Sent: 31/10/2017 1:00:02 PM

Subject: GATEWAY PROPOSAL in Fern Creek and elsewhere in Warriewood Valley

Attachments: AA -8-Hello General Manager.pdf; 161202-NSWCSE-koala-report-Dec 2016.pdf; AAA Peter Williams.docx; menkhorst_qon (1).pdf; Sydenam to Bankstown Bridge Construction Project-SMH.docx; PRIORITY PRECINCTS - Warriiewood Valley Environmental Habitat lands.docx;

Attention :: Chief Executive Officer :: Mark Ferguson

Hello CEO Mark Ferguson.

The Following is provided " in-confidence" and " Commercial-in- confidence "

In looking at a few GATEWAY PROPOSALS in Warriewood Valley, recently it becomes obvious that the required Environmental Habitat needs for the "sustainable populations " of both Koala and Squirrel Glider are not solved by Habitat losses continuing, and noted by Peter Smith, ecologist, in 1989.

The viewing of Priority Precinct " standard form " in other parts of Sydney creates a " concept for greater density ", so that suggests the Warriewood Valley " Urban Housing " may have NO MERIT, but where is the Fauna Habitat area ? = Maybe it is Warriewood Valley ?? The Internal Ombudsman's Unit can't get the answer.

I have referred the Bayview Golf Course " Site Compatibility Certificate " issue to the Greens Party MLA Dawn Walker, who is there spokesperson on Koala Matters in NSW. As Northern Beaches Council has no Koalas, the conclusion suggested is THAT a KOALA REOVERY is needed to avoid the impact of the 95 dwelling project, within GOLF COURSE LANDS. Glider Possums may be considered for the area, using NEST BOXES as habitat

Hills Shire Council s apparently looking at ways to preserve the bushland at the 55 Coonara Avenue Site, adjacent to Cumberland State Forest.

The response of Tod Dickenson, organised by the Internal Ombudsman's Unit of the COUNCIL is inadequate.The Eastern Pigmy Possums have been Trans-located to North Head Sanctuary, proving its is possible. The Over-Sight of NSW Planning and Environment historically have created a Habitat Loss of 580 Ha as noted by Peter Smith in 1989.

The proposal to drain Warriewood Wetlands will allow it to provide 16 ha of koala habitat. But the " international bird habitat can be " re-located " to Western Sydney.

In Pottsville, on the North Coast, the Endangered Koala population Dawn Walker is seeking extra land adjacent to the Wetland as Koala Habitat. But they have a " REAL POPULATION" in Pottsville, that could become extinct. In the Northern Beaches you needed the Victorian Solution 30 years ago, to have a long-term sustainable population.

The NCC NSW have a critical assessment of Bio-diversity Off-set legislation, so the " solutions " here may use development Off-set to achieve the " improvement in the NSW Planning System. Peter Williams was the Director of the Urban Planning Masters Degree Course at UNSW.

As Pittwater Council was formed after 1989, the Habitat needs of the local Koala Population

was understood to be " compromised " . Its now 30 years later, and with " better management technique" a sustainable population could exist. In Victoria the have done trans-locations to " start-up " populations in multiple locations in Victoria, so I have correspondence from Rob Stokes" Office (as Planning Minister supporting that technique) .

The Chief Govt Scientist Report, Dec 2016 has 11 recommendations with the first being its a " WHOLE OF GOVT " responsibility, so this includes NCAT, and Northern Beaches Council.

The Criticism of Angelo Candelapas, is from a Professor of Architecture, that has got a number of other award-winning architects to criticise the Priority Precinct Proposals of NSW Planning and Environment. Independent of that is criticism of the 55 Coonara Avenue, Gateway proposal of Mirvac Group that is "marginally within a Priority Precinct area. So the Bay View Golf Course proposal may succeed by the FAILURE of Local Govt to manage its " Triple-Bottom-Line " responsibility, by contrast the "review" of the Bilgola Valley Public Transport (B-Line) dedicated lanes also proposes environmental upgrades (avoided for 30 years or more) .

Hello General Manager,

Northern Beaches Council.

RE :: Gateway Proposals in Warriewood Valley.

While Northern Beaches Council Urban Planner Sylvania Mok is assessing the " merit " of Gateway Proposals, a review of the Native Fauna Habitat Needs of the Threatened Species should be done (to overcome past failure to provide a sustainable habitat area, for a local sustainable population) .

The existing Report done in 1989 by Peter Smith (Smith and Smith) has been referred in a report done for the Angophra Reserve Plan of Management. In that report it is noted that Angophra Reserve is inadequate habitat for the Squirrel Glider, but in 2017 the " credible sustainable population size " and "habitat needs " are unknown publically.

This lack of Triple-Bottom-Line management skill or over-sight has resulted in not a " sustainable recovery " of both the Koala and Squirrel Glider populations but both becoming extinct or unsustainable populations, with the Squirrel Glider an unsustainable population at time of listing. The Chief Government Scientist Report Dec 2016, has 11 recommendations.

It's a " Whole of Govt " responsibility to stabilises the populations and then increase the populations. As Pittwater had an unsustainable population in the early 1990's as noted by the Peter Smith Report of 1989, claiming " it's a new issue " is inappropriate. The NSW RZS submission to the Bio-diversity Reforms Review, was not fully in favour of the Bio-diversity Off-set Law proposals.

So then refer to the 11 recommendations of the Chief Govt Scientist's Report, Dec 2016.

As there is an Obvious " LACK OF HABITAT " a review of the Warriewood Valley Land Release and the Warriewood Valley Wet-lands is proposed.

The "Migratory bird sanctuary function " can be Off-set, to a Western Sydney Migratory Bird Wetland area that could become a " HOUSING ESTATE " instead of preserved as a Bird Sanctuary.

This is Riverstone Wetlands, in the Marsden Park / Riverstone area. (refer to Blacktown and District Environment Group web-site, which is a member of NCC NSW) .

With that " off-set " achieved, the Wetland could be drained (using an alternative Storm Water mitigation solution) and turned into 16 Ha of native fauna habitat (for koala and squirrel Gliders (using nest boxes as " habitat dwellings " (as Tree Hollows will form in later years)) . In addition to the " WETLAND AREA " is the Gateway Proposal sites including the Fern Street site part owned by Northern Beaches Council (nee Pittwater Council) .

So the proposed " Plan to Grow Sydney " justification for the Warriewood Land Release area proposals, may be " challenged " as lacking the " triple-bottom-line " management skill of an Ecologically Sustainable Development, as the failure of the Local Council to rectify the " Habitat Loss" for a Listed Threatened Species, displays the " sub-standard ESD approach of the Local Council " .

The amount of Sustainable Habitat needed for a Koala Population, should be known in 2017, but owning to the Council Merger, it is not known. The Wedderburn Koala Population has a 100 to 140 koala population that has a 30,000 Ha Range. This is much larger than the Barrenjoey Population so the habitat in Northern Beaches should be known in 2017, and the " fragmentation of bushland patches " solved, before the changes in Bio-diversity Laws, in late 2017.

As other parts of Metro Sydney are having " Priority Precincts " concepts proposed with 25 or 30 storeys high " Urban Uplift " areas, in areas where there is now just one or storey high dwellings, so the options to Regionally (within the Former Pittwater area ?) to provide both the Environmental Lands and the Urban Uplift areas, can be re-assessed, to overcome the past " mistakes ", and the Bayview Golf Course " Urban Uplift " proposal that may be in conflict with the Native Fauna Habitat needs of Listed Threatened Species (and unlisted fauna).

As the Internal Natural Resources Staff have failed for 30 years to achieve a sustainable recovery of both Koala and Squirrel Glider populations, it might suggest that the URBAN PLANNING STAFF and General Manager are not operating in a " triple-bottom –line " management standard.

The Merged Northern Beaches Council has a reported annual $ 10 million " savings " after 4 years of the Merger. This suggests a past of " waste " at Pittwater, and denied by its General Manager?

As a consequence a " review of the " independent report "" on the Gateway Proposal/s may be required. And the Gateway Proposals are then rejected, and the affected property owners compensated, for the LOCAL GOVERNMENT Management (or mis-management ?). The Urban Density in Warriewood Valley would be reduced, so an Urban Planning Tool " TDR " could be applied as part of the solution. This may reference the Chief Govt Scientist Report , Dec 2016 Recommendation 4 : Improvement in the NSW Planning System for koala.

An independent team of ecologists and urban planners, may be required to assess how to achieve the " double task " of sustainable Fauna Populations, and " Urban Uplift " (population growth targets), as the current Ingleside Land Release proposal fails the " Sustainable Fauna Habitat solution " for both the Koala and Squirrel Glider, and offers a lower housing density than 5,000 dwellings in Ingelside (or its alternative " priority precinct " area of Mona Vale), which may imply defective design of Public Transport solutions to Northern Beaches, which favours approval of 95 dwelling Housing product in Bayview Golf Course lands, as a socially responsible decision, which may " BLOCK " the passage of Native Fauna to Barrenjoey Peninsula, and " affordable apartments " in Mona Vale Town Centre that cost over $ 1 million each. The " Priority Precinct " proposal in Cherrybrook is reportedly 800 m radius from the New Train Station and 25 to 30 storey high within 400 m radius of the Train Station, so why not use that " standard model " within the review of Ingleside and Mona Vale " Priority Precincts "?

The Former NSW Planning Minister, Rob Stokes MP, member for Pittwater, complained about the Bayview Golf Course being granted a Site Compatibility Certificate in early 2017, but in 2015 rejected the concept as NSW Planning Minister.

Rob Stokes MP has in past claimed *in his maiden speech lamented the loss of Sydney's bushland to development. I am a supporter of ecological sustainable development, and we need to focus on development that can be sustained indefinitely, but there has to be a balance". The more recent Chief Govt Scientist Report, Dec 2016, into the decline of Koala Populations has 11 recommendations, with the first being it's a " WHOLE OF GOVT " responsibility (that does not exclude the Northern Beaches Council).*

Only Pittwater and Port Stephens have listed koala populations, but Pittwater has the distinction of a listed " extinct " population, without even a sustainable Recovery Plan. This is " ecologically unsustainable development ". It is not " triple-bottom – line " best practice. Rob Stokes MP has supported an 80% increase in population in Sydney. So extra population density may be required in Northern Beaches, but where can 580 Ha of " Bushland Habitat loss" of Barrenjoey Peninsula be locally sourced for a sustainable population of koala and other native fauna ? if its not available in Barrrenjoey Peninsula ?

- *Is Warriewood Valley Wetland and*
- *Gateway Proposal Sites in Warriewood Valley part of the solution ? = YES.*
- *Can Migratory Birds go to the Riverstone Wetlands = YES (if its preserved)*
- *Is Mark Ferguson's assurance that the " environment issues " will be addressed with the Bayview Golf Course 95 dwelling DA , adequate ? = NO.*

The NSW Planning and Environment Dept have provided this email letter.

The extract is as follows:

As you are aware, the Koala and their habitats are protected by various legislation such as the *Threatened Species Act 1995* and the *Native Vegetation Act 2003*, and State policies, such as the State Environmental Policy No. 44 (SEPP 44), which encourages the conservation and management of koala habitat whilst also providing provisions for developers and more specifically councils, in order to develop plans of management which deal with any potential impacts to koalas.

