

**Nomination Form for listing, changing the status, or  
delisting a native species under the *Environment  
Protection and Biodiversity Conservation Act 1999*  
(EPBC Act)**

To fill out this form you must refer to the attached Guidelines for species nominations.

**Species Details**

**Scientific Name of the species:**

*Phascolarctos cinereus*

**Common Name or Names (if any) by which the Species is known:**

Koala

**Is the species conventionally accepted?**

Yes

No\*

**\*If the species is NOT conventionally accepted, please provide:**

(i) a taxonomic description of the species in a form suitable for publication in conventional scientific literature; or

(ii) evidence that a scientific institution has a specimen of the species and a written statement signed by a person who is a taxonomist and has relevant expertise (has worked, or is a published author, on the class of species nominated), that the person thinks the species is a new species

**Category for which the species is nominated under the EPBC Act:**

Extinct

Extinct in the Wild

Critically Endangered

Endangered

Vulnerable

Conservation Dependent

Delisting

## **Justification for this nomination**

**For a Critically Endangered, Endangered or Vulnerable species nomination, please provide material that shows why the species meets at least one of the criteria as listed in the Guidelines for nominations. The Committee encourages nominations which are as comprehensive as possible against as many of the criteria as are relevant.**

### **Justification for Vulnerable Nomination for the Koala**

#### **1.0 Background**

##### **1.1 Previous nominations**

In 1995, the Australian Koala Foundation (AKF), jointly with Humane Society International (HSI), nominated the Koala for national Endangered or Vulnerable listing under the provisions of the Endangered Species Act 1992. Although the Endangered Species Scientific Subcommittee (ESSS) recommended against the listing, it advised the Minister that the Koala “is clearly declining in parts of its range and there is much scientific and public concern about its conservation. Because the Koala is declining, ESSS will consider its status again in 5 years”. HSI submitted another nomination for the Koala in late 2001, without AKF’s participation. As a result, the Minister wrote to AKF in April 2002 advising that there was “no compelling publicly available data or information to support the suggestion that the Koala has significantly declined or become more threatened at a national level”, but advised AKF that the Koala would be re-eligible for nomination should “new or additional scientific information be made available which indicates the Koala is under a new or increased level of threat such that its survival is threatened nationally”. Notably, we were not made aware of the fact that the Humane Society had requested a re-appraisal in 2001. Had we known, we would have delayed the assessment because from what we understood, no new scientific data had been sent for the Minister and Committee to evaluate.

Given our Foundation’s scientific expertise pertaining specifically to the Koala (derived from its 18 year history) and comprehensive, unprecedented body of scientific evidence,

we consider it imperative that the Commonwealth Government takes another, more concerted and scientifically-rigorous look at the current status and future of this species. In recent times, AKF has taken legal advice (Appendix 1) regarding a further nomination in a bid to protect the Koala from any further negative responses from the committee. It is AKF's view that in the past, experts whose opinions were sought either cited their own personal views or made comments that lacked scientific merit. For example: "there is no evidence that Koala populations are threatened by forestry activities", "Koala is essentially a woodland, not a forest animal and that logging in native forests managed for timber production is not a problem for Koala conservation", "Regrowth resulting from logging favours Koalas, evidently more than compensating for any disadvantage caused by loss of old growth trees", and "that he saw no immediate and significant threat to the species". Should this nomination be rejected, AKF is aware that we have opportunity for recourse. We understand our legal and legislative options and wish to make it clear that should this nomination be refused that we will be seeking full recourse through the courts as to why and in what manner it was refused. Unless significant scientific data are provided as a basis for opposing this listing, we wish to make it clear that the Minister and his committee will be under immense scrutiny.

The level of protection that the Koala's declining status warrants is, in our experience, long overdue (if for no other reason than to safeguard its iconic status and enormous economic benefit to our country) (Appendix 2). This nomination presents sound ecological arguments for affording Vulnerable status as a matter of national urgency. Given the sheer size of our country relative to the availability of scientific resources, it is not possible, of course, for any scientist (including our own) to argue with absolute certainty the case for every single Koala population in Australia. This nomination does, however, satisfy the criteria associated with the Act for many key populations that provide reliable indicators of the true status of the Koala across its natural range.

Should the Minister's scientific committee raise any doubts with regards to any deficiencies in arguing our case, then we would argue that unless it can provide substantial data to argue to the contrary, that a precautionary approach must be taken. Although hopeful that political forces will not be brought to bear whilst this nomination is processed, our real-world past experiences alert us to the role that politics often plays wherever the Koala is concerned. Whatever role it assumes in this nomination, we are

confident in the quality and validity of our science in terms of it meeting the criteria and presenting an urgent case for recognising the Koala's Vulnerable status.

The Koala should be seen as a symbol of what can be achieved when the Commonwealth Government makes the positive step of intervening in its protection before it is too late. Across the globe, it is widely recognised that if a country waits until a species reaches Endangered status, that in most cases by this stage it is unfortunately too late. It is our intention to remind Australia that in at least one case – the Tasmanian Tiger - the Commonwealth Government only acted in the last few months preceding the species' extinction. The species was listed in June 1936 only to be declared extinct September 7, 1936.

The paper 'Black August' (Appendix 3) describes how in 1927, the Commonwealth constantly refused to intervene in states' rights when conservationists of the day were calling for an end to the Koala fur trade. We are concerned that, some 77 years on, present arguments might mirror those given so long ago. The states (previous and present) have proven incapable of protecting the Koala and its habitat. While travelling in Queensland, the then Prime Minister, Stanley Bruce, was quoted as telling the Mayor of Warwick that he was "continually getting into trouble for interfering with State rights, and the native bear question was a State matter". He was prepared to concede, however, that the matter of exportation (of Koala skins during the fur trade) was one of Commonwealth control. Conservationists of the day – including the Wildlife Preservation Society in a letter to Prime Minister Bruce - strongly suggested that the Federal Government step in to protect the Koala from the last cull on record. They argued that it was of "general Australian interest" in that the Queensland Government's action would neutralise the good effects of protection in the other states. Page 77 of Black August states "The Commonwealth Government's apathetic attitude towards putting an end to a slaughter which it knew had not ceased made the task of saving the Koala an even more difficult one".

We are concerned that nothing has changed. AKF and others have continually tried, without success, to engage both sides of the House in discussion and action to address the Koala's diminishing status. In May 2000, the United States Government determined that the Koala meets the criteria for vulnerable (Appendix 4). This is the second time

Australia has needed to ask for America's help with regards to the Koala and it is interesting to note that it was essentially only President Hoover's intervention in refusing to receive Koala skins into America that forced the fur trade to cease. At the time, Australia's governments were not prepared to demonstrate such foresight.

We ask both the Minister and his scientific committee to have this foresight. We want you to be visionary and bold now in taking the necessary steps to ensure that at some time in the future, Australians will not have to bear the shame of the Koala's extinction.

Based on our 18 years of experience monitoring the decline of fragmented Koala populations, it is our expert opinion that the proposed level of protection will be critical to ensuring a future for Australia's wild Koalas across their natural range. In addition, it will indirectly benefit many other species that inhabit our continent's eucalypt woodlands.

**Recognising that what we are submitting is likely to be unprecedented in terms of reflecting the largest body of scientific research undertaken for any one species in Australia, we hereby provide a comprehensive collation and synthesis of analyses carried out by the Australian Koala Foundation and external scientists as compelling evidence for an urgent national Vulnerable listing under the EPBC Act.**

### **1.2 How current knowledge differs from previous nominations**

A number of major advances have been made since the previous nomination for Koalas to be listed as federally Vulnerable. New information has been gained in relation to widespread Koala conservation status and ecology, habitat identification and mapping, rates and extent of habitat loss, disease, genetics, impacts of habitat fragmentation, population monitoring, and approaches to conservation planning.

Koala population declines have now been documented or modelled from a wide range of study sites. It is now possible to more reliably estimate the dramatic extent of Koala habitat loss and fragmentation based on the National Vegetation Information System mapping (2001) and local studies such as the AKF Koala Habitat Atlas project described below. These recent data are critical for appreciating the recent escalation of degradation

and destruction of Koala habitat in what are already largely cleared and fragmented landscapes. Furthermore, the need for connectivity of native vegetation at not only property, but regional and landscape levels, is being increasingly reflected in the scientific literature and by regional landscape planning and habitat restoration bodies.

Impacts of habitat loss and fragmentation on Koala populations and their prospects for survival have recently been investigated during a three-year ARC SPIRT research project through the University of Queensland, in partnership with the Australian Koala Foundation and the NSW National Parks and Wildlife Service. This research confirms that Koala populations are less likely to persist in highly fragmented landscapes and suggests that thresholds in habitat loss and connectivity have probably already been surpassed for the majority of remaining Koala populations.

This nomination presents, for the first time, the collated results and analyses of Koala-specific data collected at **1,109 field sites**. Extensive data have been collected from these sites, including Koala usage and other data from **51,447 trees**. This is supported by Koala Habitat Atlas maps recently generated using mapping methodology and technology that was either not available or has been significantly refined and updated since the 1996 nomination. This mapping methodology and project was awarded the highly prestigious Computerworld Smithsonian Award for innovative use of technology in Washington, DC in 1998. This body of evidence is further supplemented by analyses of detailed records (*e.g.* hospital data) contributed by a number of special interest groups such as Koala carer groups who work at the ‘coal face’ of Koala decline. Furthermore, the conservation status of a number of case study areas, for example South East Queensland, has recently been determined using population modelling and data analysis. Sadly the listing of the Koala as Vulnerable throughout the Southeast Queensland bioregion is the lynchpin to our argument and we could argue that all populations east of the dividing range from Newcastle to Gladstone face the same or similar pressures. It would be impossible for them to be in better shape than this population. Southeast Queensland is unarguably the stronghold for Koalas on the east coast. No other population has greater numbers, despite having an estimated future of as little as 10-15 years if threats are not abated.

It is also important to note that this nomination does not pertain to the small number of

isolated Koala populations located outside of the Koala's natural range (see below).

**KEY POINT: New research confirms Koala populations are less likely to persist in highly fragmented landscapes and suggests habitat loss and connectivity thresholds have probably already been surpassed for the majority of remaining Koala populations.**

### 1.3 AKF research

AKF has undertaken Koala Habitat Atlas research over the past 11 years. During this time, data have been collected on over 51,400 trees from more than 1,100 field plot sites in project areas from Southeast Queensland, through much of eastern and central New South Wales, to Ballarat Shire and the Strzelecki Ranges region in Victoria. Analysis of these data has provided local-scale information on Koala tree species and habitat preferences (*e.g.* Phillips & Callaghan 2000; Phillips *et al.* 2000; Lunney *et al.* 1998), which underpins Koala Habitat Atlas maps currently covering approximately 4 million hectares. The field surveys and data analysis has also provided important information on habitat clearing, fragmentation, disturbance and degradation. AKF Koala Habitat Atlases have been used as the basis for preparing three Comprehensive Local Government Area (LGA)-wide Koala Plans of Management (CKPoMs) in NSW under *State Environmental Planning Policy No.44-Koala Habitat Protection*: namely Port Stephens Council CKPoM (Port Stephens Council 2001); *draft* Greater Taree City Council CKPoM (Callaghan *et al.* 2002); and *draft* Campbelltown City Council CKPoM (Callaghan *et al.* 2003).

In addition, the AKF has undertaken detailed studies and conservation planning for Koalas and other threatened species in conjunction with the Koala Beach development in the Tweed LGA on the far north coast of New South Wales.

AKF Koala Habitat Atlas mapping project locations and field survey sites are shown on Map 1 attached. AKF has contributed in excess of \$4 million towards this project, not

to mention countless hours of volunteer time in helping us to gather data (Appendix 5). It is important to recognise here that each and every tree – all 51,447 – has been individually measured by a Koala-loving volunteer from somewhere in the world. An astounding achievement and unprecedented anywhere in the world as far as we are aware.

#### **1.4 Other research funded by the AKF**

Over the past 16 years, AKF has provided more than \$1.2 million in funding for Koala research through universities and government departments in Queensland, New South Wales, Victoria, South Australia and Tasmania. Approximately 50 projects have been funded during this time including Honours, Masters and PhD programs. The range of research topics funded by the AKF have included Koala population ecology and dynamics, Chlamydia and other disease research, genetic studies, reproductive biology, anatomy and physiology, diet and nutrition, habitat ecology, population risk assessments, management and recovery, ecological history and conservation planning. These projects have provided enhanced understanding of Koala biology and ecology from a multitude of locations throughout many parts of the Koalas geographic range, from the Mulgalands and Brigalow Belt in Queensland, numerous areas in New South Wales, South Gippsland and Raymond Island in Victoria, to Kangaroo Island and the Mt Lofty Ranges in South Australia. This body of research, together with that undertaken by the AKF, has been heavily drawn upon in preparing this Federal nomination.

Details concerning the research projects and their locations, the researchers and institutions funded, and relevant publications are shown on Map 1 attached.

#### **1.5 Our proposal for Victoria**

Based on advice we have received from scientists at the University of Queensland, and statements made in the IUCN Red List Categories and Criteria, this nomination does not pertain to the nine isolated Koala populations located outside of the Koala's natural range. In this way, a Vulnerable listing will not attract the controversial genetic and management issues associated with the aberrant populations of Victorian and South Australian isolates and islands, specifically: Tower Hill, Framlingham, Mt. Eccles,

Sandy Point, French Island, Phillip Island, Raymond Island, Snake Island and Kangaroo Island. In our opinion, these populations are subject to management and research that falls outside the normal requirements of a recovery planning process. As the United States Government stated in their determination “As we pointed out in the proposed rule, the actual number of Koalas that were present at various times in the past and that may still exist is of much interest and helps to give some perspective but, as for many species, may not be the critical factor in determining whether the species is threatened. A low figure may reflect natural rarity of a population in marginal habitats. A high figure may be misleading if the entire habitat of the involved population faces imminent destruction”. AKF would further argue that imminent isolation and/or loss of ecological functioning may be similarly crucial.

### **1.6 How Koalas will benefit from a Federal Vulnerable listing**

AKF hopes a Vulnerable listing will help pave the way for meaningful protection for the Koala. This has not been the Koala’s experience to date, with existing legislation in each state having played no role in preventing the dramatic declines documented in this nomination (despite some having the potential to do so).

In being listed as Vulnerable, the Koala will test the EPBC Act’s power to protect a species and it’s habitat. It follows that many key issues will need to be resolved. It remains to be seen whether this Act is capable of preventing habitat damage and fragmentation. As we know "land clearing", is not a trigger for the Act. Will the Act, for example, be able to step in when injurious affection in Queensland takes control over a prime piece of habitat (injurious affection is where landholders can be compensated if they are prevented from developing their land).

We must be optimistic, however, that a Vulnerable listing would benefit Koalas by providing a legislative basis for establishing a consistent approach to the management and recovery of Koala populations and Koala habitat throughout their remaining range. The AKF is also hoping that a new and innovative Recovery Plan could be created to meet the needs of the Koala. The AKF would not like to see a Recovery Plan written and then languish on the shelves of inactivity. We have watched Koala Plans of Management in a number of local authorities do so. A meaningful recovery plan could

include the identification and mapping of core Koala populations and critical Koala habitat, as well as the design and implementation of programs for habitat protection, management and restoration. This would benefit many other species, not just the Koala. It has been our experience in mapping local shires (see for example the attached Port Stephens and Noosa Koala Habitat Atlas maps), that the mapped and ranked Koala habitat represents a significant amount of the remaining vegetation. Mapping of critical Koala habitat is essential in order to direct resources to priority areas requiring immediate conservation efforts. We believe that this could best be achieved at a national level through an innovative National Koala Recovery Plan incorporating incentives schemes for private property owners such as might be achieved through taxation legislation, federal funding and cooperative arrangements to support State-based conservation programs. To date, AKF believes that there has been no meaningful process where landholders of biodiversity are adequately compensated by innovative ideas for conservation. Innovative models for tax reform could be created as part of a National Koala Recovery Plan. This Plan could also make provisions for regular monitoring and reporting on the conservation status of Koalas and Koala habitat, which might include a future follow-up national Koala survey.

### **1.7 Ecological characteristics of Koalas**

Koalas are ecological specialists that feed predominantly on the leaves of selected (or preferred) species of *Eucalyptus* (Phillips & Callaghan 2000; Phillips *et al.* 2000). The food tree species preferences of Koalas are known to vary regionally (NPWS 2003). Koalas are also known to use other *Eucalyptus* species and a range of non-eucalypt species as supplementary food and shelter resources (Phillips & Callaghan 2000; Phillips *et al.* 2000; NPWS 2003). The Koala varies in size across its range from an average weight of approximately 6.5kg in Queensland to ~ 12kg in Victoria. Males can weigh as much as 50% more than females (Martin and Handasyde 1999). Females reach sexual maturity at around two years of age (Martin & Handasyde 1990), and whilst they could theoretically produce one offspring each year, this does not generally occur because of the metabolic pressures associated with lactation and the poor nutrient status of their preferred food resources (NPWS 2003). Further information on the feeding behaviour and habitat requirements of Koalas is outlined through this nomination.

## **2.0 The AKF Team**

This document reflects the collective effort, knowledge and expertise of the Australian Koala Foundation as well as the significant contributions of many external individuals, organisations and groups within Australia and beyond. It reflects 18 years of AKF's practical experience monitoring the decline of fragmented Koala populations, during which time our knowledge-base and expertise has enjoyed significant expansion and refinement.

The result is a submission that is likely to be unprecedented in terms of reflecting the largest body of scientific research undertaken for any one species in Australia. This has been achieved at no expense to Australian tax payers, but through the generosity of AKF supporters across the globe, committed staff and dedicated volunteers – including past and present AKF board members whose contribution has been invaluable.

The following sections of this nomination that address the listing criteria have been prepared on behalf of the Australian Koala Foundation (AKF) by John Callaghan (Chief Ecologist, Head of Conservation & Research), Carol de Jong (Research Officer), Renee Sternberg (Research Officer), Jane Thompson (Research Officer), Dave Mitchell (GIS Specialist), Rolf Schlagloth (Liaison Officer: Victoria) and Christophe Blanc (Ecologist, AKF volunteer). The document has been edited by Science Writer, Ms. Julie Hinchliffe. At the time of writing and to our knowledge, our nomination has been supported by many scientists including Dr. Flavia Santamaria, Dr. Clive McAlpine, Mr. Pat Prevett, Professor Paul Canfield, Dr. R. Carman, Dr. P.F. Woodall, Dr. Greg Baxter, and Dr. B. Sherwin. Other may have written to the Minister directly. Koala Carers and carer groups around the country who also support this nomination include: Hunter Koala Preservation Society, Tanilba Bay (NSW), Jill Taylor (NSW), Bob Westbury (NSW), Ron Swan (NSW), Peter Kenway (NSW), G.A. Parker (NSW), Brenda Taylor (NSW), A.E. Arnold and Family (NSW), Murray Black (NSW), The Myall Koala and Environment Support Group. Inc, Hawks Nest (NSW), Cheryl Tyler (NSW), Narrandera Koala Regeneration Centre (NSW), John A. Sullivan (NSW), Geoffrey Sullivan (NSW), John Foster (NSW), Athol Jackson (NSW), Antonio Andracchio (NSW), Ian M

Lockhart (NSW), Mrs D. A. Collins (NSW), Archdeacon John Gibson (NSW), Alastair J. MacDonald (NSW), A.F. Mc Vicker (NSW), Mark Robertson (NSW), David Cooturton (NSW), Ken Langley (NSW), Koala Rescue and Rehabilitation, Tyabb (VIC), Jennie Bryant (VIC), Michael Abott (WA), Betty Economos (NSW), John Clarke (NSW), Wanda Grabowski, Pine Rivers (QLD), Mr. Don Sinclair, Gympie, (QLD), Jean Goodwin, QNAC (QLD), Bronwyn Hickey (QLD), J McCloud (QLD), Lynn F Frigg (NSW), Neville David Rose (NSW), Megan Benson, Greater Taree, (NSW), Jean Shaw, Hawks Nest (NSW), Jeny Calway, Esk (QLD), Mr Mark and Mrs. Jane Powell, Noosa Veterinary Clinic, Julie Prior, (VIC), Pam Strykowski, WIRES (NSW), Lorraine Vass, President, Friends of the Koala, Native Animal Trust Fund, Port Stephens, (NSW) and Australian Fauna Care (Appendix 6).

It would not have been possible without the tireless commitment of the National Board of the Australian Koala Foundation, Current Chairman, Mr. Robert Lockhart Gibson, Vice Chairman, Dr. John Woolcock, Mr. Barry Scott (Founder), Mr. Nigel Stubbs, Mr. Andrew Timbs, Ms. Aileen Bratton, Mr. Russ Dickens, and the Friends of the Australian Koala Foundation, in the United States, Mr. Joseph Heywood, Mr. Donald Lehr and Ms. Amy Frey. This nomination reflects at least a dollar amount of \$5.2m that has, by and large, been raised by selling t-shirts, merchandise and donations from a generous world public. AKF staff are an incredible group and I personally want to thank Mrs Lorraine O'Keefe, Ms. Jane Mathers, and Ms. Jo Knights, all of whom have been loyal and committed to the Koala for over 13 years.

Hundreds of postcards of support have also been sent directly to the former Minister for the Environment, Dr. David Kemp and an international campaign to Mr. Ian Campbell, the new Minister, will ensue after the nomination is lodged. It is interesting to note that 40 organisations in both Australian and the United States supported the listing in the United States and that the U.S. Federal Government received some 3000 responses from individuals around the globe. The Minister can expect a similar response in Australia.

### **3.0 Forward**

AKF cannot express strongly enough our concerns for the Koala. The research findings reported in this submission define the Koalas' clearly diminishing prospects, particularly on the east of the Great Dividing Range where relentless urban expansion represents an ongoing, and often increasing, threat. The Vulnerable listing recently afforded to the Koala in the Southeast Queensland Bioregion is a regrettable reflection of the states' inadequate planning regimes that purport to be in place to protect this unique species. It is with a great sense of urgency that we convey to the Threatened Species Committee and the Minister for Environment and Heritage the urgent need for formal recognition of the Koala's vulnerability across its natural range via a national Vulnerable listing. We also emphasise that the arguments put forward in this nomination are clearly separate from - and cannot be diminished by - the small number of islands and isolates (nine) within which Koalas are perceived to be a management issue. Rather, this nomination acknowledges outright, the tendency for the 'isolate problem' to be used as a 'smoke screen' over the scientific arguments for the Koala's protection that hold for the remainder of the country.

**A Vulnerable listing will accurately reflect the true status of Koalas persisting in remnant habitats throughout their natural range.**

We also draw attention to the fact that the applicability of the IUCN Red List Criteria is generally restricted to species that occur **over smaller geographic ranges** and for which **population numbers** can therefore be **more easily quantified**. We are confident, however, that the Threatened Species Committee will look beyond this limitation and past debates to the more pertinent and urgent issues that directly affect Koalas, including the clearing, degradation and fragmentation of their habitat and the immense ongoing impacts on remaining local and regional Koala populations throughout their natural distribution. The permanent loss of the Koala would incur significant ecological, economic and cultural costs. Rather than waiting until the situation escalates, we urge the Threatened Species Committee and the Minister for Environment and Heritage to take immediate action and in doing so, approach this issue in a manner consistent with precautionary principles. Prompt and decisive action taken at this time will increase the

potential for widespread recovery over the decades ahead. From a purely economic and preventative view, a precautionary approach would mirror the principle upon which the Sustaining our Natural Systems and Biodiversity report rests - that it is far cheaper to maintain our natural systems than it is to allow them inadvertently to be damaged and, subsequently, to inherit a costly repair bill (Prime Minister's Science, Engineering and Innovation Council 2002).

