Senate Standing Committee on Environment and Communications
Legislation Committee
Answers to questions on notice
Environment portfolio

Question No: 37

Hearing: Supplementary Budget Estimates

Outcome: Outcome 5

Programme: Wildlife, Heritage and Marine Division

Topic: Koalas – Victoria's Koala Populations

Hansard Page: N/A

Question Date: 27 November 2013

Question Type: Written

Senator Rhiannon asked:

Victoria's koala populations were not considered by the federal Scientific Committee as vulnerable and therefore not listed as threatened under national environment law.
May I have copies of the evidence the scientific committee relied on to make that decision? If not, why not?
May I have a copy of the information provided by the Victorian government? If not, why not?
May I have the details of the populations surveys carried out to inform this decision. Including but not limited to:

- Full survey methodology
- Transect or quadrats way points and GPS points
- Data from those surveys that is in a form that can be mapped.

Answer:

The evidence used by the Threatened Species Scientific Committee to provide a recommendation to the Minister regarding the listing of the koala as a threatened species under the *Environment Protection and Biodiversity Conservation Act 1999* is contained in the listing advice. The listing advice is publicly available and a copy is provided (**Attachment A**).

All references cited within the listing advice are publicly available. The listing advice also used information from a workshop held by the Threatened Species Scientific Committee on 10 November 2009. A summary of the workshop is provided (**Attachment B**).

A copy of the Victorian Government submission to the Senate Environment and Communications Reference Committee report, *The Koala – saving our national icon* is provided (**Attachment C**). The department does not have survey data for koala populations in Victoria.

ATTACHMENT A

Advice to the Minister for Sustainability, Environment, Water, Population and Communities from the Threatened Species Scientific Committee (the Committee) on Amendment to the list of Threatened Species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

Summary

This advice considers the conservation status of the koala *Phascolarctos cinereus* at two levels – across its entire range, and for the Queensland-New South Wales-Australian Capital Territory portion of its range. This advice revises that previously given by this Committee in September 2010, through the consideration of new information mostly arising from the Senate Inquiry (Senate Environment and Communications References Committee 2011).

Of the five eligibility criteria relevant for conservation listing, the koala approaches or meets only that criterion relating to the extent of population decline over a three generational period (in the koala's case, 20 years). The data available for this assessment remain extremely patchy, inconsistent and incomplete. The Committee considers that, at the national level, the koala's decline over the last 20 years approaches but does not meet the required eligibility threshold (loss of 30% of total population size). Accordingly, the Committee advises that the koala is ineligible for listing as threatened at the national level.

However, the Committee recognises that the koala faces stark conservation challenges across much of its distribution, particularly in the northern portion of its range. If the koala populations in Queensland and New South Wales (along with the very small koala population within the Australian Capital Territory) together are considered as a designatable "species" for the purposes of the EPBC Act, then their rate of decline over the last 20 years readily meets the eligibility threshold for listing as vulnerable. Such a listing would deliver a conservation benefit most focused at the koala's major management concerns.

The Committee notes that the circumscription of a "part-range" population and its treatment as a species under the Act has few precedents, and that these few cases involved populations that were notably more distinct and disjunct than that of the "northern" population of koala. The Committee advises that it recognises a pressing priority to develop sound guidelines for the application of "part-range" designations.

1. Name

Phascolarctos cinereus.

The species is commonly known as the koala. It is the only extant species in the Family Phascolarctidae**.**

2. Reason for Conservation Assessment by the Threatened Species Scientific Committee

The Threatened Species Scientific Committee (the Committee) provided advice to the Minister on 30 September 2010, finding the koala ineligible for listing as vulnerable. Although there had been a marked decline over the species' national range, there was too much uncertainty in the population data to be confident that the decline warranted threatened species status. While the Minister was considering this recommendation, a motion calling for a Senate inquiry into the status, health and sustainability of Australia's koala population was passed, on 17 November 2010.

The Minister decided to defer his decision until the Senate inquiry reported, in the expectation that additional information gathered by the inquiry could resolve the uncertainty around the koala's status. The Senate inquiry's report "The koala – saving our national icon" was released on 22 September 2011 (Senate Environment and Communications References Committee 2011). The report noted that the most prominent issue raised during the inquiry was whether the koala should be listed as a threatened species. The Senate committee declined to offer their own view on the matter due to a lack of technical expertise, but made recommendations that the Minister and the TSSC reconsider the matter on the basis of information provided in submissions to, and appearances before, the Senate committee.

The Minister subsequently requested the Committee's advice on the following recommendations from the Senate report:

- **Recommendation 5:** ...that the Threatened Species Scientific Committee review its advice to the Minister on the listing of the koala in light of the findings of this inquiry.
- **Recommendation 17:** The (Senate) committee recommends that the Environment Minister consider options to improve the conservation status of the diverse and rapidly declining koala populations in New South Wales and Queensland to ensure a nationally resilient population is maintained. These options include listing the koala as vulnerable under the EPBC Act in areas where populations have declined significantly or are at risk of doing so.

2.1. Circumscription of part-range populations

With respect to the latter recommendation (#17 above) the Committee has here adopted the approach of "designatable units" (Green 2005). The designatable unit approach acknowledges that while the fundamental conservation unit is the species, in some circumstances there is value in identifying units below the species level and assessing their status separately such that conservation efforts are more appropriately focussed to achieve the best conservation outcome. Designatable units may be subspecies or other taxonomically distinct groupings, but such units can be difficult to resolve (e.g. see Taxonomy section below). Thus a further pragmatic extension of designatable units is to make a division at the highest geographic level where variation in conservation status within each unit can be adequately described by a single category. Divisions at smaller scales are inappropriate as they provide no greater resolution and thus offer no advantages in prioritising conservation efforts.

The Committee here determines that the most appropriate designation is to treat the combined populations of Queensland, New South Wales and the Australian Capital Territory as a single designatable unit. The Committee recommends that the Minister determine the combined populations of Queensland, New South Wales and the Australian Capital Territory to be a "species for the purposes of the Act" under s517 of the EPBC Act. The Committee did not formally consider other permutations of koala populations (for example, the Queensland population alone, or that of south-eastern Queensland), on the grounds that its responsibility lies chiefly with the national extent, and that there is clear consistency in the threats affecting koala populations (and the management actions required to address these threats) across the koala populations in Queensland, New South Wales and the Australian Capital Territory.

The detailed supporting data for this recommendation are to be found below, but are summarised briefly here. The division between the two designatable units is the state border between New South Wales and Victoria. The status of the koala differs significantly because of the history of translocation in Victoria and South Australia that has led to large populations in several areas in these states, including some that require active management to suppress population growth to prevent habitat damage. The Victorian koala population is large and the evidence suggests broadly stable at present. In contrast, in Queensland, New South Wales and the Australian Capital Territory there has been no systematic program of translocation, habitat loss has been extensive, koalas are exposed to a suite of ongoing threats and populations show declining trends in most areas. The designatable unit consisting of the combined koala populations in Queensland, New South Wales and the Australian Capital Territory is supportable on the basis of a substantial variance in conservation status and resulting focus of conservation management within and external to it

There is some morphological and genetic variation across the koala's extensive range, but the Committee notes that the case is weak for circumscribing the combined koala populations in Queensland, New South Wales and the Australian Capital Territory as a biological "entity" on such grounds.

3. Summary of Conclusion

The Committee judges that at the national level the species **is not** eligible for listing on the EPBC Act list of threatened species at this time.

The Committee judges that the designatable unit, consisting of the combined koala populations in Queensland, New South Wales and the Australian Capital Territory, has been demonstrated to have met sufficient elements of Criterion 1 to make it **eligible** for listing as **Vulnerable.**

4. Taxonomy

The species is conventionally accepted as *Phascolarctos cinereus* (koala) (Goldfuss, 1817). Three subspecies of koala have been described: *Phascolarctos cinereus adustus* (Queensland) (Thomas 1923), *P. c. cinereus* (New South Wales) (Goldfuss 1817 in (Iredale and Troughton 1934) and *P.c. victor* (Victoria) (Troughton 1935). These were dismissed (treated as synonyms) in the most recent taxonomic revision (McKay 1988), but are currently recognised by the Australian Biological Resources Study (see discussion below under 7.2 Genetic and morphological variation).

5. Description

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

6. National Context

The koala is endemic to Australia, and is widely distributed in coastal and inland areas from north-eastern Queensland to Eyre Peninsula in South Australia (see Figure 1 attached at end – map showing distribution and places named in the text). The range extends over 22^{o} of latitude and 18^{o} of longitude, or about 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; NSW DECC 2008).

6.1 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-eastern Queensland to the south-east corner of South Australia (ANZECC 1998).

As a consequence of translocations, several koala populations occur outside the species' natural range. These include the Kangaroo Island, Eyre Peninsula, Riverland and Adelaide Hills populations in South Australia. As there are no records of natural occurrences on any Victorian islands (ANZECC 1998), the koala populations on Phillip Island, French Island, Snake Island and Raymond Island in Victoria occur outside the species' natural range (Menkhorst 2008). Similarly, there are introduced koala populations on several islands off the Queensland coast, including Brampton, St. Bees, and Magnetic Islands (Melzer et al. 2000), which could be considered outside the species' natural range. Populations on Newry and Rabbit Islands may be introduced but recent anecdotal evidence suggests that they may be natural (Lee 2010; Ellis 2010 personal communication).

Not all populations that have wholly or partly originated from translocations occur outside the species' natural range. There are several re-introduced populations, in the Australian Capital Territory, mainland Victoria and the south-east of South Australia, which occur within the koala's natural range (Natural Resource Management Ministerial Council 2010).

6.2 Distribution in the States and Territories

6.2.1 Queensland

Koala populations 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. 2003a).

Biogeographic regions of Queensland where koalas have been recorded include the Einasleigh Uplands, Wet Tropics, Desert Uplands, Central Mackay Coast, Mitchell Grass Downs, Mulga Lands, Brigalow Belt, South Eastern Queensland and Channel Country (Patterson 1996).

The greatest density of koalas in the State occurs in south-east Queensland, and lower densities occur through central and eastern areas (Queensland EPA 2006). For example, population densities range from moderately high in south-east Queensland and some parts of central 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).

6.2.2 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 (NSW DECC 2008).

Koalas mainly occur on the Central and North Coasts, although significant 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 (Jurskis and Potter 1997; NSW DECC 2008; Allen et al. 2009).

Population densities range from high in parts of the NSW North Coast (e.g. 3 koalas per hectare in an artificially planted reserve at Tucki Tucki (Gall 1980)) to very low (0.006 koalas per hectare (Jurskis and Potter 1997)) near Eden on the South Coast.

6.2.3 Australian Capital Territory

In the Australian Capital Territory, small populations are known from the Tidbinbilla and Brindabella Ranges, around Bushfold, and in Orroral Valley, Namadgi National Park (Fletcher 2009 personal communication).

There have been several introductions of koalas from Victoria into the ACT between 1939 and the present. It is likely that the current koala population in the ACT is derived mainly from these deliberate introductions, although it is possible that some koalas originate from surviving local populations (Fletcher 2009 personal communication).

6.2.4 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 of the suitable habitat available in the State (Menkhorst 2004). Koalas are widespread in the low altitude forests and woodlands across central and southern mainland Victoria, and also occur on four islands (Raymond, Snake, French and Phillip) (Menkhorst 2004, 2008). Koalas are largely absent from the arid woodlands in the north-west and the high altitude areas of the north-east (Martin and Handasyde 1999).

In Victoria, large populations occur in the Strathbogie Ranges, Cape Otway, 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.

In Victorian forests and woodlands, the population density of koalas is generally less than one koala per hectare (Menkhorst 2004). However, there are several sites where koalas can be at greater densities, including the Strathbogie Ranges, Cape Otway, Mt Eccles National Park, Warrandyte State Park, French Island and Raymond Island (Menkhorst 2008). In some areas, the high density of koalas is putting unsustainable browsing pressure on tree species (Martin 1985a; McLean 2003). These areas include Mt Eccles National Park, Snake Island, Raymond Island and parts of the Otway Ranges (Menkhorst 2008).

6.2.5 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, Adelaide Hills and the South East (Melzer et al. 2000).

Koalas were introduced to Kangaroo Island from French Island (Victoria) in the 1920s. Kangaroo Island now supports a large population of koalas, which put unsustainable browsing pressure on preferred food tree species such as manna gum (*Eucalyptus viminalis*). Consequently this population 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. The current Riverland population is thought to be low in numbers 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).

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 Adelaide Hills (2.4 to 8.9 koalas per hectare) (SA Govt 2005).

The koala population in South Australia's South East was introduced from Kangaroo Island. Non-sterilised koalas were introduced prior to 1997 and approximately 3000 sterilised koalas have been introduced since 1997 as part of the Kangaroo Island population-control program (Masters et al. 2004; Duka and Masters 2005).

6.3 Status in jurisdictions across distribution

The koala is found across several jurisdictions and has variable threatened species status as outlined below. The koala has been the subject of a variety of conservation plans, including a national strategy developed in 1998 and revised in 2009. Additionally, the koala is the subject of a state management strategy in Victoria (2004), a recovery plan (2008) and specific state environmental planning policy in New South Wales and a conservation plan in Queensland (2005). The Queensland plan has been repeatedly modified as part of the Queensland koala response strategy.

Status

- Queensland - *vulnerable* throughout the South East Queensland Bioregion, and 'least concern' (common) elsewhere in the state under the *Nature Conservation Act 1992*.
- New South Wales - *vulnerable* under the *Threatened Species Conservation Act 1995* Two populations are listed as *endangered*; one in the Hawks Nest and Tea Gardens area of Great Lakes local government area, and one in the Pittwater area of Warringah local government area.
- Victoria - listed as Other Protected Wildlife under the *Wildlife Act 1975*. Not listed as threatened under the *Victorian Flora and Fauna Guarantee Act 1988*.
- South Australia - protected under the *National Parks and Wildlife Act 1972* but not listed in any rare or threatened category.
- International - listed as 'of least concern' on the 2011 IUCN Red List of Threatened Species.
- Listed as threatened on the US *Endangered Species Act 1973*.

7. Relevant Biology/Ecology

7.1 Life history

Female koalas can potentially produce up to one offspring each year, with births occurring between October and May but averages tend to be lower, ranging from 0.3-0.8 per year (McLean 2003). 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. The generation length [1]of koalas was estimated to be 6-8 years by Phillips (2000). Additional data from Phillips for other north-eastern New South Wales sites, Pilliga and south east Queensland continues to support a figure of approximately 6 years (Phillips 2009 personal communication). Generation times from Victorian populations ranged from 4.5 years (Snake Island) to 6.0 years (Framlingham, French Island) (McLean 2010 personal communication). Population growth rates estimated for koalas range from doubling times of 3.2 (Chlamydia free, high quality habitat on French Island) to 20 years (Phillips 2000; McLean 2003).

Longevity in the wild is more than 15 years for females and more than 12 years for males (Martin and Handasyde 1999). Mortality rates per annum at two sites in Queensland (Springsure and Oakey) were estimated to be: subadult females annual mortality 17% and 16% for Springsure and Oakey respectively, adult females 9.2%/8.5%, subadult males 23%/23%, adult males 26%/26% (Penn et al. 2000). In Port Stephens, northern New South Wales, where dog attack is significant, mortality of subadult females was 39%, adult females 23%, subadult males 40%, adult males 40% (Lunney et al. 2004).

7.2 Genetic and morphological variation

Three subspecies of koala have been described but their validity has been questioned by genetic and morphological analyses (Takami et al. 1998; Houlden et al. 1999). The subspecies' boundaries are along state lines, but there are few barriers to dispersal of koalas across these boundaries and the subspecies are unlikely to be truly isolated. Southern koalas can be distinguished from northern koalas by physical features such as fur colour and body size. However, the variation is considered to be predominantly clinal, changing gradually along the distribution of the koala in response to different environmental conditions (Bergmann's rule), although some regional variation is apparent (Melzer 1995).

The most informative study at the national scale is that of Houlden et al. (1999) who examined variation in mitochondrial DNA from over 200 individuals from 16 populations. Their principal conclusion was a lack of support for the separation of the species into subspecies and tentative support for a single Evolutionarily Significant Unit[2] (Moritz 1994) for the species. Individual populations were strongly differentiated, suggesting limited gene flow and a pattern of isolation by distance. Gene flow has been further restricted by contemporary habitat fragmentation. As a result of this analysis, the appropriate management unit for koalas was suggested to be the local population (Houlden et al. 1999). The exception to the trend of population differentiation was the majority of Victorian populations (except Strzelecki Ranges and South Gippsland (Lee et al. 2011)) and South Australian populations, which are all descendants of island populations in Victoria as a result of translocation programs.

These latitudinal clines may reflect important differences of adaptation to factors such as temperature, and there may also be east-west differences in adaptation. Therefore, loss of all the sub-populations in any one part of the range could reduce the ecological amplitude of the species and would certainly diminish the genetic variation (Sherwin et al. 2000).

Sherwin et al. (2000) noted that at the time of their paper, no studies had enough detail to allow mapping of the boundaries between management units. Additional studies have been undertaken since then that examine genetic variability at smaller scales. In the south east Queensland region koalas of the Koala Coast, a 375 km^2 area in the eastern part of Brisbane,

[1] Generation length is the average age of parents of the current cohort (i.e., newborn individuals in the population)

[2] The term evolutionarily significant unit (ESU) is used to designate populations that have diverged significantly over evolutionary time. An ESU identifies a geographically discrete set of historically isolated populations.

have been shown by microsatellite analysis to be distinct from adjacent populations and should be considered a distinct management unit (Lee et al. 2009). This differentiation was interpreted to be recent, as a function of isolation due to barriers to dispersal imposed by roads and urban development. The Koala Coast cluster contained few alleles that were not also present in adjacent mainland populations; however, the remainder of the mainland koalas had many alleles that were not present in the Koala Coast animals (Lee 2010). In the same PhD study distinct population clusters were identified in adjacent New South Wales, around Lismore (Lee 2010) which are likely indicative of colonisation of the area by koalas from the north.

Similar research has been conducted in other areas of New South Wales, but is still in the preliminary stages (Lee 2010 personal communication). In western Sydney, three populations with very limited gene flow between them have been identified (Lee et al. 2010).

7.3 Movement/dispersal

The koala is not territorial and the home ranges of individuals extensively overlap (Ellis et al. 2009). 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). Home ranges are variable depending on the location, with ranges in "poorer" habitats larger than in higher quality habitats. On average, males usually have larger home ranges on average than do females. For example, at Blair Athol in central Queensland, home ranges are estimated at males 135 ha, females 101 ha (Ellis et al. 2002) while at Bonville in New South Wales they were estimated at males 20 ha, female approximately 10 ha (Lassau et al. 2008).

Koalas tend to move little under most conditions, changing trees only a few times each day. There is little evidence for longer movements in most cases (Ellis et al. 2009), though dispersing individuals, mostly young males, may occasionally cover distances of several kilometres over land with little vegetation. In south east Queensland, the average distance between natal and breeding home ranges was similar for males and females, at approximately 3.5 km (Dique et al. 2003b). Maximum dispersal distances were up to approximately 10 km for males and females (Dique et al. 2003b). Other studies have reported moves of up to 11 km in Tucki Tucki Reserve in New South Wales (Gall 1980) and 16 km in rural south east Queensland (White 1999).