Northern Beaches Council (formally Pittwater) is included in SEPP 44, but has not developed a comprehensive koala plan of management. We encourage you to continue to meet with Council to discuss your recommendations and continue to provide community leadership in the development of such a plan.

In response to the recommendations of the Chief Scientist and Engineer, the Government is working collaboratively towards a whole of Government Koala Strategy. This work is being led by the Office of Environment and Heritage, which will identify how to better protect the koala from extinction in NSW. The Office of Environment and Heritage invited input on developing the strategy from 4 December 2016 to 3 March 2017. The Office of Environment and Heritage can be contacted on 131 555.

Yours sincerely

16 June 2017

Stephen Murray
Executive Director, Regions
Planning Services

So after listening to Amanda Smith, ABC Presenter for Life Matters, ABC National Radio, the similarities between a confessed Female Alcoholic, and Mark Ferguson's " hiding his Lack of Sustainable Recovery of Native Species " the similarities become obvious. Both are hiding the truth. Both will have a string of " White Lies " , and convenient excuses. Claiming you have to approve the Gateway Proposal in Warriewood Valley to meet "Plan for Growing Sydney" is FLAWED, as is the " support for Bayview Golf Course's 95 dwelling proposal, achieved by a "refusal to allow a Sustainable Recovery of Koala " in 2011, and in 2003/6/7 ?? thus creating " little need ? " for the Wildlife Corridor as Claimed by Rob Stokes MP in 2017.

The Female Alcoholic went to AA meetings to " reform" , then was interviewed on National Radio by Amanda Smith for Life Matters Program.

For Mark Ferguson, the solution Starts with Accepting the Sustainable Recovery Plan is part of a " Whole of Govt " responsibility, that includes Northern Beaches Council, and uses the Recommendation 4. Improve the NSW Planning System, when bio Off-set solutions fail to achieve a real Ecologically Sustainable Development solution.

For Mark Ferguson, and Rob Stokes MP, Former NSW Planning Minister, Former NSW Environment Minister this includes an Public Transport Solution thru Bilgola Valley to Avalon, that may mean funding a BUS LANE or B-Line (BUS RAPID TRANSIT) LANE/S (or alternative including Light Rail ?), as part of the " SMART CITY / 30 Minute City / Future Streets concept ") . One option is a Green Roof over wider Barrenjoey Road thru " Bilgola Bends " area. The Northern Beaches Council in recent past supported a B-line on a East-West Route to Chatswood, but historically, Bilgola Bends has long queues of cars trying to get thru the Round-about at Kamaksi Corner, so Both Mark Ferguson, and Rob Stokes MP should support adequate Space for B-line (or its alternative ?) thru Bilgola Valley.

This Bilgola Valley proposal is also part Environmental Rectification of the late 1960's RMS Destruction of Livistonia (Cabbage Tree)Palm Forest in the Valley (caused by RMS 1960's road-widening project to 6 lanes was abandoned in Bilgola Valley but Road-Widening south of Newport Shops was completed in late 1960's thus explaining the 2017 " Newport Terminus Decision?" to stop at Newport).

Clearly, the Northern Beaches Council's Natural Resources Unit has been unable to organise a Sustainable Recovery of Squirrel Glider, and Koala in the Local Area in 30 years So perhaps the cause is General Management, and Town Planning Staff decisions and loss of bushland habitat and Fragmentation of bushland before 1989?

The Newport Residents Association meeting at Newport Beach in late Oct, 2017 was not in favour of Newport Beach being the Terminus, and criticised the Width of the Round-a-Bout. They have just provided " reasons " to use " Critical Thinking " and " innovation " to provide the Northern Beaches Version of the Tunnel under Lane Cove National Park for the North West Rail, and Lane Cove Road Tunnel, and let the Terminus of the B-Line or Alternative go to AVALON (to save Bus –Travel time)

The Bio Off-set Report prepared for NCC NSW is attached

So the proposed BAM applications for the Ingleside Land Release may be reviewed with the " expertise of NCC and its alumni " and then assess how to proceed with a Sustainable Koala Recovery Plan for the Northern Beaches, that may include

1 *100 Ha of Koala Habitat, either at normal ground level or using a " GREEN ROOF " vegetated Habitat over an Industrial or Housing or Office " land–use below in the Ingleside area.*

2 *It may also evaluate the Warriewood Wetland area, and " discover" that the Migratory Birds could be " re-directed to Riverstone Wetlands " ?*

This then allows the Wetland to be converted to 16 ha Bushland Habitat for Koala?

3 *It may also need to consider Manly Dam Bushland as a Koala Habitat Area as there is past records of Koala and Platypus in the area. It can provide Safe Access for Native Fauna to this Bushland area from Narrabeen Lakes Bushland area.*

Then the 11 Recommendations in the Chief Govt Scientist Report assessed.

Recommendation 4 :: Improvements in the Planning System can include the expertise of Peter Williams, and include

URBAN GROWTH MANAGEMENT IN NEW SOUTH WALES: MARKET-BASED APPROACHES FOR NATURAL RESOURCE CONSERVATION

Peter Williams
University of New South Wales, Sydney, NSW, Australia

INTRODUCTION

Urban growth management in New South Wales (NSW) has had a patchy history. Deficiencies have existed at the State level for example, in the policies and mechanisms for the management of the impact of development on natural resource values and environmental quality. Included in this scenario are various market-based instruments, the utilisation of which have been part of the Australian policy and regulatory landscape for more than two decades. Investigation, advocacy and, in some specific instances adoption, of a hybrid approach of regulatory, and statutory and policy-based economic, instruments has been evident over this time in the areas of urban planning, environmental protection and resource management (Williams, 2004). Yet despite this earlier promise and enthusiasm, the reality is that the extent and successful application of market-based tools in the Australian planning systems has been somewhat underwhelming. One reason for this poor record is the long-standing reliance on traditional 'command and control' approach using mechanisms such as land use zoning, development standards and other regulatory tools. Further, as market-based mechanisms constitute a more recent public policy approach, they are possibly a less understood planning tool that has been perceived to challenge the traditional regulatory framework. As a consequence there has been some reluctance on the part sections of government and other stakeholders to fully embrace this option to complement other planning other tools such as regulation.

This paper considers the potential benefits of market-based instruments, particularly from a property rights perspective. The paper examines two types of market-based instruments – transferable development rights (TDR) and tradeable offsets – that have been utilised in NSW. Several past and current TDR and tradeable offsets schemes are identified, ranging from schemes designed to conserve heritage buildings, agricultural land, scenic landscapes and biodiversity, and protect water quality. Review of the application of these TDR and tradeable offsets seeks to identify both problems experienced and benefits achieved. Identification of the difficulties faced and successful elements of these schemes permits the distillation of the necessary ingredients or conditions if market-based instruments are to be more fully implemented as part of the range of policy options or tools available to achieve planning and natural resource objectives.

Development control in NSW operates within the framework of what can be described as a *regulatory based statutory planning system* (Williams, 2007). This emphasis on regulation through statutory planning continues to have its advocates for both philosophical and practical reasons. From a conceptual perspective, regulation of development – 'development control' – is seen as fundamental to planning (Dawkins, 1996); at the same time, from a practical viewpoint, it is argued that regulation and prescriptive planning controls promote greater certainty and consistency in decision-making (Walton, 1997). The defining character of such 'command' regulation is its obligatory nature – it involves an authoritative relationship between the individuals or groups being regulated and the government (Stone, 1982).

Although the statutory and regulatory emphases remain in Australia – particularly in the form of land use zoning – more recently planning approaches influenced by United States systems of financial and planning incentives have emerged to complement this traditional 'command and control' regulation hegemony. Part of a self-styled 'smart regulation' package, these seek to give Australian planning systems greater flexibility through the use of market-based mechanisms and financial incentives (Gunningham and Grabosky, 1998). These tools include planning bonuses, green offsets, and the acquisition of development 'rights' pertaining to land. Often these also involve the utilization of traditional common law mechanisms such as covenants and easements. One sphere of application of this hybrid mix of planning approaches and tools is the protection of biodiversity and other natural resource values such as agricultural lands in areas subject to urbanization. Further fields of application of hybrid regulatory and market-based mechanisms include heritage conservation and landscape protection.

KOALA POPULATIONS in Decline in NSW

There is evidence of native fauna Species decline in many parts of NSW. Not all native fauna prefer habitat of the National Park system. There is no Koala populations in Blackheath (source: NPWS Ranger in Blackheath whose son was tracking Koalas in Port Stephens and Wedderburn areas) in the Blue Mountains, but they are possibly in the Lower Blue Mountains and Marsden Park area of Western Sydney.

In Victoria, ANU's David Lindenmayer, a Conservation Ecologist is proposing a vast National Park in Central Victoria, for preservation of the Leadbeater Possum. He is an expert, but his comment seems "anti- development ", and critical of current forest harvesting practice.

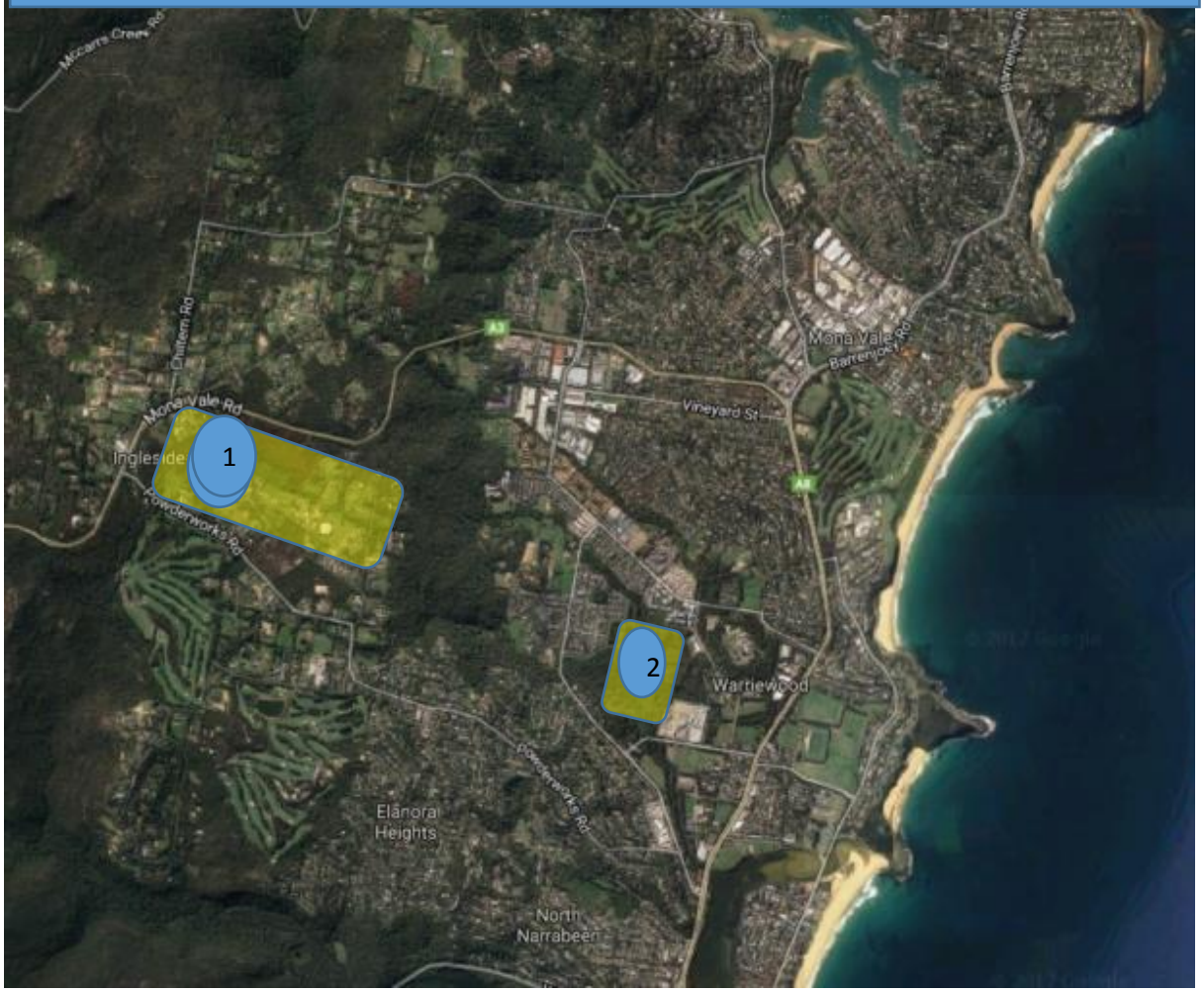
In NSW the NPA are proposing a Great Koala National Park in the Bellingen area. It may help preserve 20% of the State Koala population.

