.

Hrdina, F. and G. Gordon (2004). The Koala and Possum Trade in Queensland, 1906-1936 in Australian Zoologist 32(4):543-585.

Interim Biogeographic Regionalisation for Australia (IBRA), Version 6.1. (2004)

IUCN (2001). IUCN Red List Categories: Version 3.1. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Kavanagh, R. and E. Barrott (2001). Koala populations in the Pilliga forests in Perfumed Pineries: Environmental history of Australia's Callitris forests, J. Dargavel, D. Hart and B. Libbis (eds), pp 93-103. CRES, Australian National University, Canberra.

Lunney, D., L. O'Neill, A. Matthew and W.B. Sherwin (2002). Modelling mammalian extinction and forecasting recovery: Koalas at Iluka (NSW, Australia) *in* Biological Conservation 106:101-113.

Martin, R. and K. Handasyde (1999). The Koala: Natural History, Conservation and Management. UNSW Press Australian natural history series. University of New South Wales Press Ltd, Sydney.

Masters, P., T. Duka, S. Berris, and G. Moss (2004). Koalas on Kangaroo Island: from introduction to pest status in less than a century *in* Wildlife Research 31: 267-272.

Melzer, A. (1995) Aspects of the ecology of the koala, *Phascolarctos cinereus (Goldfuss, 1817)*, in the sub-humid woodlands of central Queensland PhD Thesis, University of Queensland, Brisbane.

Melzer, A., F. Carrick, P. Menkhorst, D. Lunney and B. St John (2000). Overview, Critical Assessment, and Conservation Implications of Koala Distribution and Abundance in Conservation Biology 14(3):619-628.

McAlpine, C.A., J.R. Rhodes, J. Callaghan, M. Bowen, D. Lunney, D. Mitchell, D. Pullar and H.P. Possingham (in review). Is Habitat Area the Key Predictor of Forest Mammal Occurrence? A Koala Case Study. In review in Biological Conservation.

National Carbon Accounting System (2005). Forest extent 1972-2004. Australian Greenhouse Office, Canberra.

Native Vegetation Information System (NVIS) Version 3, Stage 1 (in prep.)

NPWS (New South Wales National Parks and Wildlife Service) (1998). Koala population, Pittwater Local Government Area – endangered population listing, NSW Scientific Committee – final determination. Accessed from: http://www.nationalparks.nsw.gov.au on 7 March 2005.

NPWS (New South Wales National Parks and Wildlife Service) (1999a). Koala population, Hawks Nest and Tea Gardens – endangered population listing, NSW Scientific Committee – final determination. Accessed from: http://www.nationalparks.nsw.gov.au on 7 March 2005.

NPWS (New South Wales National Parks and Wildlife Service) (1999b). Threatened Species Information Sheet: Koala, *Phascolarctos cinereus* (Goldfuss, 1817), NSW National Parks and Wildlife Service, Hurstville, NSW.

NPWS (New South Wales National Parks and Wildlife Service) (2003). Draft Recovery Plan for the Koala (*Phascolarctos cinereus*). New South Wales National Parks and Wildlife Service, Hurstville, NSW.

Patterson, R. (1996). The distribution of Koalas in Queensland – 1986-1989 *in* Koalas-Research for Management. Proceedings of the Brisbane Koala Symposium, 22nd-23rd September 1990. World Koala Research Incorporated, Brisbane.

Phillips, S.S. (2000). Population Trends and the Koala Conservation Debate *in* Conservation Biology 14(3): 650-659.

Queensland EPA (Environment Protection Agency) (2005). Draft Nature Conservation (Koala) Conservation Plan 2005 and Management Program 2005-2015. Queensland Government, Brisbane.

Robinson, A.C. (1978) The Koala in South Australia *in* The Koala: Proceedings of the Taronga Symposium on Koala Biology, Management and Medicine, Sydney 11th and 12th March 1976, T.J. Bergin (ed), pp 132-143. John Sands Pty Ltd, New South Wales.

Robinson, A.C., R. Spark and C. Halstead (1989). The Distribution and Management of the Koala (*Phascolarctos cinereus*) *in* South Australia in South Australian Naturalist 64(1): 4-25.

SA Govt (South Australian Government). Submission to the Australian Government Department of the Environment and Heritage. 18 January 2005.

Sherwin, W.B., P. Timms, J. Wilcken and B. Houlden (2000). Analysis and Conservation Implications of Koala Genetics *in* Conservation Biology 14(3):639-649.

Sullivan, B.J., G.S. Baxter, A.T. Lisle, L. Pahl and W.M. Norris (2004). Low-density koala (*Phascolarctos cinereus*) populations in the mulgalands of south-west Queensland. IV. Abundance and conservation status *in* Wildlife Research 31:19-29.

Sullivan, B.J., W.M. Norris and G.S. Baxter (2003). Low-density koala (*Phascolarctos cinereus*) populations in the mulgalands of south-west Queensland. II. Distribution and diet *in* Wildlife Research 30:331-338

White, N. A. (1999). Ecology of the koala (*Phascolarctos cinereus*) in rural south-east Queensland, Australia *in* Wildlife Research 26:731-744.

Wood Jones, F. (1924). The Mammals of South Australia Part II. Government Printer, Adelaide.