#### **4.0 Criteria for Vulnerable Listing**

**Criteria 1: It has undergone, is suspected to have undergone or is likely to undergo in the immediate future a substantial reduction in numbers.**

**Criteria 2: Its geographic distribution is precarious for the survival of the species and is limited.**

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

**Criteria 4: The estimated total number of mature individuals is low.**

**Criteria 5: The probability of its extinction in the wild is at least 10% in the medium-term future.**

**5.0 Addressing Criteria 1: It has undergone, is suspected to have undergone or is likely to undergo in the immediate future a substantial reduction in numbers.**

**Relevant IUCN Red List Criteria:**

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of  $\geq 50\%$  over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are: clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
  - (a) *direct observation*
  - (b) *an index of abundance appropriate to the taxon*
  - (c) *a decline in area of occupancy, extent of occurrence and/or quality of habitat*
  - (d) actual or potential levels of exploitation
  - (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
  
2. *An observed, estimated, inferred or suspected population size reduction of  $\geq 30\%$  over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.*
  
3. A population size reduction of  $\geq 30\%$ , projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.
  
4. An observed, estimated, inferred, projected or suspected population size reduction of  $\geq 30\%$  over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, AND where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

## **5.1 NATIONAL CONTEXT**

Koalas are classed as *Near Threatened* in the National Action Plan for Monotremes and Marsupials (Maxwell *et al.* 1996). Koalas are currently listed as *Vulnerable* in the Southeast Queensland Bioregion and as *Protected Wildlife* elsewhere in Queensland

under the *Nature Conservation Act 1992*; as Vulnerable throughout NSW under the *Threatened Species Conservation Act 1995*; and as Rare in South Australia under the *National Parks and Wildlife Act 1972*. The species is not currently listed as threatened in Victoria or the Australian Capital Territory.

In reporting on the 1986-87 nationwide Koala survey, Phillips (1990) stated that **local Koala population extinctions are inevitable in northeast New South Wales and southeast Queensland unless land management practices take account of habitat requirements**. Similarly, Melzer *et al.* (2000) maintained that the population decline is likely to continue unless current habitat clearing regimes change, especially in New South Wales and Queensland. Norton and Neave (1996) argued that **absolute numbers of Koalas may mean very little over the long term if remaining populations are largely restricted to marginal habitats and fragmented core areas**.

Melzer *et al.* (2000) state that evidence suggests the national Koala population declined dramatically in the early 1900s due to habitat loss, hunting, disease, fire and drought. In addition to reporting that **declines are continuing in Queensland and New South Wales, they recommend that the conservation status needs to be reviewed in light of extensive land clearing in both states since the national Koala survey in 1986-87**. Melzer *et al.* (2000) propose that broad-scale clearing should be curtailed and that regular national Koala surveys should be undertaken. We recognise that while land clearing legislation has been enacted in both states, authorised clearance represents a significant ongoing issue. In Queensland, a ballot will be conducted in 2004 for the clearing of ~ 500,000 hectares of remnant vegetation – much of which is known to be important to Koalas – over a two-year period, with minimal control on clearing of regrowth vegetation except for endangered ecosystems. National studies of rates of habitat clearing reveal that clearing is a contemporary – not purely historical - issue. During 1999, for example, it is estimated that governments granted permits for clearing a total area in excess of one million hectares of vegetation (Australian State of the Environment Committee, 2001). Another study, which examined the effectiveness of tree clearing legislation on vegetation clearing in central western New South Wales (Nyngan region), found that the implementation of the Native Vegetation Conservation Act 1997 appeared not to have significantly reduced the level of clearing. In fact, annual clearing rates in Nyngan increased after the introduction of the Act (Scully

2003).

### **5.1.1 National Koala Conservation Strategy**

The National Koala Strategy, whilst providing a valid framework for Koala conservation, has not resulted in actions that will halt the widespread decline of Koala habitat and Koala populations at local, state or national scales. In fact, AKF would argue that it has played no meaningful role in the real life management of Koala habitat in Australia. Although the document shows some innovative thinking, realistically there is no way for this thinking to be incorporated into the activities of local government or planning authorities. This is because, in many cases, there is no matching economic support for landholders affected by re-zoning in an endeavor to protect Koala habitat. The National Koala Conservation Strategy (ANZECC 1998) was prepared jointly by the Commonwealth, States and Territories through the Australian and New Zealand Environment and Conservation Council to provide a national framework for Koala conservation. The main aim of the strategy is **“to conserve Koalas by retaining viable populations in the wild throughout their natural range”**. The strategy makes the following recommendations concerning the conservation of Koalas and Koala habitat in the wild:

#### **Conservation of Koalas in their Existing Habitat**

Identification and conservation of significant Koala habitat; development of monitoring programs for Koala habitat and Koalas at national, regional and local level; integration of Koala conservation planning into local government planning processes; development of incentive-based mechanisms for the conservation of Koala habitat on private land; implementation of strategies to minimise impacts of dogs on Koala populations; development of appropriate road designs in Koala habitat; and inclusion of threats such as fire, extractive industries, disease and drought in government strategies.

#### **Restoration of Koala Habitat and Populations**

Revegetation to restore habitat and habitat links to facilitate natural dispersal; encourage habitat retention and restoration on private land; integration of Koala conservation

measures more effectively into government revegetation programs; and compliance with IUCN Translocation Guidelines (1987) for re-introduction and restocking programs.

#### **Develop a Better Understanding of Koala Conservation Biology**

Rigorous scientific research, essential to guiding effective Koala management practices including assessment of Koala populations and population dynamics; identification, ranking and mapping of Koala habitat; development of approaches to Koala population and habitat recovery; and assessment of the economic and other non-biological values of Koalas.

#### **Ensure Community Access to Information at National, State and Local Scale**

Development of educational material to provide accurate information about the distribution, conservation and management of Koalas; and community involvement in Koala conservation.

**KEY POINT: Whilst the National Koala Strategy provides a valid framework for Koala conservation, the strategy has not resulted in actions that will halt the widespread decline of Koala habitat and Koala populations at local, state or national scales.**

#### **5.1.2 Overall Koala Distribution**

For the purposes of this nomination, an approximate geographic distribution for Koalas has been prepared, derived primarily from available historical and recent Koala records (see Map 1 attached).

Within this overall geographic range, quite extreme variations are common in terms of the areas of current occupancy and Koala densities. Research undertaken by the Australian Koala Foundation and other researchers confirms that remaining Koala populations are often fragmented and isolated, primarily in response to habitat clearing and landscape-scale fragmentation. Koalas and Koala faecal pellet evidence is

commonly lacking from many areas within the Koala's overall distribution. This has been attributed to the general loss of habitat connectivity, combined with the frequent small size, degraded nature and patchiness of much of the remaining habitat (*e.g.* Phillips 1990; Reed *et al.* 1990; Patterson 1996; Callaghan *et al.* 2002; Callaghan *et al.* 2003). Ecological history research on the Koala (*e.g.* Knott *et al.* 1998; Seabrook *et al.* 2003) provides further evidence in support of the argument that Koalas were historically more widespread and far more abundant within their overall distribution than they are today.

**KEY POINT: Koalas were historically far more widespread and abundant within their overall distribution than they are today.**

### 5.1.3 Major Threatening Processes

The dramatic contraction, fragmentation and decline in Koala populations reflects threatening processes, which are often cumulative, including clearing and habitat fragmentation, historical mass hunting during the 1900s Koala fur trade and other ongoing pressures associated with urban and agricultural development.

In the years up until the 1930's, millions of Koalas were shot for their pelts. By 1924, Koalas had been driven to extinction in South Australia, and severely depleted in New South Wales and Victoria. At this time, the focus of the fur trade moved north to Queensland. In 1919, the Queensland Government announced a six-month open season on Koalas during which 1 million Koalas were killed. Although the season officially remained closed until 1927, when the season re-opened, over 800,000 were slaughtered in just over one month. The high numbers of Koala pelts exported during the fur trade suggest Koalas were common at that time. In fact Black August suggests that at least three, or even 4 times that number of animals may have been shot with their fur damaged that did not go to market. It is not inconceivable that there may have been in excess of 10 million Koalas at white settlement. There is **no scientific evidence in support of the notion that Koalas were rare across their range at the time of European settlement, (although this myth persists in both the literature and**

**government propaganda**) and that numbers probably increased significantly after European settlement due to a reduction in hunting by Aborigines and predation by dingoes. Given this, we emphasise that it cannot be argued that any increase in abundance occurred as a result of reduced hunting or that such a perceived increase may have partly offset the habitat loss that has occurred due to agricultural and other clearing.

Since comments of this nature were made in response to our 1995 nomination, we wish to pre-empt any repetition of such arguments. Dr. Tim Flannery opposed our 1995 proposal to list the Koala on the grounds that “The discussions of the historic status of the species are particularly poor as they do not cover the historical work by Parry and others which suggests that the Koala was rare at the time of European settlement.” He stated that “the contention that Koala numbers are currently low is poorly substantiated, neglecting much relevant material.”

The document attributed to Mr. Parris (incorrectly referred to as Parry by Dr Flannery) is plainly unscientific, highly subjective and speculative (see Appendix 7). In terms of its providing evidence to support an argument against listing the Koala, it can only be viewed as grossly inadequate. Dr Flannery did not specify who he meant by “and others”. Having conducted our own research into this, it greatly concerns us that the only “others” we were able to identify were not primary sources and simply cited the above-mentioned musings of Parris. Our research failed to turn up any substantial argument to support the notion that Koala numbers were low at the time of white settlement. Furthermore, such an argument’s relevance must be questioned, given the substantial cumulative threats facing today’s surviving Koala population.

As part of our commitment to debunking what we suspect to be a myth perpetuated by Dr Flannery and others, and instead gain an accurate understanding of possible associations that traditionally existed between Aborigines and Koalas, the AKF is funding the first detailed historical research on the subject. For the first time, Indigenous Australians will be encouraged to contribute their knowledge. This study, which is currently being discussed with prospective researchers, will reveal whether there is any truth behind the assertion that Aborigines kept Koala numbers low before European settlers arrived. According to this argument, as more and more Aboriginal people were

decimated and displaced, hunting pressure lifted, causing Koala numbers to dramatically rise. The same argument was used to justify the fur trade in the 1930s, as well as other, more recent, proposals to cull or not afford greater protection to Koalas.

The notion that white man wiped out Aborigines in the late 1800's, allegedly causing the Koala population to increase sufficiently to mount a fur trade around the turn of the century, have (and ought not to) determined conservation measures in the 21st century.

Furthermore, Dr Flannery's statement that "the contention that Koala numbers are currently low is poorly substantiated, neglecting much relevant material" was not supported by any examples of the "relevant material" he alludes to.

Whilst acknowledging that drought, wildfire, disease, predation, and vehicle collisions pose threats to Koala distribution and abundance, Melzer *et al.* (2000) state that the most significant threat to Koalas is habitat loss.

#### **i) Habitat Loss, Fragmentation and Degradation**

It is important to note that Koala conservation is a private land issue and that protected areas such as National Parks are grossly inadequate for sustaining the Koala across its range into the future. Not only do conservation reserves comprise as little as 7.7% of Australia (Commonwealth of Australia 1996), but they tend to be predominantly rugged, infertile areas, rather than the preferred Koala habitat which has instead been cleared for agricultural development (Patterson 1996).

Clearing of native vegetation is listed as a **Key Threatening Process** under the EPBC Act 1999.

It is widely recognised in the scientific literature (*e.g.* Lunney *et al.* 1990; Reed *et al.* 1990; ANZECC 1998; Martin and Handasyde 1999; Melzer *et al.* 2000) that habitat clearance constitutes the greatest threat to the survival of the Koala. Clearing of native vegetation is recognised as the major threat to biodiversity, including the Koala.

However, **the threat posed by clearing cannot be fully appreciated because it is predicted that fragmented landscapes enter a long period of relaxation to lower population levels** (Tilman *et al.* 1994).

The act of clearing breaks up continuous tracts of habitat into fragments or results in the wholesale removal of vegetation. In this way, any given landscape can be viewed as a 'habitat matrix' within which human use and habitat destruction occur at multiple levels and to varying degrees. According to this conceptual framework, a modifying influence that is intense or protracted, will eventually lead to habitat destruction or the transition of habitat to a more degraded state (McIntyre and Hobbs 1999).

The fragmentation of habitat, leading to the isolation of previously-connected Koala populations, is identified as an additional significant threat to Koala survival (Lee and Martin 1988; Hume 1990). Hume (1990) argued that habitat fragmentation posed the greatest threat to Koalas and maintained that this factor was primarily responsible for the prevalence of Chlamydial disease in Koala populations.

#### **ii) Predation by Roaming Dogs**

Predation by dogs is widely recognised as a significant threat to Koalas in both urban and rural areas. The National Koala Conservation Strategy (ANZECC 1998) identifies predation by dogs as one of the major management issues to be addressed and proposes a range of strategies to minimise the impact of dogs, including prohibition or restriction of dog ownership in areas that contain Koala habitat.

In South East Queensland alone, some 6045 animals were confirmed dead at the Moggill Koala Hospital from 1995 to 2001 (Appendix 8), half of which were due to dog attacks. The other half were motor vehicles and disease, arguably on the increase due to habitat pressures.

Motor vehicles and domestic dogs are consistently reported in the literature as the main threats to Koalas in urban areas that support remaining habitat considered adequate for sustaining Koalas and where further clearing is less likely (*e.g.* Phillips 1990; Summerville 1990; Callaghan *et al.* 1994; Ashworth 1998; de Villiers 1999; Martin and Handasyde 1999; Leathley *et al.* 2000a; Leathley *et al.* 2000b).

The total prohibition on dog ownership has been applied with early success at the Koala

Beach Estate in Tweed LGA in northern NSW. This remains a vital measure to allow for continued use of the site by members of the local Koala population.

Evidence of a significant impact of dogs on Koalas occupying tracts of native bushland in the vicinity of semi-rural and residential areas on Hunter Water Corporation lands in the Port Stephens LGA was reported by D. Lunney and W. Maitz in Callaghan and Curran (2000). Lunney and Maitz indicated that dogs were the second major killers of Koalas in their study area, next to fire.

Recent investigations into the impact of dogs and cars on Koalas in the Koala Coast area of South East Queensland (Redland, Brisbane, and Logan Shires) have been undertaken by the Koala Research Unit from the Queensland Parks and Wildlife Service. The results of this work confirm that Koalas are particularly vulnerable to attacks by dogs in urban areas. Whilst large dogs are generally considered to have the potential to inflict the most severe injuries, 5% of the reported attacks on Koalas from the Koala Coast Study involved small dogs, all resulting in death of the Koalas (de Villiers 2000).

### **iii) Traffic Mortality**

There is broad recognition within the scientific community and Koala welfare groups of the significant threat to Koalas posed by traffic (*e.g.* Phillips 1990; Callaghan *et al.* 1994; Phillips 1994; Martin and Handasyde 1999; Leathley *et al.* 2000a; de Villiers 2000). Dique *et al.* 2003a report that 1407 Koalas were recorded to have been hit by vehicles in the Koala Coast area in South East Queensland (a small component of the Southeast Queensland Bioregion) between 1995 and 1999, with approximately 83% fatality.

In some areas in which community concern has been expressed or certain individuals or groups (including AKF) have been influential, slow traffic speed zones and / or Koala crossing signs are used in and near Koala habitat areas. A 40km speed limit, for example, is applied at the Koala Beach Estate in Tweed LGA.

#### **iv) Bushfire**

Fire has been identified as one of the most significant threats to Koalas throughout their range, particularly where exacerbated by habitat fragmentation (Reed *et al.* 1990; ANZECC 1998).

Under most circumstances, low intensity bushfires or prescribed (hazard reduction) burns are not considered likely to significantly affect Koalas. In contrast, high intensity bushfires are known to kill many animals including Koalas. While high intensity bushfires are likely to dramatically reduce fauna populations over the short-term, studies of some species and their habitat following bushfire suggest that their long-term survival may not be threatened by high intensity bushfire (Catling 1991).

However, the ability of fauna species to recolonise a specific area of habitat following a high intensity bushfire is likely to be affected by a number of factors including:

- ❖ The extent and intensity of the bushfire;
- ❖ The rate and nature of habitat regeneration;
- ❖ The capacity of adjacent fauna populations to provide adequate levels of recruitment to re-colonise burnt areas; and
- ❖ The impact of threats posed by factors such as feral and native predators, and traffic which could affect the potential for recolonisation from adjacent unburnt habitat, as well as potentially affecting survivorship of any fauna occupying regenerating habitat (Callaghan & Curran 2000).

**All of these threats directly affect Koalas.** The isolation of Koala populations, for example, severely limits or can altogether exclude recruitment.

When intense bushfires affect extensive areas of significant habitat for species such as Koalas, the impact at the population level could be dramatic over both the short and long-term. This is particularly likely where habitat has already been highly fragmented, often as a result of development activity, and where the young in the population have been predominantly eliminated (Callaghan & Curran 2000).

Examination of the long-term impacts of fire requires consideration of the fire regime. The fire regime is the pattern of fire over time and across the landscape (Pickett and White 1985). Components of the fire regime include intensity, frequency and season of occurrence (Gill 1975). High Frequency fires resulting from arson could cause changes to Koala habitat by reducing the survival of juvenile trees and potentially causing the decline of populations of tree species utilised by Koalas. The majority of *Eucalyptus* species are generally capable of surviving a fire: they can grow new shoots from epicormic buds protected from the fire by bark or in underground lignotubers (Williams and Gill 1995). However, this ability to survive a fire is dependent on the presence of a number of features (*e.g.* fire resistant bark, stores of buds and energy reserves), which may not develop in juvenile plants for several years (Keith 1996). In the interim such plants are likely to be killed by fire, and if a series of fires occurs with such frequency that the aforementioned features are unable to develop, then all such juveniles may be lost, senescent adults will not be replaced, and the population will decline (Keith 1996). Even plants that have developed energy reserves and a supply of buds can be killed by frequent fires; if the interval between fires is insufficient to allow for their replenishment (Keith 1996). Both adult and juvenile eucalypts could be killed in this way. Hazard reduction burns are more likely to affect juvenile eucalypts, as it would be expected that the crown of adult eucalypts would remain largely intact. Furthermore, the frequency and severity of bushfires (and drought) is likely to increase into the future, in association with global warming.

#### **v) Disease**

The most widely recognised diseases affecting Koalas are those associated with the *Chlamydia* bacterium (ANZECC 1998). Chlamydial infection in Koalas can cause a range of symptoms such as conjunctivitis, urinary, respiratory and reproductive tract infections, and can potentially cause infertility in females (Melzer *et al.* 2000). According to the National Koala Conservation Strategy (ANZECC 1998), *Chlamydia*-related infertility can reach sufficiently high levels to cause depression of population reproductive rates. Chlamydial disease is not generally considered to threaten the survival of populations due to the generally low frequency of severe cases (ANZECC 1998). **However, because of a possible link with nutritional and environmental stress, widespread clinical expression of the disease may reflect other significant**

**problems such as habitat loss and fragmentation** (ANZECC 1998).

Recent DNA analysis has identified at least two species of *Chlamydia*; namely *C. pneumoniae* and *C. pecorum* (Glassick *et al.* 1995; Sherwin *et al.* 2000). *C. pecorum* is believed to be primarily responsible for reproductive-tract infections in female Koalas (Jackson *et al.* 1997).

Gordon *et al.* (1990) noted that a study population at Oakey in south-eastern Queensland appeared to be limited by combined effects of depressed fecundity and cystitis (*Chlamydiosis*). According to Gordon *et al.* (1990), their study on major limiting factors affecting Koala populations in Queensland indicated that reproductive disease might cause rarity on a wider scale under some circumstances.

Research has only recently begun to look at the impacts of renal disease on Koala populations, the nature of the disease and to what extent stress (*e.g.* caused by environmental pressures, dog attacks) leads to the expression of symptoms. Wildlife attendants at Cleland Wildlife Park suggest that in their locality, more than 10% of captive Koalas, and probably the same proportion of wild Koalas, suffer from kidney disease. Symptoms can include poor coat quality, weight loss, depression and excessive thirst. Because of the concerns, the disease is currently being researched by scientists from Adelaide University's Department of Anatomical Sciences, veterinarian Dr Ian Hough and Cleland Conservation Park, with support from AKF. The extent of the disease throughout eastern Australia is not presently known.

#### **5.1.4 Impacts Associated with Reduced Genetic Variability**

There is a growing body of evidence that draws attention to the threat posed to surviving Koala populations by reductions in genetic variability. Genetic variation is low in Victorian and South Australian Koala populations as a result of the small founder stock used for translocation programs to re-establish Koala populations in those states (Houlden *et al.* 1996). According to Sherwin *et al.* (2000), **there should ideally be no further reduction in the overall number of individual Koalas nor increase in isolation of populations.** Fragmented populations and those experiencing declining numbers are more likely to incur reduced genetic variability within individual animals

and across the population (Sherwin *et al.* 2000). In such cases Sherwin *et al.* (2000) argue that some genotypic variants are likely to be lost before being recognised and before their conservation significance is assessed. Threatening processes such as habitat fragmentation may increase the prevalence of inbreeding, exacerbating any rise in homozygosity caused by decreased variation between individuals. One study of captive Koalas indicated that inbreeding depression may increase juvenile mortality (Sherwin *et al.* 2000). Populations with reduced genetic diversity may adapt more slowly to environmental change (cited in Fowler 1999), and experience diminished reproductive output and growth rates (Sherwin *et al.* 2000). Genetic drift may also occur when a population is reduced to small numbers, resulting in further loss of genetic variation. Genetic processes such as drift, gene flow and natural selection are important influences on small populations (Moritz *et al.* 1996). Therefore assessing genetic variation within and among threatened species is important for determining appropriate management guidelines (Fowler 1999). The National Koala Conservation Strategy (ANZECC 1998) recommends that genetic monitoring and management should be an integral part of Koala conservation efforts, a view supported by Sherwin *et al.* (2000).

**KEY POINT: Four years ago, researchers warned there should ideally be no further reduction in the overall number of individual Koalas nor increase in isolation of populations.**

#### **5.1.5 Koala Population Size Estimation and Precautionary Principles**

**We propose that uncertainty inherent in estimating overall Koala population size should be addressed in part by treating habitat loss, fragmentation and degradation as valid indicators of decline in the overall Koala population.** We argue that fertility rates within populations (and sub-populations) decline with increasing incidence of population destabilisation, isolation and stress-related disease. With widespread increasing threats to Koalas associated with an expanding human population (*e.g.* ongoing habitat loss, habitat fragmentation and degradation; increased traffic volumes; more domestic dogs; and likely increase in stress-related disease and infertility), Koala populations will inevitably reach thresholds beyond which they can no

longer replace annual mortality through successful breeding. **We believe this threshold has already been surpassed for many local and regional Koala populations.**

The United States Endangered Species Act listing determination noted that Phillips (1998) illustrated statistically equivalent declines (trends) in three Koala populations over several decades. In a subsequent paper on this topic, **Phillips (2000) argued that due to the uncertainty inherent in estimating Koala population numbers and demographic trends, a precautionary approach would be essential when applying the IUCN Red List Criteria** (see Appendix 9). A precautionary attitude to uncertainty is absolutely consistent with the recommendations contained in Annex 1 of the IUCN Red List Criteria (International Union for the Conservation of Nature and Natural Resources: Species Survival Commission 2001). Akcakaya *et al.* (2000) indicate that a significant source of uncertainty regarding the status of species relates to the absence of precise information across a broad geographic range such as the number of mature individuals and rates of recent decline. **Hence, we argue that documented declines for local and regional Koala populations (e.g. Phillips 2000; Lunney *et al.* 2002; Callaghan & McAlpine 2003; Callaghan *et al.* in review), provide a valid basis for addressing uncertainty across broader areas of the Koala's distribution.**

From our experience, there appears to be a widespread tendency for researchers to over-estimate Koala numbers when making assessments. Local population estimates extrapolated over large geographic areas inevitably lead to gross over-estimates of regional population size. This is because population density and distribution is likely to change significantly in response to variations in factors such as: dominant tree species and vegetation communities; patterns of habitat loss and fragmentation; threatening processes; historical disturbance and current land uses; soil fertility; water availability; and population dynamics. Therefore, Koalas are not distributed at equal densities across very large areas. Field surveys undertaken by the Australian Koala Foundation at plot sites ( $n = 1,109$ ) in Queensland, New South Wales, and Victoria have consistently indicated that **substantial areas of identified preferred or supplementary Koala habitat appear to be largely unoccupied by current Koala populations.** In total, evidence of Koala activity was not recorded at 21% of the 1,109 AKF plot sites. However, the actual percentage of unoccupied habitat at any given time is likely to be much higher than this as the AKF site selection methodology combines initial random

stratification, with follow-up adaptive sampling to target areas where Koala pellets have been located. Assessments undertaken in the Coffs Harbour LGA indicated that only 31% of surveyed sites had evidence of use by Koalas (Lunney *et al.* 2000).