In the Tweed Coast area the population is in danger of long-term extinction, as the population is 100 to 125 (Circa).

In Western NSW the koala population has crashed say NPA.

So a LOCAL RECOVERY PLAN is the preferred option, that acknowledges Angophra Reserve, purchased in 1938 by Wildlife Preservation Society of Australia as important to connect into a Sustainable Habitat for Koala and Squirrel Gliders.

MAP of Warriewood Valley and Ingleside and Bayview Golf Course



The Chief Govt Scientist Report Dec 2016 Recommendations

RECOMMENDATIONS

This review makes 11 recommendations to inform the development of a NSW koala strategy.

Recommendation 1
That Government adopt a whole-of-government koala strategy for NSW with the objective of stabilising and then starting to increase koala numbers.

Recommendation 2
That Government initiate a program to improve data on the number, location and occurrence of koalas in NSW, including trends over time, taking advantage of new sensor and communication technologies and data analytics within 12 months of receipt of this report.

Recommendation 3
That Government publish a state-wide predictive koala habitat map within three years of receipt of this report, with immediate priority given to improving coverage of the north coast.

Recommendation 4
That Government improve outcomes for koalas through changes to the planning system.

Recommendation 5
That Government improve outcomes for koalas through the Biodiversity Conservation Bill and associated Regulations.

Recommendation 6
That Government investigate models for guiding and incentivising collaborative best practice for new development and ongoing land use occurring in areas of known koala populations across tenures, industries and land users.

Recommendation 7
That Government agencies identify priority areas of land across tenures to target for koala conservation management and threat mitigation.

Recommendation 8
That Government, through the Office of Environment and Heritage, convene two symposia within 12 months of receiving this report: one for scientists active in koala research and land managers to develop a koala research plan; and one focussed on koala rehabilitation to identify actions to optimise the delivery of and support for the network of koala rehabilitation groups and carers.

Recommendation 9
That Government establish the Australian Museum as a preferred repository for koala genetic samples in NSW, and all data and metadata associated with these samples should be deposited into the SEED Environmental Data Portal (extended if necessary to include flora and fauna).

Recommendation 10
That Government facilitate the exchange of information among land managers, local government, the research community and the broader community.

Recommendation 11
That Government draws on knowledge and shares information with local community members through a program that supports localised engagement between liaison people and residents and industry.

Report of the Independent Review into the Decline of Koala Populations in Key Areas of NSW

NSW Chief Scientist & Engineer

December 2016

www.chiefscientist.nsw.gov.au/reports

NSW GOVERNMENT | Chief Scientist & Engineer

The Hon Mark Speakman SC MP
Minister for the Environment
Minister for Heritage
Assistant Minister for Planning
52 Martin Place
SYDNEY NSW 2000

Dear Minister

Report - Independent Review into the Decline of Koala Populations in Key Areas of NSW

In March 2016, you asked me to establish and chair a committee to undertake a review into the decline of koala populations in key areas of NSW.

I am pleased to present my report as Chair of the Koala Advisory Committee. This report is intended to provide the basis from which a koala strategy for NSW can be prepared.

The report outlines some of the major issues requiring attention if we are to ensure that healthy koala populations can continue to persist. I make 11 recommendations that can form the basis for a state-wide strategy.

I would like to acknowledge the time and expertise provided by the members of the Committee established for this review, which included two independent experts and their colleagues, and officers from a range of NSW Government agencies.

Yours sincerely

Mary O'Kane
Chief Scientist & Engineer
2 December 2016

EXECUTIVE SUMMARY

Koalas are one of Australia's most iconic animals, recognisable around the world. However, koala populations are under increasing pressure. The NSW and Commonwealth Governments listed the koala as threatened in 1992 and 2012 respectively. In 2012, Adams-Hosking et al. (2016) estimated that Australia had approximately 330,000 koalas, with an estimated 36,000 in NSW. For NSW, this study estimated a 26% decline over the past three koala generations (15-21 years) and the next three generations.

In March 2016 the Minister for the Environment asked the Chief Scientist & Engineer to conduct an independent review into the decline of koala populations in key areas of NSW. A Koala Advisory Committee was established to provide advice to this review. This report is intended to provide the basis for preparing a whole-of-government koala strategy for NSW.

Many of the threats to koala populations are well known, for example, habitat loss and fragmentation, vehicle strike, dog attack, fire, disease, drought and heatwave. However, the scale and impact of particular threats vary across the state. There is still much to learn about many of these existing threats and the most effective actions to mitigate them. However, we can say that many of these threats are unlikely to abate and several will be intensified or exacerbated by climate change.

Government and the community have a range of actions available for managing these threats including legislative and regulatory controls, the requirements of the planning system, incentives for private conservation, community initiatives, and management of the reserve estate and other public land. However, outcomes are not always aligned across different tenures and land uses. Often, the effective use of management tools is hampered by lack of adequate data and information to inform decisions.

This report recommends that the objective of a NSW koala strategy should be to stabilise and then start to increase koala numbers.

This will require actions to protect, rehabilitate and connect koala habitat, as well as a range of actions to manage and mitigate threats to koalas. Some threats to koalas are widespread and others vary in intensity between bioregions. Therefore, some threats will require state-wide action, for example, through appropriate policy settings and investment in data collection, while others need to be addressed on the ground regionally or locally.

An important finding of this review is that it may not be possible to ensure all koala populations continue to persist in all locations. There are some populations where government and community action can help secure ongoing viability but there are also areas where the historical land use decisions, current competing land uses, as well as risks from road strike, dog attack and, in some areas, drought and bush fire events mean that it will be much more difficult to secure those populations. Government will need to make clear choices and invest resources where it is most likely to make a difference.

Critical to this are data. We need more and better quality data and more information to prioritise investment, to get the most out of the various regulatory and management tools we have available and to know if we are making progress towards the overall goal. New sensor and data analytics technology can make data gathering more efficient and cost effective.

Key elements of a whole-of-government koala strategy should be to:

- prioritise data gathering and research about populations, habitat and threats, including the cumulative impacts of multiple threats, to inform better planning and management decisions
- review and align the various legislative and management arrangements to ensure improved outcomes for koalas across different land uses and tenures
- work across tenures to identify and implement on-ground actions that improve connectivity and resilience against threats
- identify incentives for best practice new development and ongoing land use in all cases where koala populations may be adversely affected across tenures, industries and land users
- establish a framework for on-going coordination and cooperation of land managers, policy makers, researchers and the community to deliver the defined actions.

While many of the recommendations in this report aim to understand and address threats to koala populations, it is also important to support those who respond when the threats cannot be mitigated. Fauna rehabilitation groups play a critical front-line role in assisting the recovery of individual koalas, most commonly injured by car strikes, dog attacks or fire.

Successful implementation of a NSW koala strategy should lead to the following outcomes:

- we will know which koala populations have the potential for long term viability
- we will have evidence that threats to these populations have been identified and mitigated
- the community will feel confident that new development and ongoing land use will not threaten key koala populations
- our scientific knowledge of koala populations, dynamics and health will be substantially increased
- the number of koalas will become stable and then start to increase.

A NSW koala strategy should provide clear benefit to key koala populations in NSW. However, in identifying and protecting koala habitat and managing key threats, this strategy will also benefit other native species and NSW landscapes more broadly.

RECOMMENDATIONS

This review makes 11 recommendations to inform the development of a NSW koala strategy.

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Contents

1 INTRODUCTION

1.1 PURPOSE OF THE REVIEW

In March 2016 the Minister for the Environment asked the Chief Scientist & Engineer to conduct an independent review into the decline of koala populations in key areas of NSW. The Minister asked that the Review provide an evidence base from which a koala strategy for NSW can be prepared.

This report presents information about the current state of koala populations across their range in NSW and provides an initial evidence base for actions to address key threats to those populations. This report makes 11 recommendations, with the overarching recommendation for government to adopt a whole-of-government koala strategy for NSW with the primary objective of stabilising and starting to increase koala numbers.

1.2 PROCESS OF THE REVIEW

A Koala Advisory Committee was established with NSW government agency representatives and independent experts to provide advice and input to the review process. The Koala Advisory Committee met seven times between May and November. The Terms of Reference for the Review and the committee membership are in Appendix 1.

The Review has examined the hierarchy of threats to koala populations across NSW bioregions and the current legislative and regulatory framework for managing koalas and their habitat at the state and national level. The Review has investigated the historical context that has led to the current koala population distribution and numbers and also considered what other jurisdictions are doing to manage koalas and examples from other relevant programs.

A supporting paper examining four koala population case studies, which was commissioned by the Office of Environment and Heritage (Predavec, 2016), is published on the Chief Scientist & Engineer website.

1.3 CURRENT NSW POLICY SETTINGS AND PROGRAMS

Relevant government legislation

The combined koala populations of Queensland, New South Wales and the Australian Capital Territory are listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act (1999)*(EPBC Act). It means that project proponents need to consider whether their project will have a significant impact on important koala populations in these jurisdictions. If a project has or will have a significant impact, the EPBC Act requires the project to be referred for a decision by the Federal Environment Minister on whether the project is a 'controlled action'. If unsure, project proponents may refer the project to the Minister. The Australian Government is currently developing a recovery plan for the koala populations of the ACT, NSW and Queensland.

Koalas are listed as vulnerable under the NSW *Threatened Species Conservation Act (1995)* (TSC Act). There are also three listings of the koala as an endangered population in NSW; the Hawks Nest and Tea Gardens area of Great Lakes Local Government Area (LGA), the Pittwater area of Warringah LGA and the area between the Tweed and Brunswick Rivers, east of the Pacific Highway.