7.4 Habitat and diet

Koalas inhabit a range of temperate, sub-tropical and tropical forest, woodland and semi-arid communities dominated by species from the genus *Eucalyptus* (Martin and Handasyde 1999). The distribution of koalas is also affected by altitude (limited to <800m ASL), temperature and, at the western and northern ends of the range, leaf moisture (Munks et al. 1996).

The koala is a leaf-eating specialist. Its diet is restricted mainly to foliage of *Eucalyptus* species. It may also consume foliage of related genera, including *Corymbia, Angophora* and *Lophostemon* and at times supplement its diet with other species, including species from the genera *Leptospermum* and *Melaleuca* (Martin and Handasyde 1999; Moore and Foley 2000). While koalas have been observed sitting in or eating up to 120 species of eucalypt (Phillips 1990), the diet of individual koalas is usually limited to obtaining most of their nutrition from one or a few species present at a site (Moore and Foley 2000). Species-level preferences may also vary between regions or seasons (Moore and Foley 2000). Consequently, assessment of habitat quality for koalas is usually based on the identification of local preferences for species and quantification of the availability of those species (Phillips and Callaghan 2000; Phillips et al. 2000).

Koalas also show strong preferences between individual trees within species (Hindell et al. 1985; Martin 1985a). Captive no-choice experiments show that chemical anti-feedants may limit or prevent koalas feeding on foliage of individual trees even when the species is considered preferred (Lawler et al. 1998; Moore et al. 2005). This variability creates a nutritional patchiness such that species-based assessments of habitat likely result in overestimates of the availability of high quality habitat (Moore and Foley 2005; Moore et al. 2005; Moore et al. in press).

Leaf chemistry, and thus feeding choices, are also influenced by elevation and temperature (Moore et al. 2004), water content in semi-arid areas (Munks et al. 1996) and soil nutrients (Moore and Foley 2000 and references therein). Soil nutrients, and their influence on leaf nutrients, may be particularly important. Koalas are able to maintain positive nitrogen balance at a foliage concentration of slightly above 1% (Cork 1986). However, in significant proportions of forest the foliage of many trees may be close to, or below, this threshold. For example, in the Eden forests of southern New South Wales most arboreal marsupials are concentrated in less than 10% of the forest, and this corresponds closely with the most fertile soils (Braithwaite et al. 1983). Foliage nitrogen concentrations in those forests are close to, or below, the threshold of 1% below which koalas cannot maintain a positive nitrogen balance (Cork 1986; Moore and Foley 2000). The majority of these forests do not support another eucalypt folivore with similar nutritional requirements to the koala, the greater glider *Petauroides volans* (Braithwaite et al. 1983) suggesting that these forests do not have enough available nitrogen to support large folivores (see also Section 8.4).

Where koala populations reach high densities they may affect the composition of the eucalypt community, through preferential herbivory. This is apparent in some areas of Victoria and South Australia where koalas have been introduced and become overabundant, causing the deaths of preferred food trees (Menkhorst 2004, 2008). Koalas may impose selective pressure on favoured eucalypts, causing evolutionary divergences among related sympatric species (Moore et al. 2005).

7.5 Population dynamics

Phases of population crashes and recovery associated with rainfall variability occur in the semi-arid west of the koala's distribution (Gordon et al. 1988; Gordon and Hrdina 2005). In these regions the riparian zones offer a refuge from drought where a subset of the population may persist. In more extreme circumstances, there may also be substantial variability in survival rates along watercourses. Gordon et al. (1988) describe koalas along dry stretches of creek occurring at lower density, being in poorer condition and suffering higher mortality during the drought, than those in habitat adjacent to permanent water. During drought the population persists in lower numbers but, following episodes of drought-breaking rainfall, may expand out from riparian zones to occupy adjacent habitat as population size increases. While more than 63% of the individuals in the Mungalalla Creek population died in less than a year, Gordon et al. (1988) considered that survival of the population itself was not threatened.

Population fluctuations associated with over-browsing may be at least partly a natural occurrence, as a function of the temporal and spatial variability in food resources and the koala's dispersal ability (Martin 1985b). Population crashes following defoliation of food trees by over-abundant koalas are often perceived to be a modern problem of unbalanced ecosystems. However, such population crashes occurred as early as 1905 at Wilsons Promontory in Victoria (Menkhorst 2008). Menkhorst (2008) notes that fragmentation of habitat may increase the likelihood of overpopulation and consequential vegetation and then population impact, and reduce the likelihood of subsequent recolonisation.

Large fluctuations in koala populations may be a feature of koala biology, but repeat events occur over a time period that is not amenable to the short time scale of many studies. Direct observational studies may report changes in koala numbers for periods of one to a few years, but establishing a baseline against which to judge them requires the use of historical and anecdotal records. In the known history of the koala they are also confounded with habitat modification and direct impacts such as harvesting. Gordon and Hrdina (2005) used the records from the possum and koala harvest period 1906-1927 in Queensland to elucidate the trends in koala population status during that period. They describe substantial fluctuations in koala populations, with multiple contributing factors. These include declines due to the harvest (but not in all regions), disease and drought but none of these was consistently a major factor in decline or recovery (Gordon and Hrdina 2005). Gordon and Hrdina (2005) suggest that the reported rapid population increases and subsequent crashes demonstrated a south to north spread, and were associated with initial clearing and flushes of high quality eucalypt regrowth foliage. Thus their interpretation is that relatively stable populations were freed of the constraint of limited food and increased to exceed overshot carrying capacity and subsequently collapsed due to depletion of food.

Therefore there is a high degree of uncertainty in establishing a baseline against which contemporary koala populations and trends may be judged. Populations at a range of scales (local, regional) may fluctuate in response to drought or to irruptions, but their dynamics are likely human influenced.

8. Description of Threats

Note:

For clarity, the range of threats to which koalas are exposed have been treated separately. However, many of the threats may act on a given koala population at the same time, and thus may be greater than is indicated by their impact considered in isolation. For example, in urban environments the effect of habitat fragmentation is exacerbated by exposure to predation by dogs and vehicle strike. While drought *per se* is a natural phenomenon and thus may not be considered a threat under some circumstances, the potential for increased drought frequency or severity is considered under climate change.

8.1 Habit loss, fragmentation and/or degradation

Large scale land clearing for agricultural purposes has effectively ceased, most recently with Queensland having introduced legislation to end large scale land clearing. Prior to this, land clearing was a significant cause of mortality to koalas, particularly in the Brigalow Belt Bioregion (Cogger et al. 2003). However, even without further clearing there is likely to be an ongoing “extinction debt” (Tilman et al. 1994) to be paid, as extinction processes continue to operate on habitat patches that are now too isolated or small to support viable populations (Cogger et al. 2003; McAlpine et al. 2006a; McAlpine et al. 2007). Habitat fragmentation may also impede post-drought recovery of koala populations.

The effects of habitat loss and fragmentation may be greater than is indicated simply by estimating the proportion of land cleared. Land clearing is focussed disproportionately on flatter, more fertile areas, which constitute high quality habitat for koalas, so that what remains is often the poorer quality habitat on steep terrain and/or poorer soils (McAlpine et al. 2006a; McAlpine et al. 2006b). The impact of fragmentation and habitat isolation is also influenced by the relative hostility of the intervening habitat matrix. Urban environments, with higher densities of roads and dogs exacerbate the effect, while in rural settings, greater isolation has relatively less impact (White 1999; Gordon et al. 2006; McAlpine et al. 2006a;

McAlpine et al. 2006b). For a given amount of habitat available, a landscape of more numerous, smaller patches is less likely to be occupied than one of fewer, larger patches (McAlpine et al. 2006a; McAlpine et al. 2006b).

Urban expansion continues to threaten koalas, particularly in coastal regions. Urban development also brings the additional threats of predation by dogs and vehicle strike (see below). The most stark example of this in the Greater Brisbane area of South East Queensland where the koala population of the Koala Coast declined by 64% over 10 years, from an estimated 6250 (4802-7691 95% confidence limits)(Dique et al. 2004) to 2280 koalas, and is considered to be approaching functional extinction (Queensland Department of Environment and Resource Management 2009). In the Pine Rivers District, to the north of the Koala Coast, the urban population of koalas declined by 45%, and the bushland population by 15% in a similar timeframe (GHD 2008), leading to an overall decline of 40% from an estimated 4600 (Dique et al. 2003a) in 2001 to less than 2700 in 2008. Koala populations in all SEQ coastal local government areas (Sunshine Coast; Moreton Bay; Brisbane; Redland; Logan; and Ipswich) appear to be following a downward trend, as evidenced by a rapid increase in the numbers of sick, injured and dead koalas (as a consequence of development activities), followed by a decline in reporting due to a crash in koala numbers. It is also likely that the drought between 2001 and 2007 has had an impact on these populations (McDonnell 2010) (see below under Climate Change).

Local extinctions of small populations have occurred in the past and have highlighted the need for recognition of metapopulation structure, and the need for facilitating movement of individuals between smaller areas (Lunney et al. 2002). However, a recent study on the koala population at Port Stephens suggests that even relatively large populations (up to 800 individuals) may be vulnerable to extinction and that this vulnerability will be increased with further fragmentation (Lunney et al. 2007). It is therefore expected that koala populations in coastal New South Wales will continue to decline (Lunney et al. 2007; Lunney et al. 2009).

Koala habitat may also be lost due to logging, however the effect at the population level is a function of the management regime. For example, while clearfelling will remove habitat, koalas may persist in selectively-logged forests (Kavanagh et al. 1995; Kavanagh et al. 2007). Thus the level of threat posed by logging is situation-specific and is determined by the appropriateness of the management regime, and adherence to its prescriptions. Koalas have also been recorded to have established home ranges within revegetated eucalypt woodlands

Additional potential threats to koala habitat include Bell Miner Associated Dieback (BMAD) and myrtle rust. BMAD occurs patchily from South-East Queensland to Victoria but the area of greatest concern is north-eastern New South Wales and it is recognised as a Key Threatening Process (KTP) by the NSW government (http://www.environment.nsw.gov.au/determinations/bellminerfd.htm). BMAD affects wet and dry sclerophyll forest communities often dominated by eucalypts. The KTP determination cites the koala as occurring in forests damaged by BMAD in New South Wales. Myrtle rust is a recently arrived fungal pest of plants of the family Myrtaceae, including eucalypts (http://www.dpi.nsw.gov.au/biosecurity/plant/myrtle-rust). It is now found extensively across eastern New South Wales and Queensland and has infected over 90 plant species. A small number of koala food tree species have been infected but these infections have been minor to date such that myrtle rust does not appear to be a current threat to koala habitat.

8.2 Encounter mortality - Dogs and Cars

Dogs and cars are two threats to koalas that are closely associated with urban expansion, with exposure to both increasing as land adjacent to koala habitat is developed and occupied. However, while these threats are most intense in the urban and peri-urban environment, both may also be threats in rural areas (Crowther et al. 2010; Senate Environment and Communications References Committee 2011). As both directly cause mortality of individuals they are treated here together.

Data on mortality of koalas are often collected by koala care groups and some of those data were provided to inform this nomination. The data provided by care groups demonstrates that mortality from dogs and cars occurs wherever koala habitat is close to urban environments. Such mortality is not restricted to the South East corner of Queensland (detailed below). However, there are difficulties with the use of these data for several reasons: 1. The catchment area, and distribution of search effort over that area, is often not defined; 2. It is unclear what proportion of incidents go unreported; 3. The size of the population from which the incidents are drawn is often unknown, and 4. There may be considerable overlap in the areas for which different groups report.

To illustrate the last point, data were provided by the Friends of the Koala, Currumbin Wildlife Sanctuary, Australian Wildlife Hospital and the Queensland Department of Environment and Resource Management. Friends of the Koala take injured animals for which they are unable to care to both Currumbin Wildlife Sanctuary and Australian Wildlife Hospital. Currumbin Wildlife Sanctuary occasionally transfers animals to Australian Wildlife Hospital, and Queensland Department of Environment and Resource Management report data for their own Moggill Koala Hospital and Australian Wildlife Hospital. Consequently, the mortality data derived from Queensland Department of Environment and Resource Management (Table 1) are used below as they provide the best overall estimate of mortality within a relatively defined region and they address the other three problems with this type of data.

Between 1997 and May 2011 in south east Queensland at least 1144 koalas were killed by dogs and 4055 were killed by cars (Queensland Department of Environment and Resource Management 2011). An additional 5757 deaths were attributed to a combination of cars, dogs and/or disease. While it is not possible to ascribe each of these deaths to a particular koala population, the substantial declines noted above for the Koala Coast and Pine Rivers populations suggest that such mortality rates are unsustainable. The mortality due to vehicles alone on the Koala Coast area of South East Queensland has been formally assessed (Dique et al. 2003c). At a time when the koala population was estimated at approximately 6250 (Dique et al. 2004) mortality due to vehicle strike alone averaged some 281 koalas/year. This equates to an annual mortality rate of approximately 5% due to vehicle strike alone (note that this is not necessarily the rate of population decline as it does not include other causes of mortality nor births or migration).

Table 1. Mortality of koalas in South East Queensland (derived from Queensland Department of Environment and Resource Management 2011). n.b. These data are only for those koalas that were located and presented to the koala hospitals and thus underestimate mortality by an unknown amount.

Year	Dog	Car	Disease	Combination (cars, dogs, disease)	Other	TOTAL DEATHS
1997	105	278	268	163	42	856
1998	69	237	250	225	62	843
1999	87	266	332	234	59	978
2000	95	311	450	361	82	1299
2001	114	324	303	398	90	1229
2002	103	342	245	381	73	1144
2003	94	342	180	475	83	1174
2004	68	333	238	436	93	1168
2005	60	234	262	314	96	966
2006	69	280	193	425	88	1055
2007	68	287	179	588	90	1212
2008	58	296	256	435	97	1142
2009	76	248	210	630	108	1272
2010	67	246	131	567	88	1099
2011*	11	31	19	125	21	207
Total	**1144**	**4055**	**3516**	**5757**	**1172**	**15644**

* 2011 figures up until May only.

Another example comes from the Tilligerry Peninsula of Port Stephens. The Hunter Koala Preservation Society has collected data on rescues for this defined area within the Port Stephens Local Government Area. In 1995 38 koalas were found dead, or died after rescue (29 attributed to dogs or vehicles). The Port Stephens koala population at the time was estimated to be 350-800 animals (Lunney et al. 2007). The data from this subset of the habitat alone suggest mortality of 5-10%. Since 1995 the number of mortalities has declined linearly to less than half that level. As trends in road deaths can be an indicator of abundance for animal species (Mallick et al. 1998) this may indicate a substantial decline in the population. This interpretation is supported by the modelling of Lunney et al. (2007) which indicated a likely rapid decline in the Port Stephens koala population, even under their base model (which included dog attack as a major source of mortality but did not include vehicles). It is also noteworthy that the Port Stephens Council has had a Comprehensive Koala Plan of Management (CKPoM) since 2002. In a submission to the Senate inquiry, the CKPoM Steering Committee noted "Unfortunately, despite the CKPoM being in place, the simple fact is that loss of Koala habitat through vegetation clearing, fragmentation of existing habitat, cars, disease and dogs are the significant causes of the dramatic population decline in Port Stephens." Coffs Harbour City Council was the first council to implement a CKPoM in 1999. A recent review of its effectiveness concluded that actions to protect koalas from road risk had been only partially achieved and those to protect koalas from dogs had not been achieved such that there was no indication that the plan had "reversed the trend of koala population decline" (Eco Logical Australia 2006).

Mortality due to dogs and cars has been invoked as a threat to koala populations throughout much of their range (Canfield 1991; Menkhorst 2004; Ward and Close 2004; Lassau et al. 2008; NSW DECC 2008; Natural Resource Management Ministerial Council 2010). Despite growing awareness of the problems, and attempts to address them, there is little evidence that such management responses have been effective thus far.

8.3 Disease

The most well known disease present in koala populations until recently is associated with chlamydia (Natural Resource Management Ministerial Council 2010). 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 (Natural Resource Management Ministerial Council 2010). 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 (NSW DECC 2008). 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 (NSW DECC 2008). However, through reducing female fertility, chlamydiosis may also prevent some koala populations from reaching very high densities and over-browsing their food trees (NSW DECC 2008). 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). Recent research has shown that up to half of south east Queensland koalas have detectible reproductive disease likely to result in infertility (Hanger and Loader 2009). Hanger and Loader (2009) also caution that the ultrasound method used to detect the disease likely underestimates its prevalence.

Another recently discovered disease may have significant implications for koala conservation. Koala Retrovirus (KoRV) was recently identified and is thought to be responsible for a range of conditions, including leukaemia (Tarlinton et al. 2005) and an immunodeficiency syndrome. Up to 100% of koalas in Queensland and NSW have KoRV, but the proportions are lower in southern populations (Tarlinton et al. 2006; Hanger and Loader 2009; Lee 2010) which until recently showed none of the associated conditions (Bodley in Hanger and Loader 2009)(see below). There is some evidence that chlamydiosis may be exacerbated by KoRV (Tarlinton et al. 2005).

Koala Retrovirus has endogenised in koalas (Tarlinton et al. 2006) in Queensland and New South Wales. That is, it has infected germ line cells (spermatozoa or oocytes) and is transmitted genetically (by inheritance) from parents to offspring. Although this is a known mechanism of transmission, KoRV may also spread from koala to koala (horizontal spread) by close contact, and from infected mothers to their joeys via the milk, in a manner similar to the way that many other retroviruses spread (Hanger 1999). Whether KoRV can be transmitted by biting insects has yet to be determined.

The effects of disease on koala populations are of growing concern (Lunney et al. 2002; Hanger and Loader 2009; Queensland Government 2009), particularly in south east Queensland and northern New South Wales. The south east Queensland koala hospital data (Table 1) report 3134 deaths attributable to disease in the years 1997-September 2009, with an additional 4538 due to a combination of cars, dogs and disease (Queensland Department of Environment and Resource Management 2011). Due to a change in the method of recording the data, where the main cause of mortality may in the past have been recorded as disease

these cases are increasingly being attributed to the "combination" category. Consequently, there is a strong negative correlation between the number of deaths attributed to disease and those attributed to "combination" (Table 1). Thus disease as a primary cause of death has apparently declined from over 30% to approximately 20% of overall mortality. However, this category alone is equivalent to the mortality due to vehicles (described above) and when the combined category is added they have been consistently around 60% of the causes of mortality of koalas in south east Queensland over 10 years. Indeed 60% of mortality in the recent Koala Coast declines was attributed to disease (Queensland Department of Environment and Resource Management 2009). The mortality data reported by koala care groups support the observation that disease is a significant contributor to overall mortality: Hunter Koala Protection Society (mean 16%, range 6-47%), Friends of the Koala (41% 2009), Coffs Harbour City Council (30% 1999-2002, 15% 2003-2006), Currumbin Wildlife Hospital (46% 2000-2009), Native Animal Trust Fund (20% 2009).

While the above discussion focuses on the growing recognition of disease as a threat to koalas in a particular region, the threat of disease is also recognized elsewhere. Both the Victorian and New South Wales state governments acknowledge that disease should be considered a threat to koala populations in some circumstances, particularly where they combine with other threats (Menkhorst 2004; NSW DECC 2008). Increasing incidence of KoRV has recently been reported on Kangaroo Island (Senate Environment and Communications References Committee 2011), along with the first reported case on the island of lymphoma (Koala Research Network 2010).