Our experience from fieldwork in many areas of the Koala's distribution indicates that private property owners rarely estimate Koala numbers accurately. For example in some areas landholders often over-estimate the number of Koalas inhabiting scattered trees or remnant habitat on their properties, perhaps in their efforts to create the impression that their management practices have not harmed Koalas. Whilst some may give the impression that thousands of Koalas occur on their properties, formal investigations generally only indicate small numbers in the 10s or occasionally in the 100s. The only regional Koala populations that AKF is aware of that are likely to exceed 5,000 animals (excluding the nine pre-mentioned isolates) include the following: South East Queensland; the Brigalow Belt (North and South) Bioregions extending to the Pilliga region in NSW; the Mulgalands Bioregion; the overall NSW North Coast Bioregion; the Strathbogie Ranges in Victoria; and possibly the Strzelecki Ranges in South Gippsland.

The above points further highlight the shortcomings and deficiencies when attempts are made to assess the conservation status of Koalas on the basis of population estimates. Rather, **we suggest that primary focus be placed on consistent widespread trends in population declines, habitat loss, fragmentation and degradation; irrespective of the estimated size and notional geographic limits of current populations.**

**KEY POINT: We strongly maintain that uncertainty concerning overall Koala population size should not overshadow the dramatic extent of historical and ongoing habitat clearing, fragmentation and degradation that, together with other threatening processes, have caused the national Koala population to decline from estimated millions at the time of European settlement, to a relatively small and scattered fraction of that today.**

## 5.2 STATE CONTEXT

### 5.2.1 Queensland

The National Koala Conservation Strategy (ANZECC 1998) states that the overall Koala population in Queensland is declining due to clearing of forests and woodland for agriculture and urban development. In some areas (ie those for which data are available) Koala populations are considered to have declined severely, and may be threatened or locally extinct, with ongoing active declines (ANZECC 1998). Melzer *et al.* (2000) concur that Koala population declines are continuing in both Queensland and New South Wales and recommend a review of the conservation status of Koalas in Queensland, together with an end to broadacre land clearing practices. The overall level of habitat protection in Queensland is low with much of the habitat occurring on privately owned or leased land. Development pressures threaten remaining Koala habitat and the long-term survival of local Koala populations (Queensland Government, 1997).

South East Queensland and north eastern New South Wales are considered to contain some of Australia's most significant Koala populations (Queensland Government, 1997; Pahl 1992). However, South East Queensland is recognised as the most rapidly growing metropolitan region in Australia, with a recorded human population of 2,532,677 in 2001. The human population increased by 25 per cent between 1991 and 2000, largely as a result of interstate migration and immigration from overseas. By 2021 the regional population is projected to have increased to 3.5 million, one third of Australia's total projected population growth over that period, and the greater Brisbane area is expected to be the size of Sydney today (Queensland Department of Local Government and Planning 2001).

Clearing of native vegetation in Queensland has accompanied pastoral, agricultural and urban development over the past 150 years (McAlpine *et al.* 2002). Historical patterns of land allocation have resulted in much of the most preferred Koala habitat being cleared for agricultural development with predominantly rugged, infertile areas being protected in National Parks (Patterson 1996). Seabrook (2002) determined that **approximately 50% of Koala habitat from Noosa Shire in South East Queensland had been**

**cleared since 1860.** Statewide Landcover and Trees Study (SLATS) reports confirm that significant areas of woody vegetation cover were lost across Queensland between 1991 and 2001 (Queensland Government 1999a; 1999b; 2000; and 2003). From eight biogeographic regions in Queensland (Sattler and Williams 1999) where Koalas are known to occur, a total of 3,770,664 hectares of woody vegetation cover was cleared over the ten-year period. McAlpine (2003) argued that **Koala populations are in decline across all bioregions in which they occur** based on the proportion of native vegetation remaining and the rate at which this vegetation has been lost from 1989-2001.

Whilst Sullivan *et al.* (2004) estimated that approximately 59,500 Koalas occur in the Mulgalands Bioregion (190,000 km<sup>2</sup>) in south-west Queensland, we consider this is likely to represent an over-estimate, stemming from the problems inherent in extrapolating results over very large areas; see section 5.1.5. We would argue that this figure is questionable given the statement that “The most favoured habitat was riverine vegetation, which covered only 0.9% of the region but supported 45% of the Koalas”. It seems unrealistic to suggest that ~ 27,000 Koalas would occur within only 0.9% of the Mulgalands region. AKF fieldwork in other bioregions has consistently indicated that substantial areas of remaining preferred habitat are largely unoccupied. This could be due to a range of possible reasons and combinations of factors such as the extent of habitat loss and fragmentation; other historical disturbance and threatening processes including bushfire, drought, predation and stress-related disease; social factors and population dynamics. Between 1991 and 1995, ~ 633 km<sup>2</sup> (0.34%) of the Mulgalands Bioregion was cleared annually; the eastern Mulgalands has been identified as a hotspot for clearing since 1995 for improved pastures and irrigated agriculture (SLATS 1999). According to Sullivan *et al.* (2004), **approximately 30% of potential Koala habitat was cleared from the Mulgalands Bioregion in Queensland between 1969 and 1995.** Sullivan *et al.* (2004) argue that Koala conservation strategies for the Mulgalands will need to strive to mitigate impacts from habitat clearing and fragmentation, whilst conserving a representative vegetation mosaic and a high level of habitat connectivity.

In March 2004, the Queensland Government **listed the Koala as a Vulnerable species throughout the Southeast Queensland Bioregion** under the *Nature Conservation Act 1992* (NCA) (Appendix 10). The government is currently preparing a *draft Koala*

**Conservation Plan** for Queensland under the NCA. The decision followed a joint submission from the Australian Koala Foundation and Koala Working Group citing habitat loss, predicted population declines and probabilities of extinction developed by Australian Koala Foundation and University of Queensland scientists. The models suggested the region's population may have plummeted by 57% over three Koala generations and that Koalas could be wiped out in the region in as few as 15 years. 6,045 actual Koala deaths were recorded at Brisbane's busiest Koala hospital between 1995 and 2001.

The diminishing status of Koalas in SE Qld is likely to be the case for many other heavily urbanised areas within this overall region (Sydney to Gladstone) and that this decline is likely to progress throughout most of the remaining coastal populations if human population growth projections (and the associated threats from habitat loss, fragmentation, traffic, dogs, stress-related disease etc) are correct over the next few decades.

**KEY POINTS QUEENSLAND:**

- ❖ **Koala populations are in decline across all bioregions in which they occur.**
- ❖ **The overall level of habitat protection is low with much of the remaining habitat occurring on privately owned or leased land.**
- ❖ **3,770,664 hectares of woody vegetation cover has been cleared in Koala regions from 1991-2001.**
- ❖ **Koalas recently listed as Vulnerable in Queensland's Koala 'strong-hold', the Southeast Queensland Bioregion.**
- ❖ **The South East Queensland problem is likely to mirror many other heavily urbanised areas east of the Great Dividing Range.**

### 5.2.2 New South Wales

The 1986-87 survey in New South Wales indicated that Koalas mainly occurred on the north coast, with an extensive but fragmented distribution west of the divide and in the south eastern part of the State. Koalas were considered uncommon at the majority of locations and it was concluded that they had been lost from many localities throughout the State, particularly in southern and western areas (Reed *et al.* 1990). Only 24% of Koala sightings were in National Parks, Nature Reserves or State Forests. The National Koala Conservation Strategy (ANZECC 1998) confirms that Koala habitat in NSW is poorly represented in National Park and State Forest estates and that habitat loss is the principal cause of the decline of Koalas in NSW. Lunney *et al.* (1990) reported **that at least 63% of the forest and woodland in New South Wales is estimated to have been cleared or severely modified since European settlement, with partial modification of the remaining area by grazing, forestry and/or recreational use.** Lunney *et al.* (1990) argued that the persistence of Koalas in the often rugged forested lands fringing river valleys in extensively cleared north coast areas of the State suggested the distribution was a result of early land clearing practices. **They conclude from an historical perspective that the Koala population in New South Wales has suffered a major range contraction since European settlement and will contract further as land clearing, fire, grazing and urban expansion continue.**

Scientists fear Koalas may now occupy as little as one quarter of the species' original range, with all estimates pointing to a severe contraction. For example, Lunney *et al.* (2000) reported that expert assessment of the status of Koalas in New South Wales determined that the Koala population was rapidly declining in specific regions; the distribution was assessed as including up to 50% of NSW; and **the area occupied was assessed as having declined by 51-75% since European settlement.** Maxwell *et al.* (1996) reported that Koala populations were continuing to decline in many areas. An assessment of ecological history for **Port Stephens Shire on the New South Wales central coast estimated that only 25% of the Koala habitat remained** since European settlement in the early 1800's (Knott *et al.* 1998).

The prospects for Koalas in the south coast region of NSW are bleak. In reporting to the Australian Koala Foundation on the conservation status of Koalas in the far south coast

region of New South Wales, Chris Allen (June 2004) concluded that when existing survey evidence was combined with other information **a case for declining numbers and imminent extinction in the far south coast was apparent** (see Appendix 11). This assessment incorporated summary results from all Koala surveys undertaken in that region over the past few decades, with overall evidence indicating the likelihood of ongoing widespread declines.

The NSW Department of Environment and Conservation (DEC) is currently reviewing comments on a State-wide **draft Koala Recovery Plan** (NPWS 2003) prepared in accordance with the *Threatened Species Conservation Act 1995*. The *draft* Koala Recovery Plan aims to establish a landscape-scale framework using legislative mechanisms for Koala conservation and management throughout NSW. Proposed recovery plan actions aim to update and facilitate the implementation of existing legislation, identify and map Koala habitat, protect and restore Koala habitat, prioritise on-ground actions, identify research priorities, and increase awareness within the community and government bodies concerning Koala management and conservation.

It is important to note, however, that this plan is experiencing significant bureaucratic delays. Meanwhile, the actions detailed in the Plan have not been implemented.

**Population Estimate for New South Wales:** A State Koala population size estimate of up to 10,000 was derived from the collective advice provided by experts as part of the assessment of conservation status that underpinned the Vulnerable listing throughout NSW (Lunney *et al.* 1996; ANZECC 1998; Lunney *et al.* 2000; NPWS 2003).

#### **KEY POINTS NEW SOUTH WALES:**

- ❖ **The Koala's range has contracted severely (51-75%) since European settlement and this process is continuing.**
- ❖ **The Koala was listed as Vulnerable throughout NSW in 1991, with two local populations currently listed as Endangered.**
- ❖ **Widespread extinction may be imminent in the far south coast.**
- ❖ **To date, the state-wide Koala Recovery Plan remains in draft form.**
- ❖ **AFK modelling for the NSW North Coast Bioregion indicates localised**

**extinctions between Newcastle and Tweed; refer to Section 9.1 below.**

### **5.2.3 Australian Capital Territory**

According to the National Koala Conservation Strategy (ANZECC 1998), anecdotal reports indicate that Koalas were common in the ACT and adjacent areas **until early this century when they were reported as rare**. The Koala population decline was attributed to a combination of several possible causal factors including habitat destruction, disease, fire, hunting and drought.

- ❖ No reliable estimates are available for the current Koala population size in the ACT, **but it appears clear that the population is small and fragmented.**

#### **KEY POINTS ACT:**

- ❖ **Remaining Koala population is small and fragmented.**
- ❖ **Only 1 Koala “Lucky” thought to have survived the 2003 bushfires in Tidbinbilla Nature Reserve.**

### **5.2.4 Victoria**

Koalas are reported to have once been common throughout large areas of Victoria. By the mid-1920s, however, **habitat destruction and hunting had decimated the species to the point of near extinction** (Phillips 1990). The National Koala Conservation Strategy (ANZECC 1998) reported that 65% of Victoria’s forests and woodlands had been cleared since European settlement, with only 6% out of the approximately two-thirds of Victoria in private ownership containing greater than 10% tree cover (ANZECC 1998). In some areas of western Victoria only 3% of the original vegetation remains. Victoria’s draft Koala Management Strategy (Menkhorst 2003) concedes that a detailed understanding of the constituents and distribution of Koala habitat in Victoria is currently lacking.

The only Koala population in Victoria with its original genetic integrity intact is that located in the Strzelecki Ranges region of South East Gippsland. Dr B. Houlden stated in response to our original vulnerable nomination in 1995 that she supported the status of vulnerable, and that her research had concluded that genetic variability was significantly reduced in all populations studied from south-eastern Australia except those in east Gippsland. Although the AKF is currently working with key landholders in that region to minimise impacts, logging continues on a daily basis.

All other Koalas in Victoria that occur on private land are suffering the same fate as Koalas elsewhere in Australia and many, we understand, are beginning to exhibit morphological changes resulting from genetic complications (*e.g.* missing testicles). (pers comm Julie Pryor, Victoria).

Koala translocation officially commenced in Victoria in the 1920s (Phillips 1990). The program was initiated with translocations from the mainland to islands in order to establish populations in areas with low fire risk. There are no records of natural occurrence of Koalas on any Victorian islands (ANZECC 1998). (Note: This nomination does not pertain to those populations). Formal monitoring of the success of the ongoing translocation program in terms of Koala survivorship did not commence until very recently (2003). This recent radio-tracking study, carried out for Mount Eccles, produced results so poor as to warrant an immediate halt to surgical sterilisation and relocation as well as the Victorian Government stating that it could “no longer be confident in predicting the suitability of habitat for Koala relocation”. Most of the translocated Koalas had subsequently died or were taken into veterinary care.

Furthermore, Koala translocation programs have not been shown to effectively maintain or supplement Victoria’s declining populations. In fact, a study of the Mount Macedon population has produced decline curves mirroring those of New South Wales populations – this is in spite of the regular injection of translocated animals to Mount Macedon (Phillips 2000). This is due in part to the poor quality of habitat across the Koala’s range; habitat that is highly fragmented and subject to pressures such as edge effects, weed invasion, insect attack, loss of biodiversity and so on. In other words, the destination sites are in poor ecological health, as is arguably all remnant habitat across

the Koala's range.

Victoria's draft Koala Management Strategy (Menkhorst 2003) recognises that **due to the small founder stocks and associated genetic bottlenecks underpinning the translocation program, there is a higher risk of inbreeding depression in Victorian Koala populations than those in New South Wales and Queensland.** This is supported by the findings of Houlden *et al.* (1996) and Sherwin *et al.* (2000). Seymour *et al.* (2001) identified an elevated incidence of testicular aplasia amongst male Koalas on French Island. Menkhorst (2003) reported that **remnants of the original wild Koala genepool are only thought to survive in South Gippsland, where remaining habitat is highly fragmented and threatened by unsympathetic land uses, with very little of the region reserved for conservation.**

Currently, three subspecies of Koalas are generally recognised: *Phascolarctos cinereus adustus* from Queensland, *P. c. cinereus* from New South Wales and *P. c. victor* from Victoria. Taxonomic classification is based on characteristics that include the size and colour of three type specimens, with the distribution of each subspecies delineated by state political borders. Whether or not morphological variation is genetically based has not been investigated in detail as yet as this would require studies involving hundreds of related animals of the same age. The existing subspecific classification of Koalas may not accurately reflect genetic diversity, so conservation priorities based on currently recognised subspecies may be deficient. This emphasises the importance of ensuring that Koala populations are adequately conserved throughout their entire natural distribution, with remnant populations such as that in South Gippsland treated as a priority.

The National Koala Conservation Strategy (ANZECC 1998) indicates that **much of the remaining habitat is fragmented and Koala populations are consequently discontinuous and isolated** (ANZECC 1998). Phillips (2000) critically reviewed a 1995 estimate of >180,000 Koalas for the 50,000 ha Strathbogie Ranges in Victoria that was apparently based upon localised density estimates derived for a small number of forest remnants, with extrapolation across a broad geographic area. Population modelling for the Strathbogie Ranges undertaken by Phillips (2000), based on the known history of introductions, an expected "intrinsic" rate of increase and an

assumption of no limiting factors produced an upper population estimate of approximately 27,000 Koalas. When Phillips (2000) factored-in an estimated 60% reduction in the population as a result of intense bushfires that occurred over the area in 1990, his modelling produced an upper population estimate for 1995 of just 18,000 Koalas.

- ❖ No reliable estimates are available for the current mainland Koala population size in Victoria.

For further background on Victoria see the AKF's detailed comment to the Victorian Government's draft Koala Management Strategy and Habitat Islands fact sheet (see Appendix 12).

#### **KEY POINTS VICTORIA:**

- ❖ **Driven to near extinction by the fur trade and habitat clearing.**
- ❖ **Subsequent decades of translocation have created a genetic and ecological 'mess', further compromising the prospects of mainland populations.**
- ❖ **The Mount Macedon population proves that, even with a regular injection of translocated animals, population declines continue.**
- ❖ **Habitat is fragmented; where Koalas still occur, populations are isolated.**
- ❖ **Recently-translocated animals have shown high mortality due to poor vegetation health and quality.**

#### **5.2.5 South Australia**

Koalas were known only from the lower southeast part of South Australia at the time of European settlement in 1836. However, by the turn of the century they were considered rare due to hunting for pelts, habitat loss, fire and possibly disease. The original Koala population was thought to have been virtually extinct in South Australia by the late 1930s (ANZECC 1998). Koalas from Queensland and New South Wales were subsequently used to re-establish a population in the Mount Lofty Ranges. Koalas were

introduced onto Kangaroo Island from French Island in Victoria.

Note: This nomination does not pertain to the Kangaroo Island population. AKF is unsure as to whether the Mount Lofty Ranges constitutes part of the Koala's natural range and will leave this to the Threatened Species Committee's discretion and investigation.

- ❖ No reliable estimates are available for the current mainland Koala population size in South Australia.

#### **KEY POINTS SOUTH AUSTRALIA:**

- ❖ **Driven to virtual extinction by the fur trade and habitat clearing.**
- ❖ **Kangaroo Island issue has confused people into thinking that Australia's mainland population cannot be seriously threatened.**

### **5.3 Assessment of Koala Population and Habitat Declines**

To address Criteria 1 for Vulnerable Listing we focus on the following:

- ❖ Case studies where analysis of available detailed information has provided examples of Koala population declines, which we argue **reflects the likely status of populations in other areas and regions throughout much of the geographic range of Koalas.**
- ❖ The extent of historical, contemporary and projected Koala habitat clearing, fragmentation and degradation throughout the Koalas geographic range. **We argue that this provides the most credible substitute for estimating the extent of decline within the overall Koala population.**
- ❖ The current extent of mapped Koala habitat and native vegetation clearing for AKF Koala Habitat Atlas project areas in Southeast Queensland, New South Wales and

Victoria.

### 5.3.1 Case Studies for Koala Population Declines

In an assessment of documented Koala population trends, **Phillips (2000) argued that overall the species satisfied the IUCN Criteria for Vulnerable listing, notwithstanding management issues in Victoria and South Australia.** This assessment was based upon modelling of population declines for a number of case study areas where long term population estimates and monitoring data were available including populations in NSW at **Barrenjoey** (Smith and Smith 1990) and **Tucki Tucki** (using data from NSW NPWS); and **Mount Macedon** in Victoria (using data from the Macedon Range Conservation Society). **For these case study areas, Phillips (2000) modelled population declines of 93%, 73% and 68% respectively, over a three-generation period (approximately 18 years) or less.** Phillips (2000) also undertook modelling of potential population growth in the Strathbogie Ranges (Victoria), which had been cited in submissions opposing earlier nomination for vulnerable listing. For this modelling, Phillips (2000) applied intrinsic rates of increase of 0.04 and 0.09 (corresponding to population doubling times of 16 years and 8 years, respectively) to derive a range of growth curves. These models produced substantially lower population estimates for the study area than had previously been reported (*i.e.* between 2,000 and 18,000 as opposed to > 50,000 and > 180,000). In arguing for a national vulnerable listing for Koalas, Phillips (2000) discussed **the need for application of a precautionary approach in response to issues of uncertainty**, as recommended by the IUCN (1994).

**Lunney *et al.* (2002) documented the demise of a small Koala population at Iluka in north eastern NSW.** According to Lunney *et al.* (2002), Koalas were considered common on the Iluka Peninsula prior to 1970. The most significant threats to the local Koala population were identified as habitat loss from urban development, high mortality due to traffic, dogs and disease, and low fertility. Bushfires in adjoining areas were also thought to have impacted on the Iluka population by reducing immigration. A minimum 32% (maximum 44%) annual mortality rate was reported, concurrent with low fertility over the 10-year study, and population viability analysis indicated that immigration had an important role in maintaining the local population. Lunney *et al.* (2002) also noted

that public perceptions appeared to lag behind the actual population decline, which they argued emphasises the need for early action rather than waiting until it is too late for an effective recovery program.

The rates of decline reported for the Iluka population are a looming reality for many small and isolated near-urban populations in many coastal areas *e.g.* Noosa Heads (Noosa Shire); Point Halloran (Redland Shire); Coombabah, Helensvale and Coomera (Gold Coast Shire); South Tweed Heads, Bogangar and Pottsville (Tweed LGA); Redhead (Greater Taree LGA); Dunbogan (Hastings LGA); Hawks Nest-Tea Gardens (Great Lakes LGA); Tilligerry Peninsula (Port Stephens LGA); Wallarah Peninsula (Wyong LGA); and Barrenjoey Peninsula (Pittwater LGA).

**South East Queensland** is recognised as the most rapidly growing metropolitan region in Australia. The overall Koala population in Queensland is declining due to clearing of forests and woodland for agriculture and urban development. Estimated decline in the Koala population in South East Queensland was modelled by Callaghan *et al.* (in review) using available mortality data. This involved the development of four models, each with four sub-models, and a total of 288 scenarios. Overall 90.28% (n = 260) of the scenarios estimated declines in the Koala population. A total of 18 scenarios were selected for further investigation on the basis that their estimated populations at the end of 2001 were between 10,000 and 14,000. The modelled mean percent population decline (1996 to 2001) for the 18 scenarios was 15.8% (SE = 3.3543). Outcomes were applied to evaluate the conservation status of the South East Queensland Koala population using the IUCN 2001 Red List of Threatened Species Categories and Criteria (Version 3.1). **A projected population reduction of 47.4% (SE = 10.0629) was estimated over three Koala generations (approximately 18 years; Phillips 2000).** **The modelling provided clear support for Vulnerable listing of the remaining Koala population in South East Queensland. A Vulnerable listing was recommended for the entire Southeast Queensland Bioregion given similar threatening processes and development pressures throughout much of the broader regional area.** With elevated threats from a growing human population including further habitat loss and fragmentation, increased traffic and more domestic dogs, together with a likely increase in stress-related disease and infertility, it seems inevitable that the regional Koala population will reach a threshold beyond which it is no longer

sustainable. The modelling strongly suggested that this threshold has already been surpassed.