The listing of koalas as vulnerable means they must be considered under the *Environmental Planning and Assessment Act (1979)* (EP&A Act) when preparing environmental planning instruments and when undertaking development assessments. The koala is also protected under the *Native Vegetation Act (2003)* (NV Act), which requires impacts of clearing on threatened species to be avoided or offset in order to improve or maintain environmental outcomes. The review noted that the draft *Biodiversity Conservation Bill* proposes to repeal the NV Act and TSC Act and replace them with one integrated act.

Under the EP&A Act, consent authorities must consider the impacts of actions on species listed under the TSC Act. This is specified in the objects of the Act and must be considered for all development assessments. The Act also allows for issue-specific policies to be prepared such as State Environmental Planning Policies (SEPPs). SEPP 44 – Koala Habitat Protection (1995) was introduced to encourage the conservation and management of koala habitat. SEPP 44 applies to 107 LGAs, to land greater than one hectare in area and to projects where council is the determining authority. It requires the consideration of potential and core koala habitat before development consent can be granted. SEPP 44 encourages councils to prepare Comprehensive Koala Plans of Management (CKPOM). If a CKPOM has not been prepared for an area then a project proponent may need to prepare an individual Koala Plan of Management. The Department of Planning and Environment is currently reviewing SEPP 44 to identify ways to improve the existing protections and to modernise them. This includes how koala habitats are defined, as well as the tree species list in SEPP 44. This report recommends a second review stage could also assess how effective SEPP 44 and CKPOMs have been and their roles in the planning system (refer to Recommendation 4).

There are also other regulatory requirements for specific activities. For Private Native Forestry (PNF), there is a code of practice that includes koala specific measures for Property Vegetation Plans (PVPs). For non-PNF PVPs the Threatened Species Assessment Tool allows for clearing where offsets would improve the habitat of specific threatened species to at least the same extent as the habitat values lost through the proposed clearing. The assessment does not allow clearing where impacts are unsustainable for a local population of a threatened species. The NSW Government is reviewing the current legislation framework, these arrangements may change in the future.

The Environment Protection Authority (EPA) regulates the Forestry Corporation of NSW (FCNSW) native forestry operations under Integrated Forestry Operations Approvals (IFOAs). IFOAs are made under the *Forestry Act (2012)* and bring together the requirements for environmental planning and assessment, protection of the environment and the protection of threatened species and their habitat.

Environmental standards and controls are applied and enforced at all phases of mining, from exploration to production, to mine closure and post mine closure.

All new mining and petroleum projects (this includes gas extraction), and modifications to existing projects, require approval under the EP&A Act before they can commence. As part of this approval process, the proponent must prepare an Environmental Impact Statement with opportunities for public comment, which covers a range of issues, including flora and fauna, threatened species assessments and landscape management. If a project is approved conditions may be imposed to minimise or mitigate environmental impacts through biodiversity offsets or require future rehabilitation.

Recent amendments to the *Mining Act (1992)* and the *Petroleum (Onshore) Act (1991)* have also given the NSW Government greater control and power to ensure environmental protections for threatened biodiversity such as koalas. The grant of all new exploration titles for coal and petroleum will be administered under the Government's new Strategic Release framework which assesses a range of environmental, social and economic factors before

any new areas are released. The grant, transfer and renewal of titles also require more explicit environmental protection considerations before a decision is made. Conditions imposed on titles under *Mining Act (1992)* and the *Petroleum (Onshore) Act (1991)* must be consistent with the development consent granted under the EP&A Act.

As part of these conditions, proponents of major mining projects must pay a security deposit for the costs of rehabilitation and develop a rehabilitation management plan, and the Department of Industry (Resources and Energy) currently manages approximately $2.2 billion in rehabilitation security deposits. This deposit is not released until the titleholder can demonstrate all rehabilitation obligations have been met. The Department of Industry (Resources and Energy) has created a Resources Regulator with widespread powers to carry out compliance and enforcement of resources activities including regulation of rehabilitation obligations. Under the *Mining Act (1992)* and the *Petroleum (Onshore) Act (1991)* there are penalties up to $1.1 million for non-compliance.

Roads and Maritime Services NSW (RMS) also has a responsibility under the EP&A Act when considering development projects. The majority of RMS's projects are assessed under part 5 of the Act. This assessment is often documented in a review of environmental factors.

Appendix 2 provides a detailed summary of legislation and policies that relate to koalas in NSW. The NSW flagship conservation program Saving our Species seeks to align resources and efforts for threatened species conservation and management under a single program. The koala has been assigned to the "iconic species" management stream due to its status as a national icon and its important social, cultural and economic values. A conservation project is being developed for each iconic species, outlining the critical conservation actions necessary to achieve the stated conservation objective for the species.

Many of the legislative settings for koalas rely on habitat mapping (prepared under SEPP 44), site specific surveys or historical records as triggers. As discussed later in this report, there are many limitations in this: SEPP mapping has limited coverage and is expensive; site surveys are expensive and can have poor reliability in some terrain and vegetation types; and the historical records are patchy with very limited data available for many areas of the state. During the writing of this report the Department of Planning & Environment proposed amendments to SEPP44. An Explanation of Intended Effect was released for public submissions (NSW Department of Planning & Environment, 2016).

Community initiatives

There are many dedicated response and wildlife rehabilitation groups working at the front-line of rehabilitation of orphaned, injured or ill koalas found in the wild. Collision with cars, attacks from wild and domestic dogs, disease and wildfire are the most common causes of illness and injury to koalas in NSW (NSW OEH, 2016c). Overall, rates of koalas returning to the wild are very low and provide evidence that prevention of the harmful effect of certain risks will provide much better outcomes for koalas. During the 2013-2014 NPWS reporting period 816 sick, injured or orphaned koalas were taken into care in response to requests for assistance, 197 required no follow up response (NSW OEH, 2016c). Of those taken into care, 331 koalas (53%) died of their injuries or were euthanised and 182 (or 30%) were successfully rehabilitated and released alive to the environment. All remaining animals are either still undergoing rehabilitation or have been transferred to zoos to remain in captivity.

1.4 COMMUNITY CONCERNS

There is a wide range of interest groups and stakeholders that publicly express their concerns regarding threats to koalas and their conservation. The main issues have been summarised below, following a desktop survey of relevant websites and publications from key groups and organisations.

The foremost concern for many groups involved in koala conservation is ongoing habitat loss. Conservation groups regard the removal of vegetation as the greatest threat to koala populations. Some groups aim to restore as much habitat as possible through revegetation projects (NVI, 2016). Others such as the Australian Koala Foundation and Friends of the Koala also seek to strengthen legislation and regulatory processes around forestry and land clearing (AKF, 2016). Some groups view land conservation as the most effective way to protect koalas, and often work closely with other environmental groups involved in land care. For example, the National Parks Association of NSW, with support from community and environmental groups, have developed a proposal for the Great Koala National Park (NPA NSW, 2016a).

Closely linked to this are concerns about resource developments and the perceived impacts they have on koalas and their habitat. Several prominent mining proposals are currently subject to opposition campaigns by environmental groups such as The Wilderness Society and The Nature Conservation Council of NSW (The Wilderness Society, 2015). In many cases these campaigns are strongly backed by local communities in the affected areas (NPA NSW, 2016b).

Some groups are also concerned about the impacts of extreme weather events and climate change on koalas, given their vulnerability to droughts, heatwaves and fires, especially following loss and degradation of habitat.

Other leading causes of injury and death to koalas including vehicle strike (Shoebridge, 2016), dog attack (Kontos, 2015) and disease (AKF, 2016) are of critical concern to the community, especially where mortality is greater than the replacement rate of koalas. Many groups involved in the care and rehabilitation of koalas raise concerns about the rate of injured and diseased koalas entering care, and the capacity of rehabilitation centres to function effectively given very limited resources (Griffith, Dhand, Krockenberger, & Higgins, 2013). In many cases koalas entering care do not survive, or will remain in care facilities for the long term (Wildcare Australia Inc., 2016). Many of these care facilities believe that community education programs are the best approach to preventing koala injury and death. The most common threats in residential areas are vehicle strike, dog attacks and drowning in swimming pools, and many local residents are unaware of the best way to prevent or deal with an injured koala. There are several campaigns designed to build awareness in communities about how to protect koalas, including making properties koala friendly, ensuring pets are kept responsibly and driving safely within key koala areas (Koalas In Care, 2016).

Many local councils view koalas as an important asset for their communities and for local tourism, but also seek to balance conservation outcomes with development activities, such as through application of SEPP 44 and the preparation of CKPoMs. Conservation groups often advocate strongly for the development and implementation of these plans, particularly in LGAs where they have not been finalised (Ecosure, 2015). They argue that the current framework needs strengthening to support its aims to ensure there is consistency in koala management and protection (NPA NSW, 2016c).

Those who campaign for more awareness also call for more research into koala populations to address local threats more effectively. The Australia Koala Foundation has suggested that it is difficult to make regulatory decisions without a solid foundation of evidence (AKF, 2015). For example, some community groups have argued for the establishment of designated ‘koala-friendly’ communities with appropriate regulations for pet ownership, pool construction and fencing. Without appropriate mapping of these areas, these regulations are difficult to implement.

Industry concerns

Key stakeholders in industries such as mining, forestry and agriculture support improving planning mechanisms in order to ensure clarity and reach an appropriate balance between conservation and development. Many suggest that regulations are overly complex and confusing, and that simplifying legislative mechanisms can provide benefits for both biodiversity and production (NSW Farmer's Association, 2016; NSW Minerals Council, 2016; Timber NSW, 2016). Recent submissions to government processes have also shown that a majority of natural resource management industries support changes to regulatory processes such as PNF codes of practice and the NV Act (NSW Farmer's Association, 2016; NSW Minerals Council, 2016; Timber NSW, 2016). They advocate for the streamlining of planning and land management regulations in order to ensure socioeconomic and environmental outcomes can be met efficiently by all landholders.

1.5 HOW THE REPORT IS STRUCTURED

The evidence base underpinning the report is summarised in Chapter 2 and major issues needing attention are discussed in Chapter 3. Chapter 4 presents the recommendations with detailed commentary.

2 CURRENT INFORMATION

2.1 STATUS OF THE KOALA IN NSW

Koalas were historically distributed throughout the woodlands and forests of NSW but have experienced significant declines in both numbers and distribution. The Recovery Plan (DECC, 2008) states that "most populations in NSW now survive in fragmented and isolated habitat and many of the areas in which koalas are most abundant are subject to intense development pressures." (DECC, 2008).

Despite a range of regulations, recovery programs, strategies and numerous community initiatives overall koala numbers in NSW are in decline.

Although historically spread across a wide geographic range in all states (except Tasmania and the Northern Territory), extreme climatic conditions in the Pleistocene (which ended approximately 11,700 years ago) resulted in substantial range constriction. Genetic evidence also suggests that koala population levels were relatively low at this time. The first recorded sightings of koalas by Europeans occurred in 1798, 10 years after European settlement (Black, Price, Archer, & Hand, 2014). It is reported that koala populations experienced rapid growth in the decades following European settlement, which has been attributed to a reduction in indigenous hunting practices and predation pressure from the dingo, which was displaced or exterminated. However, urban development in the late 19th century, combined with fire events and agricultural expansion, led to a decline in the geographic range of the koala due to the loss of habitat (Black et al., 2014).