It has been suggested that the effects of disease may be exacerbated by the effects of habitat fragmentation and associated stress (Melzer et al. 2000; NSW DECC 2008). Hanger and Loader (2009) offer an alternative view, suggesting that the disease threat is significant and independent of habitat fragmentation. However, they note that this does not detract from the need to protect habitat, but rather that it requires better information on the effects of disease on population dynamics in addition to those induced by habitat fragmentation directly.

8.4 Climate change and drought

Drought is a natural phenomenon that has occurred, and will continue to occur, irrespective of the extent to which predicted climate change scenarios prove accurate. However, as the major influences of climate change are anticipated to manifest via more frequent and/or more intense droughts, climate change and drought are considered together here.

Climate change is a potential threat to the koala, as it is expected to lead to increased temperatures, changes to rainfall, increasing frequency and intensity of droughts and increased fire risk over much of the koala's range (Natural Resource Management Ministerial Council 2010). Increased temperatures inland are expected to cause the koala's range to contract eastward (Dunlop and Brown 2008; Queensland Office of Climate Change 2008; Steffen et al. 2009; Adams-Hosking 2011; Adams-Hosking et al. 2011). This effect would be compounded by extended drought that may be expected under climate change scenarios (Queensland Office of Climate Change 2008). In the south of the koala's range, in Victoria, more hot days, increased risk of intense fire and more droughts are expected (Victorian Department of Sustainability and Environment 2009). Adams-Hosking (2009) estimated, using bioclimatic modelling, that the koala's range, and particularly its core (10-90%) range, would contract by 20-30% by 2030 (consistent with the three generation timescale of the listing criteria), leaving bioregions such the Mulga Lands, Mitchell Grass Downs and Einasleigh Uplands uninhabitable by koalas (Adams-Hosking 2011).

In the west and north of their range in Queensland, the distribution of koalas is determined by heat in combination with water availability (Munks et al. 1996; Sullivan et al. 2003b). This is

reflected in a tendency to find the highest densities of koalas along creek lines. Anecdotal evidence suggests that the distribution of koalas in south-west Queensland contracted eastwards in response to drought in the 1920s (Sullivan et al. 2003b). Sullivan et al. (2003b) also noted that koalas were at higher densities in the north and central portions of their study area than in the south and west, consistent with rainfall patterns. In Mungalalla Creek, in the Mulga Lands bioregion, a koala population crashed by at least 63% in the summer of 1979-80 in response to a continued drought (Gordon et al. 1988). Gordon et al. (1988) suggested that the regional persistence of koalas may rely on the protection of 'survival' habitats around permanent water holes, from which koalas may disperse into other habitats as conditions allow (but see below). The length of the drought may also have significant implications for the capacity of a population to recover. Gordon et al. (1988) noted that dominant adults were more likely to occupy refuge habitat, such that younger individuals died earlier in the drought. It may be hypothesised that this is an appropriate adaptation for shorter droughts, but if the drought is extended beyond a generation, there may be little recruitment. As a result the population of reproductive individuals is very low when the drought ends.

In research reported at the National Koala Abundance Workshop (convened by the TSSC in November 2009), in northern and central western Queensland, near Hughenden and at Moorinya National Park, koalas were at very low densities and confined to drainage lines where extensive searching was required to locate them. There is evidence of tree dieback along drainage lines and this situation is exacerbated by the practice of landowners building small dams on creek lines with subsequent death of downstream vegetation. In central Queensland (such as at Springsure and Tambo) koala densities have also declined markedly, although density appears to be stable at Norwood Creek where the presence of the more drought tolerant *Eucalyptus crebra* (Melzer 1995) provides a food source not available to koalas elsewhere. Here also, mature eucalypt trees were stressed or dying back along drainage lines and koala populations were contracting to refuge areas where water is more reliable.

Under climate change projections there is expected to be a general eastwards shift in the edge of the distribution of koalas (Adams-Hosking et al. 2011). Discussion at the 2009 National Koala Abundance Workshop noted that this situation is complicated by hydrological changes that do not necessarily follow this directional trend. It is expected that, if recovery occurs, it will include a phase shift in riparian communities, with *E. camaldulensis* replacing *E. tereticornis*. *Eucalyptus camaldulensis* is more drought tolerant, but grows at lower densities so that, if there is a post-drought recovery, koala populations may be expected to re-establish but stabilise at a lower density, as illustrated by the Mungalalla Creek population following a drought-induced population crash in the 1980s (Gordon et al. 1988). However, the expert workshop noted that tree age in western Queensland and New South Wales is much greater than previously appreciated, such that the ability of these habitats to recover from drought is much lower than has been estimated previously even if moister conditions return. The deaths of trees substantially older than normal drought cycles may be indicative of a process not part of normal climate cycles and indicative of a long term or permanent decline (Carrick 2010 personal communication).

The Mulga Lands bioregion in south-western Queensland was estimated in the 1990s to have some 59 500 koalas, occupying riparian habitats but also extending out at lower densities into expansive surrounding habitats (Sullivan et al. 2003a; Sullivan et al. 2003b; Sullivan et al. 2004). A severe population decline is indicated as a result of the 2002/2003 drought (Seabrook et al. 2011). A general decline in rainfall has led to the distribution of koalas contracting to riparian areas and, overall, towards the north east of the bioregion. The density of koalas on Sullivan's 'residual' habitats is now extremely low. Additional declines may continue to occur as the koala population adjusts to habitat loss and fragmentation since the cessation of clearing (akin to 'extinction debt' *sensu* Tilman et al. (1994)). Using the same methods as Sullivan et al (2004), a more recent estimate of 11 600 (9 843-13 430 95%

confidence limits) koalas was calculated for the region (Seabrook et al. 2010). This is a substantial decline from Sullivan et al.'s 59 555 (44 000-78 000 95% confidence limits). As noted above, Adams-Hosking (2011) suggests the bioregion may not be able to support koalas by 2030.

While there are no recent data for koala populations in the semi-arid north western region of NSW, the trends are likely to be consistent with those observed for the adjacent western Queensland part of the koala's range. Days of extreme heat have been invoked as a threat to koalas in the Pilliga forests (Kavanagh and Barrott 2001; Kavanagh et al. 2007) and anecdotal information suggests a substantial population decline occurred with the recent drought (Parnaby 2010 personal communication). Given that climate change scenarios for the western part of the koala's range suggest higher temperatures and less rainfall overall, and more extreme hot days each year, there is potential for the distribution of the koala to be significantly reduced permanently in New South Wales and in Queensland.

Drought may also be a significant factor in the decline in koalas in coastal south east Queensland (McDonnell 2010), where the substantial decline has largely been attributed to habitat fragmentation, vehicle strike and predation by dogs (see above). McDonnell (2010) notes that many of the secure habitats where koalas had declined in the 2008 survey (Queensland Department of Environment and Resource Management 2009) are on drier sites. He also suggests that drought-related stress may have made koalas more susceptible to disease. McDonnell (2010) also suggests that if drought was a significant factor in that decline, there should be observable signs of recovery via higher fecundity rates after the end of the drought. These data are not yet available. Nevertheless, other sources of mortality as described above remain severe, particularly with the population size much diminished.

In parts of the koala's range, the effects of climate change may be manifest, or exacerbated, by their influence on the fire regime. In recent times devastating fires have occurred (e.g. Victoria's Black Saturday, wildfires in Pilliga 1998 and 2006) and in 2009 governments introduced a new fire risk category (Catastrophic). The mortality of koalas resulting from these fires has not been quantified, but loss of habitat was extensive and koalas are particularly exposed to injury in crown fires that occur in these intense bushfires. A substantial proportion of koala habitat has been burned in Victoria in recent years (Senate Environment and Communications References Committee 2011). A recent study of the influence of fire and other factors on koalas in Port Stephens suggested fire is a significant threat to koalas, but that changing the fire regime may not improve the population's viability. That is, changing the regime from infrequent, large fires to more common, smaller fires did not improve modelled population viability (Lunney et al. 2007).

Increasing atmospheric CO_2 will have effects independent of climate change *per se*. When eucalypts are grown under elevated CO_2 the ratios of carbon to nitrogen in the foliage increase such that concentrations of carbon-based anti-herbivore compounds like tannins increase while nitrogen (protein) decreases (Lawler et al. 1997). It has recently been shown that the balance between tannins and proteins determines protein digestibility and that subtle differences may have profound effects for reproductive success of eucalypt folivores (Degabriel et al. 2009). Tannins reduce the availability of nitrogen for digestion, such that a measure of "available" nitrogen is necessary to elucidate the role of leaf nitrogen in herbivore demography. Degabriel et al. (2009) showed that female common brushtail possums *Trichosurus vulpecula* with home ranges containing trees with greater nitrogen availability have higher fecundity and produce offspring that grow faster and have greater overall fitness. Thus the results "*suggest a link between the combined effects of plant nutrient concentration and chemical defence, and reproductive fitness, which is important for explaining patterns of distribution and abundance in plant-mammal systems*" (Degabriel et al. 2009). Not all nitrogen in eucalypt foliage is available to koalas (Cork et al. 1983), indicating the negative effect of tannins on protein digestibility. Koala population dynamics are likely to be

negatively impacted by the changes in leaf chemistry induced by elevated CO_2. It is not yet possible to assess forest nutritional quality over much of the koala's range, and thus to quantify the effect described above.

8.5 Habitat degradation due to overbrowsing

Many koalas in Victoria and South Australia live in areas where overpopulation is a significant problem. The density of koalas is so high that they may damage the food trees on which they depend, resulting in a substantial population crash, such as has occurred several times in Victoria (e.g. at Framlingham, Walkerville, Sandy Point) (Martin 1997; Martin and Handasyde 1999; Menkhorst 2008).

A range of options has been used to address the overpopulation problem, principally translocation and sterilisation. These interventions have been effective in managing some smaller populations but the logistics and costs may be prohibitive for larger populations. Menkhorst (2008) estimates that the currently favoured option of sterilisation via hormone implants costs approximately $200 per animal. Additionally, the extensive program of relocation in Victoria has been so successful in re-establishing populations that there are few available options for translocation and future management will need to rely more heavily on *in situ* sterilisation. Modelling suggests that a target for sterilisation to produce significant population declines is in the order of 70% (McLean 2003; Duka and Masters 2005). With substantial management effort (Duka and Masters 2005), it was reported at the 2009 National Koala Abundance Workshop that the koala population of Kangaroo Island has been reduced by approximately 40% following sterilisation of some 10 000 koalas, of which 3000 were translocated to the mainland. The National Koala Abundance Workshop also noted that koala populations have also been reduced in some Victorian populations, again with substantial effort: at Mt Eccles National Park, some 8000 koalas have been sterilised over several years and the population has been reduced to approximately 6000 from approximately 11 000 in 2004. It is often noted that this expenditure comes at the cost of conservation efforts for other species (Duka and Masters 2005) and it will have to continue into the future indefinitely. While culling has been suggested to be one of the few logistically feasible ways to reduce populations before they reach the point where habitat damage occurs, it is considered an unacceptable alternative (Martin 1997; Tabart 1997; Menkhorst 2008; Natural Resource Management Ministerial Council 2010).

Significant large populations may not be amenable to control by sterilisation. Large populations occur at Cape Otway and in the Strathbogie Ranges and are not subject to fertility control (Menkhorst 2008) so remain vulnerable to resource depletion and rapid and substantial population decline (Martin 1997). Current management aims to maintain koala population density at or below one koala per hectare to prevent over-browsing and damage to habitat is (Menkhorst 2004; Duka and Masters 2005). The National Koala Abundance Workshop heard that in 2009 koala densities in some manna gum (*E. viminalis*) stands of Cape Otway were up to 17.1 koalas per hectare. Substantial loss of manna gums in the area, and a crash in the koala population, is a likely outcome.

8.6 Low genetic variability

A function of the translocation program in Victoria is that large populations of koalas began with only a very few individuals (Menkhorst 2008). Most populations in both Victoria and South Australia were established, or re-established, via individuals from islands in Victoria's Westernport Bay. Those source populations were themselves founded from a small number of individuals. As a consequence, genetic variability is low across most Victorian and South

Australian koala populations and they have suffered severe bottleneck and founder effects (Houlden et al. 1996; Seymour et al. 2001; Cristescu et al. 2009).

Seymour et al. (2001) and Cristescu et al. (2009) investigated the relationship between genetics and testicular abnormalities. Seymour et al. (2001) compared inbreeding across several populations and identified a correlation between the level of inbreeding and the proportion of the population exhibiting testicular abnormality. Cristescu et al. (2009) did not find the same trend when they examined the relationship between an estimate of individual animal's level of inbreeding and testicular abnormality within the Kangaroo Island population. However, they cautioned that this should not be seen as definitive as the high proportions of abnormalities means the genes are widespread and can be passed on without the individual's parents necessarily being closely related. In addition to the visible abnormalities considered above, inbreeding also has effects on testicular morphology and sperm morphology and thus on reproductive characteristics of male koalas (Montogomery 2002).

The above studies caution that the high numbers of individuals should not be taken to indicate that the populations are genetically secure. The majority of Victorian koalas, and all South Australian koalas, are derived from a limited number of individuals and thus represent little genetic capital (Houlden et al. 1996; Seymour et al. 2001; Cristescu et al. 2009). The impact of observed testicular abnormalities in some South Australian populations (Seymour et al. 2001; Cristescu et al. 2009) on individual or population fertility rates is unknown. However, the inbreeding coefficients measured for all southern Australian koala populations examined to date are above a threshold where extinction is considered substantially more likely (Seymour et al. 2001; Cristescu et al. 2009). Low genetic variability, as exhibited by both Victorian and South Australian populations, also reduces the population's ability to adapt to change, which may exacerbate the effects of disease, over browsing or climate change (Cristescu et al. 2009). The Koala Research Network has raised concern about the vulnerability of these populations to KoRV (Koala Research Network 2010).

9. Public Consultation

The nomination was made available for public exhibition and comment for 30 business days. The Committee has had regard to all 223 responses to consultation that was relevant to the survival of the species. The Committee has also considered information provided to the Senate inquiry into the status, health and sustainability of Australia's koala population.

10. How judged by the Committee in relation to the criteria of the EPBC Act and Regulations

The Committee judges that at the national level the species **is not** eligible for listing on the EPBC Act list of threatened species at this time.

The Committee judges that the designatable unit, consisting of the combined koala populations in Queensland, New South Wales and the Australian Capital Territory, has been demonstrated to have met sufficient elements of Criterion 1 to make it **eligible** for listing as **Vulnerable.**

The data provided below are first considered at a regional (or equivalent) level within states, before syntheses of the data against Criterion 1 both for the national population and the combined koala populations in Queensland, New South Wales and the Australian Capital Territory.

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[3] reduction in numbers

There is at present no published scientifically peer-reviewed estimate of the total number of koalas in Australia and no definitive past estimate within an appropriate timeframe to enable comparison. The report on the 1986-7 national survey of koala distribution noted that a total population size was "impossible to estimate as survey techniques varied greatly from area to area" (Phillips 1990). Similarly, in the previous assessment of the koala's national status, the TSSC noted that there have been no direct measurements of change in the size of the national koala population over the past three generations (Threatened Species Scientific Committee 2006).

Estimates of koala population size at regional and national levels remain highly divergent and contested. For many regions, there have been no surveys or published population estimates. Nonetheless, for this criterion to be evaluated, the Committee has attempted to compile or estimate population size for the requisite baseline year (around 1990) and currently (2011), across all portions of the koala's range. This is a challenging task, and our assessments will be open to criticism. In tabular summaries in the sections below, we provide the rationale for our assessments, and indicate the level of confidence that we have in these values.

Wet Tropics and Central Mackay Coast Bioregions

The TSSC could find no published estimates of koala population size or density in the Wet Tropics and Central Mackay Coast bioregions. There are some anecdotal reports of koala sightings but these are uncommon and suggestive of very low densities. The northern limit of the distribution of the koala in Queensland has contracted to the south from approximately Cooktown to inland of Cairns since the late 1960s (Phillips 1990; Gordon et al. 2006).

Mitchell Grass Downs, Desert Uplands and Einasleigh Uplands Bioregions

There are no published estimates of the number of koalas in this region, but some localised formal survey work has been undertaken to assess density. In part of the Desert Upland bioregion koalas occur at low density, such that surveys of the animals were considered impractical and faecal pellet surveys were used instead to assess relative abundance (Munks et al. 1996). Munks et al. (1996) found that koalas were principally associated with creek lines and leaf moisture was probably a critical determinant of their occurrence. There are few data on the koala population of the Einasleigh Uplands.

It was reported at the 2009 National Koala Abundance Workshop that at sites to the west of the study area of Munks et al. (1996), in the Mitchell Grass Downs bioregion, koalas have been surveyed at Moorinya National Park in August 2000 and February 2003. With six people conducting intensive searches over two days along creek lines (areas most likely to support koalas) they found only traces of koalas in 2000 and one dead koala in 2003. At Hughenden, to the northwest of Moorinya, searches by five people over five days, covering over 16 km of drainage lines over four consecutive years (2006-2009), found an average of 2.25 koalas per year. At Tambo, well to the south but also within the Mitchell Grass Downs, densities were very low, with only two and three koalas (one of which was dead) found in 2008 and 2009 respectively, in extensive searches of approximately 10 km of creek lines.

[3] The indicative thresholds used by the Committee, based on IUCN guidelines, are that a very severe decline is ≥80% reduction in population size, a severe decline is ≥50% and a substantial decline is ≥30% over 10 years or three generations, whichever is the longer. In the case of the koala, the timespan is approximately 20 years.

There are no prior estimates of koala density against which to compare the above figures. However, it is notable that distributional surveys in 1967 (Kikkawa and Walter 1968) and 1977 (Campbell et al. 1979) recorded koalas well to the west of the sites described above, while they are close to the western edge of distribution recorded in the more extensive 1986/1987 national survey (Phillips 1990). This result may indicate an eastward contraction of the koala's distribution (Gordon et al. 2006).

Brigalow Belt North and Brigalow Belt South Bioregions

Koalas have been studied at Springsure and Blair Athol in this region, typically occurring in low densities and with large home ranges (Ellis et al. 2002). The most recent estimates for Springsure were provided to the 2009 National Koala Abundance Workshop.

Data are available for four sites at Springsure in 1992 and 2009 (Table 2). The koala density was estimated via intensive searches of 1 km^2 plots, and declined from an average of 0.155 to 0.01 koalas/ha (a decline of >90%). There was no decline at the Norwood Creek site, initially the lowest density of the sites, where *Eucalyptus crebra*, a more drought tolerant species is dominant (but see (Fensham and Holman 1999) who describe 29% dieback of adult trees in northern Queensland, with the *E. crebra-E. xanthoclada* complex being most susceptible). At the other sites the dominant tree species, *E. tereticornis*, has undergone extensive mortality.

Table 2. Density of koalas (/ha) at fixed 1km^2 sites at Springsure, Central Queensland, surveyed in 1992 and 2009

Site	1992	2009
Wallalee	0.4	0.02
Koala Creek	0.15	0.0
Pinnacle	0.05	0.0
Norwood Creek	0.02	0.02

Mulga Lands Bioregion

Significant research work has been undertaken in the Mulga Lands bioregion, with a method for estimating koala abundance from faecal pellets developed and calibrated for the local conditions (Sullivan et al. 2002). In 1995 the koala population of the Mulga Lands was estimated at 59 500 (44 500 - 75 600 95% confidence limits) (Sullivan et al. 2004). Sullivan et al. (2004) also estimated a decline in koala numbers of approximately 10% due to land clearing in 30 years from 1969. During this survey a substantial proportion of koalas were in habitat on residual landforms away from riparian areas.