The above modelling outcomes together with preliminary PVA analysis for the same population and a bioregional assessment of land clearing across Queensland were used as a basis for a nomination to the Queensland Environment Minister and Scientific Advisory Committee for the Koala to be listed as Vulnerable for the Southeast Queensland Bioregion. This also recommended that consideration to be given to extending the listing throughout Queensland (Callaghan & McAlpine 2003; see Appendix 10).

Gordon *et al.* (1988) reported a Koala population crash along Mungalalla Creek in south-western Queensland associated with a heatwave and drought in the summer of 1979-80. **An estimated 63% of the Koala population died during the summer** due to a combination of malnutrition and dehydration, with recovery in the years following the population crash prevented by continuing drought conditions (Gordon *et al.* 1988). **This study emphasised the vulnerability of western populations to natural disasters such as severe droughts or bushfire, particularly in circumstances where extensive habitat fragmentation restricts or prevents recruitment and population recovery.**

It is important to note that the prospects for Australia's remaining fragmented Koala populations are further diminished by the fact that droughts and bush fires are predicted to increase into the future, in association with global warming,

#### **KEY POINTS:**

- ❖ **Koala population declines outlined above provide unequivocal support for listing of those populations as Vulnerable in accordance with the EPBC Act and IUCN Red List Categories and Criteria; with in excess of 30% modelled population declines over three Koala generations (approximately 20 years). We argue that these examples are representative of widespread declines in remaining populations throughout much of the Koala's natural distribution.**

❖ **The likelihood of imminent extinction is a looming reality for many small and isolated near-urban populations in many coastal areas of South East Queensland and Northern NSW.**

**Listed Endangered Koala Populations in NSW:**

**i) Pittwater Population**

The Koala population of Pittwater LGA is listed as an “endangered population” in Part 2 of Schedule 1 of the *Threatened Species Conservation Act 1995*.

The NSW Scientific Committee cited the following reasons for listing the population as endangered:

- i) The population has particular conservation significance as one of the few Koala populations remaining in the Sydney area.
- ii) The population was reduced to an estimated 6 individuals (1993) from a population of 123 in the 1970s, placing the population in immediate danger of extinction.
- iii) Habitat loss and fragmentation due to increasing urbanisation has been the most significant cause of Koala population decline in the Pittwater LGA. The remaining bushland reserves were thought to have an insufficient representation of food trees and were considered inadequate for the continuing viability and rehabilitation of the population. According to Smith and Smith (1990), clearing for residential development reduced the area of forested habitat from around 705 ha in 1946 to around 125 ha in 1989.

(Source:<http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Koala+population+Pittwater+Local+Government+Area+endangered+population+listing>)

**ii) Hawks Nest and Tea Gardens Population**

The Hawks Nest and Tea Gardens Koala population is listed as an “endangered population” in Part 2 of Schedule 1 of the *Threatened Species Conservation Act 1995*.

The NSW Scientific Committee cited the following reasons for listing the population as endangered:

- i) The population is geographically isolated and the movement of Koalas between Hawks Nest and Tea Gardens is at a very low frequency.
- ii) In 1998 the population was thought to contain as few as 12 Koalas, declining from  $\geq 21$  in 1989.
- iii) The population is continuing to decline due to ongoing sub-division and associated clearing of food and habitat trees, road mortality and dog attacks.

(Source: <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Koala+population+Hawks+Nest+and+Tea+Gardens+endangered+population+listing>)

### **5.3.2 Koala Carer and Koala Hospital Data**

Koala carers, almost all of whom are volunteers, work at the 'coal face' of the Koala's decline. For the purpose of this nomination, a number of licensed Koala carer groups and Koala hospitals from Queensland, New South Wales and Victoria supplied Koala records for analysis of the main reasons that Koalas have come into care or died. Some records extended from as far back as 1992, up to 2003.

The data collected from all three states indicates that the overall number of Koala rescues and subsequent deaths have generally tended to increase. For example, data provided by Julie Prior (Victoria), shows an increase in the number of Koala deaths recorded each year between 1998 (5 deaths) and 2003 (19 deaths). Similarly, the Friends of the Koala Inc. (NSW Northern Rivers) records also indicate that the number of Koalas taken into care has slowly increased with a peak of 153 in 2003, and a corresponding peak in recorded annual deaths of 92 in that year. The Noosa Koala Hospital (Noosa, Queensland) also reported an increase in the total number of Koalas rescued and the total number of deaths between 1993 (9 rescues and 3 deaths) and 2003 (45 rescued and 23 deaths). The number of Koala admissions and deaths also increased at the Moggill Koala Hospital (Brisbane, Queensland). Between 1995 and 2001, an alarming total of 6,045 Koalas died (or 77%) from total hospital admissions of 7,831 Koalas, which includes 2,208 that were dead on arrival and 2,893 that were euthanased shortly afterwards.

The Native Animal Trust Fund (Port Stephens, NSW) rescued 1,033 Koalas between 1994 and 2000 due to motor vehicle trauma, dog attacks, disease, or other injuries; with 58% subsequent deaths. Data collected by Koala Rescue and Rehabilitation (Tyabb, Victoria) indicated that nearly half (45.2%) of rescued Koalas subsequently died due to vehicle collisions, dog attacks, other injuries, drowning or disease. The Friends of the Koala Inc. rescued a total of 1,217 Koalas between 1992 and 2003. Of these, 650 (just over half) died. During a ten-year period between 1993 and 2003, the Noosa Koala Hospital rescued 215 Koalas, of which 110 died. The Myall Koala and Environment Support Group Inc. (Hawks Nest, NSW) have collected data on Koala sightings, rescues and deaths since 1995; with a total of 15 Koalas dead, and 15 Koalas rehabilitated and released. The Hunter Koala Preservation Society (Port Stephens, NSW) collected comprehensive data on Koala rescues since 1995. Out of 979 Koalas rescued since 1995, a total of 367 (37.5%) died. At the time of writing, Port Macquarie Hospital was still collating data and could be provided if necessary.

The general increase in Koala rescues and deaths recorded by the Koala carer groups and hospitals mentioned above may correspond in part to an increase in public awareness. However, with increasing human populations, the threats associated with habitat destruction and fragmentation, dog attacks, vehicle mortality and stress-related disease also increase. Hence, it is highly likely that increasing Koala rescues and deaths are also a strong reflection of increasing threats and diminishing habitat. The overall records for Koala rescues and deaths clearly only represent a proportion of the actual overall deaths from areas where Koala carer groups are established. These losses place significant added pressure on remaining Koala populations, particularly in many parts of the coastal zone where human populations are also focused. The threatening processes that lead to Koala injuries, illness and mortality will need to be addressed in conjunction with more effective conservation planning for Koalas in the future, particularly if there is to be any hope for recovery of already seriously declining coastal and near-coastal Koala populations.

In Victoria, tens of thousands of Koalas have been moved to alternative habitat as part of the Victorian Government's Koala translocation program. It is by no means clear, however, how many of these Koalas have died, succumbed to illness or otherwise

suffered. Given the extremely poor results of a recent radio-tracking study of Koalas at Mount Eccles (most subsequently died or were taken into veterinary care), AKF has not seen any evidence to suggest that the vast majority of Koalas translocated throughout the program's history have not met the same fate. An extract from the Mount Eccles study revealed that after 6 months 90.9% of the males translocated into a mixed forest died or had to be taken into vet care. Furthermore, 90.9% of sterilised females that were moved to mixed forests suffered the same outcomes. Even 54.5% of sterilised females that were returned to the site of capture subsequently died or had to be taken into veterinary care, along with 45.5% released into red gum forest. These alarming figures strongly suggest that the decades of translocation in Victoria has been wasteful (in terms of resources), cruel and provided little more than a superficial temporary 'top up' of populations on the mainland already declining as a result of Chlamydia, cars and dogs, habitat loss and other ongoing threats.

### **5.3.3 Habitat Clearing, Fragmentation and Degradation: Overview**

According to the Australian Terrestrial Biodiversity Assessment 2002 (Sattler and Creighton 2002), the most significant threatening processes for biodiversity include amongst other factors: extensive vegetation clearing in Queensland and New South Wales; increased fragmentation of remnant habitat in New South Wales; overgrazing in parts of the pastoral zone; widespread impacts of feral animals in arid areas; and salinity in parts of southern Australia. **The mapping of threatening processes in Sattler and Creighton (2002) indicates that the primary areas for threats from vegetation clearing and fragmentation overlap with virtually the entire Koala distribution.** Sattler and Creighton (2002) maintain that landscape modification in Australia has resulted in 2891 ecosystems and ecological communities being threatened.

Cogger *et al.* (2003) argue that **mammals are especially sensitive to impacts from habitat loss and fragmentation on the basis that they generally occur at low density, with a requirement by individuals for relatively large habitat areas.** It is thought that mammal species are often unable to replenish isolated habitat patches due to severely curtailed movement and dispersal as a consequence of habitat fragmentation and reduction in land cover (Cogger *et al.* 2003).

The Australian Native Vegetation Assessment 2001 **estimates that a total of over 98 million hectares of native vegetation has been cleared throughout Australia since European settlement** (Cofinas & Creighton 2001). The Australia State of the Environment 2001 report indicates that **the rate of land clearing has accelerated in more recent times, with as much clearing during the last 50 years as in the 150 years prior to 1945**. It has been estimated that during 1999, Australian governments issued permits for clearing in excess of one million ha of native vegetation. More than 1.2 million ha were reportedly cleared between 1995 and 2000 (State of the Environment Advisory Council 2001).

Average total clearing of 300,000 ha per year was estimated for native vegetation in Queensland; 150,000 ha per year in New South Wales; 7,780 ha per year in Victoria; and 9,300 ha per year in South Australia, over the ten-year period between 1983 and 1993 (Glanzign 1995). **Queensland and New South Wales contribute the most significant impacts on Koalas from current rates of habitat clearing. Clearing in Queensland was reportedly 47% higher in the last years of the previous decade than in the 1990–1995 period, when the average was 289,000 ha per year.** Between 1995 and 1997 annual clearing increased to 340,000 ha per year, and 425,000 ha per year between 1997 and 1999 (State of the Environment Advisory Council 2001).

The greatest percentage loss of native vegetation in Queensland has occurred in the Brigalow Belt Bioregion, where approximately 12% of total woody vegetation cover was cleared between 1991 and 2001. Approximately 10% of woody vegetation cover was cleared from the Mulgalands and Desert Uplands Bioregions, while 8% and 5% were lost within the Northern New England Tablelands and Southeast Queensland Bioregions respectively during this same period (McAlpine 2003).

Up to 18,000 Koalas have been estimated to die annually in the Brigalow Belt Bioregion in Queensland as a result of land clearing at the rate of 260,200 ha per year (Cogger *et al.* 2003). This estimate was based on extrapolation of localised Koala population density predictions across the total area cleared. The AKF maintains that Koalas rarely occur at even densities throughout habitat areas, and consequently we believe that this estimate exaggerates the overall number of Koalas in the Brigalow Belt Bioregion. Notwithstanding, it is assured that **substantial numbers of Koalas are killed annually**

**by current land clearing practices in Queensland and New South Wales** in particular.

According to the Australia State of the Environment 2001 report, substantial government funding has been allocated since 1997 through the National Heritage Trust to Landcare and Bushcare programs, with landholders and community groups planting millions of trees annually. However, **the beneficial effects of this effort will not become apparent for many years, and are vastly exceeded by ongoing land-clearing practices.** Lack of funding and capital continues to be the major limitation to effective control of feral pests, weeds, soil erosion, and loss of biodiversity (State of the Environment Advisory Council 2001).

#### **5.3.4 Habitat clearing: *Eucalyptus* and *Callitris* forests and woodlands (Potential Koala Habitat)**

According to Graetz *et al.* (1995), ***Eucalyptus* forests have suffered between 33% and 92% loss (depending on the forest type), Australia-wide since European settlement.** Yates and Hobbs (1997) report that temperate eucalypt woodlands have been almost completely eliminated from the landscape in south-eastern and south-western Australia, with remnants threatened by further clearing, livestock grazing, salination, altered fire regimes and weed invasion.

For the purpose of this nomination, the Australian Koala Foundation undertook GIS-analysis to estimate the extent of clearing of ***Eucalyptus* forests and woodlands and *Callitris* forests and woodlands (potential Koala habitat)** since European settlement, within the approximate geographic distribution of Koalas. This analysis was based on digital Native Vegetation Information System (NVIS) vegetation mapping of pre-European and present major vegetation groups prepared in conjunction with the Australian Native Vegetation Assessment 2001 (Cofinas & Creighton 2001). According to Cofinas and Creighton (2001), the NVIS data provides the first Australia-wide hierarchical classification of native vegetation.

For our analysis the area within the approximate Koala distribution in mainland Australia (see Map 1 attached), was clipped from the Australia-wide NVIS digital

vegetation mapping. *Eucalyptus* forests and woodlands and *Callitris* forests and woodlands were then tallied for both pre-European and present vegetation mapping and compared to calculate the percent clearing of potential Koala habitat across: i) the overall Koala distribution; ii) within each State; iii) within each biogeographic region as defined by Thackway and Cresswell (1995); and iv) within individual Local Government Areas.

The analysis indicated that approximately **44.7% of *Eucalyptus* forests and woodlands and *Callitris* forests and woodlands (potential Koala habitat) has already been cleared since European settlement from within the overall range of Koalas in mainland Australia.** Acacia forests and woodlands are also known to contain scattered Eucalypts and can provide supplementary habitat for Koalas such as in the Mulgalands Bioregion. When *Acacia* forests and woodlands are added to the overall clearing figure, the percentage **total clearing of potential Koala habitat increases to 45.9%**. These overall figures comprise the following losses:

- **Eucalypt tall open forests = 34.3%**
- **Eucalypt open forests = 39.1%**
- **Eucalypt woodlands = 52%**
- **Eucalypt open woodlands = 31.4%**
- ***Callitris* forests and woodlands = 29.7%**
- ***Acacia* forests and woodlands = 52.8%**

Eucalypt woodlands have been the most extensively cleared and modified and in many regions only remain as small isolated patches (Cofinas & Creighton 2001).

**Note: These percentages for the approximate extent of Koala habitat clearing are based on NVIS vegetation mapping data collected and collated between 1997 and 2001. Considerable additional habitat clearing and fragmentation has occurred since that time and is expected to have increased the overall loss of *Eucalyptus* forests and woodlands and *Callitris* forests and woodlands within the natural range of Koalas in mainland Australia to over 50%.**

Assessment of *Eucalyptus* forest and woodland and *Callitris* forest and woodland

**clearing percentages within the overall range of Koalas in mainland Australia** by State and Territory indicated the following **losses**:

- **Queensland = 33.6%**
- **New South Wales = 52.5%**
- **Australian Capital Territory = 27%**
- **Victoria = 60.1%**
- **South Australia = 91.2%**

**Loss of *Eucalyptus* forests and woodlands and *Callitris* forests and woodlands** has been greatest in the following **biogeographic regions** within the overall range of Koalas in mainland Australia: Brigalow Belt South (**50.2% loss**); South Western Slopes (**83.4% loss**); South Eastern Highlands (**41.1% loss**); Riverina (**90.1% loss**); Victorian Midlands (**73.7% loss**); South Eastern Queensland (**60.2% loss**); and Brigalow Belt North (**36.1% loss**).

An assessment of the **percentage loss of *Eucalyptus* forests and woodlands and *Callitris* forests and woodlands for the 349 Local Government Areas (LGAs) or councils within the overall range of Koalas in mainland Australia** provided the following results, subject to local-scale limitations of the NVIS vegetation mapping:

- **90-100% loss = 95 LGAs**
- **70-89% loss = 75 LGAs**
- **50-69% loss = 70 LGAs**
- **30-49% loss = 56 LGAs**
- **10-29% loss = 32 LGAs**
- **<10% loss = 21 LGAs**

**These results are very alarming in terms of reflecting the gross inadequacy of remaining Koala habitat within Local Government Areas** (and more generally, biodiversity). Highest percentage losses were generally recorded in smaller, more intensively developed LGAs and many Council areas across Victoria and South Australia.

### 5.3.5 Local-scale habitat clearing: AKF Koala habitat mapping data

The following summary of remaining Koala habitat and habitat loss at local-scale is based on Koala Habitat Atlas research undertaken by the Australian Koala Foundation over the past 11 years. During this period data has been collected on over 51,400 trees from more than 1,100 field plot sites in project areas from Southeast Queensland, through much of eastern and central New South Wales, to Ballarat Shire and the Strzelecki Ranges region of Victoria. Analysis of this data has not only provided local-scale information on Koala tree species and habitat preferences (*e.g.* Phillips & Callaghan 2000; Phillips *et al.* 2000; Lunney *et al.* 1998) and the subsequent preparation of **Koala Habitat Atlas maps currently covering approximately 4 million hectares**, but has also provided **important information on habitat clearing, fragmentation, disturbance and degradation**. AKF Koala Habitat Atlases have been used as the basis for preparing three Comprehensive LGA-wide Koala Plans of Management (CKPoMs) in NSW under *State Environmental Planning Policy No.44-Koala Habitat Protection*: namely Port Stephens Council CKPoM (Port Stephens Council 2001); *draft* Greater Taree City Council CKPoM (Callaghan *et al.* 2002); and *draft* Campbelltown City Council CKPoM (Callaghan *et al.* 2003).

The Koala Habitat Atlas (KHA) provides a local-scale indication of the extent of clearing of native vegetation. Much of the cleared native vegetation from the following KHA project areas is likely to have constituted Koala habitat. The extent of native vegetation clearing within KHA project areas outlined in the following tables include: Brisbane/Logan/Redland/Redcliffe/Pine Rivers = **70.4%**; Noosa LGA = **47.8%**; East Tweed LGA = **66.3%**; Port Stephens LGA = **42.1%**; Campbelltown LGA = **48.6%**; Greater Taree LGA = **39.2%**; Walgett LGA = **21%**; and Ballarat LGA = **85.7%**. The Pilliga KHA indicated little current total clearing because of the focus for this project on the State Forest estate. However in a broader context, the Pilliga scrub on the north-western slopes and plains of NSW is surrounded by dramatic historical clearing, to the extent that remnant native vegetation is generally confined to small and predominantly isolated patches scattered throughout the regional landscape.

<b>Brisbane/Logan/Redland/Redcliffe/Pine Rivers KHA (Qld):</b>		
<b>Habitat Category</b>	<b>Area (hectares)</b>	<b>Proportion (%)</b>
Primary	4 134	1.9
Secondary (Class A)	13 410	6.1
Secondary (Class B)	6 972	3.2
Secondary (Class C)	25 271	11.5
Unknown	3 816	1.7
Other Vegetation	10 281	4.7
Plantation	957	0.4
<b><i>Mainly Cleared Land</i></b>	<b><i>154 209</i></b>	<b><i>70.4</i></b>
<b>TOTAL</b>	<b>219 051</b>	<b>100</b>
<b>Noosa KHA (Qld):</b>		
<b>Habitat Category</b>	<b>Area (hectares)</b>	<b>Proportion (%)</b>
Primary	2 369	3.0
Secondary (Class A)	12 124	15.1
Secondary (Class B)	11 270	14.1
Secondary (Class C)	3 283	4.1
Marginal	3 231	4.0
Other Vegetation	9 492	11.9
<b><i>Mainly Cleared Land</i></b>	<b><i>38 277</i></b>	<b><i>47.8</i></b>
<b>TOTAL</b>	<b>80 046</b>	<b>100</b>
<b>East Tweed KHA (NSW):</b>		
<b>Habitat Category</b>	<b>Area (hectares)</b>	<b>Proportion (%)</b>
Primary	957	2.5
Secondary (Class A)	4 043	10.7
Secondary (Class B)	3 862	10.3
Unknown	253	0.7
Other Vegetation	3 577	9.5
<b><i>Mainly Cleared Land</i></b>	<b><i>24 916</i></b>	<b><i>66.3</i></b>
<b>TOTAL</b>	<b>37 608</b>	<b>100</b>
<b>Port Stephens KHA (NSW):</b>		
<b>Habitat Category</b>	<b>Area (hectares)</b>	<b>Proportion (%)</b>
Primary	5 390	6.5
Secondary (Class B)	36 370	43.7
Unknown	170	0.2
Other Vegetation	6 200	7.5
<b><i>Mainly Cleared Land</i></b>	<b><i>35 020</i></b>	<b><i>42.1</i></b>
<b>TOTAL</b>	<b>83 150</b>	<b>100</b>
<b>Campbelltown KHA (NSW):</b>		
<b>Habitat Category</b>	<b>Area (hectares)</b>	<b>Proportion (%)</b>
Secondary (Class A)	2 423	7.8
Secondary (Class B)	2 197	7.0
Secondary (Class C)	4 448	14.3
Marginal	6 814	21.8
Unknown	121	0.4

Other Vegetation	17	0.1
<b>Mainly Cleared Land</b>	<b>15 148</b>	<b>48.6</b>
<b>TOTAL</b>	<b>31 168</b>	<b>100</b>
<b>Greater Taree KHA (NSW):</b>		
<b>Habitat Category</b>	<b>Area (hectares)</b>	<b>Proportion (%)</b>
Primary	3 455	0.9
Secondary (Class A)	86 725	23.5
Secondary (Class B)	49 685	13.5
Secondary (Class C)	30 816	8.4
Unknown	976	0.3
Other Vegetation	51 442	14.0
Rock	908	0.2
<b>Mainly Cleared Land</b>	<b>144 618</b>	<b>39.2</b>
<b>TOTAL</b>	<b>368 625</b>	<b>100</b>
<b>Walgett KHA (NSW):</b>		
<b>Habitat Category</b>	<b>Area (hectares)</b>	<b>Proportion (%)</b>
Primary	25 874	1.1
Secondary	947 391	39.9
Marginal	416 419	17.5
Unknown	7 798	0.3
Other Vegetation	481 317	20.3
<b>Mainly Cleared Land</b>	<b>497 804</b>	<b>21.0</b>
<b>TOTAL</b>	<b>2 376 603</b>	<b>100</b>
<b>Pilliga KHA (NSW):</b>		
<b>Habitat Category</b>	<b>Area (hectares)</b>	<b>Proportion (%)</b>
Primary	42 814	10.7
Secondary (Class A)	107 505	26.8
Secondary (Class B)	19 131	4.77
Marginal	199 132	49.64
Unknown	11 515	2.87
Other Vegetation	20 941	5.22
<b>Mainly Cleared Land</b>	<b>118</b>	<b>0.03</b>
<b>TOTAL</b>	<b>401 156</b>	<b>100</b>
<b>Ballarat KHA (Vic):</b>		
<b>Habitat Category</b>	<b>Area (hectares)</b>	<b>Proportion (%)</b>
Primary	232	0.3
Likely Primary	642	0.9
Secondary (Class A)	3 979	5.6
Likely Secondary (A)	33	0.0
Secondary (Class B)	1 660	2.4
Likely Secondary (B)	52	0.1
Secondary (Class C)	458	0.6
Unknown	238	0.3
Other Vegetation	2 816	4.0
<b>Mainly Cleared Land</b>	<b>60 397</b>	<b>85.7</b>
<b>TOTAL</b>	<b>70 509</b>	<b>100</b>

### **Relevant findings from ecological history research case studies:**

An understanding of the regional historical ecology of Koalas can be vital for interpreting contemporary survey results in the context of historical habitat and population declines. The following brief summaries pertain to very relevant examples of the principal reasons for dramatic declines.