Surveys in NSW indicate that since 1949, populations of koalas have disappeared from many areas, particularly from the southern and western edges of their distribution (Reed, Lunney, & Walker, 1990). A dynamic occupancy modelling study of the occurrence of koalas in NSW using historical state-wide koala survey data has also shown that the probability of occurrence has declined steadily (Santika, McAlpine, Lunney, Wilson, & Rhodes, 2014; McAlpine et al., 2015).

Current estimates suggest there are now approximately 36,000 koalas in NSW, representing a 26% decline over the past three koala generations (15-21 years) (Adams-Hosking et al., 2016). Across 13 regional koala populations in NSW, nine koala populations were estimated to be in decline, three stable and one increasing (McAlpine et al., 2015).

While declining numbers is of great concern, we also note analysis of historical records and genetics provide a range of evidence that the number and range of koalas have expanded and contracted over time due to environmental and anthropogenic causes. Indeed, in the 1920s koalas were thought to have been extinct in South Australia, and reached levels as low as 500 – 1000 individuals in Victoria due to factors such as bushfires and the fur trade (Black et al., 2014). Interventions such as re-establishment programs (Black et al., 2014) have led to increases in koala numbers in some cases. Careful planning does need to be undertaken, however, to avoid negative consequences of such activities. For instance introduced koalas have thrived in some specific locations and are now overcrowded in some restricted locations such as Kangaroo Island (where numbers were estimated at 27,000 in 2001) (Masters, Duka, Berris, & Moss, 2004). Another problem has been the low genetic diversity in South Australian koalas, brought about by the relatively small number of koalas used in the relocation initiatives.

Summary of threats to koalas

The koala is considered a specialist folivore, as each individual feeds on a handful of primary food trees from over 70 *Eucalyptus* species and 30 non-eucalypt species. As a result of this

restricted diet it is indicated that they are highly susceptible to changes in the environment (Black et al., 2014).

The koala is threatened across its range by a wide variety of processes that includes: habitat loss and fragmentation, vehicle strikes, dog attacks (both domestic and wild dogs), disease, and climate change. Individually and collectively these threats provide major challenges to koala recovery (McAlpine et al., 2015). These threats also vary spatially across NSW, so different threats are prominent in different places. Against this backdrop of spatially varying threats, climate change is an emerging threat that is likely to shift suitable climatic conditions for the koala toward the coast, thus constraining the potential range of the species (Adams-Hosking, Grantham, Rhodes, McAlpine, & Moss, 2011; Santika et al., 2014; Briscoe, Kearney, Taylor, & Wintle, 2016).

Chlamydia will continue to be a factor in future population resilience in response to significant and multiple threats, given there is currently positive but slow progress towards vaccination (Redland City Council, 2016; Waugh, Khan, Carver, Hanger, Loader, Polkinghorne, Beagley, & Timms, 2016). It is widespread in koala populations and symptoms of blindness, pain, incontinence and infertility are exacerbated when an individual is exposed to additional stressors such as loss of habitat, harassment by predators, heatwaves, nutritional stress or overcrowding (Waugh et al., 2016). They become weakened and consequently more vulnerable to death from other threats in particular dog attacks and severe weather conditions (DECC, 2008). Chlamydia is likely to continue to drive pronounced population declines in urban coastal regions in association with other mortality from habitat destruction, domestic dog attack and vehicle strike (McAlpine et al., 2015).

Koala habitat and home ranges

Koala habitat can be defined broadly as forests or woodlands containing koala food and shelter trees and other parts of the landscape that koalas use for movement.

A range of eucalyptus forests and woodland communities such as woodlands of the tablelands and Western slopes, coastal forests and riparian communities of the Western plains, as well as isolated paddock trees make up koala habitat (DECC, 2008). Quality of habitat is influenced by climate and rainfall, species and size of the trees present, structural diversity of the vegetation, soil nutrients and size and disturbance history of the habitat (DECC, 2008).

A koala's home range depends on the variety of food trees available and the quality of the habitat. In NSW for example, a koala's home range can vary greatly. Some home ranges have been recorded at 10-15 hectares (AMBS, 2012), while others have been recorded at up to 500 hectares (DECC, 2008). In a study of koalas in an urban area, males were estimated to have a least twice the home range size of females (Goldingay & Dobner, 2014).

Koalas are known to both be restricted by and also to use development boundaries, in some areas moving along linear pathways or boundaries (AMBS, 2012). Disruptions to continuous habitat have been shown to alter home ranges and territories in other mammals (Donaldson & Bennett, 2004).

2.2 KOALA POPULATION CASE STUDIES

Four NSW koala population case studies were prepared to inform the review, and the report prepared by Predavec (2016) is available at the Chief Scientist & Engineer's website. Key findings from the case study report are summarised below. The case studies have examined historical and recent population trends for koala populations in different parts of the state and cover populations that are declining, stable and increasing and subject to a range of local, regional and state-wide threats.

2.2.1 Coffs Harbour – a stable coastal koala population

Coffs Harbour LGA is located on the mid north coast of NSW. Coffs Harbour was the first LGA in the state to adopt a CKPoM under SEPP 44 in 2000. The koala population has persisted between 1990 to 2011, following a perceived decline in the 1980's (Lunney, Predavec, Miller, Shannon, Fisher, Moon, Matthews, Turbill, & Rhodes, 2016). While the Coffs Harbour population can be best characterised as stable to slowly declining, there are a number of coastal urban and peri-urban areas where koalas are no longer present.

This case study highlights the key issue faced by koala populations in urbanising coastal areas: namely that koala and human habitat overlap, increasing the potential for conflict and threats. Given the spatial distribution of koalas within Coffs Harbour it is likely that future urbanisation, and the associated threats of vehicle strike and dogs, will have an increased impact on the koala population.

The apparent stability of the population in this area merits further study to determine the contributing factors. Regular monitoring should determine if the population remains stable.

2.2.2 Pilliga Forests, Liverpool Plains and Gunnedah – declining inland population

This case study focuses on a large area of north-west and central NSW including the Pilliga Forests in the west, Gunnedah LGA in the east and the Liverpool plains in the south and centre. It is debated whether this region contains a single koala population, a metapopulation or isolated populations. Predavec (2016) suggests there is sufficient consistency in patterns of population trends for the koalas of the area to be considered together. Recent studies within this area suggest a dramatic decline in koala populations. Surveys of the Pilliga forests in the 1990s suggest that the forests were carrying the largest population of koalas west of the Great Dividing Range in NSW, with the population estimated at 15,000 (Kavanagh & Barrott, 2001). Repeat surveys within the Pilliga forests show a decline of over 80% since the 1990s.

Although many of the threats to this area's koala population are common across much of NSW, west of the Great Dividing Range, koalas are also affected by drought and extreme heatwaves as was seen in the 2009 heatwaves (Lunney, Crowther, et al., 2012). The impact of these extreme weather events on koalas is likely to increase with predicted climate change impacts and may also exacerbate other recognised threats such as disease (Lunney, Crowther, et al., 2012). Koalas have been shown to tolerate a degree of habitat alteration caused by selective harvesting of cypress trees in the Pilliga, an important day-time shelter tree (Kavanagh, Stanton, & Brassil, 2007).

The interaction of threats has led to decline of koalas within the Pilliga Forests. The magnitude and pattern of decline is similar to that in other semi-arid regions such as south-west Queensland (Seabrook, McAlpine, Baxter, Rhodes, Bradley, & Lunney, 2011). The Pilliga forest koalas are likely to have faced extreme (but less frequent and long) heat events in the past and responded by retreating to creek lines with either available free water or a higher moisture content in the leaves of their food trees. However, land clearing within and on the periphery of the forests and from road construction since the early 1900s has resulted in creeks within the Pilliga forests silting up (Hesse & Humphreys, 2001). Habitats that would have once likely functioned as refugia during times of drought are now highly disturbed and are unlikely to provide the required level of protection for the koala (Lunney et al., 2016).

2.2.3 Campbelltown – a low density peri-urban population

Campbelltown LGA is situated in the south-west metropolitan area of Sydney and illustrates a case of a low density population that is persisting. The current population is estimated at between 100 and 150 individuals over an area of 31,166 hectares, representing a low

density population (Biolink, 2016). The current population within Campbelltown LGA is best described as stable or increasing, acknowledging that the population is low and always has been (Close, Ward, & Phalen, 2015). The Campbelltown case makes the point that a low density population does not lead to the conclusion that it is in decline or unviable.

The Campbelltown koala population is the longest known koala population to Europeans in Australia, with the first sighting recorded in January 1798 (Lunney, Close, Bryant, Crowther, Shannon, Madden, & Ward, 2010). This population has persisted through early settler land clearance and a series of fires last century. Close et al. (2015) provide findings from a 20-year radio-tracking study showing that female koalas lived long lives and produced multiple offspring.

The type and level of threat affecting a population can change over time and the present significant threats for this area are vehicle collision, domestic dog attack and habitat loss. Campbelltown currently has a draft CKPOM, which if approved, will provide support for data gathering on the koala population and define management strategies for their future.

2.2.4 South Coast – a reduced population affected by habitat loss

The south coast koala population referred to in this case study falls within the Bega Shire LGA and is situated in the south-east corner of NSW.

Historical evidence suggests that koala numbers were high enough to support a commercial pelt industry in the late 19th century (Lunney & Leary, 1988). Declines in the koala population was noted following successive land-use changes from the 1830's onwards, which included clearing for agricultural land, intensive logging and urban development (Lunney, Stalenberg, Santika, & Rhodes, 2014).

By 1970, the koala population in this region had been significantly reduced to several isolated pockets. Recent estimates from surveys conducted in 2012-14, and information on the extent of available habitat and estimated home ranges, the remaining population in the north-east corner of the LGA is estimated at 30 – 60 individuals (NSW OEH, 2016a).

Further studies also suggest that other factors involved in koala decline in this region are disease (Lunney & Leary, 1988) and climate change (Lunney et al., 2014).

In 2016, approximately 12,000 hectares of state forest in this region was reclassified into flora reserves, adjacent to reserve estates, and will be managed by NSW National Parks and Wildlife Services for the conservation of koalas and other wildlife (NSW OEH, 2016d).

2.2.5 Overall conclusions for the case studies

Case studies are a useful way to understand both the local differences and the common themes in the conservation of a species. Predavec (2016) indicated that the emerging themes across the case studies were:

- *"it is only through long term and repeat studies of koala populations that we start to understand the patterns of population change*
- *koala populations are subject to a range of threats across the state, some of which are common, others that are localised*
- *low density populations are possibly more common than we once thought and that low density does not necessarily equate with a population in peril*
- *despite the multiple levels of legislative and policy protection afforded the koala, we still have populations in decline*
- *the level of information available on koala populations is variable across the state and there is no mechanism in place to collect consistent data*

- *koala populations and their population trends can change rapidly and a lack of consistent and regular monitoring means we are not in a position to promptly identify these changes."*

2.2.6 Additional case study on Port Macquarie-Hastings

The Port Macquarie-Hastings LGA encompasses some 368,113 hectares of land between Taree and Kempsey on the mid-north coast of NSW. The area has a long history of koala occupation with over 6,000 koala records on the NSW Wildlife Atlas for the LGA. A koala habitat study of the LGA (Biolink, 2013) estimated a conservative population size of 2,000 animals with more than half of these occurring in the coastal area east of the Pacific Highway between the Hastings and Camden Haven Rivers. This includes a nationally significant source population with an estimated population size of greater than 500 animals located on private and public lands surrounding Lake Innes (Biolink, 2013).