At re-sampling using the same procedures in 2009, the koala population in the region was estimated to be 11 600 (range 9 800-13 400 95% confidence limits), a decline of approximately 80% (Seabrook et al. 2011). This represents the most substantial and robust regional-scale koala population monitoring information available, and its timing is particularly relevant to consideration of criteria for the assessment of the koala's conservation status. However, it is difficult to contextualise the observed decline relative to the national koala population change, as the mulga lands koala population is a peripheral one, at the arid limit of the koala's distribution.

In the Mulga Lands, the koala distribution has contracted under drought conditions to the riparian areas, with very few koalas currently using the habitat on residual landforms as

observed by Sullivan et al. (2004). Seabrook et al. (2011) also noted that additional clearing of habitat may have contributed to the decline in koala numbers between 1995 and 2009. Heavy rains occurred through much of the region in early 2010 and drought declarations for the region have been removed as at 31 July 2010 (Queensland Department of Environment and Resource Management 2010).

Southeast Queensland Bioregion

Attempts to derive population estimates for southeast Queensland have been focussed particularly on the Koala Coast and Pine Rivers Shire (the latter now part of Moreton Bay Regional Council). The Koala Coast had an estimated 6246 (4802-7691 95% confidence limits) koalas in 1996-1999. That population had declined by 65% to an estimated 2279 koalas in 2008 and was expected to fall further (Queensland Department of Environment and Resource Management 2009). The final report of a 2010 survey of the Koala Coast Population has not yet been released, however ongoing koala mortality (Table 1) is high relative to the koala population size and thus suggests further decline has occurred since 2008. Pine Rivers Shire supported approximately 4600 koalas in 2001 (Dique et al. 2003a) and this declined by 40% to fewer than 2700 koalas in 2008.

In the Gold Coast the koala population was estimated at 4,724 koalas (4316 - 5131 (95% confidence limits)) in 2007 (Phillips et al. 2007). This estimate includes a population of 510 koalas (381 - 639) inhabiting the Coomera-Pimpama Koala Habitat Area where already approved development will see over a third of the resident koala population lost. Anticipated further development will see additional losses, while an escalation of associated threats (e.g. cars, dogs) will invariably lead to further population decline. The population is likely to be rendered unviable (in the absence of an assertive management response) once incidental mortality arising from the associated threats referred to above exceeded 6% of total population size (Phillips 2007).

Koala populations in all SEQ coastal local government areas (Sunshine Coast; Moreton Bay; Brisbane; Redland; Logan; and Ipswich) appear to be following a similar downward trend to the Koala Coast and Pine Rivers populations, as evidenced by a rapid increase in the numbers of sick, injured and dead koalas, followed by a decline in koala numbers . Further north, koala populations are less well known, often becoming known as a result of development applications, but are generally considered to be at low density (<0.2 koalas/ha) (White et al. 2005; Queensland EPA 2006).

Queensland (overall)

The Queensland Nature Conservation (Koala) Conservation Plan 2006 and Management Program 2006-2016 cites an overall figure for Queensland's koala population of 100 000 to 300 000 but gives little indication of its derivation. Specific population figures are given only for the Mulga Lands, Koala Coast and Pine Rivers (as described above) where the estimates sum to slightly more than 70 000 and declines average more than 75% since the 1990s. The remainder of the estimated figure includes the koalas in the low density populations (0.005-0.2 koalas/ha) over the remainder of their extensive distribution. The Committee has given consideration to this figure, and data available on koala densities and bioregional areas, and concludes that a plausible range of population sizes for Queensland in the 1990s is 250 000 – 350 000 koalas, with a best estimate (*sensu* (IUCN Standards and Petitions Subcommittee 2011) of 295 000. A summary of the figures used by the Committee in its consideration of Queensland's koala population are below at Table 3.

Consideration of the population trend in Queensland requires that the known population data (Mulga Lands, South East Queensland) are considered in combination with inferred population sizes and trends for the remainder of the koala's Queensland range. The majority of the koalas in these bioregions are expected to be in the Brigalow Belt, given its extensive size and more favourable conditions than Mulga Lands (the only bioregion for which data on the broadscale response to the drought are available). The Committee's best estimate consists of, on a bioregional basis, approximately: South East Queensland 25 000; Mulga Lands 60 000, Mitchell Grass Downs, Desert Uplands and Einasleigh Uplands combined 85 000, Brigalow Belt North and South 115 000 and Wet Tropics, Central Mackay Coast combined 10 000 (Table 3).

The inferred trend in the Brigalow Belt is considered to be a decline of 30-40%, somewhat less than that in the Mulga Lands, and a similar decline has been applied also to the Mitchell Grass Downs, Einasleigh Uplands and Desert Uplands bioregions in the Committee's modelling. In the absence of appropriate data, the koala populations of the Wet Tropics and Central Mackay Coast have been considered to be broadly stable. The plausible range of estimates for the inferred decline in the Queensland koala population is thus approximately 39-46%.

Table 3. Summary of the Committee's assessment of Queensland koala populations, for the time period relevant to Criterion 1.

Region	Date	Best Estimate	Range	Basis, and Assumptions	Confidence in population estimate
Wet Tropics, Central Mackay Coast	1990	10 000	n/a	Limited data, small coastal bioregions	Low
	2010	10 000	n/a	As above, less affected by the drought than inland bioregions	
Desert Uplands, Mitchell Grass Downs, Einasleigh Uplands	1990	85 000	67 000 – 107 000	Approximate area by density: Mitchell Grass Downs 0.001 koalas/ha, Desert Uplands and Einasleigh Uplands 0.005 koalas/ha.	Low
	2010	55 000	51 000 - 59 500	Decline 30-40%, range based on decline from 1990 best estimate.	Low
Brigalow Belt	1990	115 000	90 000 – 145 000	Approximate area by density: 0.005 koalas/ha	Low
	2010	75 000	69 000 - 80 500	Decline 30-40%, range based on decline from 1990 best estimate.	Low
Mulga Lands	1990	60 000	44 500 - 75 600	Taken from published paper	High
	2010	11 600	9 800-13 400	As above	High
Southeast Queensland	1990	25 000	n/a	Based on aggregate of formal estimates	High
	2010	15 000	n/a	As above	High
QUEENSLAND TOTAL	1990	295 000	250 000 – 350 000		
	2010	167 000	157 000 – 177 000		

North-east NSW

North-east NSW is often held to be the stronghold of koalas in this state. While population densities tend to be highest in this part of New South Wales, there are few contemporary estimates of the size of koala populations and it is not possible to give an overall estimate. However, there are data to assess the distribution of koalas which give a coarse indication of population density (Lunney et al. 2009). Lunney et al. (2009) report results of a community survey to estimate changes in distribution and relative abundance between 1986 and 2006 and noted that most of the areas in NSW that indicated decline were in the north east. Of the populations for which population information is available, Iluka is considered to have become extinct (Lunney et al. 2002) and Port Stephens had a population of 350-800 koalas in 1998 (Lunney et al. 2007). However, Lunney et al. (2007) modelled the available population parameters for Port Stephens and showed that it was susceptible to decline unless mortality due to fire and dogs were both eliminated. Lake Innes Nature Reserve was reported to have a population of approximately 600 koalas in 1999 (NSWNPWS 1999) while adjoining freehold lands comprising the remainder of the Innes Peninsula and associated Thrumster planning area collectively supported an associated population of approximately 300 koalas (Forsman and Phillips 2005; Phillips 2008). In the Lismore area there is evidence that koalas may be extending their range into eucalypt forest/woodland that has become established since clearing of the Big Scrub rainforest (Lee 2010). There are substantial areas of National Park and State Forest in the region for which there are few data on population size.

Thus the number of koalas in north-east NSW is uncertain and population audits are required to establish current population size. Nevertheless, they likely numbered in the high thousands in recent times but the nature and extent of exposure to threats suggests that declines have occurred, and will continue, in many areas.

Central Coast NSW and Sydney Bioregion

In the Sydney Basin Bioregion koalas occur around the Central Coast, Blue Mountains and the fringes of the Cumberland Plain. Records from reserves are uncommon, though they are found in Dharug, Wollemi and Tomaree NPs. There are scattered records through the South Eastern Highlands Bioregion. The Campbelltown (and surrounding areas) population of south-west Sydney has been increasing slowly since the 1980s and is considered to have approximately 300 animals. Given the large areas of National Park in the Sydney region, low density koala populations may support several hundred individuals (Close 2010 Personal communication). A number of other populations are identified in the NSW recovery plan but these are likely to be small and some (e.g. Pittwater) may now be extinct (NSW DECC 2008).

Northwest NSW

In New South Wales west of the Great Dividing Range key populations occur at Pilliga and Gunnedah with smaller populations elsewhere (NSW DECC 2008). The Pilliga population is important as it has been estimated to support some 15 000 koalas (Kavanagh and Barrott 2001). However, the estimate has been questioned because of mapping and recording matters (NSW DECC 2008) and may be a significant overestimate. The estimate is also now 10 years old and the Pilliga has been subject to severe drought. In areas where koalas were once abundant in the 1990s they are now rare or absent and there has been little sign of recovery (Parnaby 2010 personal communication).

Despite formal studies of the koala population (Smith 1992; Curran 1997), there are no quantitative estimates of population size for Gunnedah. State-wide surveys of koala

distribution indicate that the Gunnedah population is regionally significant (Crowther et al. 2009) and has expanded, against the state trend, due to revegetation aimed at addressing soil salinity problems (Lunney et al. 2009). However, the proximity of plantings adjacent to roads and railway tracks creates high exposure of koalas to vehicle strike, and a heatwave in 2009 led to high mortality (Crowther et al. 2010).

Southern NSW

A synthesis of recent koala surveys was prepared for the purposes of this nomination by Chris Allen of NSW DECCW, combining the results of surveys conducted using various methodologies (Allen 2009). Densities for all areas were low. The combined estimates for the region from approximately Goulburn south to the New South Wales-Victoria border sum to approximately 800 koalas. Allen (2009) notes some indications of an increase in the population in the coastal forests north east of Bega, but it must be noted that this is an extremely small population. Recent intensive surveys show that a population at Tantawangalo/Yurammie is now very small and possibly extinct.

New South Wales (overall)

The Committee's New South Wales koala population estimate was based on a series of population estimates for populations at local and regional scales (summarised in Table 4). These estimates included several populations along the northern and southern coasts. The Pilliga population estimate (approx. 15 000) comprises a particularly high proportion of the overall state estimate. The Committee infers that declines have occurred for most north coast populations based on published modelling studies, a common suite of threats and anecdotal information from care groups. Anecdotal reports suggest a severe, but unquantified, decline in the Pilliga population. Based on submissions to the Senate inquiry, the estimated base New South Wales population used here is slightly larger than used in the 2009 nomination (Table 2, TSSC 2009). In its deliberations the Committee has considered the NSW population to be approximately 31 400 in 1990 and 21 000 in 2010 (approx. 33% decline). The Committee notes that the 2008 New South Wales Recovery Plan for the Koala states "The continuation of the major population centres for koalas is encouraging, but the detailed local studies which have examined population dynamics in relation to existing threats, such as land clearing, habitat fragmentation, fire, dogs and cars, identify that most of these populations are failing and that the status of the koala as being vulnerable is well justified."

Table 4. Summary of the Committee's assessment of New South Wales koala populations, for the time period relevant to Criterion 1.

Region	Date	Best Estimate	Basis, and Assumptions	Confidence in population estimate
North East	1990	10 500	Higher density than in most other parts of the state, extensive areas of National Park and State Forest.	Moderate
	2010	7 500	Declines measured or inferred via modelling studies for several urban areas, particularly along the coastal region. Data lacking for significant forested areas.	Moderate
Central coast NSW and Sydney bioregion	1990	1 500	Estimates for Campbelltown area, extrapolated based on expert advice of large area with low density populations	Moderate
	2010	1 900	Inferred increase based on expert advice on Campbelltown population.	
Northwest (other than Pilliga)	1990	2 000	Inferred based on community survey data suggesting widespread occurrence across region but with substantial areas of cleared land.	Low
	2010	3 000	Increase inferred based on unquantified increase in koala population in Gunnedah region due to revegetation	Low
Pilliga Forest	1990	15 000	Published estimate	High
	2010	7 500	Decline inferred based on drought, wildfire, anecdotal reports of substantial decline	Low
South East	1990	2 400	Published estimate for Eden-Bermagui extrapolated to broader region	Moderate
	2010	1 100	Published estimate for region.	High
NEW SOUTH WALES TOTAL	1990	31 400		
	2010	21 000		

Australian Capital Territory

The koala population of the ACT is likely to be very small. There have been at least six introductions from Victoria but no large or dense populations have ever become established. There have been no reports of wild koalas following a bushfire in 2003 (Fletcher 2009 personal communication).

Victoria

The size of the koala population in Victoria is largely a function of the translocation program that has been operating for several decades. Most potential koala habitat now has established koala populations. In its 2010 listing advice the TSSC used an estimate of the total population for Victoria of 73 500 but the Victorian government, in its submission to the Senate inquiry, stated that this was "certainly an under-estimate"(Senate Environment and Communications References Committee 2011). However, no formal estimate was provided and thus the Committee has had to consider a broad range of estimates as plausible and to consider the influence of those values on the determination of the national trend. Additionally, there are few data by which to discern a trend in the state population but the Committee has noted the exposure of some populations to predation by dogs, vehicle strike and wildfire; and some localised increase due to revegetation. In its deliberations the Committee has considered a range of population sizes between 150 000 and 300 000 and inferred a 20 year decline in the Victorian koala population of between 5 and 10%.

South Australia

The main South Australian population is the introduced one on Kangaroo Island. In 2001 the population was estimated to be 22 000 to 27 000 koalas (Masters et al. 2004). Since 1997 there has been an extensive program of translocation (3000 koalas) and sterilisation (10 000 koalas) aimed at reducing over browsing pressure on the habitat. In 2010, the population of Kangaroo Island was estimated at 13 660 (Senate Environment and Communications References Committee 2011).On the mainland there are four other populations - at Eyre Peninsula, the Riverlands, Lucindale (a single population within 10 ha) and the Adelaide Hills. There are no formal estimates of population size available, but overpopulation may possibly be an issue in the Adelaide Hills (Natural Resource Management Ministerial Council 2010). The Committee considers plausible estimates for the South Australian koala population to be approximately 32 000 in 1990 declining under direct management to 19 500 in 2010 (approx. 39%).

Overall synthesis of koala trends

National Scale

The Committee notes that there are substantial uncertainties in the estimates of koala population sizes across the species' national range. While some regions or populations are very well studied, for many others there are few data or a lack of a baseline against which to formally evaluate a decline. Nevertheless, there is sufficient information to gauge relative population sizes and complementary information on habitat condition or other indicators to enable inference about regional population trends, despite the inherent uncertainty in the data.

Before consolidating information on national status, we note briefly an interpretational issue relating to consideration of population management in South Australia and Victoria. The

Committee includes in its assessment of national trends all introduced populations in the range states, following the IUCN guidance that "benign" introductions should be considered in evaluating a species' status (IUCN Standards and Petitions Subcommittee 2011). That is, although some populations occur outside the koala's natural range, they are still included in the assessment.

The most substantial koala population in South Australia is Kangaroo Island, for which formal quantitative estimates provide evidence of a strong declining trend. This decline is the direct result of management intervention for habitat protection. Similar considerations apply to some intensively-managed Victorian populations. The managed decline in the South Australian population has relatively little influence at the national level because it is a small proportion of the national population.

The koala population of Victoria can be considered to be broadly stable or declining slightly at the state level, although individual population trajectories may vary. The current koala population estimate of Victoria is unknown but considered to be large, and thus has a buffering effect on declines in other states.

In New South Wales koala populations have declined across most of the state due to a suite of threats. The declines have been severe in many areas and the threats are ongoing. Increases in the number of koalas in Gunnedah and Campbelltown are insufficient to counterbalance the state's declining trend.

Queensland is the state for which estimation of the overall population is most problematic for derivation of national trends, because the Queensland population probably comprises a relatively high proportion of the total Australian population (most likely 40-50%), and because estimation is difficult due to the koala's expansive distribution to the north and west, and the lack of quantitative data in those regions. As the Committee judges the 1990 Queensland koala population to have been large, and that a substantial declined has occurred, it has a strong influence on the national trend.

Combining the estimated changes in koala populations for each of its range states, the large size and relative stability of the Victorian population tend to dampen the effect of the Queensland decline. It is pertinent here to reiterate two key changes in the available data that were identified during the course of the Senate inquiry (Senate Environment and Communications References Committee 2011). The first is that the estimated decline in the Mulga Lands bioregion in Queensland was recalculated by the researchers and increased from the 50% used in the Committee's 2010 listing advice (Threatened Species Scientific Committee 2010) to 80% (Seabrook et al. 2011). The second is that the Committee's 2010 listing advice relied on an estimate of the Victorian population that has been described as "certainly an under-estimate" (Senate Environment and Communications References Committee 2011) and a considerably larger population has been inferred here. The dampening effect of the Victorian estimate has thus increased, and exceeds the additional decline estimated for the Mulga Lands, such that the Committee has again determined that, at the national scale, the koala is **ineligible** for listing as **vulnerable**.

Table 5. Summary of the Committee's assessment of national koala populations, for the time period relevant to Criterion 1. Note that in South Australia and Victoria population-control programs have been operating, and that the population of the ACT is considered to be very low (fewer than a hundred) and is not included in this tally.

Region	Date	Best Estimate	Decline
Queensland	1990	295 000	
	2010	167 000	43%
New South Wales	1990	31 400	
	2010	21 000	33%
Victoria	1990	215,000	
	2010	200,000	~7%
South Australia	1990	32 000	
	2010	19 500	39%
NATIONAL TOTAL	1990	573 400	
	2010	407 500	29%
COMBINED QUEENSLAND AND NEW SOUTH WALES TOTAL	1990		42%
	2010		

Designatable Unit consisting of the combined koala populations in Queensland, New South Wales and the Australian Capital Territory

In assessing the status of the designatable unit consisting of the combined koala populations in Queensland, New South Wales and the Australian Capital Territory the Committee has had regard to the guidelines developed by the IUCN for the application of listing criteria to regional populations (IUCN 2003). These provide guidance on whether the regional population's interaction with populations of the species outside the region are sufficient to influence the category to which the species/entity is assigned within the region. In this context, the important question is whether there is potential for sufficient koalas to immigrate into the range of the combined koala populations in Queensland, New South Wales and the Australian Capital Territory to provide a "rescue" effect from the decline experienced within the region. It is the Committee's view that there is very limited potential for any rescue effect. While koalas may potentially move across the border from Victoria into New South Wales, the fact that the southern New South Wales koala populations have shown little to no recovery for an extended period indicates that any rescue effect is minimal. Additionally, this potential dispersal is only possible at the southern extreme of the ≥2000 km latitudinal range of the combined koala populations in Queensland, New South Wales and the Australian Capital Territory, rendering maintenance of adaptive potential entirely reliant on processes within the unit's boundaries. The combined koala populations in Queensland, New South Wales and the Australian Capital Territory Unit is effectively demographically independent and thus the listing criteria are applied as per a normal species-level assessment as advised by IUCN (2003).