#### **i) Port Stephens LGA on the NSW Central Coast**

**Source:** Knott, T., Lunney, D., Coburn, D. & Callaghan, J. 1998. An ecological history of Koala habitat in Port Stephens Shire and the Lower Hunter on the Central Coast of New South Wales, 1801-1998 In *Pacific Conservation Biology* 4(4), 354-368.

Vegetation clearing in western parts of the Port Stephens and Lower Hunter area began in the early 1800s and progressed so rapidly that little of the original vegetation remains today. Between 1823 and 1870 the majority of the Shrubby Tall Open Forest, Open (swamp) Forest and Vine-Fern Closed Forest has been cleared, and the surrounding Open Forest country substantially modified. The small number of Koalas which remained in the upper reaches of the Williams River and between Seaham and Karuah were affected by intensive logging and silvicultural activities between the 1920s and 1970s. Settlement progressed at a slower rate in the east until after World War II. From the 1950s large areas of habitat were removed for housing developments and infrastructure along with mineral sand mining which contributed to the reduction and fragmentation of Koala habitat in this area. Knott *et al.* (1998) estimated that approximately half of the Koala habitat on the Tilligerry Peninsula was removed during the period from 1954 to 1992.

The historical records showed that Koalas were widespread and common in the region during early settlement, **prior to the estimated removal of approximately 75% of the pre-European Koala habitat** (Knott *et al.* 1998).

## **ii) Noosa LGA in South East Queensland**

**Source:** Seabrook, L.M., McAlpine, C.A., Phinn, S.R., Callaghan, J. and Mitchell, D. 2003. Landscape legacies: Koala habitat change in Noosa Shire, South-east Queensland. *Australian Zoologist* 32(3):446-461.

This paper investigated the legacies of European settlement of Noosa Shire, South-east Queensland, with particular emphasis on the economic and political drivers and the resultant loss and fragmentation of Koala habitat. Patterns of habitat loss between 1860 and 1970 were quantified at a coarse level from historical and land tenure records, while changes over the past thirty years were mapped at a finer spatial resolution from aerial photography and satellite imagery. **Approximately 50% of the Koala habitat in Noosa Shire has been cleared since 1860**, with habitat classes 2A and 2C suffering the highest proportion of loss. The period of greatest loss occurred between 1890 and 1910 and was linked to development of the dairy industry in the western half of the Shire. A second significant phase of loss has occurred since 1970 linked to exotic pine plantations, urbanisation and rural subdivision, with 35% of remaining habitat being cleared in the southern part of the Shire. Cumulative loss of habitat has been accompanied by increasing fragmentation with reduced patch size and increased patch linearity. Further temporal analysis of habitat change is required in order to test the hypothesis that there is a relaxation period between the timing of habitat loss and the current pattern of habitat occupancy (Seabrook *et al.* 2003).

## **iii) Campbelltown LGA southwest of Sydney**

**Source:** Research undertaken by Jane Thompson (AKF) and reported in Callaghan, J., Curran, T., Thompson, J. and Taylor, A. 2003. Campbelltown City Council *Draft* Comprehensive Koala Plan of Management. Prepared by the Australian Koala Foundation on behalf of Campbelltown City Council.

European settlement in the Campbelltown area began soon after 1798. Cultivation of land within the area was rapid. Over the forty years following settlement, native vegetation was continually cleared for wheat and other cereals and had been extensively cleared by 1839 (Benson and Howell 1990). Many variables are likely to have

contributed to the low density of the remaining Koala population in the Campbelltown LGA. **A history of dramatic habitat loss and disturbance, including the removal of most of the expected preferred Koala habitat from the more fertile soils, hunting and bushfires is arguably responsible for the present restriction of the remaining Koala population to sub-optimal habitat.** The shale country, poorer sandstone lands along the Georges River east of Campbelltown and the river gorge itself were not used for agriculture and were left relatively in tact (Benson and Howell 1990). Prior to clearing, the arable land is likely to have provided the most significant habitat for Koalas, particularly given that preferred Koala food trees dominating in these areas.

Hunting by European settlers may also have impacted the local Koala population. Koalas were afforded limited protection under the *Native Animals Protection Act of 1903*. Although protected, the trade in Koala furs continued with 57, 933 Koala skins exported from Sydney in 1908 (Phillips 1990). Some local residents of the Campbelltown area reported their parents and grandparents hunting Koalas for pelts at the turn of the 20<sup>th</sup> Century (Close 1993; Longhurst pers.com. 1997). A proportion of those pelts processed through the Sydney markets would have been taken from the Campbelltown area.

#### **iv) Greater Taree LGA on the NSW North Coast**

*Source:* Research undertaken by Jane Thompson (AKF) and reported in Callaghan, J., Curran, T., Thompson, J. and Floyd, R. 2002. Greater Taree City Council *Draft* Comprehensive Koala Plan of Management. Prepared by the Australian Koala Foundation on behalf of Greater Taree City Council.

Koala habitat in the Greater Taree LGA has severely contracted since European settlement commenced in the area in the 1830's. **The common practice of clear-felling and ringbarking within the LGA combined with the hunting of Koalas for their skins during the economic depression has led to the greatly reduced and disjunct Koala population remaining today.** Native vegetation within the Lower Manning Valley and on the valley floors of the Upper Manning Valley has been continuously cleared and/or disturbed for agriculture and forestry over the past 170 years. This has left a mosaic pattern of native vegetation, the majority of which occurs on the more inaccessible and less fertile lands on the upper ridges of the valley (Holstein & Lyon,

1987; Birrell, 1987).

Historical information indicates that Koalas were abundant in the Manning Valley up to the turn of the 20<sup>th</sup> Century (Hannah, 1997; Holstein & Lyon, 1987; Connors pers com. 1997). In the early 1900's hunting for pelts supplemented the incomes of local farmers and visitors from Sydney (Hannah, 1997). Koalas were hunted in large numbers during this period. In 1898 the Manning River Times reported "A dray loaded with bear skins arrived from Marlee (approximately 20kms north-west of Taree) containing many thousands of skins". Today Koala records are relatively few throughout the majority of the Greater Taree LGA.

### **5.3.6 Habitat fragmentation: *Eucalyptus* and *Callitris* forests and woodlands**

Papers prepared for the Prime Minister's Science Council (1992) concerning biodiversity issues identified habitat loss and fragmentation as the primary factors causing loss of biodiversity. Prime Minister's Science Council (1992) indicate that a lag effect extends over several decades, with the final loss of species from an area often occurring many years after the main causal events. Examples include the loss of bird species today from the wheatbelt in Western Australia as a result of habitat clearing and fragmentation several decades earlier (Prime Minister's Science Council 1992).

The **National Koala Conservation Strategy (ANZECC 1998) identifies habitat fragmentation as one of the major threats to Koalas, next to habitat loss and degradation.** The NSW overview states that habitat fragmentation increases the vulnerability of Koalas to other processes including disease, drought and bushfire.

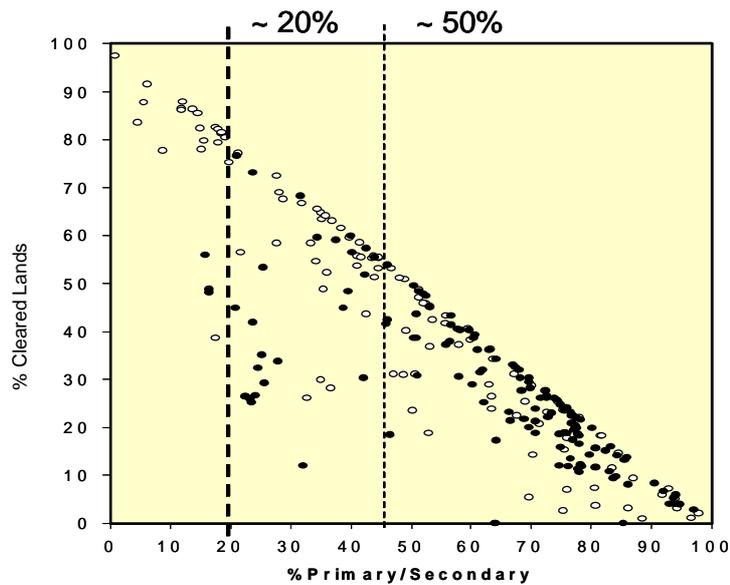
Landscape fragmentation produces patches of remnant vegetation surrounded by different vegetation or land use, which imposes a range of different physical, microclimatic and biological conditions on patches of remnant vegetation (Saunders *et al.* 1991). Fragmentation and associated edge effects are known to cause degradation to the remnant vegetation as well as impacting on fauna (Saunders *et al.* 1991; Murcia 1995). **In the case of Koalas, impacts could include increased risks of predation by roaming domestic and feral dogs, particularly where the area beyond the edge has**

**been heavily degraded.** Edge effects have also been reported as impacting specifically on Koala habitat. For example, increased run-off from adjacent urban areas was implicated in the dieback of Koala food trees in the Pittwater area of Sydney (Smith and Smith 1990).

#### **Research into Impacts of Habitat Fragmentation on Koala Populations:**

Over the past three years the AKF has been an Industry Partner, together with NSW NPWS, on an ARC SPIRT research project through the University of Queensland led by Professor Hugh Possingham and Dr. Clive McAlpine. The project aimed to investigate the **Conservation and Restoration of Koala Populations in Fragmented Landscapes** and is currently in the data analysis and write-up phase. The first paper submitted for publication earlier this year (McAlpine *et al.* in review) focused on landscape ecology features that influence the occurrence and distribution of Koalas across fragmented landscapes in Noosa Shire, Southeast Queensland. Other case study sites include the Port Stephens LGA on the NSW central coast and Ballarat Shire in Victoria. A number of *a priori* models were developed to predict the presence/absence of Koalas throughout the Noosa Shire. Koala faecal pellet and habitat surveys ( $n = 245$ ) were conducted across the habitat mosaic to test the models. Taking into account the patch and landscape context and neighbourhood effect of adjacent sites where Koala faecal pellets was recorded, logistic regression and information-criterion-analysis were applied to rank the models and the predictor variables. Strongest support was for a global, multi-scaled model, which provided the best explanation for the decline of Koala populations. **Koala presence was best predicted by the neighbourhood effect, area of suitable habitat, density of sealed roads, the number of secondary habitat patches, the proportion of preferred tree species, and log focal patch size.** The analysis indicated that Koalas are more likely to persist in landscapes with **>50% high quality habitat (see Figure 1) configured in large patches (>100 ha), and with a low density of sealed roads.**

**These results are particularly alarming given that our clearing analysis concluded that over 50% of *Eucalyptus* forests and woodlands and *Callitris* forests and woodlands (potential Koala habitat) has already been removed since European settlement from within the overall range of Koalas in mainland Australia. This lends substantial support to a national Vulnerable listing for Koalas.**



**Figure 1.** Scatterplot showing the relationship between the percent of the landscape occupied by primary/secondary habitat and cleared lands, and sites where Koalas were present (black circles) or absent (hollow circles). The scatterplot illustrates the identified ~ 50% threshold of landscape occupied by Koala habitat, below which there is less likelihood of Koalas being present (McAlpine *et al.* in review; McAlpine *et al.* 2004; see technical reports on AKF website [www.savethekoala.com](http://www.savethekoala.com)).

**KEY POINT:**

**This modelling can be used to help understand reasons for Koala population declines and to predict the likely consequences of future land use planning decisions including those that would lead to further habitat loss and fragmentation and a higher density of roads or, alternatively, those that focus on habitat protection and restoration (McAlpine *et al.* in review).**

### **Fragmentation Analysis for AKF Koala Habitat Atlas Mapping Projects:**

The comparatively new science of Landscape Ecology offers tools to quantify a range of indicators for habitat fragmentation such as those utilised by McAlpine *et al.* (in review) to investigate landscape and patch-scale effects on Koala populations. Such indicators include landscape spatial pattern, and interspersed and dispersed with other habitat types (McAlpine & Eyre 2002). Recent landscape ecology studies have indicated that extinction of fauna species is more likely where these indicators exceed critical thresholds, such as those outlined above (McAlpine & Eyre 2002; McAlpine *et al.* in review).

In conjunction with this nomination the Australian Koala Foundation undertook fragmentation analysis for a number of our Koala Habitat Atlas mapping projects in order to quantify the degree of habitat fragmentation and associated fragmentation effects. Analyses were undertaken using Patch Analyst (Rempel & Carr 2003), an extension to the capabilities of the Spatial Analyst Extension of ArcView GIS (ESRI 1996). Patch Analyst (Grid) employs the core algorithms of Fragstats fragmentation analyses software (McGarigle & Marks 1994; McGarigle *et al.* 2002).

Eight Koala Habitat Atlas areas were analysed ranged in size from 31,000 ha (Campbelltown LGA) to 2,234,000 ha (Walgett LGA), with mapping scales varying from 1:10,000 (Ballarat Shire) to 1:100,000 (Walgett LGA). Pre-clearing Koala Habitat Atlases were derived for Southeast Queensland, Noosa Shire and Walgett LGA, with Preferred and Supplementary habitat classes. Where pre-clearing data was not available, one class (native vegetation) was compared to two current classes (native vegetation/cleared). Analyses compared pre-clearing and post-clearing within available areas, and total native vegetation (or eucalypts forests and woodlands if possible) and habitat classes between Koala Habitat Atlases. Further analyses were performed on the much coarser-scale National Vegetation Inventory System (NVIS). With a cell size of 0.01 degrees, this scale of analyses is more suited to bioregional, state or national scales. Metrics derived from NVIS datasets are indicative only. Notwithstanding, comparisons between scales were made for Walgett LGA, Southeast Queensland and Noosa Shire where all datasets were available. Refer to Appendix 13 for descriptions of the

following fragmentation metrics codes.

### **Analysis over the distribution of Koalas**

Pre-clearing and post-clearing fragmentation analyses over the Koala's current range indicated that the Number of Patches (NumP) has increased by 270%, the Total Edge (TE) has increased by 19% and edge density by 216%. When these metrics are considered in the context of a 44.7% reduction in eucalypt forest and woodland cover, **a reduction in Mean Patch Size MPS of almost 80% confirms the fragmentary nature of current Koala habitat**, even at broad scale. **Increases in Edge Density (ED) of 216% and a decrease in the Area-weighted Mean Shape Index (AWMSI) of 62% indicate that remaining habitat is subject to greatly increased edge effects** even though remaining habitats are "smoother" around the edges. **Patches are more isolated in view of the 96% decrease in the Mean Proximity Index (MPI).**

The same analyses on a State-by-State basis revealed that **Victoria and SE South Australia have the greatest increase in NumP, with 93.9% and 98.7% decrease in Mean Patch Size** (respectively). Total Edge (TE) has increased most markedly in New South Wales, with a 34% rise. Edge Density (ED) has generally doubled with the greatest rise in NSW (242%). **Decreases in AWMSI are highest in SA (-62.2%) and QLD (-50.7%), indicating smaller patches with a disproportionate amount of edge.** Mean Proximity Index (MPI) has decreased in all States with the more populous areas (NSW, VIC and SA) recording the most decline. It is instructive to compare the ACT metrics with those of other States, the ACT is mostly National Park which has not been as affected by clearing and consequent fragmentation. **On a National scale, South Australia showed the worst habitat fragmentation as well as the most habitat loss, followed by Victoria, New South Wales and Queensland.**

Fragmentation analyses by Bioregion was performed for pre-clearing and current Vegetation datasets, with three metrics illustrated in Figures 2-4. Most metrics showed greater fragmentation. A simple method of assessing each bioregion is to score a point for each metric exceeding the average metric for all bioregions, with an extra point awarded if individual bioregions exceeded the overall average decrease in eucalypt forest and woodland cover of 44.7%, making a maximum nine points.

a) **8 points: Brigalow Belt North (BBN) and South East Corner (SEC)**

BBN scored a point for every metric except change in Mean Shape Index (dMSI), dMSI was still negative however, indicating simpler shapes. Alarming, dNumP has increased from 11 to 560, a 50-fold increase, corresponding with a **99% decrease in Mean Patch Size (dMPS)**. A 78.5 % increase in Total Edge (dTE) corresponds with a 841% increase in Edge Density (dED). BBN scored second-highest for AWMSI with a change of +157.6%, indicating smaller patches with longer edges. Change in Mean Proximity Index (dMPI) was -97.2%, ranking BBN 9th for this statistic. Overall, BBN had the highest measure in four of the eight metrics. SEC had an increase in NumP (1,344%), second after BBN, and was mid-ranked in most metrics.

b) **7 points: South East Coastal Plain (SCP), Gulf Plains (GUP), Victorian Volcanic Plains (VVP).**

SCP has a 13-fold increase in NumP with 94% reduction in patch size and 3-fold increase in dED. SCP had the highest dAWMSI with 244%, second-highest increase in ED (470.4%), and also ranked highly on decrease in MPS (-97.6%) and increase in TE (61.5%). dIJI was -28.6% off a below-average pre-clearing base (IJI= 30.1%), implying that the eucalypt communities in this Bioregion that have been cleared are in particular parts of the landscape, for example alluvial flats cleared to the edge of ranges and hills. GUP was mid-placed in most metrics, with a large change in the Interspersion Juxtaposition Index between pre-clearing eucalypts (IJI=12.2%) and current eucalypts (IJI=5.9%). These metrics are amongst the lowest in any case, indicating that GUP eucalypt communities were and still are widely scattered. VVP scored equal first with BBN for decrease in Patch Size (dMPS= -98.7%). A large decrease in Total Edge (-168.2%) and below-average change in Edge Density is indicative of wholesale clearing. VVP scored highest for decrease in Mean Proximity Index (dMPI= -99.9%), an extremely high degree of isolation.

c) **6 points: Brigalow Belt South (BBS), New England Tableland (NET), Murray Darling Depression (MDD), Wet Tropics (WT).**

It should be noted that a *decrease* in TE, such as in the BBS Bioregion (-85.4%) indicates firstly, smaller patches, and secondly, simpler shapes. It is useful to contrast this metric for BBN (-78.5%). Similarly, decrease in MPI (-99.2%) is greater for BBS, indicating greater distance between remaining patches. Although BBN has greater fragmentation on other scores, these two metrics, coupled with the fact that BBS has twice the area, confirms BBS as the Bioregion "hotspot" for fragmentation.

NET scored fourth on increase in NumP, up 937%, coupled with a 95.6% reduction in Mean Patch Size (dMPS). Total Edge (dTE) increased 37.4%, with Edge Density (dED) increasing 289.3%. This indicates that in the NET Bioregion clearing has occurred by subdivision of habitats, but more particularly by "sculpting" edges to increase the edge effect on habitats. Below-average changes in Shape Index (MSI/AWMSI) support this conclusion. MDD, with the highest clearing rate (dArea= -95%), ranked equal-second on dMPS with a 98.6% reduction in Mean Patch Size. Other metrics to note are an increase in Total Edge of 29.5%, dED= 257% and dAWMSI= 136.5%.

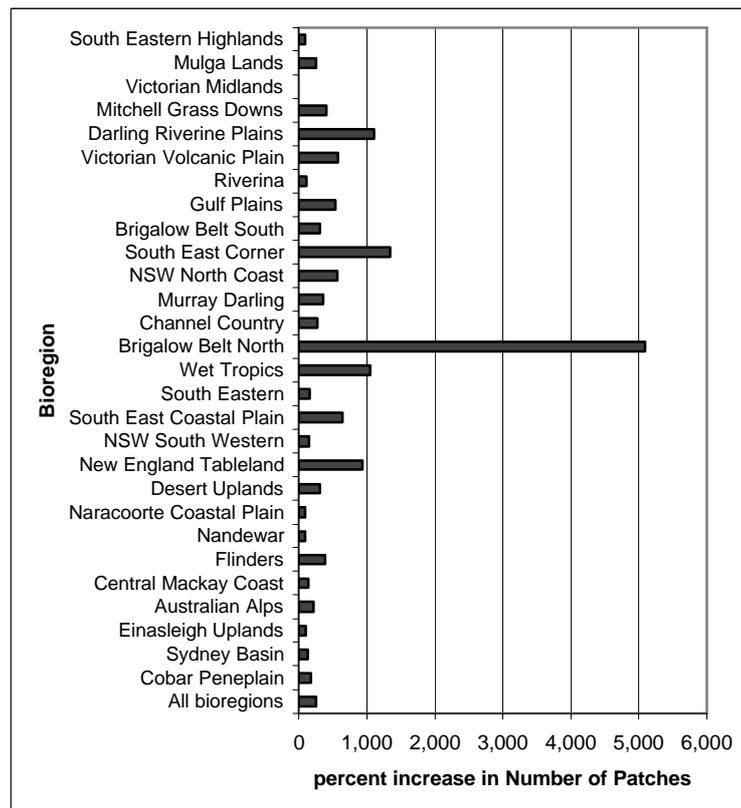
**d) 5 points: NSW North Coast (NNC), Victorian Midlands (VM), Channel Country (CHC), Darling Riverine Plains (DRP), Mitchell Grass Downs (MGD), and Mulgalands (ML).**

NNC has a 571% increase in NumP, 88% decrease in Patch Size (dMPS), 37.8% decrease in Total Edge (dTE) and an increase in Edge Density (131.4%). These metrics indicate more, and smaller, patches of a convoluted nature. Mean Proximity Index (dMPI= -99.9%) is the same as that for VVP.

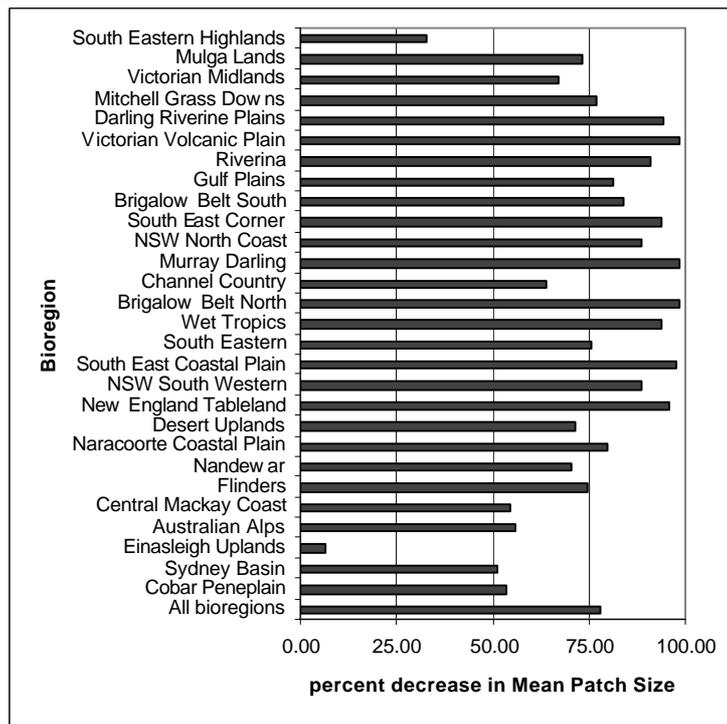
VM is the only Bioregion to record a substantial *decrease* in NumP (-81%), indicating clearing of entire patches of eucalypt forests, typically on more fertile lower landscapes. Remaining patches decreased in area (dMPS= -67.3%). VM has the greatest decrease in Total Edge (dTE= - 435.3%), again indicating wholesale clearing of patches. Proximity to other patches is also reduced (dMPI= -98.3%).