As there is a large and significant koala population in Port Macquarie that is a major tourist attraction, the Port Macquarie Koala Hospital was established in 1973 to treat and care for sick and injured koalas. The hospital has a number of paid expert staff and numerous volunteers who care for the 200 – 250 koalas admitted through the hospital annually (Koala Hospital, 2016). The hospital alone has approximately 100,000 visitors a year.

While the area has a long historical association with koalas it has also seen rapid urban expansion and development of infrastructure, including major expansions to the roads and highways, conflicting with koala habitat. As a result of these developments, koala habitat has declined and the remaining habitat has become more fragmented (Biolink, 2013) Threats to koalas associated with urban development, such as dog attacks and road strike by vehicles, has also increased. In response to the findings in the study by Biolink, council has commenced the preparation of a draft CKPOM.

In July 2016, the Port Macquarie-Hastings Council held a 'koala roundtable' to bring koala experts and key stakeholders together to discuss the emerging data that suggests that the Port Macquarie-Hastings koala population may be in the early stages of decline. This trend has also been confirmed by data from the Port Macquarie Koala Hospital, which shows a decline in admissions, with no juvenile admissions. Mortality rates of koalas from a combination of road strike, dog attack and disease are considered high and the population is likely to be unsustainable in the long term, with at least 82 koalas recorded to be lost each year east of the highway and many more lost but not recorded (Koala Hospital, 2016). This mortality rate is likely to be higher than the breeding potential in the population, with the potential for continued declines and localised extinction in many areas in the long term (30 – 50 years) unless threats and associated mortality rates can be significantly reduced. This is a scenario common to many northern NSW coastal koala populations.

2.3 HABITAT MAPPING AND POPULATION DATA

Maps of koala distribution, habitat, threats, and other factors can be developed through spatially enabled monitoring and records, or through modelling or expert elicitation when there is not sufficient data available. A range of different mapping approaches will inform and guide the management of koala populations, from local to state-wide scales. This section discusses approaches to mapping the actual or predicted location of koalas and their habitats, while Section 2.4 describes mapping of the threats to koalas.

Three types of map that are typically developed for species conservation or management being maps showing the occurrence of animals (from records or models), the trends in the population of the animals, and maps of suitable habitat (actual or predictive habitat maps). In developing an informed management and conservation approach for koalas, it would be preferred to have access to all three map types.

2.3.1 Koala likelihood of occurrence

The last state-wide survey of koalas was undertaken in 2006 as part of a broad community-based (citizen science) wildlife survey (Lunney, Crowther, Shannon, & Bryant, 2009). The survey asked the community whether they had seen koalas in their area, the locations of those sightings and whether they thought the local population was increasing, decreasing or staying the same. This survey method, combined with occupancy modelling, allowed the likelihood of koala occurrence to be compared to the 1986-87 state-wide survey and therefore population trends to be determined.

The Atlas of NSW Wildlife is the main repository for koala records and is drawn on for many decision making purposes (NSW OEH, 2016e). While the Atlas is an important and essential source of data it is important to understand that there is a bias in the spatial distribution of the koala records. There is a bias towards data from state forests due to a statutory requirement to carry out site surveys before harvesting. There is also a bias towards data collected from roadways as many of the citizen science records and other sightings are recorded along roads (where there are more people to observe), and include road killed koalas. There is also a bias against records of sightings on private lands due to access restrictions, and only patchy survey across the public land estate.

To overcome these issues of bias, the number of koala records within a certain area was compared with the overall number of mammal records in that area: providing an indication of the likelihood of koalas in that area that is independent of the number of people surveying. More details of this methodology are available in Predavec, Lunney, Shannon, Scotts, Turbill, and Faulkner (2015).

For locations that have data (i.e. records of koalas having been present), the koala likelihood of occurrence maps show the probability of a koala being recorded in a particular area, with the output being a value between 0 (no likelihood) and 1 (certain likelihood of occurrence). The methodology as described by (Predavec et al., 2015) also allows an assessment of the confidence levels in the data (i.e. how robust are the data and what are their deficiencies).

The resulting information can be put to a range of uses including informing decisions about further monitoring and ground-truthing campaigns where there is no data, or where the data has low confidence levels.

For locations where there are data, the likelihood values provide a metric that relates to the presence and distribution of the animals, which is important for prioritisation of management and conservation activities. Currently, NSW has a map of probability of koala occurrence for the period of 1990-2015 at 10 km resolution (Predavec et al., 2015). The map shows likelihood of occurrence, the level of confidence in likelihood value and also areas where there are no data (Predavec et al., 2015). Combined with a predictive koala habitat map, likelihood of occurrence data helps decision makers develop informed decisions.

2.3.2 Predictive koala habitat mapping

Habitat mapping provides a representation of the geographic distribution of habitat. We do not currently have a map of koala habitat that is state-wide and across all land tenures. Therefore, agencies across government may not always be able to account for important koala habitat at a landscape scale when making decisions and private land holders may not be aware that koala habitat is on their property.

Currently, SEPP 44 is the main driver for habitat-based mapping to influence development decisions. However, the amount of habitat mapping that occurs under SEPP 44 is limited, as mapping only covers areas where local councils are the decision making authority. Only four local councils currently have approved CKPOMs in place, although nine other councils have drafts in preparation and others have decided to proceed with a strategy instead of a

CKPOM. Regional based decision making is not possible using the CKPOM mapping at the moment as it is at a local scale. Habitat mapping also occurs as part of specific studies in localised areas. Again this is not useful for regional scale decision making.

There are improvements that can be made to ensure habitat mapping is expanded across NSW and in the most effective manner. Predictive habitat suitability models are developed by bringing together information on environmental variables such as soil type, weather patterns, vegetation type and quality, elevation, frequency of wild fires, topography etc. These characteristics are modelled and then compared with existing records of koalas to produce a map of predicted habitat suitability that is correlated with likelihood of occurrence of koalas (GHD, 2009). The end product is further validated in the field to increase the confidence in and reliability of the model. This development in predictive koala habitat modelling would provide an important basis for the development of a state-wide, cross-tenure predictive habitat map.

2.3.3 Population data

Population trend data are also important. They allow us to see a change in population, either in numbers or distribution or both. These data may reveal if a koala population is responding to interventions, or whether interventions are required. Population trends are determined by analysing data from comparable repeat surveys and also through expert elicitation (Predavec et al., 2015; Adams-Hosking et al., 2016).

Not all populations of koalas will show the same trend, as described in the koala population case studies. However, koala populations are declining in many, if not most areas of NSW and the trajectory of population change can alter rapidly. Regular, systematic monitoring of koala populations will help us understand the patterns of population change, inform appropriate interventions, and allow success to be identified.

2.4 ESTABLISHING A HIERARCHY OF THREATS

Threats to koalas are well documented (DECC, 2008; NRMMC, 2009a). The impact varies both temporally and spatially. Mapping of the threats to koalas at a bioregional scale, as determined by the International Biogeographic Regionalisation of Australia version 7, (IBRA7) (Commonwealth Department of the Environment and Energy, 2016), was evaluated at a workshop convened by the Australian Centre for Ecological Analysis and Synthesis in 2012 (McAlpine et al., 2014).

This workshop gathered 15 koala researchers with in-depth knowledge and experience in koala ecology and conservation, to identify and estimate the impact of 14 threats to koalas for the previous three koala generations (15-21 years) and future three generations (Adams-Hosking et al., 2016).

The threat mapping was conducted using a structured process of expert elicitation. This method is often used to synthesise diverse sources of information, particularly where data from surveys and models are limited or have significant gaps, and has led to it being used increasingly to inform and support decision making (Adams-Hosking et al., 2016). It is particularly valuable when a species' status is uncertain or unknown yet its persistence in the wild is subject to multiple and potentially synergistic threats (Adams-Hosking et al., 2016).

The threat mapping method proposed by this workshop could provide a useful baseline for policymakers and conservation managers, as it would give a preliminary indication of the nature, intensity and scale of the threats and to tailor appropriate remedial actions to secure koala populations and improve conservation outcomes. The threat mapping also represents a useful starting point in identifying priority research. An example of a map-supported threat abatement plan is the NSW Fox Threat Abatement Plan (NSW OEH, 2010).

While a valuable indicator of past and future threats at a bioregion scale, it needs to be recognised that there is a wide variation of threat distribution, scale and intensity within the regional scale (Santika, McAlpine, Lunney, Wilson, & Rhodes, 2015) and care should be taken in interpreting the data. Finer scale mapping such as at the scale of LGA, is likely to be a prerequisite for any planned localised conservation actions, assessment of development proposals or research scoping.

Acknowledging that some threats could be categorised as being widely distributed over a bioregion (e.g climate change), while others are more localised, such as those from mining or roads, a mapping approach that illustrates both threat categories could be looked at through the strategy development phase.

2.4.1 Cumulative impacts

Where more than one threat impacts a species in a particular area, understanding the cumulative and synergistic impacts of the threats is crucial. This is particularly important where the impact of each individual threat is small, but the cumulative impacts are large.

Importantly, threats can impact on species synergistically, such that the combined effects of multiple threats may be much greater than the sum of the individual threats (Brook, Sodhi, & Bradshaw, 2008). There is strong evidence that many threats can interact synergistically, including interactions between climate change and other threatening processes such as habitat loss and fragmentation (Brook, 2008; Brook et al., 2008; Mantyka-Pringle, Martin, & Rhodes, 2012; Doherty, Dickman, Nimmo, & Ritchie, 2015).

In these cases, managing threats individually is unlikely to be a successful strategy (Rhodes, Ng, de Villiers, Preece, McAlpine, & Possingham, 2011; Santika et al., 2015) and a more holistic approach that considers cumulative impacts and interactions among threats is necessary (Auerbach, Wilson, Tulloch, Rhodes, Hanson, & Possingham, 2015; Mantyka-Pringle, Martin, Moffatt, Udy, Olley, Saxton, Sheldon, Bunn, & Rhodes, 2016). In the koala context, Santika et al. (2015) have demonstrated the importance of strategically tackling multiple threatening processes to koalas in NSW.

In particular, evidence suggests that climate change and the interaction with other threats to koalas are likely to be severe. This may arise because climate change simply increases the cumulative impacts beyond that which can be sustained by koalas. However, it may also arise through a synergistic interaction between climate change and the other threats present, exacerbating the cumulative impact of existing threats further (Seabrook et al., 2011).

A realistic future scenario for koalas in NSW, which illustrates how multiple threats may interact at broad scales, is that koala distributions could contract from the west due to climate change and contract from the east due to urban development and habitat loss. This potential scenario suggests the need to identify climate refugia that are relatively insulated from climate change and are also locations where other threats are low or can be realistically reduced (Briscoe et al., 2016). As such, although koala conservation strategies can do little to directly influence climate change, these must be considered in developing koala conservation responses as they can have dramatic implications for the best choice of strategy (Santika et al., 2015).