As described above, the Committee considers the plausible range of estimates for the decline in the Queensland koala population to be approximately 39-46% while the corresponding figure for New South Wales is approximately 33% (Table 5). The baseline population size for Queensland is an order of magnitude larger than that of New South Wales and thus the trend for the combined unit is approximately the same as for Queensland alone. (If extant) the very small population of the Australian Capital Territory has no effect on the combined designatable unit. The Committee has determined that the combined koala populations in Queensland, New South Wales and the Australian Capital Territory has experienced a substantial decline, exceeding the threshold of ≥30% over three generations, and thus considers this designatable unit **eligible** for listing as **vulnerable.**

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

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; NSW DECC 2008).

The Committee does not consider that the species' geographic distribution is both precarious for the survival of the species and very restricted, restricted or limited. Therefore, as the species has not been demonstrated to have met the required elements of Criterion 2, it is **not eligible** for listing in any category under this criterion at either the national scale or that the combined koala populations in Queensland, New South Wales and the Australian Capital Territory.

Criterion 3: The estimated total number of mature individuals is limited to a particular degree; and either

(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

The koala population is described under Criterion 1. The Committee does not consider that the estimated total number of mature individuals of the species is very low, low or limited at either the national scale or that of the combined koala populations in Queensland, New South Wales and the Australian Capital Territory. Therefore, as the species has not been demonstrated to have met the required elements of Criterion 3, it is **not eligible** for listing in any category under this criterion.

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

The koala population is described under Criterion 1. The Committee does not consider that the estimated total number of mature individuals of the species is extremely low, very low or low. Therefore, as the species has not been demonstrated to have met any required element of Criterion 4, it is **not eligible** for listing in any category under this criterion.

Criterion 5: Probability of extinction in the wild that is at least

(a) 50% in the immediate future; or

(b) 20% in the near future; or

(c) 10% in the medium-term future

While there have been Population Viability Analyses conducted for individual populations (Penn et al. 2000; Lunney et al. 2002) there are insufficient data available to estimate a probability of extinction of the whole species, or the combined koala populations in Queensland, New South Wales and the Australian Capital Territory, in the wild over a relevant timeframe. Therefore, as the species has not been demonstrated to have met the required elements of Criterion 5, it is **not eligible** for listing in any category under this criterion.

11. CONCLUSION

Conservation Status

The koala has an extensive distribution that spans four states and the Australian Capital Territory. The status of individual populations varies across this range, but pressures overall have increased over time and human impacts also act to exacerbate the effects of, or impede the recovery from, natural pressures such as drought. Where koala habitat coincides with growing human populations and urban development, koala habitat continues to be cleared despite a range of preventative management measures, and koalas in remaining habitat areas continue to be vulnerable to threats from dogs, cars and disease. In northern and western parts of the koala's distribution, in Queensland and New South Wales, drought and heatwaves have had a severe impact on koala populations and the trees on which they depend for food. The vulnerability of koala populations to these effects is increased by the loss of habitat due to clearing and the fragmentation this has produced in the landscape.

Conversely, koalas remain at least locally abundant in Victoria and South Australia. Some populations in these states are "over-abundant" and must be managed to reduce population density in order to prevent habitat degradation. However, other populations in these States face similar threats to koalas elsewhere, and may face further problems in the future associated with their relatively low genetic diversity.

The overall effect at the national scale is that the decline over three generations in Queensland and New South Wales is counterbalanced by the size and relative stability of the Victorian population and the species overall cannot be considered eligible for listing in any category. However, separate consideration of the combined koala populations in Queensland, New South Wales and the Australian Capital Territory removes the counterbalance effect and allows the substantial and ongoing declines within the unit to be the focus. The combined koala populations in Queensland, New South Wales and the Australian Capital Territory has undergone a substantial decline over three generations, due to the combination of a range of factors. The Committee therefore consider the combined koala populations in Queensland, New South Wales and the Australian Capital Territory to be **eligible** for listing as **vulnerable**.

Recovery Plan

The Committee recognises that there is an unusually diverse and encompassing set of conservation and research instruments, guidelines and plans already in place for the koala across its entire range, in individual states, and for some regional populations. However, there is no existing overarching conservation strategy for the entity "koala populations occurring in Queensland, New South Wales and the Australian Capital Territory". This gap

may inhibit the development and implementation of the most targeted conservation actions for this entity and constrain coordination of conservation effort across relevant agencies and interest groups.

Furthermore, notwithstanding the considerable existing array of conservation initiatives and plans, the koala's conservation outlook continues to decline, demonstrating *ipso facto* the insufficiency of those existing instruments, and the need to revise them, re-focus them, or complement or replace them with new instruments. In addition, the Senate Inquiry provided numerous recommendations for further conservation management and research activities, additional to those currently included in existing plans; and the Inquiry described a series of shortcomings in the principal national conservation plan, the *National Koala Conservation and Management Strategy 2009-2014*. To some extent, that Strategy may inevitably be sub-optimal, given that it must frame management actions relating to over-population in some regions and to rapidly declining populations in other regions. A conservation or recovery plan that focuses only on those populations in most peril will deliver better conservation outcomes.

Accordingly, the Committee recommends that a recovery plan be developed for the entity "koala populations occurring in Queensland, New South Wales and the Australian Capital Territory". Particular circumstances of the koala's case have impressed the Committee with the need for suggesting here some guidelines around the development of such a recovery plan. The Committee considers that development of such a plan requires careful contextualisation, in particular with reference to:

- The time frame. Most recovery plans span 5 or 10 years. The information considered by the Committee indicates that the koala is affected by processes occurring over longer time periods (notably including the likelihood that climate change may make much of its inland range uninhabitable over the next 20-50 years, and that current development pressures are likely to result in a spate of incremental local extinctions in coastal areas over comparable time frames).
- Policy implications. The koala's conservation problems epitomise landscape-scale management challenges, in particular about the extent of clearing and habitat connectivity, "extinction debt", concepts of sustainable development, and strategic regional planning. These issues are rarely (or typically ineffectively) dealt with in recovery plans for individual species probably because they are considered "higher-order" policy. For any recovery plan for the koala to be effective, there has to be meaningful engagement with such policy. A koala recovery plan offers the opportunity of an exemplar engagement of threatened species recovery with broader strategic planning and policy.
- Pre-emption. The koala faces many pressing conservation challenges. Most existing recovery plans perforce concentrate on such immediate issues. However, the Committee also recognises that koalas may become increasingly susceptible to a range of new and developing problems, particularly relating to disease and the consequences of limited genetic variability. A recovery plan with a long-term ambit should provide the framework for balancing immediate management responses with strategic planning for management of emerging problems.

Accordingly, the Committee recommends the development of a Recovery Plan for the "koala populations occurring in Queensland, New South Wales and the Australian Capital Territory",

with such development framed to consider particularly the fundamental and challenging issues described above. Such a Recovery Plan should also include consideration of the set of recommendations provided by the Senate Inquiry. It should also include commitment to the development of integrated population assessment and monitoring across all regions (particularly those for which the current level of uncertainty about populations and their trends is greatest), the extent of post-drought recovery, and the extent to which current management interventions are having measurable success.

The Committee notes that careful consideration should be given to the relationship of this suggested Recovery Plan to that of the existing *National Koala Conservation and Management Strategy 2009-2014*. A Recovery Plan for the "koala populations occurring in Queensland, New South Wales and the Australian Capital Territory" should not obviate the need for a national koala management strategy, which should continue to provide a framework for the national integration of population monitoring, a mechanism for information exchange, a national reporting framework relating to the outcomes of management interventions, and an ongoing instrument for monitoring the conservation status of those koala populations not included in the Recovery Plan.

12. Recommendations

(i) The Committee recommends that the Minister declare the combined koala (*Phascolarctos cinereus*) populations in Queensland, New South Wales and the Australian Capital Territory to be a species for the purposes of the EPBC Act under s517 of the Act.

(ii) The Committee recommends that the list referred to in section 178 of the EPBC Act not be amended by including the koala (*Phascolarctos cinereus*) over its national extent.

(iii) The Committee recommends that the list referred to in section 178 of the EPBC Act be amended by **including** in the list in the **Vulnerable** category the combined koala (*Phascolarctos cinereus*) populations in Queensland, New South Wales and the Australian Capital Territory.

(iv) The Committee recommends that there should be a recovery plan for this species.

Threatened Species Scientific Committee

25 November 2011

References cited in the advice

Adams-Hosking C (2011) Landscape-scale conservation planning in a changing climate: a koala case study. Thesis. University of Queensland.

Adams-Hosking C, S. GH, Rhodes JR, McAlpine C and Moss PT (2011) Modelling climate-change-induced shifts in the distribution of the koala. Wildlife Research 38:122-130.

Allen C (2009) Assessing koala numbers and trends in south eastern New South Wales. NSW Depart of Environment, Climate Change and Water

Allen C, Saxon M and McDougall K (2009) Koala surveys in coastal forests north east of Bega in SE NSW 2007-2009. NSW Depart of Environment, Climate Change and Water

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

Braithwaite LW, Dudzinski ML and Turner J (1983) Studies on the arboreal marsupial fauna of eucalypt forests being harvested for pulpwood at Eden, N.S.W. II. Relationship between the fauna density, richness and diversity, and measured variables of the habitat. Australian Wildlife Research 10:231-247.

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

Campbell P, Prentice R and McRae P (1979) Report on the 1977 koala survey. Wildlife in Australia 16:2-6.

Canfield PJ (1991) A survey of koala road kills in New South Wales. Journal of Wildlife Diseases 27:657-660.

Carrick F (2010 personal communication) Koala Study Program, Centre for Mined Land Rehabilitation, University of Queensland. Personal communication.

Close R (2010 Personal communication) Koala Study Program, Centre for Mined Land Rehabilitation, University of Queensland. Personal communication.

Cogger H, Ford H, Johnson C, Holman J and Butler D (2003) Impacts of land clearing on Australian wildlife in Queensland. WWF Australia Brisbane.

Cork SJ (1986) Foliage of *Eucalyptus punctata* and the maintenance nitrogen requirements of koalas, *Phascolarctos cinereus*. Australian Journal of Zoology 34:17-23.

Cork SJ, Hume ID and Dawson TJ (1983) Digestion and metabolism of a natural foliar diet (*Eucalyptus punctata*) by an arboreal marsupial, the koala (*Phascolarctos cinereus*). Journal of Comparative Physiology B, Biochemical, Systemic, and Environmental Physiology 153:181-190.

Cristescu R, Cahill V, Sherwin WB, Handasyde K, Carlyon K, Whisson D, Herbert CA, Carlsson BLJ, Wilton AN and Cooper DW (2009) Inbreeding and testicular abnormalities in a bottlenecked population of koalas (*Phascolarctos cinereus*). Wildlife Research 36:299-308.

Crowther MS, Lunney D, Lemon J, Wheeler R and Madani G (2010) Restoration of koala habitat in Gunnedah II: movement of koalas across a patchy rural landscape. In: Australian Mammal Society 56th Meeting. Canberra

Crowther MS, McAlpine CA, Lunney D, Shannon I and Bryant JV (2009) Using broad-scale, community survey data to compare species conservation strategies across regions: A case study of the Koala in a set of adjacent 'catchments'. Ecological Management & Restoration 10:S88-S96.

Curran T (1997) Gunnedah Shire Council preliminary koala management study: Koala corridor study.

Degabriel JL, Moore BD, Foley WJ and Johnson CN (2009) The effects of plant defensive chemistry on nutrient availability predict reproductive success in a mammal. Ecology 90:711-719.

Dique D, Preece H and De Villiers D (2003a) Koalas in Pine Rivers Shire: distribution, abundance and management. Queensland Parks and Wildlife Service Brisbane.

Dique DS, Preece HJ, Thompson J and de Villiers DL (2004) Determining the distribution and abundance of a regional koala population in south-east Queensland for conservation management. Wildlife Research 31:109-117.
Dique DS, Thompson J, Preece HJ, de Villiers DL and Carrick FN (2003b) Dispersal patterns in a regional koala population in south-east Queensland. Wildlife Research 30:281-290.
Dique DS, Thompson J, Preece HJ, Penfold GC, de Villiers DL and Leslie RS (2003c) Koala mortality on roads in south-east Queensland: the koala speed-zone trial. Wildlife Research 30:419-426.
Duka T and Masters P (2005) Confronting a tough issue: Fertility control and translocation for over-abundant Koalas on Kangaroo Island, South Australia. Ecological Management & Restoration 6:172-181.
Dunlop M and Brown PR (2008) Implications of climate change for Australia's National Reserve System: a preliminary assessment. Department of Climate Change Canberra.
Eco Logical Australia (2006) Coffs Harbour City Council Koala Plan of Management Strategic Review. Eco Logical Australia Pty Ltd Coffs Harbour.
Ellis W (2010 personal communication) Integrative Ecology Lab, University of Queensland. Personal communication.
Ellis WAH, Melzer A and Bercovitch FB (2009) Spatiotemporal dynamics of habitat use by koalas: the checkerboard model. Behavioral Ecology and Sociobiology 63:1181-1188.
Ellis WAH, Melzer A, Carrick FN and Hasegawa M (2002) Tree use, diet and home range of the koala (*Phascolarctos cinereus*) at Blair Athol, central Queensland. Wildlife Research 29:303-311.
Fensham RJ and Holman JE (1999) Temporal and spatial patterns in drought-related tree dieback in Australian savanna. Journal of Applied Ecology 36:1035-1050.
Fletcher D (2009 personal communication) Research and Monitoring, ACT Parks, Conservation and Land. Personal communication.
Forsman H and Phillips S (2005) An ecological overview of koalas and their habitat on the Innes Peninsula, Port Macquarie NSW. Biolink Pty Ltd Uki, NSW.
Gall BC (1980) Aspects of the ecology of the koala *Phascolarctos cinereus* (Goldfuss) in Tucki Tucki Nature Reserve, New South Wales. Australian Wildlife Research 7:167-176.
GHD (2008) Caboolture, Pine Rivers and Redcliffe Councils: Report for koala habitat survey and mapping. GHD Brisbane.
Gordon G, Brown AS and Pulsford T (1988) A koala (*Phascolarctos cinereus* Goldfuss) population crash during drought and heatwave conditions in south-western Queensland. Australian Journal of Ecology 13:451-462.
Gordon G and Hrdina F (2005) Koala and possum populations in Queensland during the harvest period, 1906-1936. Australian Zoologist 33:69-99.
Gordon G, Hrdina F and Patterson R (2006) Decline in the distribution of the Koala *Phascolarctos cinereus* in Queensland. Australian Zoologist 33:345-358.
Green DM (2005) Designatable units for status assessment of endangered species. Conservation Biology 19:1813-1820.
Hanger J (1999) An Investigation of the Role of Retroviruses in Leukaemia and Related Diseases in Koala. PhD Thesis. University of Queensland.
Hanger J and Loader J (2009) Infectious disease in koalas: Implications for conservation. In: Koala Conservation Conference. Friends of the Koala. Lismore
Hindell MA, Handasyde KA and Lee AK (1985) Tree species selection by free-fanging koala populations in Victoria. Australian Wildlife Research 12:137-144.
Houlden BA, Costello BH, Sharkey D, Fowler EV, Melzer A, Ellis W, Carrick F, Baverstock PR and Elphinstone MS (1999) Phylogeographic differentiation in the mitochondrial

control region in the koala, *Phascolarctos cinereus* (Goldfuss 1817). Molecular Ecology 8:999-1011.
Houlden BA, England PR, Taylor AC, Greville WD and Sherwin WB (1996) Low genetic variability of the koala *Phascolarctos cinereus* in south-eastern Australia following a severe population bottleneck. Molecular Ecology 5:269-281.
Iredale T and Troughton ELG (1934) A check-list of the mammals recorded from Australia. Memoirs of the Australian Museum 6:1-122.
IUCN (2003) Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version 3.0.
IUCN Standards and Petitions Subcommittee (2011) Guidelines for Using the IUCN Red List Categories and Criteria - Version 9.0.
Jurskis V and Potter M (1997) Koala surveys, ecology and conservation at Eden. Forest Research and Development Division, State Forests of New South Wales Sydney.
Kavanagh RP and Barrott E (2001) Koala populations in the Pilliga forests. In: Perfumed Pineries: Environmental history of Australia's *Callitris* forests. CRES, Australian National University. Canberra. pp 93-103.
Kavanagh RP, Debus S, Tweedie T and Webster R (1995) Distribution of nocturnal forest birds and mammals in North-eastern New South Wales: Relationships with environmental variables and management history. Wildlife Research 22:359-377.
Kavanagh RP, Stanton MA and Brassil TE (2007) Koalas continue to occupy their previous home-ranges after selective logging in *Callitris-Eucalyptus* forest. Wildlife Research 34:94-107.
Kikkawa JA and Walter M (1968) Report on the koala survey. Wildlife in Australia 6:100-103.
Koala Research Network (2010) Submission by Steering Committee Koala Research Network on nomination to list the koala as a threatened species under the EPBC Act 1999. Koala Research Network Brisbane.
Lassau SA, Ryan B, Close R, Moon C, Geraghty P, Coyle A and Pile J (2008) Home ranges and mortality of a roadside Koala *Phascolarctos cinereus* population at Bonville, New South Wales. Too Close for Comfort : Contentious Issues in Human-Wildlife Encounters:127-136.
Lawler IR, Foley WJ, Eschler BM, Pass DM and Handasyde K (1998) Intraspecific variation in *Eucalyptus* secondary metabolites determines food intake by folivorous marsupials. Oecologia 116:160-169.
Lawler IR, Foley WJ, Woodrow IE and Cork SJ (1997) The effects of elevated CO_2 atmospheres on the nutritional quality of *Eucalyptus* foliage and its interaction with soil nutrient and light availability. Oecologia 109:59-68.
Lee K (2010) Conservation genetics of the koala (*Phascolarctos cinereus*) in Queensland and Northeast New South Wales. Thesis. University of Queensland.
Lee KE, Seddon JM, Corley SW, Ellis WAH, Johnston SD, De Villiers DL, Preece HJ and Carrick FN (2009) Genetic variation and structuring in the threatened koala populations of Southeast Queensland. Conservation Genetics
Lee T (2010 personal communication) Wildlife Health and Conservation Centre, Faculty of Veterinary Science, University of Sydney. Personal communication.
Lee T, Zenger KR, Close RL, Jones M and Phalen DN (2010) Defining spatial genetic structure and management units for vulnerable koala (*Phascolarctos cinereus*) populations in the Sydney region, Australia. Wildlife Research 37:156-165.
Lee T, Zenger KR, Close RL and Phalen DN (2011) Genetic analysis reveals a distinct and highly diverse koala (*Phascolarctos cinereus*) population in South Gippsland, Victoria, Australia. Australian Mammalogy 2011