At the other end of the scale, Einasleigh Uplands (EIU) scored two points, for dAWMSI and dMPI. The EIU metrics show an apparent anomaly with a large increase (as opposed to a general decrease) in Mean Proximity Index (dMPI). Examination of other

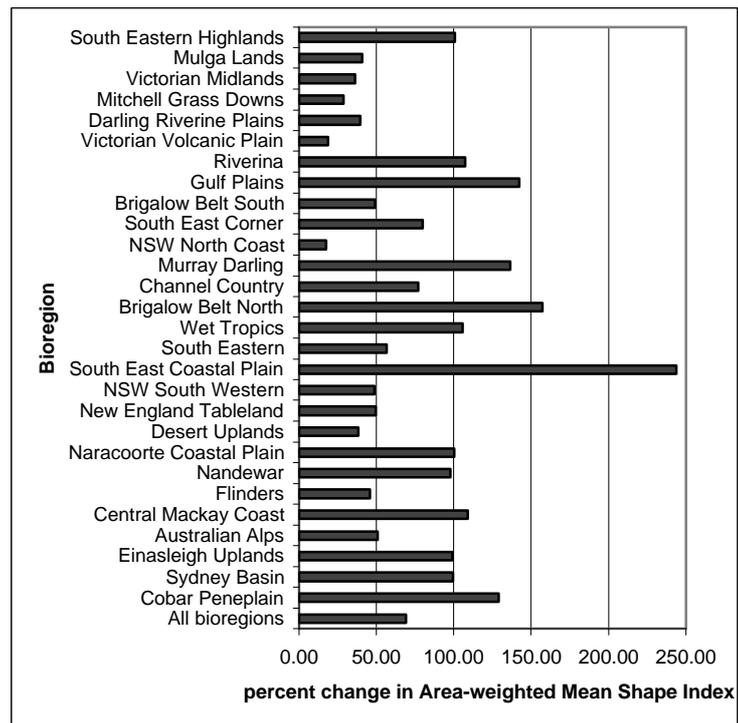
metrics is necessary to clarify this marked exception from the norm. Firstly, EIU has a relatively small 2.0% clearing rate, with a concomitant 6.48% decrease in Mean Patch Size (dMPS), the smallest of any Bioregion. AWMSI increased by 98.94%, an approximate doubling of the Perimeter-Area ratio (area-weighted). These metrics together indicate that clearing in the EIU Bioregion consists mainly of large, linear patches. In this context, the increase in MPI can be understood as a reflection of uneven spatial and patch size distribution (Gustafson & Parker 1992) within the EIU Bioregion, especially compared to its immediate neighbours.



**Figure 2.** Increase in the number of habitat patches by bioregion.



**Figure 3.** Decrease in mean patch size by bioregion.



**Figure 4.** Change in area-weighted mean shape index by bioregion.

### **Analysis for AKF Koala Habitat Atlas Projects**

Results for the western half of Walgett LGA, perhaps the least disturbed of all AKF project areas indicated that the NumP has increased by a factor of 2.4 compared to increases of from nearly five times (Noosa) to 190 times (Taree). MPS decreased by 68% compared to factors ranging from 10 (Noosa) to 316 (Taree). Total Edge (TE) increased by 56%, whereas for Taree it increased by a factor of 7. For west Walgett Edge Density doubles, while for other areas it changes by factors from 5 (Campbelltown and Noosa) to 15 (SEQ).

Results for Noosa Shire in Southeast Queensland consistently indicated substantial increases in fragmentation measures. Of particular concern is the **greatly disproportionate increase in the fragmentation metrics for Preferred Koala Habitat compared to other mapped habitat categories**. For example, the number of patches (NumP) increases by 264%, while the Mean Patch Size (MPS) decreases to just 16% of the pre-clearing MPS. For all vegetation, NumP increased by 250%, while MPS decreased to 40% of pre-clearing MPS. This disparity might reflect the fact that Preferred Koala Habitat commonly occurs on higher quality soils in floodplain areas and lower slopes, where habitat clearing for agriculture and urban development has generally been focused. The Total Edge (TE) metric increased for all habitat categories, while the Area-weighted Mean Shape Index (AWMSI) showed a disproportionate fall for the Preferred habitat category. **The Mean Proximity Index (MPI), a measure of the degree of isolation and fragmentation, indicated a drastic decrease in habitat connectivity** (17761.02 to 1198.43).

### **NVIS compared to KHA mapping: a scale comparison**

A selected number of areas were compared using NVIS data and finer-scale KHA mapping. Landscape/Class Areas (TLA/CA) are broadly equivalent at both scales. Number of Patches (NumP) varies considerably between NVIS and KHA data, with over double NumP for West Walgett extant eucalypts, and 50 times the number of patches with Greater Taree KHA data compared to the NVIS data. This difference is repeated in the Mean Patch Size (MPS) metric, where Greater Taree NVIS data has

MPS nearly 60 times bigger than the finer-scale (1:25,000) mapping. SEQ has MPS different by a factor of 3.2, whereas the Ballarat statistic is remarkably similar. Edge Densities (ED) are far greater for the finer-scale data. AWMSI is higher for all extant habitats except Ballarat at finer scale. Mean Proximity Index (MPI) is far greater for Taree and SEQ.

Vegetation mapping at 1:100,000 scale on the Queensland Clermont 1:250,000 map sheet (Johnson 1999; Bailey 2001) was also used to compare analyses at different scales. This mapping is also the base data for NVIS mapping in this section of the Brigalow Belt North Bioregion. Scale difference was indicated by the 10-fold increase in cell counts (TLA). Eucalypt proportions are similar between datasets for both pre-clearing and 1999 vegetation. Fragmentation metrics differ markedly, NumP increases by 62% for the NVIS data and 208% for EPA. Mean Patch Size (MPS) shows a similar trend, -61.2% (NVIS) and -80.2% (EPA). Edge Depth (ED) increases by 36.4% (NVIS) against 184.6% (EPA).

The similarity in fragmentation metrics when compared at different mapping scales indicates that the NVIS data is suitable for broad examination across the distribution of Koalas. Fragmentation metrics can be expected to be more pronounced with finer-scale mapping, this was certainly the case, especially with Patch Density and Size, Edge, Shape and Diversity/Interspersion metrics. Results were quite variable using the NVIS data, a reflection of the coarseness of scale.

**KEY POINTS:**

- ❖ **Habitat fragmentation analysis was undertaken by the Australian Koala Foundation for pre-clearing and current vegetation across the distribution of Koalas, as well as for States and Bioregions, and at local-scale using Koala Habitat Atlas mapping.**
- ❖ **These analyses across all scales showed consistent substantial increases in measures of habitat fragmentation; drastic reductions in measures for habitat connectivity; and increased habitat isolation.**

❖ **On a National scale, SA showed the worst habitat fragmentation as well as the most habitat loss, followed by VIC, NSW and QLD.**

### **5.3.7 Habitat degradation: *Eucalyptus* and *Callitris* forests and woodlands**

Whilst historical and ongoing habitat clearing and fragmentation are undoubtedly the most significant threatening processes for Koalas, there are many other factors that contribute significantly to the ongoing degradation of Koala habitat and the decline of Koala populations. These factors include edge effects, weed invasion, feral animals, logging practices, tree disease, and changed fire regimes.

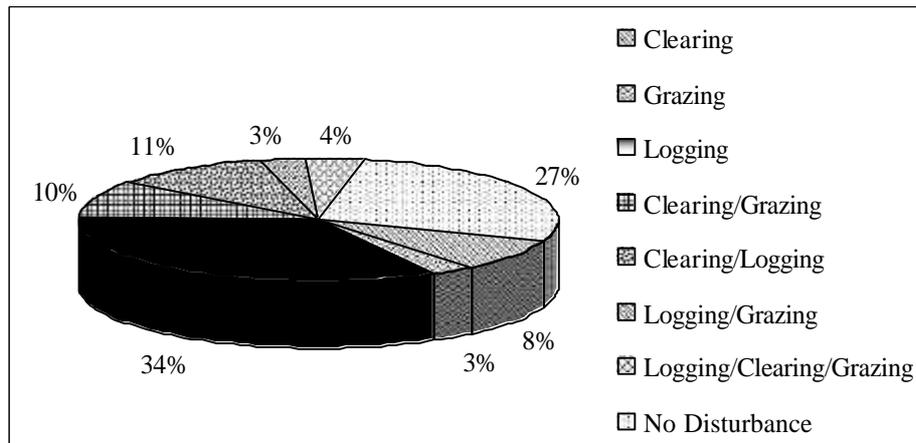
The Australian Native Vegetation Assessment 2001 (Cofinas & Creighton 2001) reports that the Native Vegetation Information System (NVIS) mapping is focused on major vegetation groups and broad-scale vegetation clearing, and that the mapping products are designed primarily for use at national and State-wide scale and for simple regional vegetation descriptions. The NVIS mapping involved compilation of a wide range of data sources with varying capture scales. Hence, at this stage the mapping has not been able to incorporate consistent quantitative assessments of the extent of disturbance and degradation within present vegetation types (Cofinas & Creighton 2001). However, **degradation of remaining native vegetation from a variety of disturbance factors is an extremely widespread and significant phenomenon, as confirmed by evidence from Australian Koala Foundation field surveys over 11 years in Queensland, New South Wales and Victoria** (AKF unpublished data).

#### **Evidence of disturbance recorded from AKF field survey sites:**

##### **i) Logging, grazing and partial clearing (Figure 5)**

- ~ 72.6% of AKF field sites recorded readily observable evidence of disturbance from logging, partial clearing, grazing, or a combination of these factors.
- ~ 51.2% of AKF field sites recorded evidence of logging disturbance only.
- ~ 27.7% of AKF field sites recorded evidence of at least two of the above disturbance factors.
- ~ 54.9% of AKF field sites that recorded logging disturbance, had hollow-bearing

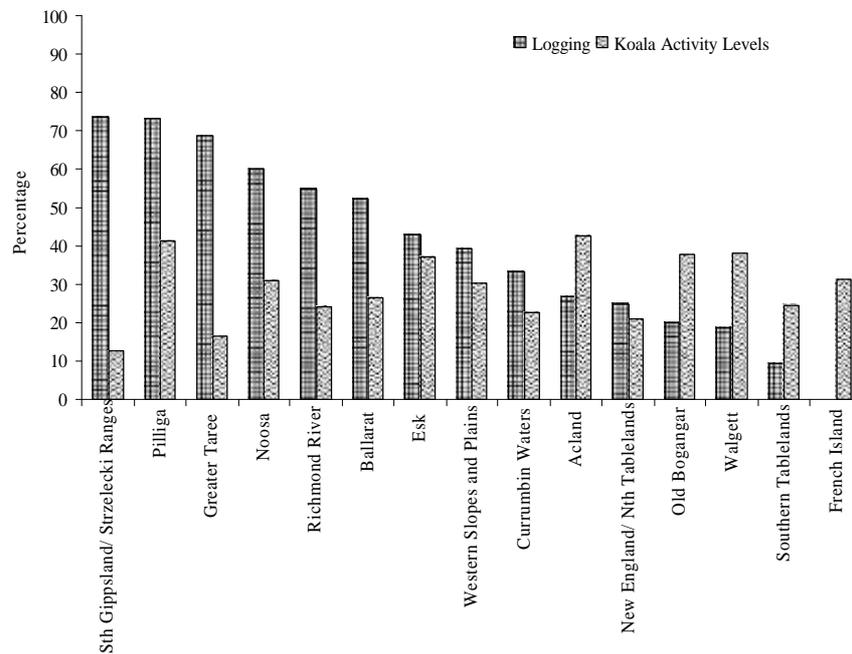
trees present.



**Figure 5.** Habitat disturbance types and percentages at AKF field sites.

**ii) Logging disturbance and Koala activity levels (Figure 6)**

- Koala faecal pellet-based activity levels recorded from AKF field sites tend to be higher (indicating more significant use) at sites that lacked readily observable evidence of logging disturbance.

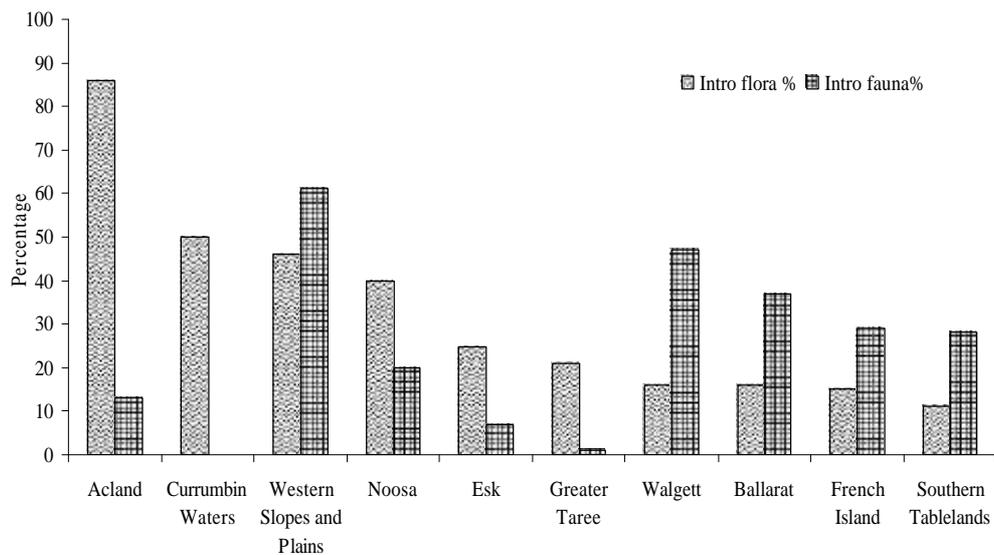


**Figure 6.** Percent AKF field sites with logging disturbances, plotted with Koala

activity levels.

**iii) Introduced flora and fauna (Figure 7)**

- ~ 24.6% of AKF field sites recorded readily observable evidence of feral animals; with NSW north western slopes and plains recording the most frequent evidence (61%) amongst project areas.
- ~ 23.8% of AKF field sites recorded introduced flora (weeds); with Acland sites in southeast Queensland recording the most frequent evidence (86%) amongst project areas.



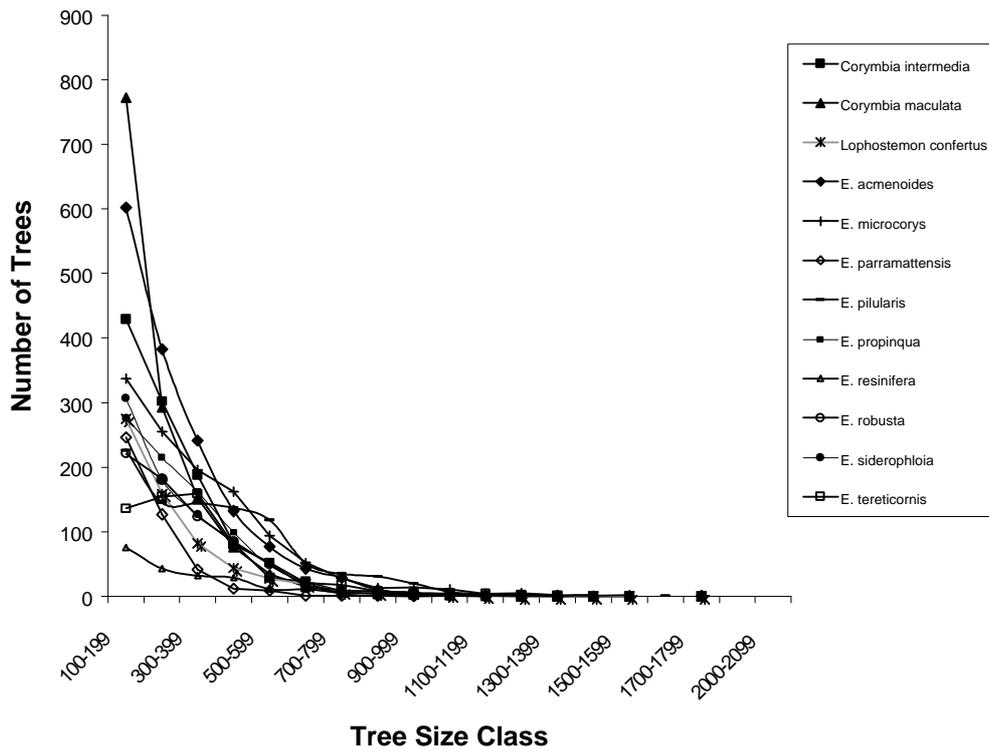
**Figure 7.** Percentage of AKF field sites with introduced flora and fauna

**Tree size data and evidence of use by Koalas:**

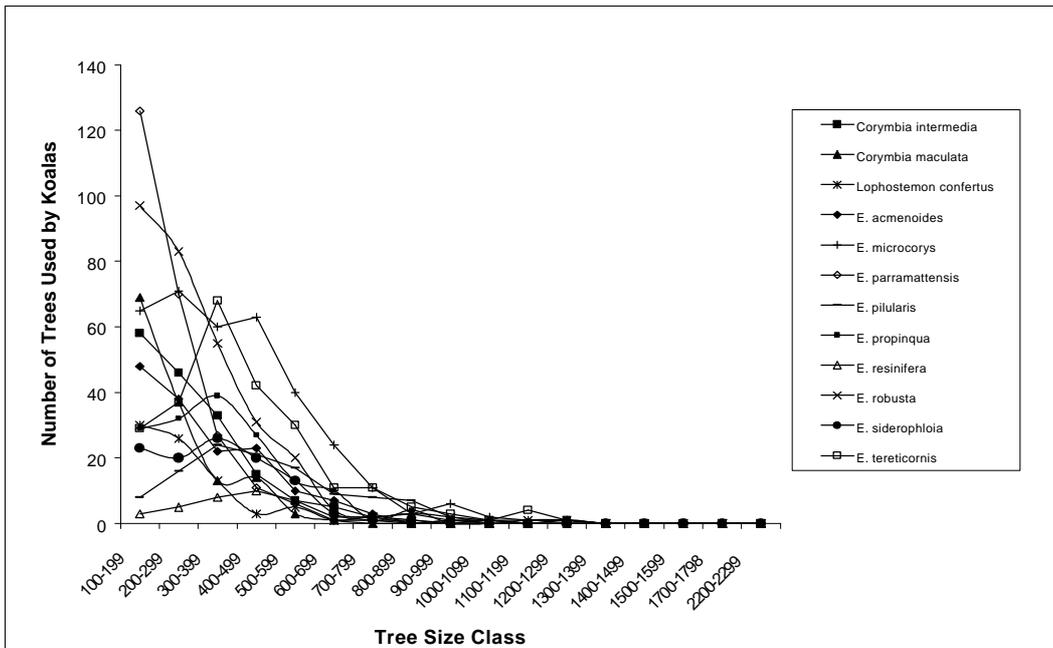
In conjunction with this nomination the AKF undertook a preliminary analysis of the distribution of tree size classes and the influence of tree size on use by Koalas for a selection of tree species in the NSW North Coast Bioregion. This analysis involved a total of 10,315 individual trees surveyed from 451 field plot sites in seven project areas within the Bioregion. Project areas include Tweed LGA (*n* = 57), Goonengerry State Forest in Byron LGA (*n* = 19), Lismore LGA (*n* = 34), Richmond River LGA (*n* = 127), Greater Taree LGA (*n* = 118) and Port Stephens (*n* = 96). Field surveys were undertaken as part of the AKF Koala Habitat Atlas project and involved searches for

Koala faecal pellets within a 1m catchment around the base of all trees (dbh  $\geq$  100mm) within 20m radial plots. The survey methodology has been designed primarily for the purpose of identifying local-scale tree species and habitat preferences of Koalas (see Phillips and Callaghan 2000; Phillips *et al.* 2000).

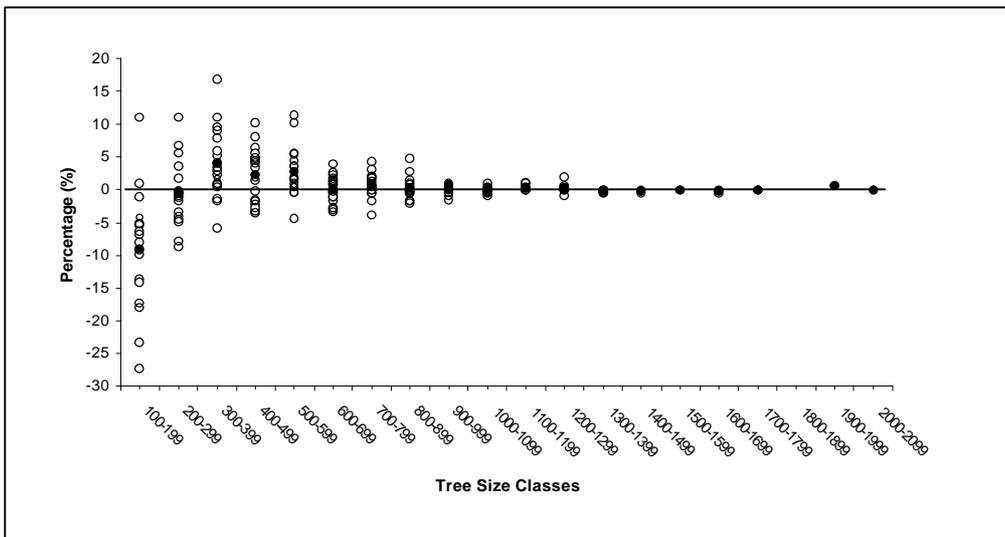
Twelve tree species were selected for size-class analysis including (Primary Koala Food Trees) *Eucalyptus microcorys*, *E. tereticornis*, *E. robusta* and *E. parramattensis*; (Secondary Food Trees) *E. propinqua* and *E. resinifera*; (Supplementary Food Trees) *E. siderophloia*, *E. acmenoides* and *E. pilularis*; and (non-eucalypt species) *Lophostemon confertus*, *Corymbia intermedia* and *C. maculata*. The number of surveyed trees for each species were tabulated and graphed according to 100mm increments in breast height diameter (dbh) as illustrated in Figure 8. Evidence of use by Koalas for each tree species is shown in Figure 9 according to size classes. An analysis of usage versus availability was undertaken for each size class based on the combined dataset for all twelve tree species (Figure 10).



**Figure 8.** Size class frequency distributions for a range of tree species surveyed by the AKF in the NSW North Coast Bioregion.



**Figure 9.** Tree usage by Koalas for size classes of a range of tree species surveyed by the AKF in the NSW North Coast Bioregion.



**Figure 10.** Koala use versus availability analysis for combined tree species data for the NSW North Coast Bioregion. • Mean %Use - %Availability.

Our analysis for each tree species confirms that Koalas consistently make use of all available tree size classes, ranging from 100mm up to the largest specimens available. However, analysis of usage compared to availability for the combined dataset indicates preferential selection for larger trees (*i.e.* those in the 300mm to 800mm size class). Trees in the 100mm to 199mm size class appear to be used far less by Koalas than

would be predicted on the basis of their availability in the landscape.

In terms of the overall distribution of size classes: 62.1% of the trees in the sample were in 100mm to 299mm size classes; 35.6% were in 300mm to 799mm size classes; and only 2.3% were in size classes above 800mm. The greatly disproportionate abundance of smaller trees is likely to be partly a result of widespread habitat disturbance involving the removal of many of the larger trees, followed by regrowth.