2.5 RISK TOLERANCE AND MITIGATION

Actions are regularly taken that require individuals, organisations and governments to make decisions about the trade-offs between environmental, social and economic values. Our ability to take actions that strike an acceptable balance between these values is in part based around how we view “risk”. In an environmental context, risk is considered to be a combination of the likelihood of an event occurring and the environmental consequence associated with that event if it does occur.

While the tools that are used to measure and account for risk have improved significantly over time, the trade-offs made generally reflect our risk tolerance. Risk tolerance can be either precautionary or evidentiary. A precautionary attitude towards risk will classify a taxon as threatened unless it is certain that it is not threatened. In contrast, an evidentiary attitude will classify a taxon as threatened only when there is strong evidence to support a threatened classification (IUCN, 2016).

Based on the evidence presented in this report, it is clear that some NSW koala populations are under stress and continue to decline. Understanding the threats to koala populations and our risk tolerance towards those threats is important in deciding if, where and how to act. Based on the precautionary principle, which is defined under the *Protection of the Environment Administration Act (1991),* if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

The International Organisation for Standardisation (ISO) and Standards Australia maintain risk management standards, with these being used across Australia to help individuals and organisations manage risks.

A key element of risk management is the identification of mitigation measures; including "measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects" (European Union Directive 2011/92/EU). The International Association for Impact Assessment present the following mitigation approach (de Jesus, 2013):

- *"Enhance positive impacts*
- *Avoid negative impacts to the greatest extent possible*
- *Minimise (or reduce) what cannot be avoided*
- *Remedy (or restore) what cannot be reduced*
- *Compensate for what cannot be remedied."*

Many organisations already apply risk management strategies where their actions interact with koalas. For example, the Department of Planning and Environment requires an Environmental Impact Assessment to be completed for all major development applications to identify potential impacts and mitigation strategies. The Environment Protection Authority maintains a risk based Compliance Policy that sets its approach to compliance and enforcement across the industries it regulates.

Maintaining key koala populations will depend on understanding the local, regional and broad scale threats to that area's koala population. This requires clearly identifying the risks associated with each threat and, based on our tolerance for those risks, developing measures that mitigate or manage those factors.

2.6 MITIGATION MEASURES IN CURRENT PLANNING PRACTICES

2.6.1 Koala protection under land management and biodiversity conservation reforms

The draft *Biodiversity Conservation Bill 2016* and draft *Local Land Services Amendment Bill 2016* were passed through NSW Parliament during the preparation of this report. This section discusses those reforms and is based on the materials publicly available at the time:

> *"A new land management framework under the Local Land Services Act (2013) (LLS Act) proposes ways NSW landholders can manage land with native vegetation. The aim is to allow farmers to undertake legitimate land clearing efficiently and improve agricultural productivity. The new Native Vegetation Regulatory Map will underpin the new land management*

framework under the LLS Act. For native vegetation clearing, land is mapped as either regulated, unregulated or excluded.

The proposed new framework will provide landholders with a range of options for native vegetation management on Category 2 Regulated Land:

1. *Allowable Activities*
   Defined low-risk native vegetation clearing activities that are part of routine land management will not require a formal approval or notification to Local Land Services.
2. *Land Management Codes of Practice*
   Codes of practice will be developed, allowing landholders to undertake clearing that supports more productive farming methods and systems, while responding to environmental risks. Each code of practice has varying requirements for notification to Local Land Services, certification or, in some cases, requiring the establishment of permanent set-aside areas on the land to improve biodiversity.

If an activity cannot be undertaken in accordance with allowable activities or a code, approval under the LLS Act will be required. In these circumstances, the biodiversity impacts of the clearing will be assessed and offset using the Biodiversity Assessment Method (BAM).

Native Vegetation Regulatory Map

Under the proposed land management and biodiversity conservation reforms, a Native Vegetation Regulatory Map will be developed to show rural lands where:

- *native vegetation clearing can occur without approval*
- *landholders need to comply with the LLS Act.*

The map won't apply to:

- *urban areas and land use zones excluded from the provisions of the regulatory map*
- *land regulated under other legislation, such as national parks and state forests.*

Land in the Native Vegetation Regulatory Map will be classified into two categories.

- *Category 1: Exempt Land (Blue): on exempt land, clearing of native vegetation will be exempt from the new land management framework.*
- *Category 2: Regulated Land (Yellow): on regulated land, clearing of native vegetation can occur in accordance with an allowable activity or code under the LLS Act.*
- *Excluded: The land management framework does not apply, and clearing is regulated under the Environmental Planning and Assessment Act 1979 and the new Biodiversity Conservation Act framework, as well as some other legislation such as national parks and forestry legislation*" (NSW Government, 2016a)."

The LLS Amendment Bill, prescribes land to be designated as Category 2 Regulated Land. This includes land identified as core koala habitat in a plan of management made under SEPP No 44—Koala Habitat (LLS Amendment Bill Div. 2 s60H (k)).

Once the state-wide predictive koala habitat and likelihood of koala occurrence maps have been developed this information could replace the core koala habitat requirement. This will be consistent with the stated intention but will draw on more up-to-date mapping and data.

Biodiversity offsets

Under the NSW Government's biodiversity reforms, a single biodiversity offsets scheme will be introduced to apply to development. The NSW biodiversity offsets scheme will be established under the Biodiversity Conservation Act. A central element of the scheme is a new Biodiversity Assessment Method to assess the impacts of development on terrestrial biodiversity and determine biodiversity offsets:

> "The BAM will replace a range of existing biodiversity requirements and methodologies under the current planning and threatened species legislation... The introduction of a single BAM should greatly increase transparency for developers and the broader community (NSW Government, 2016a)."

Biodiversity Assessment Method (BAM)

The BAM is a metric-based tool that aims to assess biodiversity impacts consistently and scientifically at a development site, and biodiversity benefits at an offset site in order to calculate 'biodiversity credits'. The BAM should create a consistent biodiversity assessment process for certain development applications under the EP&A Act and applications that require the clearing of native vegetation under the *Local Land Services Act (2013)* (LLS Act).

The BAM will give proponents guidance on ways to avoid and minimise impacts from their development, and will then calculate offsets for any remaining impacts.

For development that requires consent under the EP&A Act, the BAM will need to be used to assess the impact of the development on biodiversity values where the development is above the BAM threshold, or where the development triggers the existing threshold of significant effect. A risk-based approach has been adopted for setting the proposed BAM threshold, to capture projects with greater risk of biodiversity impacts while ensuring that lower risk developments are not required to apply the BAM. The aim of the BAM threshold test is that it is simple, practical and able to be applied by a non-expert.

It is proposed that the BAM will need to be used to assess a development if any criteria listed below are met. In addition, the BAM will also apply to any developments that will have a significant effect on biodiversity based on the existing assessment of significance (formerly known as the seven part test) under the EP&A Act. The BAM will also apply where approval to clear native vegetation under the LLS Act is required.

Proposed BAM threshold criteria:

1. Area of vegetation clearing is above the clearing threshold (for subdivision, this is area of proposed future clearing), or
2. If site is on land identified on the 'threshold values map', or
3. If proposed clearing exceeds what is allowed under the LLS Act (i.e. 'allowable activities' or codes of practice).

The 'threshold values map' is under development, however it aims to capture sensitive values. The Submission Guide (NSW Government, 2016b) suggests the map would include: core koala habitat, coastal wetlands, littoral rainforests, Ramsar wetlands identified under environmental planning instruments and areas of outstanding biodiversity importance under the Biodiversity Conservation Bill.

Once the state-wide predictive koala habitat and likelihood of koala occurrence maps have been developed this information should be used to inform the BAM threshold values map. This will be consistent with the stated intention to use core koala habitat but will draw on more up-to-date mapping and science.

Serious and irreversible impacts

The Biodiversity Conservation Bill recognises that there are some types of 'serious and irreversible impacts' that are generally not acceptable to the community. It recognises that some impacts on biodiversity value will significantly increase the risk of species extinction or long-term viability or are otherwise particularly severe.

The consent authority will determine whether a project has serious and irreversible impacts. 'Serious and irreversible' impacts must be avoided for non-major projects. For State Significant Development (SSD) and State Significant Infrastructure (SSI), "serious and irreversible impacts" will be matters for the consent authority to consider when determining the project. The offsets scheme seeks to prevent these impacts from occurring to reduce the risk of further threated species or communities becoming extinct.

The criteria to identify serious and irreversible impacts are to be set out in the regulations made under the Biodiversity Conservation Bill. Based on the evidence considered throughout this review into the decline of koala populations in NSW, consideration should be given to including impacts on the koala as a serious and irreversible impact and a threshold established, which is based around a category of the species' best quality remaining habitat.

2.6.2 Public native forestry harvesting

The current approach in NSW for managing impacts of harvesting of public forests on the environment is through Integrated Forestry Operations Approvals (IFOAs). IFOAs integrate the regulatory regimes for environmental planning and assessment, protection of the environment and threatened species conservation.

IFOAs specify sensitive areas of land which must be excluded from harvesting, for example riparian corridors (areas along streams), high conservation value old growth, rainforest, rare forest types and wetlands (Australian Government, 2015).

Informal and formal reserves within state forests account for approximately 43% (675,717 hectares, as of 2014) of native state forest estates in the regions covered by coastal IFOAs (Slade & Law, 2016). Formal reserves are flora reserves which are excluded from harvesting.

It is recognised that koalas, and other threatened species, require specific prescriptions to maintain key elements of their habitat in order for them to persist in harvested landscapes. This has included protections such as exclusion zones for areas where there is active and high use by koalas, and retention of a defined number per hectare of preferred koala feed trees in intermediate use areas. Little data is available to assess the effectiveness of these prescriptions in mitigating impacts on koala populations.

The IFOAs define the harvesting volumes and type of silviculture practice allowed in koala habitat. Silvicultural practices applied on the north coast of NSW have changed during the life of the current IFOAs, with the NSW EPA advising that a more intensive form of harvesting emerged around 2007 in public forests, referred to as regeneration harvesting.

Negotiations are underway between the EPA and Forestry Corporation of NSW to decide on specific requirements for koala protections under the remade single Coastal IFOA, which is being developed to bring together four separate current IFOAs (NSW EPA, 2016b).

The Koala Advisory Committee has recommended more studies in areas where regeneration harvesting has been applied, or where it may occur into the future. This is to determine if regeneration harvesting and associated forestry practices in these forests impact on koala populations. Further assessment of the effectiveness of current and proposed IFOA prescriptions designed to mitigate the impacts of harvesting is also required, with monitoring undertaken over the long term. This research will be necessary to understand the trajectory of koala populations in these areas and to inform evidence-based regulatory settings.

There are few studies that have considered the direct impact of native forest harvesting on koalas (Jurkis, Rowell, & Ridley, 1994; Kavanagh, Debus, Tweedie, & Webster, 1995; Roberts, 1998; Smith, 2004). Studies suggest koalas can tolerate low intensity harvesting of habitat that includes food trees but higher intensity harvesting may have a more negative effect on koala occupancy (Smith, 2004). In the Pilliga Forest, koala persistence was measured before and after low intensity harvesting of an important day time shelter tree, koalas continued to occupy this habitat for a further measured seven months post harvesting (Kavanagh et al., 2007).