Lunney D, Crowther MS, Shannon I and Bryant JV (2009) Combining a map-based public survey with an estimation of site occupancy to determine the recent and changing distribution of the koala in New South Wales. Wildlife Research 36:262-273.
Lunney D, Gresser S, O'Neill LE, Matthews A and Rhodes J (2007) The impact of fire and dogs on Koalas at Port Stephens, New South Wales, using population viability analysis. Pacific Conservation Biology 13:189-201.
Lunney D, Gresser SM, Mahon PS and Matthews A (2004) Post-fire survival and reproduction of rehabilitated and unburnt koalas. Biological Conservation 120:567-575.
Lunney D, O'Neill L, Matthews A and Sherwin WB (2002) Modelling mammalian extinction and forecasting recovery: koalas at Iluka (NSW, Australia). Biological Conservation 106:101-113.
Mallick SA, Hocking GJ and Driessen MM (1998) Road-kills of the eastern barred bandicoot (*Perameles gunnii*) in Tasmania: an index of abundance. Wildlife Research 25:139-145.
Martin R (1997) Managing over-abundance in koala populations in south-eastern Australia - future options. Australian Biologist 10:57-63.
Martin R and Handasyde K (1999) The Koala: Natural history, conservation and management. UNSW Press, Sydney.
Martin RW (1985a) Overbrowsing, and decline of a population of the koala, *Phascolarctos cinereus*, in Victoria .1. Food preference and food tree defoliation. Australian Wildlife Research 12:355-365.
Martin RW (1985b) Overbrowsing, and Decline of a Population of the Koala, *Phascolarctos cinereus*, in Victoria .3. Population-Dynamics. Australian Wildlife Research 12:377-385.
Masters P, Duka T, Berris S and Moss G (2004) Koalas on Kangaroo Island: from introduction to pest status in less than a century. Wildlife Research 31:267-272.
McAlpine CA, Bowen ME, Callaghan JG, Lunney D, Rhodes JR, Mitchell DL, Pullar DV and Poszingham HP (2006a) Testing alternative models for the conservation of koalas in fragmented rural-urban landscapes. Austral Ecology 31:529-544.
McAlpine CA, Rhodes JR, Callaghan JG, Bowen ME, Lunney D, Mitchell DL, Pullar DV and Possingham HP (2006b) The importance of forest area and configuration relative to local habitat factors for conserving forest mammals: A case study of koalas in Queensland, Australia. Biological Conservation 132:153-165.
McAlpine CA, Rhodes JR, Peterson A, Possingham HP, Callaghan J, Curran T, Mitchell D and Lunney D (2007) Planning guidelines for koala conservation and recovery: a guide to best practice. University of Queensland and the Australian Koala Foundation, Brisbane.
McDonnell J (2010) Submission on the proposed state koala policy changes 2009. Logan City Council Document No. 6361628 (Minute No 39/2010). Logan City.
McKay G (1988) Phascolarctidae. In: Walton DW (ed) Zoological Catalogue of Australia. Bureau of Flora and Fauna. Canberra
McLean N (2003) Ecology and management of overabundant koala (*Phascolarctos cinereus*) populations. Thesis. University of Melbourne.
McLean N (2010 personal communication) Threatened Species and Communities, Biodiversity and Ecosystem Services, Department of Sustainability and Environment Victoria. Personal communication.
Melzer A (1995) Aspects of the ecology of the koala *Phascolarctos cinereus* (Goldfuss, 1817) in the sub-humid woodlands of central Queensland. Thesis. University of Queensland.
Melzer A, Carrick F, Menkhorst P, Lunney D and John BS (2000) Overview, critical assessment, and conservation implications of koala distribution and abundance. Conservation Biology 14:619-628.

Menkhorst P (2004) Victoria's koala management strategy. Biodiversity and Natural Resources Division, Department of Sustainability and Environment Melbourne.
Menkhorst P (2008) Hunted, marooned, re-introduced, contracepted: a history of Koala management in Victoria. In: Lunney D, A Munn, W Meikle (eds) Too Close for Comfort : Contentious Issues in Human-Wildlife Encounters. Royal Zoological Society of New South Wales. Sydney. pp 73-92.
Montogomery ME (2002) Male reproductive characteristics and inbreeding depression in koala populations. Thesis. University of New South Wales.
Moore BD and Foley WJ (2000) A review of feeding and diet selection in koalas (*Phascolarctos cinereus*). Australian Journal of Zoology 48:317-333.
Moore BD and Foley WJ (2005) Tree use by koalas in a chemically complex landscape. Nature 435:488-490.
Moore BD, Foley WJ, Wallis IR, Cowling A and Handasyde KA (2005) *Eucalyptus* foliar chemistry explains selective feeding by koalas. Biology Letters 1:64-67.
Moore BD, Lawler IR, Wallis IR, Beale CM and Foley WJ (in press) Palatability mapping: a koala's eye view of spatial variation in habitat quality. Ecology
Moore BD, Wallis IR, Wood JT and Foley WJ (2004) Foliar nutrition, site quality, and temperature influence foliar chemistry of tallowwood (*Eucalyptus microcorys*). Ecological Monographs 74:553-568.
Moritz C (1994) Defining 'Evolutionarily Significant Units' for conservation. Trends in Ecology and Evolution 9:373-375.
Munks SA, Corkrey R and Foley WJ (1996) Characteristics of arboreal marsupial habitat in the semi-arid woodlands of northern Queensland. Wildlife Research 23:185-195.
Natural Resource Management Ministerial Council (2010) National Koala Conservation and Management Strategy 2009–2014. In. Department of the Environment, Water, Heritage and the Arts
NSW DECC (2008) Recovery plan for the koala (*Phascolarctos cinereus*). New South Wales Department of Environment and Climate Change Sydney.
NSWNPWS (1999) Lake Innes Nature Reserve Plan of Management. NSW National Parks and Wildlife Service Port Macquarie.
Parnaby H (2010 personal communication) New South Wales Office of Environment and Heritage. Personal communication.
Patterson R (1996) The distribution of the koala in Queensland 1986-1989. In: Gordon G (ed) Koalas, Research for Management: Proceedings of the Brisbane Koala Symposium. World Koala Research Inc. Corinda. pp 75-81.
Penn AM, Sherwin WB, Gordon G, Lunney D, Melzer A and Lacy RC (2000) Demographic forecasting in koala conservation. Conservation Biology 14:629-638.
Phillips B (1990) Koalas. The little Australians we'd all hate to lose. Australian Government Publishing Service, Canberra.
Phillips S (2007) Conserving koalas in the Coomera-Pimpama Koala Habitat Area: a view to the future. Biolink Pty Ltd Uki, NSW.
Phillips S (2008) Area 13 UIA Koala Plan of Management. Biolink Pty Ltd Uki, NSW.
Phillips S (2009 personal communication) Biolink Ecological Consultants Pty Ltd. Personal communication.
Phillips S and Callaghan J (2000) Tree species preferences of koalas (*Phascolarctos cinereus*) in the Campbelltown area south-west of Sydney, New South Wales. Wildlife Research 27:509-516.
Phillips S, Callaghan J and Thompson V (2000) The tree species preferences of koalas (*Phascolarctos cinereus*) inhabiting forest and woodland communities on Quaternary deposits in the Port Stephens area, New South Wales. Wildlife Research 27:1-10.
Phillips S, Hopkins M and Callaghan J (2007) Koala Habitat and Population Assessment for Gold Coast City. Biolink Pty Ltd Uki, NSW.

Phillips SS (2000) Population trends and the koala conservation debate. Conservation Biology 14:650-659.
Queensland Department of Environment and Resource Management (2009) Decline of the Koala Coast koala population: population status in 2008. Queensland Department of Environment and Resource Management Brisbane.
Queensland Department of Environment and Resource Management (2010) Queensland drought situation as at 31st July 2010.
Viewed: 11 August 2010
Available on the internet at:
http://www.longpaddock.qld.gov.au/queenslanddroughtmonitor/queenslanddroughtreport/2010/Jul.gif
Queensland Department of Environment and Resource Management (2011) Summary of koala hospital presentations, releases and major causes of death, 1997 to beginning of mid May 2011 - Southeast Queensland.
Viewed: 07 November 2011
Available on the internet at: http://www.derm.qld.gov.au/wildlife-ecosystems/wildlife/koalas/pdf/koala-hospital-data-1997-jan2011.pdf
Queensland EPA (2006) Nature Conservation (Koala) Conservation Plan 2006 and Management Program 2006-2016. Brisbane.
Queensland Government (2009) Media Release: Blight govt provides koala disease research funds.
Viewed: 22/01/2010
Available on the internet at:
http://statements.cabinet.qld.gov.au/MMS/StatementDisplaySingle.aspx?id=67713
Queensland Office of Climate Change (2008) Climate change in Queensland: what the science is telling us. Queensland Environmental Protection Agency Brisbane.
Robinson AC, Spark R and Halstead C (1989) The distribution and management of the koala (*Phascolarctos cinereus*) in South Australia. South Australian Naturalist 64:4-24.
SA Govt (2005) Submission to the Australian Government Department of the Environment and Heritage 2006 assessment of the status of the koala.
Seabrook L, McAlpine C, Baxter G, Rhodes J, Bradley A and Lunney D (2011) Drought-driven change in wildlife distribution and numbers: a case study of koalas in south west Queensland. Wildlife Research 38:509-524.
Seabrook LM, McAlpine CA, Baxter GS, Bradley A and Rhodes JR (2010) School of Geography, Planning and Environmental Management, University of Queensland. Personal communication.
Senate Environment and Communications References Committee (2011) The koala—saving our national icon. In. Senate Printing Unit, Parliament House, Canberra. Canberra
Seymour AM, Montgomery ME, Costello BH, Ihle S, Johnsson G, St John B, Taggart D and Houlden BA (2001) High effective inbreeding coefficients correlate with morphological abnormalities in populations of South Australian koalas (*Phascolarctos cinereus*). Animal Conservation 4:211-219.
Sherwin WB, Timms P, Wilcken J and Houlden B (2000) Analysis and conservation implications of koala genetics. Conservation Biology 14:639-649.
Smith M (1992) Koalas and land use in the Gunnedah Shire: a report on the Bearcare project. NSW National Parks and Wildlife Service Hurstville.
Steffen W, Burbidge AA, Hughes L, Kitching R, Lindenmayer D, Musgrave W, Stafford Smith M and Werner PA (2009) Australia's biodiversity and climate change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change. Natural Resource Managment Ministerial Council commissioned by the Australian Government Canberra.

Sullivan BJ, Baxter GS and Lisle AT (2002) Low-density koala (*Phascolarctos cinereus*) populations in the mulgalands of south-west Queensland. I. Faecal pellet sampling protocol. Wildlife Research 29:455-462.

Sullivan BJ, Baxter GS and Lisle AT (2003a) Low-density koala (*Phascolarctos cinereus*) populations in the mulgalands of south-west Queensland. III. Broad-scale patterns of habitat use. Wildlife Research 30:583-591.

Sullivan BJ, Baxter GS, Lisle AT, Pahl L and Norris WM (2004) Low-density koala (*Phascolarctos cinereus*) populations in the mulgalands of south-west Queensland. IV. Abundance and conservation status. Wildlife Research 31:19-29.

Sullivan BJ, Norris WM and Baxter GS (2003b) Low-density koala (*Phascolarctos cinereus*) populations in the mulgalands of south-west Queensland. II. Distribution and diet. Wildlife Research 30:331-338.

Tabart D (1997) Why the koala should not be culled, when the real problems are poor management and land degradation. Australian Biologist 10:40-46.

Takami K, Yoshida M, Yamamoto Y, Harada M and Furuyama J (1998) Genetic variation of mitochondrial cytochrome b genes among subspecies of koala, *Phascolarctos cinereus*. Journal of Veterinary and Medical Science 60:1161-1163.

Tarlinton R, Meers J, Hanger J and Young P (2005) Real-time reverse transcriptase PCR for the endogenous koala retrovirus reveals an association between plasma viral load and neoplastic disease in koalas. Journal of General Virology 86:783-787.

Tarlinton RE, Meers J and Young PR (2006) Retroviral invasion of the koala genome. Nature 442:79-81.

Thomas O (1923) On some Queensland Phalangeridae. Annals and Magazine of Natural History 11:246-250.

Threatened Species Scientific Committee (2006) Koala: 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). Department of the Environment, Water, Heritage and the Arts Canberra.

Threatened Species Scientific Committee (2010) Koala: 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). Department of Sustainability, the Environment, Water, Populations and Communities Canberra.

Tilman D, May RM, Lehman CL and Nowak MA (1994) Habitat destruction and the extinction debt. Nature 371:65-66.

Troughton ELG (1935) The southern race of the koala. Australian Naturalist 9:137-140.

Victorian Department of Sustainability and Environment (2009) Securing our natural future: a white paper for land and biodiversity at a time of climate change. Victorian Department of Sustainability and Environment Melbourne.

Ward S and Close R (2004) Southern Sydney's urban koalas: community research and education at Campbelltown. Urban Wildlife: More than Meets the Eye:44-54.

White D, White D and Power N (2005) Koala (*Phascolartos cinereus*) survey and habitat assessment of Lot 4 on RP 35335 Doolong South Rd, Wondunna, Hervey Bay, Queensland. Hervey Bay City Council Hervey Bay.

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

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

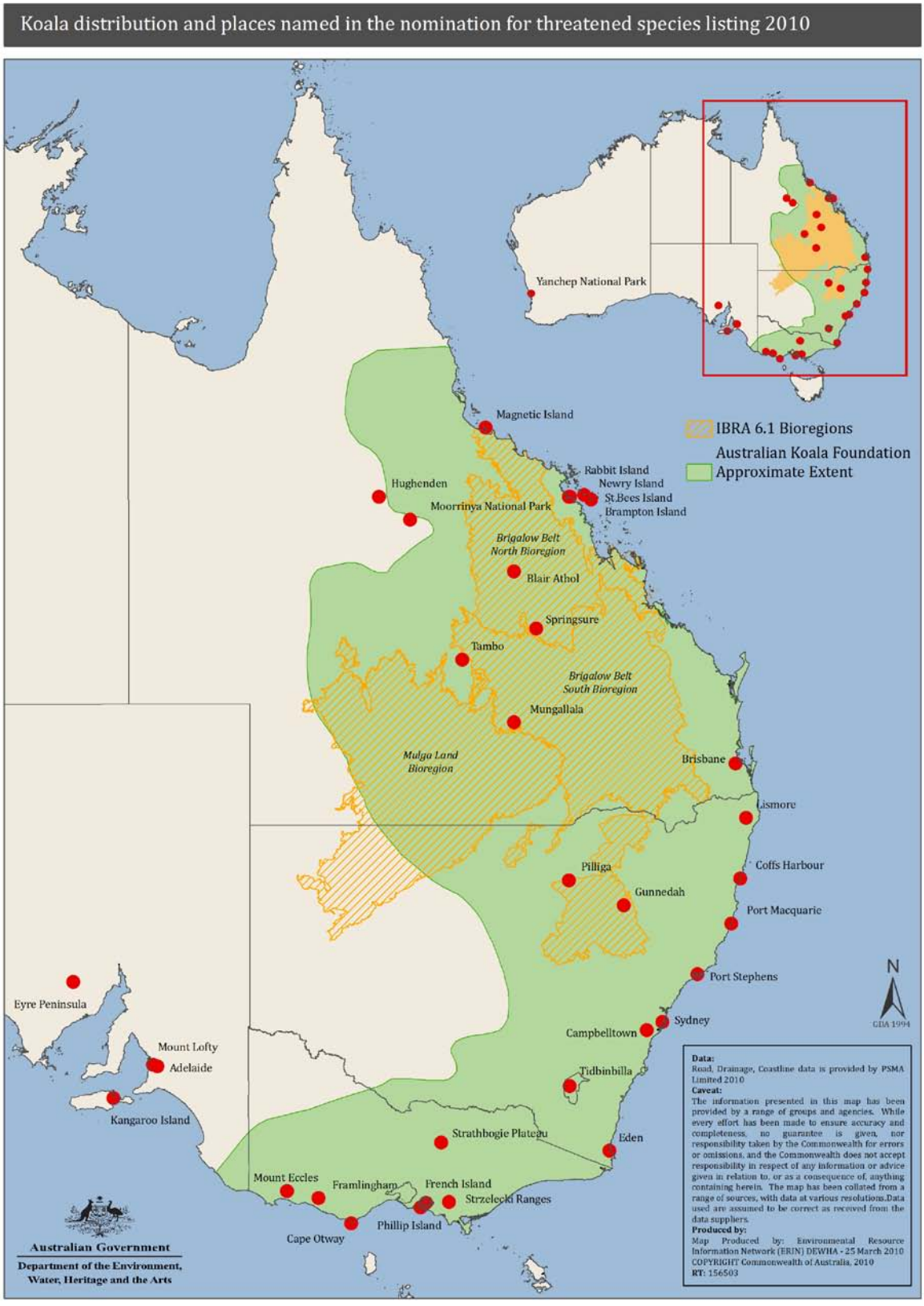

Figure 1. Distribution of the koala and places named in the text of the nomination for listing as a threatened species under the *Environment Protection and Biodiversity Conservation Act (1999).*

ATTACHMENT B

Threatened Species Scientific Committee Workshop to Determine Koala Abundance and Distribution Trends

Summary

Date: Tuesday 10 November 2009
Location: 33 Allara Street, Canberra
Chair: A/Prof Bob Beeton (Chair TSSC)
Participants:
No comment appropriate
Comments incorporated
Received, not yet incorporated

Mr Chris Allen – NSW DECCW
Prof Frank Carrick – University of Queensland
Dr David Dique – GHD
Dr Bill Ellis – University of Queensland
Dr Greg Gordon – Qld
Mr Piers Higgs – Atlas of Living Australia
* Dr Doug Kerlin – Australian Koala Foundation
Dr Ivan Lawler – Species Listing Section, DEWHA
Dr Dan Lunney – NSW DECCW
A/Prof Clive McAlpine – University of Queensland
Dr Natasha McLean – Vic DSE
Dr Alistair Melzer –Central Queensland University
* Mr Dave Mitchell – Australian Koala Foundation
Mr Maris Ozolins – ERIN, DEWHA
Mr Saravan Peacock – Director, Species Listing Section, DEWHA
Dr Steve Phillips – Biolink Pty Ltd, NSW
Dr Harriet Preece – Qld DERM
Ms Glenda Shelley – Species Listing Section, DEWHA
Dr Andrea Taylor – Member, TSSC
Dr Desley Whisson – Deakin University

Invited but unable to attend

Emeritus Prof Peter Baverstock – Southern Cross University
Dr Greg Baxter – University of Queensland
Dr Kathryn Handasyde – University of Melbourne
Dr Bill Humphreys – Member, TSSC
Dr Rod Kavanagh – NSW DPI
Ms Deidré de Villiers – Qld DERM
Mr Peter Menkhorst – Vic DSE
Dr John Woinarski – Member, TSSC

* Expressed a dissenting view of the workshop summary.

Purpose of the workshop:
To address the question: "What are the population numbers and trends across the Koala's current distribution?"

Introduction
The Chair explained that the Threatened Species Scientific Committee is currently assessing whether the koala is eligible for listing as a threatened species under the EPBC Act. This follows a request from the Minister and is being done as a Committee nomination. The assessment is due by 30 September 2010. The first outcome of this workshop will be a formal nomination document which will be as comprehensive as possible. Normal TSSC processes will be followed from this point.

The Chair pointed out that we are working against a background in which there has been little research published on koala abundance and trends since the TSSC's last assessment of the koala in 2006. Developing a clearer picture of current abundance and trends will therefore be an important component of the TSSC's new assessment.