**KEY POINTS:**

- ❖ **Koalas appear to select trees on the basis of size as well as species with overall preferences for larger trees over smaller trees.**
- ❖ **Larger trees are far less abundant in the landscape than are smaller trees, thus further limiting the availability of preferred resource for Koalas. In our sample, trees under 299mm dbh represent 62.1% of the dataset.**
- ❖ **The greatly disproportionate abundance of smaller trees is likely to be partly a result of widespread habitat disturbance.**

**5.4 Overall summary of support under Criteria 1 for Vulnerable listing**

- ❖ The Koala population decline models presented in this nomination provide unequivocal support for listing of those populations as Vulnerable in accordance with the EPBC Act and IUCN Red List Categories and Criteria; with in excess of 30% modelled population declines over three Koala generations (approximately 20 years). We argue that these examples are representative of widespread declines in remaining populations throughout much of the Koalas natural distribution; with the exception of a few high density populations following re-introduction programs in Victoria into small mainland habitat isolates, as well as islands outside the natural range of Koalas. We are unaware of any evidence of increasing Koala populations

outside of these Victorian isolates. All Koala populations that we are aware of face significant ongoing threats and many are at considerable peril including a number that arguably face almost certain prospects of local or regional extinction in the near future.

- ❖ Norton and Neave (1996) argued that absolute numbers of Koalas may mean very little over the long term if remaining populations are largely restricted to marginal habitats and fragmented core areas.
- ❖ According to Sherwin *et al.* (2000), there should ideally be no further reduction in the overall number of individual Koalas nor increase in isolation of populations. Sherwin *et al.* (2000) argue that fragmented populations and those experiencing declining numbers are more likely to incur reduced genetic variability within individual animals and across the population.
- ❖ Previous assessments have widely reported drastic historical declines in the distribution and estimated numbers of Koalas throughout their natural range since European settlement:
  - i) Maxwell *et al.* (1996) reported a 50% reduction in the distribution of Koalas since European settlement.
  - ii) Phillips (1990) stated that local Koala population extinctions are inevitable in northeast New South Wales and southeast Queensland unless land management practices take account of habitat requirements.
  - iii) Melzer *et al.* (2000) report that Koala population declines are continuing in Queensland and New South Wales.
  - iv) Patterson (1996) concluded that a range contraction of up to 50% is likely to have occurred within Queensland since European settlement, and that populations have become increasingly fragmented.
  - v) In reporting on the results from NSW component of the 1986-87 national Koala survey, Reed *et al.* (1990) stated that Koalas were considered uncommon at the majority of locations and it was concluded that Koalas had been lost from many localities throughout the State, particularly in southern and western areas.
  - vi) Lunney *et al.* (1996) reported that at least 63% of forest and woodland in NSW

is estimated to have been cleared or severely modified since European settlement.

- vii) Lunney *et al.* (1990) stated that from an historical perspective the Koala population in New South Wales has suffered a major range contraction and will contract further as land clearing, fire, grazing and urban expansion continue.
  - viii) Lunney *et al.* (2000) indicated that the area occupied by Koalas in NSW was assessed as having declined by 51-75% since European settlement.
  - ix) In the case of the ACT, anecdotal reports indicate that Koalas were common until early this century when they were reported as rare (ANZECC 1998).
  - x) Koalas were reportedly once common throughout large areas of Victoria, but by the mid-1920s had been decimated by habitat destruction and hunting to the point of near extinction (Phillips 1990).
  - xi) Koalas were known only from the lower southeast part of South Australia at the time of European settlement in 1836. The original Koala population was thought to have been virtually extinct in the State by the late 1930s due to hunting for pelts, habitat loss, fire and possibly disease (ANZECC 1998).
  - xii) Melzer *et al.* (2000) recommend that the conservation status of Koalas should be reviewed in light of extensive land clearing since the national Koala survey in 1986-87.
- 
- ❖ Our GIS analysis of NVIS vegetation mapping indicated that approximately 44.7% of *Eucalyptus* forests and woodlands and *Callitris* forests and woodlands (potential Koala habitat) has already been cleared since European settlement from within the overall natural range of Koalas in mainland Australia. However, our assessment of the likely extent of additional clearing since the 1997 to 2001 vegetation mapping that underpins the NVIS data indicated that this figure is now likely to exceed 50% loss of potential Koala habitat.
  - ❖ The mapping of threatening processes in Sattler and Creighton (2002) indicates that the primary areas for threats from vegetation clearing and fragmentation overlap with virtually the entire Koala distribution.
  - ❖ The Australia State of the Environment 2001 report indicates that the rate of land clearing has accelerated in more recent times, with as much clearing during the last

50 years as in the 150 years prior to 1945.

- ❖ Losses of potential Koala habitat vary substantially between bioregions with greatest losses estimated for the Brigalow Belt South (50.2% loss); South Western Slopes (83.4% loss); South Eastern Highlands (41.1% loss); Riverina (90.1% loss); Victorian Midlands (73.7% loss); South Eastern Queensland (60.2% loss); and Brigalow Belt North (36.1% loss).
- ❖ Assessment of potential Koala habitat clearing (based on NVIS data) from the 349 Local Government Areas (LGAs) across the overall natural range of Koalas in mainland Australia provided alarming results with losses of 90% and above in 95 LGAs; between 70-89% in 75 LGAs; between 50-69% in 70 LGAs; and between 30-49% in 56 LGAs.
- ❖ Assessment of local-scale clearing of native vegetation on the basis of Australian Koala Foundation Koala Habitat Atlas mapping projects (currently covering approximately 4 million hectares) indicate total losses ranging from 21% for Walgett LGA in NSW to 85.7% for Ballarat in Victoria.
- ❖ Ecological history research has estimated clearing of approximately 75% of pre-European Koala habitat from the Port Stephens LGA and the Lower Hunter region in NSW; approximately 50% clearing of Koala habitat in Noosa Shire in southeast Queensland since 1860; the removal of most of the expected preferred Koala habitat from the Campbelltown LGA and surrounds in NSW; severe contraction and decline of Koala habitat and the Koala population in the Greater Taree LGA in NSW since European settlement.
- ❖ Habitat fragmentation has also been widely recognised as a major ongoing threat to Koalas. Recent research into the conservation and restoration of Koala populations in fragmented landscapes by McAlpine *et al.* (in review) concluded that Koalas are more likely to persist in landscapes with >50% high quality habitat configured in large patches (>100 ha), and with a low density of sealed roads. These results are particularly alarming given that our clearing analysis concluded that over 50% of *Eucalyptus* forests and woodlands and *Callitris* forests and woodlands (potential

Koala habitat) has already been removed since European settlement from within the overall range of Koalas in mainland Australia. This percentage is much higher in the case of many bioregions and Local Government Areas.

- ❖ Fragmentation analysis undertaken by the Australian Koala Foundation for Koala Habitat Atlas projects showed consistent substantial increases in fragmentation measures; greatly disproportionate increase in the fragmentation metrics for Preferred Koala Habitat compared to other mapped habitat categories; drastic reductions in measures for habitat connectivity; and increased habitat isolation.
- ❖ Degradation of remaining native vegetation from a variety of disturbance factors is an extremely widespread and significant phenomenon, as confirmed by evidence from Australian Koala Foundation field surveys over 11 years in Queensland, New South Wales and Victoria. For example: ~ 72% of AKF field survey sites recorded readily observable evidence of disturbance from logging, partial clearing, grazing, or a combination of these factors; ~ 24.6% of AKF field survey sites recorded readily observable of feral animals; ~ 23.8% of AKF field survey sites recorded readily observable weeds.
- ❖ Recent legislation to protect native vegetation in New South Wales and Queensland will hopefully have an impact by slowing and constraining future clearing of native vegetation, particularly remnant vegetation. However, this will be dependent upon an array of factors such as: consistent commitment and resourcing on the part of the State governments; effective policing and enforcement of clearing regulations; adequate incentives programs for private property owners; the ongoing support of land holders. At this stage, none of these factors seems assured, or in some cases even likely. Recent restructuring and down-sizing of government departments in New South Wales, such as the Department of Infrastructure Planning and Natural Resources and the new Department of Environment and Conservation, together with the possible abolition of government-funded vegetation mapping programs for the state raise considerable concerns. At this stage, clearing of native vegetation in both Queensland and New South Wales continues at an extremely alarming rate, and appears likely to continue over the immediate future with increasing relentless urbanisation from Newcastle to Gladstone and clearing for agriculture in western

regions.

## Conclusions

**The above assessment confirms beyond doubt that there has been a substantial reduction in Koala numbers with an associated widespread contraction in the distribution of Koala populations across their natural range.** All evidence suggests that declines and contractions will continue, and in many cases are likely to become increasingly rapid, into the foreseeable future in the face of continuing threatening processes such as habitat loss, fragmentation and degradation (particularly in Queensland and New South Wales), bushfires, drought, stress-related disease, predation by roaming domestic and feral dogs, traffic mortality, and loss of genetic variability. The impacts from such threats are often exacerbated by the extent of habitat loss and fragmentation, and subsequent population isolation. **Whilst all remaining Koala populations have not undergone declines as severe as 30% over three Koala generations (approximately 18 years), far greater population declines can be confidently inferred throughout the natural range of Koalas on the basis of the dramatic extent of widespread habitat loss, since European settlement. In addition, declines of 30% or greater over 18 years are either known or highly likely for many local populations throughout much of the Koalas natural range.** Recent evidence is often very limited for undertaking thorough assessments of the current conservation status of many local and regional Koala populations. However, it has been clearly established that in most cases the majority of potential Koala habitat has already been cleared, with remaining areas generally fragmented and disturbed. **It is also very clear that the cause of the reductions in habitat and populations have not ceased.** As critical thresholds with respect to the area of remaining high quality habitat, habitat fragmentation and population isolation are further surpassed, it is inevitable that population reductions will continue, with likely further widespread rates of decline in excess of the criteria of 30% over three generation.

**6.0 Addressing Criteria 2: Its geographic distribution is precarious for the survival of the species and is limited.**

- ❖ Not applicable across the current national Koala population as the extent of occurrence is greater than 20,000 km<sup>2</sup> and the area of occupancy is greater than 2,000 km<sup>2</sup>.

**7.0 Addressing Criteria 3: The estimated total number of mature individuals is limited; and**

- (a) evidence suggests that the number will continue to decline at a substantial rate; or
- (b) the number is likely to continue to decline and its geographic distribution is: precarious for its survival.

- ❖ Not applicable across the current national Koala population as the population estimate includes greater than 10,000 mature individuals.
- ❖ However, this certainly is currently the case with respect to individual populations and sub-populations; many of which have become largely geographically isolated by habitat loss and fragmentation processes in association with agricultural or urban land uses.

**8.0 Addressing Criteria 4: The estimated total number of mature individuals is low.**

- ❖ Not applicable across the current national Koala population as the population estimate includes greater than 1,000 mature individuals and the population is not restricted to less than 20 km<sup>2</sup> or to five or less locations.

**9.0 Addressing Criteria 5: The probability of its extinction in the wild is at least 10% in the medium-term future.**

**Relevant IUCN Red List Criteria:** Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years.

### **9.1 Preliminary Population Viability Analysis (PVA): Refer to Appendix 14**

It was clearly not possible for us to attempt quantitative analysis to derive meaningful probability of extinction estimates for the overall current Koala population across their natural distribution. This is due to difficulties in reliably establishing and modelling a wide range in key parameters (*e.g.* habitat and landscape characteristics; population demographics; mortality rates and threatening processes; interactions and recruitment), relevant to all local and regional populations (and sub-populations), within an extremely complex metapopulation framework.

However, it was possible for us to undertake very preliminary Population Viability Analysis (PVA) for the **Southeast Queensland Bioregion and the NSW North Coast Bioregion**, which are both known to contain highly significant Koala populations in imminent peril. These regions are widely recognised as containing some of the most significant Koala populations within each respective State (*e.g.* Reed *et al.* 1990; Lunney *et al.* 1990; Patterson 1996; Meltzer *et al.* 2000; Dique *et al.* 2003b; Callaghan and McAlpine 2003; Callaghan *et al.* in review). On this basis, **the decline and potential future extinction of these regional Koala populations has profound long-term implications for the survival of Koalas in Queensland and New South Wales, as well as nationally**. Our premise in deciding to attempt preliminary PVA modelling for these bioregions was that the outcomes, whilst not in any way definitive, would hopefully provide broader insight into current regional population trends. We also aimed to investigate rates of potential future population declines in the event that habitat loss, fragmentation and degradation continue to dramatically expand, together with associated threats from urban development such as traffic, dogs, bushfire and stress-related disease. This seems the likely scenario across substantial parts of both these bioregions on the basis of human population growth projections, in the absence of significant changes to strategic planning and more substantial and more effective protection measures for Koala populations and habitat.

We used VORTEX software to undertake the preliminary PVA modelling for the

Southeast Queensland Bioregion and the NSW North Coast Bioregion. We drew upon information that we had compiled previously for a nomination to have Koalas listed as Vulnerable in the Southeast Queensland Bioregion as a basis for assigning modelling parameters (Callaghan and McAlpine 2003). Recent VORTEX modelling undertaken by Lunney *et al.* (2002) to determine the probability of extinction for a small Koala population at Iluka in north eastern NSW also helped us with assigning parameter values. We aimed to in part accommodate the variation in key parameters amongst populations and sub-populations within each region by establishing three main models each with 12 scenarios (sub-models) to vary parameters, as outlined in Tables 1, 2, 3 and 4 of Appendix 14. The following key parameters were varied amongst main models and scenarios: female fertility; mortality rates; percent males in the breeding pool; and probability and likely severity of catastrophes such a bushfire. Population estimates used for the models were: Southeast Queensland Bioregion estimate = 25,000 (Queensland Government); and NSW North Coast Bioregion estimate = 8,200 (AKF).

The key outputs from the VORTEX modelling that were used to indicate the potential rates of population decline and probability of extinctions (within the limitations of the specified parameters) include the following:

- ❖ Mean ( $\pm$  SD) population growth rate ( $r$ ).
- ❖ Mean ( $\pm$  SD) years to extinction.
- ❖ Probability of population survival ( $\pm$  SD) at 10, 20 and 30 years.
- ❖ Mean ( $\pm$  SD) population size at 10, 20 and 30 years.

PVA results for main models 1 and 2 in both bioregions consistently indicated mean years to extinction that were considered too short to be realistic. This appeared to reflect sensitivity to higher parameter values for chances of catastrophe (bushfire) and severity of effect on the population. Hence, we have only reported results for model 3 scenarios below.

**Preliminary results for preliminary VORTEX PVA modelling for the Southeast Queensland Bioregion (refer to Table 5 of Appendix 14 for full summary results)**

Scenarios	Population Negative Growth Rate	Years to Predicted Extinction
	(Mean SD)	(Mean)
1.	- 0.053 (SD 0.038)	53.7 years
2.	- 0.140 (SD 0.049)	24.87 years
3.	- 0.952 (SD 0.038)	35.64 years
4.	- 0.181 (SD 0.050)	19.62 years
5.	- 0.152 (SD 0.034)	23.84 years
6.	- 0.237 (SD 0.043)	16.04 years
7.	- 0.088 (SD 0.289)	26.53 years
8.	- 0.183 (SD 0.331)	19.18 years
9.	- 0.154 (SD 0.373)	23.05 years
10.	- 0.264 (SD 0.442)	13.78 years
11.	- 0.217 (SD 0.392)	16.10 years
12.	- 0.301 (SD 0.390)	12.61 years

**Preliminary results for preliminary VORTEX PVA modelling for the NSW North Coast Bioregion (refer to Table 6 of Appendix 14 for full summary results)**

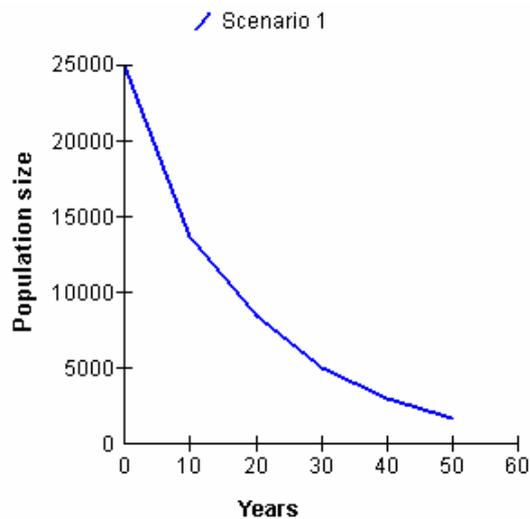
Scenarios	Population Negative Growth Rate	Years to Predicted Extinction
	(Mean SD)	(Mean)
1.	- 0.053 (SD 0.038)	43.87 years
2.	- 0.140 (SD 0.049)	18.40 years
3.	- 0.952 (SD 0.038)	26.60 years
4.	- 0.181 (SD 0.050)	15.14 years
5.	- 0.152 (SD 0.034)	17.44 years
6.	- 0.237 (SD 0.043)	11.39 years
7.	- 0.088 (SD 0.289)	19.67 years
8.	- 0.151 (SD 0.188)	13.44 years
9.	- 0.131 (SD 0.290)	13.86 years
10.	- 0.199 (SD 0.219)	11.27 years
11.	- 0.176 (SD 0.240)	13.06 years

12.

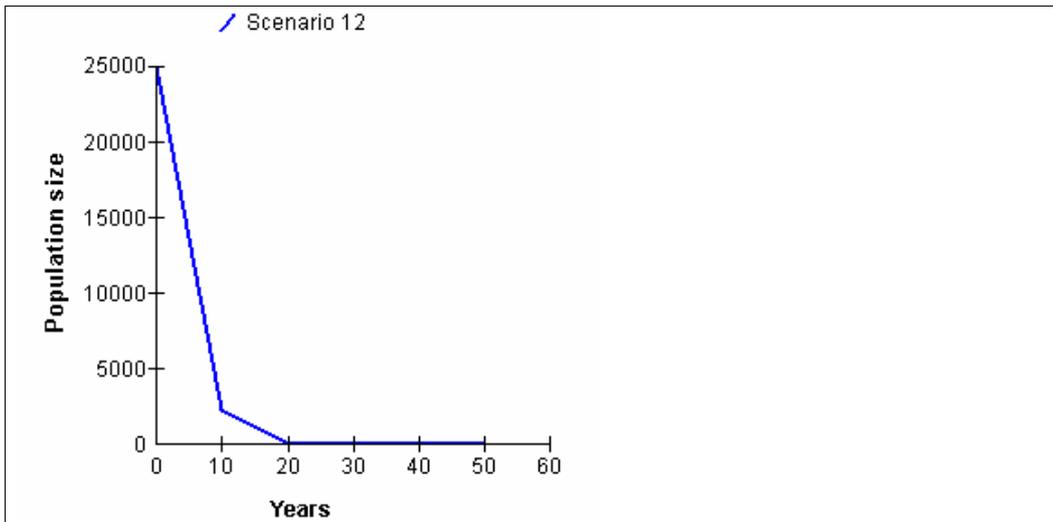
- 0.252 (SD 0.203)

9.89 years

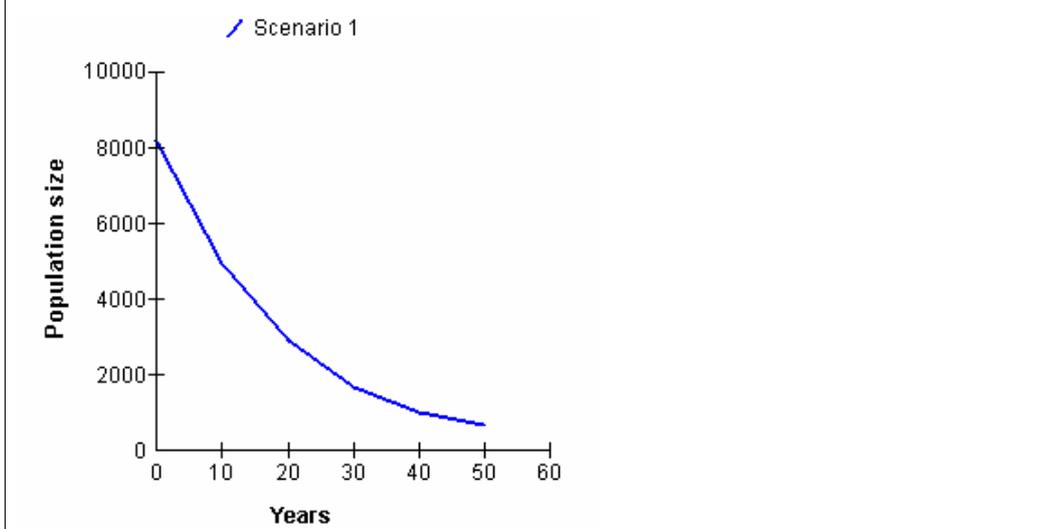
All models for both bioregions indicate population declines (negative population growth rates), with mean years to predicted population extinctions ranging from 12.61 years (Figure 11) to 53.7 years (Figure 12) for the Southeast Queensland Bioregion and from 9.89 years (Figure 13) to 43.78 years (Figure 14) for the NSW North Coast Bioregion. Whilst the worst-case predictions are clearly too extreme for the entire bioregional populations, overall the predictions suggest that both regional populations are in serious current decline and could quite conceivably become extinct from many parts of both bioregions. In our opinion, neither of these regional populations are likely to be capable of overall recovery even with the best intentions from all three levels of Government. This is a sad indictment on the planning schemes of New South Wales and Queensland. It is also likely that future human population growth will exceed current projections, which would be likely to accelerate Koala population declines. In conjunction with this process, there will undoubtedly be many localised extinction events and populations that decline beyond recovery thresholds over much shorter timeframes within both Bioregions.



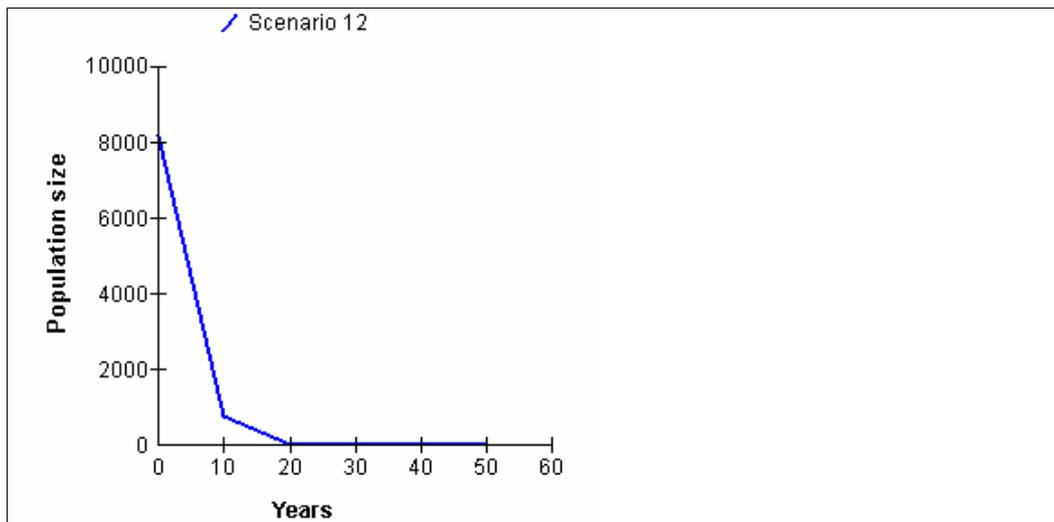
**Figure 11.** Least severe modelled Koala population decline for the Southeast Queensland Bioregion using Vortex software.



**Figure 12.** Most severe modelled Koala population decline for the Southeast Queensland Bioregion using Vortex software.