Due to the koala's wide distribution across a diverse range of habitats, it has not been possible for any single study or research program to accurately address the question of trends in its national abundance or population. While excellent research has been, and is being, conducted it is necessarily of a more limited spatial and temporal scale than that ideally required for assessment of the koala's national status. Additionally, ongoing research may inform the assessment, but not be well known outside of research circles.

Consequently, this workshop of koala researchers was convened as a first step in developing an overall picture of the trends in koala numbers and distribution. In addition the methods used to study them were open for discussion as knowledge of this will influence how the TSSC makes its assessment.

The Chair explained to all participants that the workshop was not designed to reach any conclusion about whether the koala is nationally threatened. He specifically stated that there would also be no decision about whether the koala is eligible for listing under the EPBC Act arising from the workshop. This workshop was not a formal meeting of the TSSC but part of normal TSSC process that the Committee uses to inform itself on complex issues. The results of the workshop will therefore help inform the TSSC in its deliberations. The TSSC will consider a wide range of published and unpublished data, including the results of this workshop. The Committee will also consult widely with other experts and the public, before finalising its advice to the Minister.

Summary

The summary below attempts to capture the main points of discussion and, where appropriate, the views of the assembled experts. The workshop structure was not prescriptive, but the order of presentations was loosely north to south.

During the course of the presentations, some commonality of trends and threats emerged, and this is reflected in the sub-sections below:

Queensland/North-west NSW semi-arid western part of range

In northern and central western Queensland, data were reported for near Hughenden, at Moorinya National Park and near Tambo. In these areas, koalas were at very low densities and confined to drainage lines where extensive searching was required to locate them. There is evidence of tree dieback along drainage lines and this is exacerbated by the practice of landowners building small dams on creek lines with subsequent death of downstream vegetation.

In central Queensland, data were reported for Springsure and Tambo. Koala densities have also declined markedly, the exception being at Norwood Creek where the presence of the more drought tolerant *Eucalyptus crebra* (Melzer 1995) provides a food source not available to koalas elsewhere. Here also, mature eucalypt trees are stressed or dying back along drainage lines and koala populations are contracting to refuge areas where water is more reliable. It was noted that while there may be a general eastwards shift in the edge of the distribution; this is complicated by hydrological changes that do not necessarily follow this directional trend. It is expected that a phase shift in riparian communities, with *E. camaldulensis* replacing *E. tereticornis*, will occur. *E. camaldulensis* is more drought tolerant, but grows at lower densities so that if there is a post-drought recovery we may expect the population to re-establish but stabilise at a lower density. This seems to be the case (Gordon pers com.) at Mungalalla Creek following a drought-induced population crash in the 1980's (Gordon et al. 1988).

In the western part of the range, two key factors were discussed: the extent of land clearing and the ongoing drought. Land clearing has been greatly reduced under new Queensland legislation but that which continues may be important for koalas. Concerns were expressed about the inherently slow rate of recovery of vegetation in semi-arid areas, and that this is impeded by browsing by sheep and goats. Nevertheless, the focus of discussion tended to be on the extended drought and the potential for this to be exacerbated by climate change.

Reference was often made to the studies of Sullivan, who worked in the mulgalands bioregion in Queensland in the mid 1990s and estimated the population to be 59 000 koalas (Sullivan et al. 2002; Sullivan et al. 2003a; Sullivan et al. 2003b; Sullivan et al. 2004). In general, the views presented were that koala distribution may have contracted away from the residual habitats, which Sullivan estimated contained 49% of the bioregion's koalas.

In the mulgalands, a severe population decline was indicated as a result of the 2002/2003 drought. Published data on this is not yet available but the scenario posited was as follows. Severe drought conditions from 2003-2007 have led to the distribution of koalas contracting to riparian areas and, overall, towards the north east. The density of koalas on Sullivan's 'residual' habitats is now very low. While land clearing has been reduced by new Queensland vegetation laws, there is still clearing of mulga for drought fodder and this is used as shelter

by dispersing koalas. Regeneration of vegetation is impeded by sheep and goats, and some farmers are increasingly using goats as they are more drought resistant than sheep and cattle. Additional declines may continue to occur as the koala population adjusts to habitat loss and fragmentation since the cessation of clearing (akin to 'extinction debt' sensu (Cogger et al. 2003). Using the same methods as Sullivan, a more recent preliminary estimate of 22 000-38 000 koalas was calculated for the region. This is a substantial decline from Sullivan's 44 000-78 000. However, it was suggested that Sullivan's may have been overestimates and thus the decline may be overstated by an unknown amount.

While no new data could be reported for the semi-arid north western region of NSW, there was a general agreement that the trends were likely to be consistent with those observed in western Queensland. It was noted that the age of trees in these areas was much greater than previously appreciated, such that the carrying capacity of habitats, and their ability to recover from disturbance, is probably much lower than has been estimated previously. Some discussion centred on the population estimate for koalas in the Pilliga forests. This is often cited as the largest population of koalas in NSW (at approx. 15 000 – (Kavanagh and Barrott 2001), but there is debate about that figure (NSW DECC 2008) and it was suggested at the workshop that a more accurate estimate might be 50%, or as low as 10%, of that figure. Again no data is available.

The exception to the above trends is at Gunnedah in New South Wales. Here, the state-wide community survey showed an increase in koala density (Lunney et al. 2009). The mechanism for this is suggested to be the fact that significant revegetation programs were undertaken in the region in the 1990s in response to concerns about dryland salinity. Thus habitat has likely increased in the area.

Modelling of the effects of predicted climate change on the koala's distribution was presented. At the western edge of their range, in both Queensland and New South Wales, koalas are limited by water availability and by heat stress. Given that most climate change scenarios predict reduced rainfall, higher temperatures and extended drought, the koala's range may contract permanently towards the east.

In summary, across the semi-arid part of the range of the koala there are consistent observations of population decline and range contraction coinciding with ongoing drought. Mature habitat trees have died leading to the potential for either slow recovery post-drought or for a phase shift of the vegetation to a different community type, perhaps less favourable for koalas. This recovery will be additionally impeded by browsing by sheep and goats, smaller scale clearing for drought fodder and climate change.

<u>Coastal Queensland and NSW</u>

The major threat to koalas in the coastal parts of their range is urban development. The effects are manifest principally through loss and fragmentation of habitat and associated exposure to cars and dogs. Adjacent island koala populations may also be threatened through water extraction (Stradbroke Island). Water used for urban purposes may reduce the water table, allowing the entry of salt water which could kill koala habitat trees.

In the South East Queensland bioregion, which supported around 20 000 – 25 000 koalas in the 1990s, the highest densities of koalas are in the SE corner of the region. This corresponds to the Greater Brisbane area where there is also the greatest development pressure. Lower

density populations of koalas occur in Gladstone, the Burnett-Mary region and along the Main Range, but there has been little formal survey work in these areas. Throughout the area koala populations are being identified because of development applications.

Two key areas have been surveyed thoroughly. On the Koala Coast the population has declined by 51% since 2006 and 64% since 1999. While the decline was initially in the urban areas, the more recent declines are predominantly in bushland (including protected areas). This reflects the fact that the best koala habitat is on lowland, fertile soils favoured for urban development. These urban populations have acted as a source of recruits for adjacent bushland populations but now cannot do so because of their low densities. This pattern looks set to be repeated in the Pine Rivers Shire where there has been a 45% decline in the urban population, and a 15% decline in the bushland population, since 2001.

Recent work in the Gold Coast suggests the best koala habitat is again being favoured for urban development (e.g. Coomera). In the Tweed area koalas are starting to disappear from the ridge tops, even though favoured habitat trees are present. There are few lowland refuges available, and land clearing is continuing.

In south-eastern Qld/northern NSW generally, modelling approaches to estimating extent of occurrence and area of occupancy at the local government scale in some areas (e.g. Gold Coast and eastern portion of Kempsey LGAs) have shown 30% and 40% declines respectively There is a need to re-survey a number of NSW koala populations where koalas were doing poorly according to the earlier work of Lunney (Iluka, Port Stephens)(Lunney et al. 2002; Lunney et al. 2007). Some mitigation actions have been taken (such as Comprehensive Koala Plans of Management) but there has not been an audit of their effectiveness. The current distribution of koalas appears to be stable, but they are not moving back into areas where they used to occur. They may occur in the headwaters of rivers and streams, but not lower down because of land clearing. The threats of urban expansion, cars and dogs continue to be significant. Fire frequency and its influence on recruitment processes has been identified as the most important factor impeding recovery of the endangered Hawks Nest Tea Gardens Koala population.

Southern New South Wales

It was noted that historically the area must have supported much higher densities of koalas, as indicated by the number of pelts that were sourced from the region. Logging was previously perceived to be the major contemporary threat to koalas, and is still a significant concern, but the threats of dogs and cars are growing. Koala densities in the region are very low, but there are some weak signs of recovery and/or re-occupation of their former range. There are increasing anecdotal reports of sightings, and faecal pellet surveys are showing their presence in significant areas such as Mumbulla State Forest. While sightings of koalas during surveys are very uncommon, females have been seen with joeys. While this demonstrates that there is breeding it uncertain whether this results in net recruitment into the population. Nevertheless, it was suggested that the Queensland experience is that with such low populations they are unlikely to be stable, given the increasing threat from dogs and cars.

Victoria

The management focus for koalas in Victoria has for a long period been on preventing habitat damage due to over browsing by excessively high populations. As a consequence, in some

cases there have not been formal population surveys and estimates of koala population sizes are tentative. Victoria has koala populations in a range of circumstances. These were presented as three broad categories: High population densities (Mt Eccles NP, Otways etc.) Medium density/large area (Ulupna Island, Brisbane Ranges etc.), Low density stable (You Yangs NP, Wilsons Promontory etc) and low density declining (Macedon Ranges, Phillip Island).

The koala population and distribution in Victoria has been substantially influenced by the translocation of koalas from populations vulnerable to over browsing. That is, in some areas koala populations have grown so rapidly that they risk killing the trees on which they depend, which leads both to habitat loss and a population crash of koalas. This pattern initially became evident on island populations so that koalas were moved from the islands to mainland habitats where koalas were absent. As a consequence many of the current day mainland populations are genetically similar to the island populations. Thus low genetic diversity is a concern for the Victorian koala populations due to concerns about inbreeding effects and vulnerability to disease. The koala population of the Strzlecki Ranges is considered to be one of the few natural populations and is thus of particular importance.

The translocation program has been so successful in establishing koala populations over most of their former range, that there are now few options for further translocation. Management has thus turned to sterilisation of koalas to manage overpopulation. This was initially via surgical sterilisation, but is now more often done using hormone implants, which are more humane and more cost-effective. Nevertheless, it requires the capture of the koala and a substantial proportion of the population must be sterilised to achieve stabilisation. For example, at Mt Eccles National Park, some 8000 koalas have been sterilised over several years and the population has been reduced to approximately 6000 from approximately 11 000 in 2004. In some of the island populations sterilisation is being used with the long term aim of removing koalas from the islands.

However, sterilisation is not currently a viable option for some populations which are large. Defoliation begins to become apparent at densities of approximately one koala per hectare. At Cape Otway, the densities in manna gum (*E. viminalis*) stands may reach as high as 17 koalas per hectare. The total abundance of the population is unknown, but it is large and is not currently managed. Substantial loss of manna gums in the area, and a crash in the koala population, is a likely outcome.

In the western part of the Victorian range, around Ballarat, cars are a threat to koala populations, with greater than 300 mortalities recorded along the Midland Highway (time period not specified). Other research shows that koalas may use blue gum (*E. globulus*) plantations as habitat, particularly where it is adjacent to natural habitat. These plantations normally are harvested at a young age, whereas koalas tend to prefer larger trees. However, a number of timber companies have gone into receivership in the region and the trees may not be harvested. Separate research has shown a higher likelihood of finding koala faecal pellets in higher fertility riparian/floodplain habitats, consistent with observations from Queensland.

A significant threat to koalas in Victoria is wildfire. The 2009 fires significantly affected the koala populations of Kinglake National Park, and the Cathedral, Yarra and Strzlecki Ranges. Recent modelling by the Victorian Department of Sustainability and Environment suggests that up to 46% of koala habitat may have been burnt in the last 10 years. This may be an overestimate as the model can’t yet estimate smaller unburnt patches within larger fire

boundaries, and doesn't address fire intensity (some fires may not have been intense enough to kill koalas or their habitat trees, and koalas are known to repopulate burnt forest as trees recover).

Some figures were presented for overall population size, but it was again cautioned that they were tentative. The total population was of the order of 73 500, with the largest populations in the Strathbogie Ranges, Mt Eccles and the Otways. A figure was presented for the Strathbogies which, while somewhat speculative, was considerably lower than the figures often cited from Martin (>100 000).

South Australia

The information on the distribution of koalas at the time of European arrival is poor, other than to say that it was restricted to the SE corner of the state. The current koala population in South Australia is derived entirely from translocated animals from Victoria as determined by genetic studies (Seymour et al. 2001). Consequently, low genetic variability and inbreeding are significant threats.

The main SA population is on Kangaroo Island, where there was no natural population. In 2001 the population was estimated to be 22 000 to 27 000 koalas. There has been an extensive program of translocation (3000 koalas) and sterilisation (10 000 koalas). Approximately 30-60% of the population was sterilised, and the population had reduced to 12 000 to 16 000 by 2006.

On the mainland there are four other populations at Eyre Peninsula, the Riverlands, Lucindale (a single population on 10 ha) and the Adelaide Hills. Those in the Lucindale area show some abnormalities of the skull consistent with inbreeding. There is potential for overpopulation to occur in the Adelaide Hills.

The question was asked whether the assessment should consider koalas in SA outside the natural range, noting that a population at Yanchep in WA had not been considered (n.b. it has since been established that the Yanchep population consists of only 20 individuals and is in the process of being reduced to 12).

General Discussion and National Trend/Population

Figures were presented for a national population estimate, suggesting that population numbers could be 42 450 – 98 830 in 2009. This was compared with figures of 400 000 in 1986 (American Express survey) and 250 000 in 1989 (Phillip Reed NSW NPWS). However, the methodologies used to calculate these figures were completely different, and it was suggested that these figures could not be compared with the 2009 figures to show a trend over time. A post-meeting check of the literature showed that the American Express survey could not provide an overall national estimates as it was "impossible to estimate as survey techniques varied greatly from area to area" (Phillips 1990). Similarly, no published support could be found for the figure attributed to Reed.

Limited detail was provided to participants about the methodology of the 2009 figures. Most participants considered that, in order to evaluate the reliability of the 2009 figures, further detail was needed about the methods used and the data sources underlying them. The Chair noted that for the Threatened Species Scientific Committee to appropriately consider such an

estimate it would either have to be submitted for peer review in advance of its presentation to the Committee, or that the TSSC would require the full methodology to enable the Committee to evaluate its validity.

Overall, one of the key messages from the workshop was that it was difficult to develop a single population estimate for koalas at the present time. Key areas have either not been surveyed adequately (e.g. Strathbogies, Otways in Victoria) or have not been recently surveyed (e.g. Pilliga, Port Stephens in NSW) while there are high quality current estimates for other areas (e.g. Koala Coast, mulgalands in Qld).

The second central message was that the circumstances of koala populations are highly variable, even over relatively small scales. For example, the Pilliga forest koala population was exposed to wildfire in 2006 and has likely declined by an unknown amount as a result, while the Gunnedah population, tens of kilometres away, has increased. Where koala populations are threatened the nature of the threats is also highly variable, so that cars and dogs are the source of substantial mortality in SE Qld and Northern NSW, while drought is the principal threat in the west of the range, and inbreeding may be a threat in translocated populations such as Kangaroo Island. For this reason, most participants were of the view that a single formal population viability analysis would not be feasible because of the diversity of variables and uncertainty over their values.

While the threat from disease has been raised in some quarters, it was not discussed at length in the workshop. Koala retrovirus has been suggested as a threat to koalas and it is widespread through Queensland and Northern NSW. However, some participants noted that the claims being made now about the threat from KoRV are similar to those made about Chlamydia two decades ago. Chlamydiosis may pose a threat to local populations in some areas but it has not been the major threat to the species that it was predicted to be. It will be necessary to collect additional data and expert opinion on the threat to koalas posed by disease.

These variable circumstances across the koala's range led several workshop participants to support an approach of separate assessments for sub-sets of the koala's national distribution. Substantial proportions of the koala's range are subject to high levels of relatively consistent threat and might be more appropriately assessed and managed at that scale (reflected somewhat by the structure of this summary). Additionally, while it may be very difficult to integrate the uncertainty described above in population size and trends to derive a national status, regional (or some other sub-sets) might be more readily and rigorously assessed.

It was noted that the option is available to the Minister to determine a distinct population to be a species for the purposes of the EPBC Act. The TSSC is currently considering whether it would be appropriate or possible to assess separate populations for possible listing, but there are significant difficulties as variation in the koala is regarded by some to be clinal, rather than disjunct, separate populations. Some participants argued that Victorian koalas are readily distinguished from other koalas, both morphologically and physiologically. As this is consistent with the subspecies *P. c. victor* (restricted to Victoria, while two other subspecies are described for NSW, *P. c. cinereus,* and Queensland, *P. c. adustus*) it may provide a mechanism for an appropriate division without the uncertainty and decision-making delays of other approaches to sub-dividing. It is also consistent with the evidence for ongoing threats and strong downwards trends in Queensland and possibly parts of New South Wales, while Victorian and SA populations may be increasing.

The issue of the taxonomic status of the Koala was raised and this will be checked with ABRS immediately.

Follow-up

The Chair noted that a draft summary of the workshop would be prepared and circulated to all participants for comment. The Chair asked all participants to refrain from commenting publicly about the workshop until this summary had been agreed.

The TSSC will use the final workshop summary as a contribution to its nomination of the koala for assessment. The TSSC would circulate this nomination for comment to all workshop participants, as well as to a wider group of experts, and to the public. The TSSC would consider any comments and additional data received during its final assessment of the species.

In order to assist the TSSC in evaluating the data presented, the Chair asked participants to provide details of the data and methodologies discussed by participants during the workshop.

References

Cogger H, Ford H, Johnson C, Holman J, Butler D (2003) Impacts of land clearing on Australian wildlife in Queensland. In. WWF Australia, Brisbane

Gordon G, Brown AS, Pulsford T (1988) A koala (*Phascolarctos cinereus* Goldfuss) population crash during drought and heatwave conditions in south-western Queensland. Australian Journal of Ecology 13:451-462

Kavanagh RP, Barrott E (2001) Koala populations in the Pilliga forests. In: Perfumed Pineries: Environmental history of Australia's *Callitris* forests. CRES, Australian National University, Canberra, pp 93-103

Lunney D, Crowther MS, Shannon I, Bryant JV (2009) Combining a map-based public survey with an estimation of site occupancy to determine the recent and changing distribution of the koala in New South Wales. Wildlife Research 36:262-273

Lunney D, Gresser S, O'Neill LE, Matthews A, Rhodes J (2007) The impact of fire and dogs on Koalas at Port Stephens, New South Wales, using population viability analysis. Pacific Conservation Biology 13:189-201

Lunney D, O'Neill L, Matthews A, Sherwin WB (2002) Modelling mammalian extinction and forecasting recovery: koalas at Iluka (NSW, Australia). Biological Conservation 106:101-113

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

NSW DECC (2008) Recovery plan for the koala (*Phascolarctos cinereus*). In. New South Wales Department of Environment and Climate Change, Sydney

Phillips B (1990) Koalas. The little Australians we'd all hate to lose. Australian Government Publishing Service, Canberra

Phillips S (2008) Area 13 UIA Koala Plan of Management. In. Biolink Pty Ltd, Uki, NSW

Phillips S, Hopkins M (2009) Comprehensive Koala Plan of Management for Eastern portion of Kempsey Shire LGA, Volume I – Resource Study. In. Biolink Ecological Consultants

Seymour AM et al. (2001) High effective inbreeding coefficients correlate with morphological abnormalities in populations of South Australian koalas (Phascolarctos cinereus). Animal Conservation 4:211-219

Sullivan BJ, Baxter GS, Lisle AT (2002) Low-density koala (Phascolarctos cinereus) populations in the mulgalands of south-west Queensland. I. Faecal pellet sampling protocol. Wildlife Research 29:455-462

Sullivan BJ, Baxter GS, Lisle AT (2003a) Low-density koala (Phascolarctos cinereus) populations in the mulgalands of south-west Queensland. III. Broad-scale patterns of habitat use. Wildlife Research 30:583-591

Sullivan BJ, Baxter GS, Lisle AT, Pahl L, Norris WM (2004) Low-density koala (Phascolarctos cinereus) populations in the mulgalands of south-west Queensland. IV. Abundance and conservation status. Wildlife Research 31:19-29

Sullivan BJ, Norris WM, Baxter GS (2003b) Low-density koala (Phascolarctos cinereus) populations in the mulgalands of south-west Queensland. II. Distribution and diet. Wildlife Research 30:331-338

ATTACHMENT C

State of Victoria

Submission to the Senate Environment and Communications Committee inquiry into the status, health and sustainability of Australia's Koala population

Preamble

Many of the important issues relating to Koala conservation have been carefully considered in the Threatened Species Scientific Committee's (TSSC) recent report to the Minister for Sustainability, Environment, Water, Population and Communities (TSSC 2010). This submission aims to provide additional information or, where considered necessary, an alternative view on particular matters, without repeating the information already provided by the TSSC.

The Victorian Government has been actively managing Koalas in Victoria since the 1920s (see under 1b below). During the past 15 years, the Department of Sustainability and Environment (DSE) has actively participated in the preparation of the National Koala Conservation and Management Strategy 2009-2014 (NRMMC 2009) and its predecessor the National Koala Conservation Strategy (ANZECC 1998). Victoria has prepared a statewide Koala management strategy (DSE 2004) (attachment 1), as required under ANZECC (1998), and is implementing that strategy as resources allow.

It is important to note that the status of the Koala in Victoria is fundamentally different to that in New South Wales and Queensland because the greatest management challenge here relates to over-abundance rather than decline and rarity. Because of an over-abundance of Koalas at a small number of sites in coastal Victoria, the Koala has received more management attention and State resources during the past 15 years than any other Victorian wildlife species, including our threatened species. That is not to say that Koalas are flourishing everywhere in Victoria. The vigor and stability of populations varies with habitat quality and landscape context, such that some populations in fragmented or otherwise sub-optimal habitat may not persist in the long-term; this is a natural consequence of the continuous, dynamic interaction between any population and a changing environment.

Each of the terms of reference of the inquiry is considered below.

1. The iconic status of the Koala and the history of its management

a. Iconic status

The Koala has achieved iconic status as a very recognizable and well-known Australian faunal species. However, the relevance of this to the conservation attention that the species should receive is questionable. Victorian Government policy is to focus conservation attention and resources where they are likely to achieve the greatest conservation benefit. This includes a greater focus on understanding the ecological processes that sustain species and ecosystems, and working to minimize loss of biodiversity as a whole, while also maximizing the functionality of ecosystems (DSE 2010). The implication of this policy stance for the Koala is to emphasise management of over-browsing to protect vegetation communities from damage.

b. History of management

Koalas in Victoria have a unique history that has been well documented (e.g. Martin and Handasyde 1999, Menkhorst 2008 [attachment 2]). This history has, to a large extent, determined the present

conservation status of the Koala in Victoria and needs to be clearly understood when assessing priorities for Koala management in this State (DSE 2004).

Koalas are widespread in lowland and foothill forests and woodlands across southern, central and north-east Victoria where the annual rainfall exceeds about 500 mm. Population densities vary greatly with habitat quality. In some areas, population densities are unsustainably high and serious ecological degradation is caused by Koalas over-browsing their preferred food tree species [see Figure 1 of Menkhorst (2008)]. The broader ecological consequences of over-browsing can include the temporary (or permanent) loss or degradation of local flora and fauna species. High-density, but small (< 3000 individuals) populations on French Island, Raymond Island and at Tower Hill State Game Reserve are now being controlled by very intensive and expensive programs of mass contraception using modified human contraceptive implants adapted for the Koala by DSE and Parks Victoria (Middleton *et al.*. 2004). The efficacy of this approach in the control of large-scale over-browsing, such as that occurring at Mt Eccles National Park and in the Otway Ranges (> 10 000 individuals), is not yet clear, but it would require very high levels of resourcing.

In contrast, Koalas persist at low densities, less than one animal per ha, in drier, inland habitats - for example in box-ironbark forests across central Victoria - and at intermediate and sustainable densities in numerous other forested areas, such as the Strathbogie Plateau, the Lower Glenelg River region, the Ballarat-Bendigo region and South Gippsland.

This distribution is largely the result of a massive re-introduction program carried out by the Victorian Government since the 1920s. At that time the Koala had been reduced to a few small remnant populations. Fortuitously, Koalas introduced by local people to French Island and Phillip Island in the late-nineteenth century had flourished and provided a source of animals for re-introduction to selected forests on the mainland. This re-introduction program has been highly successful, to the extent that we do not know of any extensive area of Koala habitat in this State that does not support a Koala population.

2. Estimates of Koala population number

There is no population estimate for the Koala in Victoria – it is impractical to attempt to estimate total population number because the species is so widespread, is difficult to accurately census, and occurs at widely variant population densities.

Koala numbers are monitored at sites where active population management is taking place, but these areas represent only a tiny proportion (< 1%) of the Koala habitat in the State. Data provided to the National Koala Abundance Workshop, convened by the TSSC, was taken to indicate a population estimate of 73 500 koalas (TSSC 2010). However, this figure should not be taken out of context, as it was not meant to be an estimate of the total number of Koalas in Victoria. Furthermore, it is important to note that this estimate is certainly an under-estimate because Koala populations occur in many areas away from those for which population estimates were provided and many of the estimates were highly conservative.

At sites where Koala populations are being treated with contraception, population densities are estimated using a standardized transect count method involving repeated counts with distance sampling along fixed transects. These estimates are considered to be adequately rigorous for monitoring the effectiveness of the population management programs. Considerable improvement in the accuracy of population estimates is unlikely to be achieved until airborne heat sensing devices became available and are calibrated to detect Koalas in the forest canopy. Using this technology, nighttime aircraft transects have potential to accurately sample large areas of habitat.

3. Knowledge of Koala habitat

In Victoria, the Koala occupies a broad range of environments, from wet coastal woodlands to foothill forests, plains woodlands and inland riverine flood plains. These environments encompass numerous *Eucalyptus* communities with either an open-forest or woodland structure. DSE (2004) listed 26 *Eucalyptus* species that are known to be important Koala forage species in Victoria, but that list is certainly not exhaustive. Other tree species, including Coast Banksia and some Acacias, are important as shelter sites to reduce exposure to cold and heat when Koalas are not feeding.

It is well known that there is considerable variation in forage quality between *Eucalyptus* species, and between individual trees of a given *Eucalyptus* species, and that Koalas are skilled at detecting such differences (Moore and Foley 2005, Moore *et al.*. 2005). However, there is currently no readily-available means of measuring differences in forage quality across forest stands or landscapes, including how this might change in response to climate change. The development of a means of remotely sensing palatability differences in eucalypt canopies, and how these relate to environmental factors, such as underlying geology, water availability and stand age, would be a major step towards gaining a meaningful understanding of Koala habitat availability. Until such technology is available, the best approach to ensuring adequate habitat availability is to ensure that extensive areas of a range of open-forest and woodland *Eucalyptus* communities are available, growing on fertile soils and including valleys and lower slopes where water is less likely to be limiting. This habitat requirement is most readily met in extensive stands of forest (thousands of hectares in size) but can also be met in a mosaic of forested and cleared country where retained trees provide adequate habitat connectivity. Even isolated paddock trees can provide important refuge and food sources for Koalas inhabiting semi-cleared landscapes.

4. Threats to the Koala and its habitat

a. Tree removal

The major threat to any species is the loss or degradation of its habitat. In the case of the Koala, which has rather simple habitat requirements, habitat loss equates to the removal of trees or a widespread reduction in tree health. One of the main factors causing tree decline in Koala habitat in coastal Victoria is over-browsing by the Koala itself. This issue has been discussed under 1b above.

Victoria has a well-developed vegetation retention policy (DNRE 2002) that includes a target of 'no net loss'. Implementation of this policy has significantly reduced the rate of tree removal on both freehold land and crown land throughout the State. Further, revegetation programs, aimed at restoring connectivity between forest patches at a landscape scale, are increasingly common in regional Victoria, facilitated by the Landcare movement. Restoring connectivity will be of considerable benefit to the Koala, which is particularly susceptible to habitat fragmentation due to its specialisation to a low energy, low nutrient diet that leaves little scope for increasing energy expenditure in order to travel between habitat fragments (Hume 1990).

Cessation of logging in all but the high altitude forests of the Eastern Highlands and forests of East Gippsland means that there is now little interaction in Victoria between the timber industry and the Koala. Over the last decade or so timber harvesting has been phased out of the forests of western and central Victoria, the Otway Ranges and Murray Valley flood plains, which carry the best and most extensive Koala habitat in the State.

One area where Koalas and timber harvesting is an issue is the Strzelecki Ranges where private plantation forestry occurs in areas occupied by the genetically diverse South Gippsland Koala population. However, the timber company involved, HVP Plantations, is well aware of its responsibilities in this area and is in the process of developing a detailed Koala management strategy aimed at minimizing impacts on the Koala.

b. Disease

The disease *Chlamydiosis*, which can lead to infertility in female Koalas, has been a localized concern in the past, for example at Phillip Island and Halls Gap in the Grampians during the 1970s. While we know that the disease organism *Chlamydia* is present in most Victorian Koala populations (the notable exception being French Island, an important source of disease-free individuals), we are not aware of any current situations or populations where *Chlamydiosis* is affecting population viability. Therefore, we do not consider *Chlamydiosis* to be a significant threat to the conservation of Koala populations in this State.

Colomboma, a genetically transmitted eye condition that can cause blindness, has recently been diagnosed in koalas from Raymond Island in East Gippsland. The Department of Sustainability and Environment has changed the translocation protocols accordingly for this area in line with the Victorian Koala Management Strategy.

Koala retrovirus has been detected in Victorian overabundant koala populations. Its effect on population dynamics is unknown.

c. Elevated atmospheric CO_2 and climate change

A major emerging concern for Koala habitat is the impact of greenhouse gasses and climate change. Increased atmospheric CO_2 levels will have a direct impact, regardless of any effects on climate, because they reduce the amount of protein available in *Eucalyptus* foliage and increase the amount of tannin, a toxin for folivorous animals (Lawler *et al.* 1997). Thus, elevated CO_2 will trigger a progressive and ubiquitous decline in habitat quality for the Koala (and the other *Eucalyptus* folivore the Greater Glider). Because atmospheric CO_2 levels are predicted to continue to rise, even if effective carbon emission controls can be implemented, we currently have no mechanism for eliminating this effect.

Throughout the Koala's Victorian range, climate change predictions suggest drying conditions and higher temperatures, both conditions likely to reduce the moisture content of eucalyptus leaves. This has the potential to cause renal problems in Koalas, and numerous anecdotal reports of this were received during the extreme drought and heat conditions of the 2008/09 summer. Extended periods of extreme weather, for example days over 40 degrees, are also likely to result more directly in the mortality of individuals. Gordon *et al.* (1988) first noted this in Queensland during periods of eucalypt leaf drop, but it was also noted in Victoria in 2009. This is only likely to cause significant population decline in small or otherwise threatened populations, such as those in northern Australia.

Another predicted impact of climate change is an increase the frequency of wildfire, a threat against which the Koala has no defense. Fuel reduction burns designed to limit the impact of wildfire also have potential to deleteriously affect Koalas if the burns are hot enough to scorch the canopy, rendering it unpalatable.

d. Wildfires

Extensive wildfires in Victoria during the past decade have burnt a significant proportion of Koala habitat, including parts of the foothills of the Eastern Highlands, on both the northern and southern falls, the Strzelecki Ranges, Brisbane Ranges, Grampians, far south-west and Wilsons Promontory. The effect of these fires on Koala population numbers is unknown, but likely to have been significant due to direct mortality and starvation following the widespread removal of the eucalypt canopy. Overlaying a map of potential Koala habitat on a map of areas burnt by wildfire indicates that roughly 15% of Victoria's Koala habitat has been burnt at some level of intensity since 2000. On the plus side, the elevated nitrogen content of the foliage of regenerating eucalypts provides high

quality forage, and remnant Koala populations, surviving in unburnt patches, are capable of rebounding quickly as the habitat regenerates.

e. Loss of genetic variability

A particular concern for the Koala in Victoria is the loss of genetic variability due to the low founder base of the island populations used to re-populate the mainland. This lower genetic variability may reduce the capacity of Victorian Koala populations to cope with environmental change, although there is little indication of any particular problems at present. Given the scale of the re-introduction program, there are no practicable responses to overcome this reduced genetic variability. It does, however, highlight the importance of conserving the genetically diverse South Gippsland population which has not been subject to genetic swamping by island-derived animals (DSE 2004).

f. Dogs, urbanization and vehicle collisions

While predation by dogs and vehicle collision mortality have been identified as important threats to the Koala in northern parts of its Australian range, these are not known to be significant in Victoria. Loss of habitat due to urbanization is an issue at a local scale (e.g. Inverloch, Macedon and Ballarat/Creswick), but is mitigated by Victoria's native vegetation management policy (DSE 2002). Victoria's park reserve system provides further protection.

5. Listing the Koala under the *Environment Protection and Biodiversity Conservation Act 1999*

The Victorian Government acknowledges that this decision is the responsibility of the Commonwealth Minister, after considering advice from the TSSC. It is noted that three nominations over a period of only 14 years (1996, 2004, 2010) have not resulted in advice from the TSSC to the Minister to list the Koala. The Victorian Government also notes that the most recent assessment of the conservation status of the Koala by the International Union for the Conservation of Nature (IUCN), at an IUCN Global Mammal Assessment Workshop held in Adelaide in August 2005, determined that the Koala ranked as 'Least Concern' (www.iucnredlist.org).

6. Adequacy of the National Koala Conservation and Management Strategy

The Victorian Government considers the National Koala Conservation and Management Strategy to provide an adequate and useful framework that complements Victoria's Koala Management Strategy at the national level. However, as noted in the review of the previous strategy (Parsons Brinckerhoff 2008), without dedicated funding the national strategy is unlikely to be fully implemented and, therefore, is unlikely to reach its potential to improve and secure the conservation status of the Koala.

7. Appropriate future regulation for the protection of Koala habitat

For almost a decade, the Victorian Government has been implementing and refining a comprehensive habitat protection policy. The goal of this framework is a reversal, across the entire landscape, of the long-term decline in the extent and quality of native vegetation. The removal of native vegetation is regulated through a permit system. Vegetation clearing is avoided wherever possible. Where clearing is unavoidable, its impact is minimized, and where clearing is permitted its impact must be offset with gains in the extent and quality of vegetation elsewhere. The Victorian Government considers that this policy is an adequate regulatory mechanism for the protection, enhancement and restoration of Koala habitat in the short- to medium-term. However, it will not overcome the longer-term threats posed by elevated atmospheric CO_2 or climate change. Actions to restore connectivity of Koala habitats across its range will also be important in securing the long-term future of the species.

Concluding remarks

Viewed statewide, the Victorian Government believes that the conservation status of the Koala in Victoria is secure. Its broad distribution and high population densities, combined with habitat protection measures now in place, provide some confidence that the species is buffered against the impacts of the major threats discussed above. The threats are not likely to impact directly on all populations at any one time. In the longer term, however, climate change scenarios that indicate reduced rainfall and increasing threat of wildfire pose serious concerns about the future prospects of the Koala in Victoria.

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References

ANZECC 1998. *National Koala Conservation Strategy*. Environment Australia, Canberra, ACT.

DNRE 2002. *Victoria's Native Vegetation Management: A framework for action.* Department of Natural Resources and Environment, Melbourne.

DSE 2004. *Victoria's Koala Management Strategy.* Department of Sustainability and Environment, Melbourne, Victoria.

DSE 2010. Draft *Biodiversity is Everybody's Business: Victoria's biodiversity strategy 2010-2015*. Department of Sustainability and Environment, Melbourne, Victoria.

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

Hume, I.D. 1990. Biological basis for vulnerability of Koalas to habitat fragmentation. Pp. 32-35 in *Koala Summit: Managing Koalas in New South Wales*. Proceedings of the Koala summit held at University of Sydney, 7-8 November 1988. Ed by D. Lunney, C.A. Urquhart and P. Reed. New South Wales National Parks and Wildlife Service, Sydney.

Lawler, I.R., Foley, W.J., Woodrow, I.E., and Cork, S.J. 1997. The effects of elevated CO_2 atmospheres on the nutritional quality of *Eucalyptus* foliage and its interaction with soil nutrient and light availability. *Oecologia* 116:160-169.

Martin, R. and Handasyde, K. 1999. *The Koala: Natural history, conservation and management.* University of New South Wales Press, Sydney.

Menkhorst, P. 2008. Hunted, marooned, re-introduced, contracepted: A history of Koala management in Victoria. Pp 73-92 in *Too Close for Comfort. Contentious issues in human-wildlife encounters*. Ed. by D. Lunney, A. Munn and W. Meikle. Royal Zoological Society of New South Wales, Mosman, New South Wales.

Middleton, D. R., Walters, B, Menkhorst, P. and Wright, P. 2003. Fertility control in the koala, *Phascolarctos cinereus*: The impact of slow-release implants containing levonorgestrel or oestradiol on the production of pouch young. *Wildlife Research* 30: 207-212.

Moore, B.D. and Foley, W.J. 2005. Tree use by koalas in a chemically complex landscape. *Nature* 435: 488-490.

Moore, B.D., Foley, W.J., Wallis, I.R. Cowling, A. and Handasyde, K.A. 2005. *Eucalyptus* foliar chemistry explains selective feeding by koalas. *Biology Letters* 1:64-67.

NRMMC 2009. *National Koala Management and Conservation Strategy*. Department of Environment, Water, Heritage and the Arts, Canberra.

Parsons Brinckerhoff 2008. *Review of progress in implementing the 1998 National Koala Conservation Strategy*. Department of Environment, Water, Heritage and the Arts, Canberra.

TSSC 2010. Advice to the Minister for Environment Protection, Heritage and the Arts from the Threatened Species Scientific Committee on amendment to the list of threatened species under the Environment Protection and Biodiversity Conservation Act 1999 – *Phascolarctos cinereus.*