**Figure 13.** Least severe modelled Koala population decline for the NSW North Coast Bioregion using Vortex software.



**Figure 14.** Most severe modelled Koala population decline for the NSW North Coast Bioregion using Vortex software.

**KEY POINTS:**

- ❖ **The model results are not intended to give precise predictions, but rather to highlight population trends in the event that threatening processes continue to expand over substantial areas of both Southeast Queensland and NSW North Coast Bioregions.**
- ❖ **The above examples assume that key factors such as reporting rates and fertility rates have remained constant over the past several years in conjunction with increasing threats and diminishing habitat, which is highly improbable. It is probable that fertility rates within populations (and sub-populations) will decline with increasing incidence of population destabilisation, isolation and stress-related disease, in association with ongoing habitat loss, fragmentation and degradation.**
- ❖ **The Australian Koala Foundation is unaware of any remaining Koala populations (or sub-populations) within either the Southeast Queensland Bioregion or the NSW North Coast Bioregions that are likely to be stable, or secure and not in peril.**

## 10.0 Overall Conclusions

- ❖ **There is a large and convincing body of scientific evidence indicating that the majority of surviving Koala populations across mainland Australia are in decline, with many already known or suspected to have disappeared altogether.**
  
- ❖ **We recommend that the Threatened Species Committee support a federal Vulnerable listing for Koalas under the EPBC Act throughout their natural range in Australia. We recommend excluding from this listing all introduced Koala populations outside their natural range in Victoria plus those introduced into nine mainland isolates in Victoria (*i.e.* French Island, Phillip Island, Raymond Island, Snake Island, Sandy Point, Tower Hill, Mt Eccles and Framlingham in Victoria), as well as Kangaroo Island in South Australia. We ask that the Threatened Species Committee consider whether or not the Mt Lofty Ranges should also be excluded from Vulnerable listing.**
  
- ❖ We argue that a national Vulnerable listing is resoundingly supported by the information and analysis presented in this nomination and would be fully consistent with application of precautionary principles in accordance with the IUCN Red List Categories and Criteria. In our opinion, alternative action at this time would mean that remaining Koala populations and Koala habitat will inevitably continue to decline to the extent that prospects for widespread recovery will be significantly reduced and recovery efforts would be substantially more difficult and costly.
  
- ❖ A Vulnerable listing would benefit Koalas by providing a legislative basis for establishing a consistent approach to the management and recovery of Koala populations and Koala habitat throughout their remaining range. Recovery actions would need to include the identification and mapping of core Koala populations and critical Koala habitat, as well as the design and implementation of programs for habitat protection, management and restoration. Mapping of critical Koala habitat would be essential in order to direct resources to priority areas requiring immediate

conservation efforts. We believe that this could best be achieved at a national level through an innovative **National Koala Recovery Plan** incorporating incentives schemes for private property owners such as might be achieved through taxation legislation, federal funding and cooperative arrangements to support State-based conservation programs. A National Koala Recovery Plan could also make provisions for regular monitoring and reporting on the conservation status of Koalas and Koala habitat, which might include a future follow-up national Koala survey.

- ❖ A National Koala Recovery Plan could draw upon the National Koala Conservation Strategy (ANZECC 1998), the *draft* NSW Koala Recovery Plan (currently being prepared by the Department of Environment and Conservation in NSW under the TSC Act), a Conservation Plan for Koalas in Queensland (currently being prepared by the Queensland Environment Protection Agency), and the *draft* Victorian Koala Management Strategy (recently exhibited for comment by the Victorian Department of Sustainability and Environment).

## 11.0 Literature Cited

Akcakaya, H.R., S. Ferson, M.A. Burgman, D.A. Keith, G.M. Mace, and C.R. Todd. 2000. Making Consistent IUCN Classifications under Uncertainty. *Conservation Biology* 14(4):1001-1013.

ANZECC. 1998. National Conservation Strategy. Australian and New Zealand Environment and Conservation Council, Canberra, Australia.

Australian State of the Environment Committee. 2001. Australia State of the Environment 2001, Independent Report to the Commonwealth Minister for the Environment and Heritage. CSIRO Publishing on behalf of the Department of the Environment and Heritage.

Ashworth, G. 1998. "How Pine Rivers Shire is protecting Koalas from dog attacks" in Proceedings of a conference on the Status of the Koala held at Coffs Harbour. Australian

Koala Foundation, Brisbane.

Bailey, L. P. 2001. Clermont (Northern half) 1:250,000 map sheet: 1999 Remnant Vegetation Survey and Mapping of Brigalow Belt Bioregion Queensland Herbarium, Environmental Protection Agency.

Benson, D. and Howell, J. 1990. Taken for Granted: The bushland of Sydney and its suburbs. Kangaroo Press (with the Royal Botanic Gardens). Sydney.

Callaghan, J., Leathley, S. and Lunney, D. 1994. Port Stephens Koala Management Plan: draft for public discussion NSW National Parks and Wildlife Service, Sydney.

Callaghan, J. and Curran, T. 2000. "Bushfires: Chapter 11" in Port Stephens Council Comprehensive Koala Plan of Management (CKPoM): CKPoM Resource Document. Prepared by Port Stephens Council, Australian Koala Foundation, and NSW National Parks and Wildlife Service.

Callaghan, J., Curran, T., Thompson, J. and Floyd, R. 2002. Greater Taree City Council *Draft* Comprehensive Koala Plan of Management. Prepared by the Australian Koala Foundation on behalf of Greater Taree City Council.

Callaghan, J., Curran, T., Thompson, J. and Taylor, A. 2003. Campbelltown City Council *Draft* Comprehensive Koala Plan of Management. Prepared by the Australian Koala Foundation on behalf of Campbelltown City Council.

Callaghan, J. and C. McAlpine. 2003. Documentation in support of a nomination for listing the Koala as Vulnerable in Queensland. Unpublished nomination report to the Queensland Scientific Advisory Committee. Compiled by the Australian Koala Foundation, Brisbane.

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

Catling, P. 1991. "Ecological effects of prescribed burning practices on the mammals of southeastern Australia" in Conservation of Australia's Forest Fauna. Royal Zoological Society of NSW, Mossman.

Close, R. 1993. Campbelltown Koalas: What is their future? *National Parks Journal* 37(4).

Cofinas, M. and Creighton, C. 2001. Australian Native Vegetation Assessment 2001. National Land and Water Resources Audit. Commonwealth of Australia, Canberra.

Cogger, H., Ford, H., Johnson, C., Holman, J. and Butler, D. 2003. Impacts of Land Clearing on Australian Wildlife in Queensland. Unpublished Report by WWF Australia. Commonwealth of Australia. 1996. The National Strategy for the conservation of Australia's biological diversity. Commonwealth Department of the Environment, Sport and Territories, Canberra.

de Villiers, D. 1999. "Koala Management in South East Queensland – How do we know if it works?" in Proceedings of a Conference on the Status of the Koala held on Phillip Island Australian Koala Foundation, Brisbane.

de Villiers, D. 2000. "Aspects of Koala mortality in the Koala Coast: cars and dogs" in Conference on the Status of the Koala in 2000, held in Noosa. Australian Koala Foundation, Brisbane.

Dique, D.S., J. Thompson, H.J. Preece, G.C. Penfold, D.L. de Villiers and R.S. Leslie. 2003a. Koala mortality on roads in South East Queensland: the Koala speed-zone trial. *Wildlife Research* 30:419-426.

Dique D., H. Preece and D. de Villiers. 2003b. Koalas in Pine Rivers Shire: distribution, abundance and management. Queensland Parks and Wildlife Service, Brisbane.

Dique, D., D. de Villiers and H. Preece. 2003c. Evaluation of line-transect sampling for estimated Koala abundance in the Pine Rivers Shire, South East Queensland. *Wildlife*

*Research* 30:127-133.

ESRI (Environmental Systems Research Institute Inc). 1996. Using ArcView GIS. ESRI Redlands, CA 350 p.

Gardenfors, U., C. Hilton-Taylor, G.M. Mace and J.P. Rodriguez. 2001. The Application of IUCN Red List Criteria at Regional Levels. *Conservation Biology* 15(5):1206-1212.

Gill, A.M. 1975. Fire and the Australian Flora: A Review. *Australian Forestry*. 38:4-25.

Glassick, T., Giffard, P. and Timms, P. 1995. Chlamydial infections in Koalas: gene sequencing indicates that two separate Chlamydial species are involved, *Chlamydia pecorum* and *Chlamydia pneumoniae*. Pages 154-162 in "Proceedings on a conference on the status of the Koala in 1995". Australian Koala Foundation. Brisbane.

Glanzign, A. 1995. Native vegetation clearance, habitat loss and biodiversity decline: an overview of recent native clearance in Australia and its implications for biodiversity. Biodiversity Series, Paper No. 6. Biodiversity Unit, Environment Australia. Canberra.

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

Gordon, G., D.G. McGreevy and B.C. Lawrie. 1990. Koala populations in Queensland: major limiting factors. Pages 85-95 in A.K. Lee, K.A. Handasyde and G.D. Sanson (eds) *Biology of the Koala*. Surrey Beatty and Sons, Sydney.

Graetz, R. D., M. A. Wilson and S. K. Campbell. 1995. Landcover disturbance over the Australian continent: a contemporary assessment. Biodiversity Series, Paper No. 7. Biodiversity Unit, Environment Australia. Canberra.

Gustafson, E. J. & Parker, G. R. 1992. Relationships between landcover proportion and

indices of landscape spatial pattern. *Landscape Ecology* 7(2):101-110.

Houlden, B.A., England, P.R., Taylor, A.C. and Greville, W.D. 1996. Low genetic variability of the Koala, *Phascolarctos cinereus*, in southeastern Australia following a severe population bottleneck. *Molecular Ecology* 5:269-281.

Hume, I. 1990. Biological basis for the vulnerability of Koalas to habitat fragmentation. in D. Lunney, C.A. Urquhart and P. Reed (eds) Koala Summit – Managing Koalas in New South Wales – Proceedings of the Koala summit held at the University of Sydney 7-8 November 1988. NSW National Parks and Wildlife Service, Sydney.

International Union for the Conservation of Nature and Natural Resources: Species Survival Commission. 2001. IUCN Red List of Threatened Species Categories and Criteria (Version 3.1). World Conservation Union, Switzerland.

Jackson, M., P. Giffard and P. Timms. 1997. Outer membrane protein gene sequencing demonstrates the polyphyletic nature of Koala *Chlamydia pecorum* isolates. *Systematic and Applied Microbiology* 20:187-200.

Johnson, D. 1999. Clermont (Southern half) 1:250,000 map sheet: 1999 Remnant Vegetation Survey and Mapping of Brigalow Belt Bioregion Queensland Herbarium, Environmental Protection Agency.

Keith, D.A. 1996. Fire-driven extinction of plant populations: a synthesis of theory and review of evidence from Australian vegetation. *Proceedings of the Linnaean Society of NSW*. 116:37-78.

Knott, T., D. Lunney, D. Coburn and J. Callaghan. 1998. An ecological history of Koala habitat in Port Stephens Shire and the Lower Hunter on the Central Coast of New South Wales, 1801-1998. *Pacific Conservation Biology*. 4:354-368.

Leathley, S., Callaghan, J. and Curran, T. 2000a. "Traffic Management: Chapter 8" in Draft Port Stephens Council Comprehensive Koala Plan of Management (CKPoM):

CKPoM Resource Document – November 2000 Prepared by Port Stephens Council, the Australian Koala Foundation and NSW National Parks and Wildlife Service.

Leathley, S., Callaghan, J. and Curran, T. 2000b. “Dog Management: Chapter 9” in Draft Port Stephens Council Comprehensive Koala Plan of Management (CKPoM): CKPoM Resource Document – November 2000 Prepared by Port Stephens Council, the Australian Koala Foundation and NSW National Parks and Wildlife Service.

Lee, A.K. and R.W. Martin. 1988. *The Koala: A Natural History*. New South Wales University Press, Kensington.

Lunney, D., Urquhart, C.A. and Reed, P. (Eds). 1990. *Koala Summit – Managing Koalas in New South Wales – Proceedings of the Koala summit held at the University of Sydney 7-8 November 1988* NSW National Parks and Wildlife Service, Sydney.

Lunney, D., Curtin, A., Ayers, D., Cogger, H.G. and Dickman, C.R. 1996. An ecological approach to identifying the endangered fauna of New South Wales. *Pacific Conservation Biology* 2:212-31.

Lunney, D., Phillips, S., Callaghan, J. & Coburn, D. 1998. Determining the distribution of Koala habitat across a shire as a basis for conservation: a case study from Port Stephens, New South Wales. *Pacific Conservation Biology*. 4:186-96.

Lunney, D., Matthews, A., Moon, C. and Ferrier, S. 2000. Incorporating Habitat Mapping into Practical Koala Conservation on Private Lands. *Conservation Biology* 14(3):669-680.

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

Martin, R. and Handasyde, K. 1990. Population dynamics of the Koala (*Phascolarctos cinereus*) in southeastern Australia. Pages 75-84. in *Biology of the Koala*. Lee, A.K., Handasyde, K.A. and Sanson, G.D. (eds). Surrey Beaty & Sons, Sydney.

Martin, R. and Handasyde, K. 1999. THE KOALA: Natural History, conservation and management UNSW Press, Sydney.

Maxwell, S., A.A. Burbidge, and K. Morris. 1996. The 1996 Action Plan for Australian Marsupials and Monotremes. Project 500 for the IUCN/SSG Australian Marsupial and Monotreme Specialist Group of the World Conservation Union/Species Survival Commission. Endangered Species Program, Environment Australia. Canberra.

McAlpine, C. A., R. J. Fensham, and D. E. Temple-Smith. 2002. Biodiversity conservation and vegetation clearing in Queensland: principles and thresholds. *The Rangeland Journal* 24:36-55.

McAlpine C.A. and Eyre T. J. 2002. Indicators of Habitat Loss and Fragmentation for Conserving Biodiversity in Eucalypt Forest of Sub-tropical Australia. *Part A: St Marys State Forest Case Study*. Forest and Wood Products Research and Development Corporation, Canberra.

McAlpine, C.A. 2003. A Bioregional assessment of woody vegetation cover loss throughout the range of the Koala in Queensland based on available SLATS data sets. in Callaghan, J. and C.A. McAlpine Appendix 1 of Documentation in support of a nomination for listing the Koala as Vulnerable in Queensland. Unpublished Nomination to the Scientific Advisory Committee. Compiled by the Australian Koala Foundation, Brisbane.

McAlpine, C.A., Callaghan, J., Bowen, M., Lunney, D., Rhodes, J., Mitchell, D., Pullar, D. and Possingham, H. (in review). Landscape ecology as a predictive science: case study of the Koala (*Phascolarctos cinereus*) in fragmented landscapes. *Landscape Ecology*.

McAlpine, C., Callaghan, J., Bowen, M., Lunney, D., Rhodes, R., Mitchell, D. & Possingham, H. 2004. Conserving Southeast Queensland Koalas: How much habitat is enough? Technical Report on AKF website: [www.savethekoala.com](http://www.savethekoala.com)

- McGarigal, K. & Marks, B.J. 1994. Fragstats. Spatial pattern analysis program for quantifying landscape structure. *Version 2.0*. Corvallis: Forest Science Department, Oregon State University.
- McGarigal, K., Cushman, S.A., Neel, M.C. and Ene, E. 2002. FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Computer software program produced by the authors at the University of Massachusetts, Amherst. Available at: [www.umass.edu/landeco/research/fragstats/fragstats.html](http://www.umass.edu/landeco/research/fragstats/fragstats.html)
- McIntyre, S. and Hobbs, R. 1999. A Framework for Conceptualizing Human Effects on Landscapes and Its Relevance to Management and Research Models. *Conservation Biology* pp. 1282 – 1292, Volume 13, No. 6.
- Melzer, A., Carrick, F., Menkhorst, P., Lunney, D. and St. John, B. 2000. Overview, Critical Assessment, and Conservation Implications of Koala Distribution and Abundance. *Conservation Biology* 14(3):619-628.
- Menkhorst, P. 2003. Victoria's Koala Management Strategy-Draft for public Comment. Department of Sustainability and Environment. Melbourne.
- Moritz, C., J. Worthington-Wilmer, L. Pope, W.B. Sherwin, A.C. Taylor and C.J. Limpus. 1996. Applications of genetics to the conservation and management of Australian fauna: Four case studies from Queensland. Pages 442-456 in T.B. Smith and R.K. Wayne (eds) *Molecular genetic approaches in conservation*. Oxford University Press, Oxford.
- Murcia, C. 1995. Edge effects in fragmented forests: implications for conservation. *Trends in Ecology and Evolution* 10:58-62.
- Norton, T.W. and Neave, H.M. 1990. Koala habitat: a conceptual functional model. In *Koalas-Research for Management*. Proceedings of the Brisbane Koala Symposium, 22nd-23rd September 1990. World Koala Research Incorporated, Brisbane.
- NPWS. 2003. Draft Recovery Plan for the Koala. New South Wales National Parks and

Wildlife Service, Hurstville, NSW.

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

Phillips, B. 1990. *KOALAS: The Little Australians we'd all hate to lose.* Australian Government Publishing Service, Canberra.

Phillips, S. 1994. Koala Management Plan for Proposed Searanch Residential Development. Prepared for RDC Pty Ltd. Australian Koala Foundation, Brisbane.

Phillips, S. and Callaghan, J. 2000. Tree species preferences of Koalas (*Phascolarctos cinereus*) in the Campbletown area south of Sydney, New South Wales. *Wildlife Research.* 27:502-516.

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

Phillips, S. & Callaghan, J. 1996. Koala Habitat Atlas: Tweed Coast. Prepared for Tweed Shire Council. Australian Koala Foundation, Brisbane.

Pickett, S.T.A. & White, P.S. 1985. "Patch dynamics: a synthesis" in *The Ecology of Natural Disturbance and Patch Dynamics.* S.T.A Pickett and P.S. White (eds). Academic Press, New York, pp:371-384.

Port Stephens Council. 2001. Port Stephens Council Comprehensive Koala Plan of Management (CKPoM). Prepared by Port Stephens Council, the Australian Koala Foundation and NSW National Parks and Wildlife Service.

Possingham, H.P. 1995. The practical application of population viability analysis for conservation planning. Pages 292-99 in R.A. Bradstock, T.D. Auld, D.A. Keith, R.T. Kingsford, D. Lunney and D.P. Sivertsen (eds) *Conserving Biodiversity: Threats and Solutions*. Surrey Beatty and Sons, Sydney.

Prime Minister's Science Council. 1992. *Scientific Aspects of Major Environmental Issues: Biodiversity*. Office of the Chief Scientist, Department of the Prime Minister and Cabinet, Canberra.

Prime Minister's Science, Engineering and Innovation Council. 2002. *Sustaining our Natural Systems and Biodiversity*. Commonwealth Government, Canberra.

Queensland Government 1997. *State Planning Policy 1/97 Conservation of Koalas in the Koala Coast*. Queensland Government.

Reed, P.C., Lunney, D. and Walker, P. 1990. "A 1986-1987 survey of the Koala *Phascolarctos cinereus* (Goldfuss) in New South Wales and an ecological interpretation of its distribution". Pp 55-74 in *Biology of the Koala* (A.K. Lee, K.A. Handasyde and G.D. Sanson eds.). Surrey Beatty and Sons, Sydney.

Rempel, R.S. and A. P. Carr. 2003. Patch Analyst extension for ArcView: version 3. <http://flash.lakeheadu.ca/~rrempe/patch/index.htm>

Sattler, P.S. and R. D. Williams (eds). 1999. *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Brisbane.

Sattler, P. and Creighton, C. 2002. *Australian Terrestrial Biodiversity Assessment 2002*. National Land and Water Resources Audit. Commonwealth of Australia, Canberra.

Saunders, D.A., Hobbs, R.J. and Margules, C.R. 1991. Biological consequences of ecosystem fragmentation: a review. *Conservation Biology* 5:18-32

Seabrook, L.M., McAlpine, C.A., Phinn, S.R., Callaghan, J. and Mitchell, D. 2003.

- Landscape legacies: Koala habitat change in Noosa Shire, South-east Queensland. *Australian Zoologist* 32(3):446-461.
- Scully, L. 2003. Relationships between vegetation clearance and the introduction of legislation in the Nyngan Region, Central Western NSW. Notes and Abstracts. *Ecological Management & Restoration* 4 (2), 140-157.
- Seymour, A. M., Montgomery, M.E., Costello, B. H., Ihle, S., Johnsson, G., St John, B., Taggart, D. and Houlden, B. 2001. High effective inbreeding coefficients correlate with morphological abnormalities in populations of South Australian Koalas (*Phascolarctos cinereus*). *Animal Conservation* 4:211-219.
- Sherwin, W.B., P. Timms, J. Wilcken and B. Houlden. 2000. Analysis and Conservation Implications of Koala Genetics. *Conservation Biology* 14(3):639-649.
- SLATS. 1999. Land cover change in Queensland 1991-1995. Resources Sciences and Knowledge, Queensland Department of Natural Resources, Brisbane.
- Smith, P. and Smith, J. 1990. Decline of the urban Koala (*Phascolarctos cinereus*) population in Warringah Shire, Sydney. *Australian Zoologist* 26(3 & 4):109-129.
- State of the Environment Advisory Council. 2001. Australia State of the Environment. CSIRO Publishing. Collingwood. Australia.
- Sullivan, B.J., Baxter, G.S. and Lisle, A.T. 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, B.J., Baxter, G.S., Lisle, A.T., Pahl, L. and Norris, W.M. 2004. Low-density Koala (*Phascolarctos cinereus*) populations in the Mulgalands of south-west Queensland. IV. Abundance and conservation status. *Wildlife Research* 31:19-29.
- Summerville, K. 1990. "Koalas in the Tweed Shire" in Koala Summit – Managing Koalas in New South Wales – Proceedings of the Koala summit held at the University of

Sydney 7-8 November 1988 (Eds. Lunney, D., Urquhart, C.A. & Reed, P.) NSW National Parks and Wildlife Service, Sydney.

Thackway, R. and I.D. Cresswell. 1995. An Interim Biogeographic Regionalisation for Australia (IBRA): A Framework for Setting Priorities in the National Reserves System Cooperative Program. Reserves System Unit, Australian Nature Conservation Agency. Canberra.

Tilman, D., R.M. May, C. Lehman, and M.A. Nowak. 1994. Habitat destruction and the extinction debt. *Nature* 371:65-66.

Williams, J. and Gill, A. 1995. The Impact of Fire Regimes on Native Forests in Eastern New South Wales. Forest Issues 1. NSW National Parks and Wildlife Service, Hurstville, NSW.

Yates, C.J. and R.J. Hobbs. 1997. Temperate Eucalypt Woodlands: a review of their status, processes threatening their persistence and techniques for restoration. *Australian Journal of Botany* 45(6):949-973.

### **Nominator Information**

The following information is subject to the provision of the Privacy Act and will not be divulged to third parties if advice regarding the nomination is sought from such parties

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**Declaration** (Please read carefully and sign the declaration)

*I declare that the information in this nomination and its attachments is true and correct to the best of my knowledge.*

Signed \_\_\_\_\_

DATE \_\_\_/\_\_\_/\_\_\_

**Completed nominations should be electronically lodged at  
[epbc.nominations@deh.gov.au](mailto:epbc.nominations@deh.gov.au)**

**or posted to:**

**Minister for the Environment and Heritage**  
C/O The Director  
**Species Legislation and Policy Section**  
GPO Box 787  
Canberra ACT 2601

**Queries regarding nominations should be directed to:**

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