Scats have been considered as the easiest method of determining koala presence to date (NSW Government, 2014)and their presence informs the koala survey requirements set out in the IFOAs (Jurkis et al., 1994; Smith, 2004). A pilot study conducted by the EPA tested a range of different koala habitat mapping methods in state forest, identified challenges and limitations with using scat based surveys for identifying koalas to determine koala occupancy, in particular issues in the accuracy and ease of scat detection (NSW EPA, 2016c). Other projects have used radio-tracking (Jurkis et al., 1994; Kavanagh et al., 2007) or scat detection dogs (Cristescu, Foley, Markula, Jackson, Jones, & Frère, 2015). New approaches to locating, modelling and mapping koalas would overcome the limitations of scat surveys and assist in promoting greater certainty for koala protection.

The NSW Department of Industry – Lands has advised the Committee that it is progressing research to determine the presence of koalas in high quality habitat areas, including areas that have been harvested. It covers forest areas that are being or have been commercially harvested and looks at parameters including 'time since harvesting' as well as 'harvesting intensity'. New technologies, including 'SongMeters', have recorded koala presence at more sites than previously. SongMeters target the spring peak in male calling behaviour and can be a useful tool to investigate koala occupancy across landscapes. Preliminary data shows that koalas have been recorded across the full range of forest sites, including in areas that have undergone more intensive harvesting practices (DOI – Lands pers comms.). The work is still underway and yet to undergo peer review to understand the efficacy of these technologies.

Current and recommended research is indicative of a shift towards a more holistic approach to koala conservation, with an increased focus on understanding the potential threats to koalas, improving the effectiveness of koala management, and gaining a better understanding of koala population trends over time. Landscape approaches to monitoring would be beneficial to improve the capacity to track koala population levels over time. Department of Industry – Lands indicates that more analysis of the impacts on koalas of more intensive forest harvesting is required and is being undertaken.

2.6.3 Mining and exploration

At this stage, there is sufficient information available to develop best practice principles for mitigating impacts of mining activities, including coal seam gas extraction. This includes actions as part of a development consent to establish and enhance wildlife corridors and design new areas of habitat, support pest management, install exclusion fencing and implement onsite and offsite offsets.

Shenhua Watermark Coal Pty received exploration approval in 2008. A Koala Plan of Management was developed for Shenhua Watermark by Cumberland Ecology, outlining the proposed actions to mitigate or offset the impacts on koala populations in the area (Cumberland Ecology, 2013). They were developed through surveying and mapping of the proposed site and offset areas as well as ongoing consultation with koala scientists and ecologists to determine both the risk and appropriate level of action.

The proposed measures are an example of best practice principles of avoidance, mitigation and compensation. However, the effect of these measures is not assessable as operations have not commenced at this stage.

Some key actions include:

- site-based protections, including dust and noise minimisation and koala exclusion fencing
- the establishment of a Koala Advisory Committee comprised of independent experts to advise on management strategies
- road and rail design to take into account high risk areas and known habitat corridors

- maintenance and enhancement of eight identified habitat corridors with specifications regarding tree species, location and performance criteria
- vertebrate pest management according to the Biodiversity Management Plan of the project
- a bushfire management plan developed in conjunction with the Rural Fire Service
- onsite and offsite offset measures to potentially restore around 4,500 hectares of koala habitat
- a staged clearing process based on pre-clearance surveying
- translocation measures based on OEH's *Policy for the Translocation of Threatened Fauna in NSW* (NSW NPWS 2001).

There is still an overall lack of evidence to show the short and long-term effectiveness of offset and rehabilitation activities. This may reflect the limited number of consents and associated mining leases that have specified the need to restore koala habitat to pre-mining conditions. Operational mines can impact koala populations via habitat clearing, increasing disturbance and therefore pest animal and plant activity. Mining activities can also have indirect impacts such as noise, light and dust. Construction of roads and railway lines also represents a significant threat as it can cause habitat fragmentation. The impacts of new roads and rail lines can be exacerbated by the fact that mines can operate continuously, which limits opportunities for koalas to move safely between habitats. Many mining operators propose implementing the reduction of speed limits around project sites as a mitigation measure, but this has not yet been proven to be effective (Dique, Thompson, Preece, Penfold, de Villiers, & Leslie, 2003; AMBS, 2012).

More work is required to evaluate the effectiveness of offset and rehabilitation activities, including testing the assumption that habitat restoration directly leads to species restoration. There is currently only one known study that has attempted to test this (Cristescu, Rhodes, Frére, & Banks, 2013). The research highlighted that ongoing monitoring and management of rehabilitated sites is necessary for determining whether koalas will return following mine closure.

Significantly more work is also required to assess the potential cumulative risks of major mining projects in conjunction with other threats in the landscape and to identify effective cross-tenure actions to improve and enhance koala habitat. Monitoring of mining activities should also extend to landscape-scale monitoring across the life of the mine. Most conditions of consent separate the threats that mining presents to koala populations, and in order to understand the full extent of this, detailed monitoring should occur across the site and surrounding area from the beginning of exploration through to rehabilitation.

2.6.4 Minimising and monitoring koala road mortalities

Roads can have a negative impact on koala populations due to increased competition for habitat, territorial disputes and increased stress levels (AMBS, 2012), and road-related injuries can be a major cause of mortality and entry into care for koalas (Lunney, Lemon, Crowther, Stalenberg, Ross, & Wheeler, 2012). Roads and Maritime Services (RMS) practice for new roads in koala habitat is to avoid (where possible), mitigate and offset impacts on koalas and koala habitat. Where required, RMS implements a range of mitigation actions including fauna movement structures to facilitate movement as well as koala grids and fencing to prevent road access at certain points and to redirect koalas to connectivity structures. RMS also undertakes pre-clearing processes to minimise risk to koalas during construction. These different methods have a range of costs, maintenance requirements and understanding of their effectiveness.

Barrier and exclusion fencing is intended to reduce strike mortality, however, creating barriers may exacerbate habitat fragmentation caused by road development (AMBS, 2012). Fauna movement structures include underpasses and overpasses. While commonly used

worldwide, with a variety of taxa recorded to use them (AMBS, 2012), there is limited understanding of how they benefit koala populations.

Dexter, Appleby, Edgar, Scott, and Jones (2016) provides a summary of studies on wildlife use of fauna movement structures. There are two studies which examine koala use of specifically designed structures in NSW (RTA, 2009; AMBS, 2012). Neither study recorded koalas using overpasses (RTA, 2009; AMBS, 2012), however, koalas were recorded using underpass structures in the north coast region (RTA, 2009).

Underpass structures are used by introduced predators, including cats, dogs and foxes (RTA, 2009; AMBS, 2012). The Koala Management Plan for the Woolgoolga to Ballina upgrade of the Pacific Highway includes monitoring fauna movement structures to detect predatory animals. Where identified as a threat, RMS will work with North Coast Local Land Services, NSW National Parks and Wildlife Service (Grafton), and Rural Lands Protection Board (North East) and adjacent landowners to implement controls predatory animals (NSW RMS, 2016).

A six year study on the Bonville Pacific Highway realignment found that koalas maintained home ranges up to the edge of the highway (AMBS, 2012). A high proportion of koala road mortalities occurred in the dispersal season (sub-adults) and breeding season (adults) (AMBS, 2012). There was evidence to suggest that many koalas killed by highway vehicle collisions are from more distant areas, indicating that roads may affect a wide section of the population (AMBS, 2012). The report recommended extending monitoring to include the collection of genetic information post-construction and use of the overpass following vegetation regrowth (AMBS, 2012). Clearing for construction should be undertaken outside breeding and dispersal periods, these periods should be understood before new road construction (AMBS, 2012).

More recently the Koala Management Plan for the Woolgoolga to Ballina Pacific upgrade of the Pacific Highway took a comprehensive approach to protecting, mitigating and rehabilitating koala habitat and populations (NSW RMS, 2016). A population viability analysis (PVA) from the Ballina Koala Plan indicates that irrespective of the upgrade to the Pacific Highway, the Ballina koala population will decline over the next 50 years due to a high mortality rate and low fecundity.

The Koala Management Plan (NSW RMS, 2016) contains a number of pre-construction, during- and post-construction specifications for mitigating the impact along different sections of the highway upgrade, including the procedures listed in Table 1.

Table 1: A range of mitigation procedures used in the Koala Management Plan for the Woolgoolga to Ballina Pacific upgrade of the Pacific Highway, note that these are used in various locations of the upgrade.

Pre-clearing and clearing procedures	**During Construction**	**Post-construction**
Pre-clearance monitoring aimed at determining: • population status • habitat use and movement patterns • habitat areas likely to be impacted upon/fragmented • identification of 'hot spots' of koala activity • identifying suitable locations for fauna movement structures. Clearing procedure • staged clearing and use of methods to encourage koala movement out of the area by removing food resources • daylight canopy searchers by an ecologist prior to clearing • suspension of work for 48 hours within a clearing area if a koala is found (to facilitate voluntary koala movement out of the area) • koala relocation protocol: in the case of a koala remaining there beyond the 48 hours, it will be captured and relocated by a suitably qualified person to the nearest habitat • identification of exclusion zones Development of a koala fencing strategy and construction of temporary exclusion fencing	Road signs: for risk awareness to minimise koala road mortality Temporary koala exclusion fencing implementation and maintenance protocols. Temporary fencing to transition to permanent in certain sections and to extend along certain byroads (e.g. Wardell Road) Fauna movement structures • approximately 174 underpasses Construction work method statements, including: • stop-work protocols: koala relocation protocol • worksite induction and 'toolbox' meetings • domestic dog policy • dust and noise management • exclusion zones for construction vehicles • enforced speed limits and vehicle tracking The presence of a licenced wildlife carer/ecologist during all stages of vegetation clearing Site revegetation protocols Predator controls	Monitoring of the effectiveness of mitigation strategies: • crossing zones / fauna movement structures/ fencing • offsets • predator control Monitoring of the koala population demographics to track against the PVA and determine whether there is a statistical decline Predator control programs

Pre-construction decision making to determine the type, location and number of connectivity structures, considered the following:

- known/potential koala habitat and connectivity routes
- local population density
- previous experience from monitoring programs which investigated the effectiveness of connectivity structures.

Monitoring the effectiveness of connectivity structures and other mitigation activities is imperative for understanding the most effective methods for reducing koala mortality on roads. The challenge for road authorities is to extend these learnings to the existing road network and this will require a targeted, collaborative approach at local scales. The identification of important populations as part of the koala strategy offers an important opportunity to identify key koala road kill hotspots where targeted mitigation actions can support a suite of co-ordinated efforts to conserve the local population.

2.6.5 The impact of fire

Fires are an increasing risk to koalas in several areas of NSW. Fire threatens koalas though a multitude of impacts. Intense fires can destroy habitat and cause severe injury and death to individual animals. Koalas are also affected by smoke and ash inhalation. Dog attack post-fire reduces survival rates and this is exacerbated in highly fragmented coastal urban landscapes (Lunney, Gresser, O'Neill, Matthews, & Rhodes, 2007).

NSW Rural Fire Service Bush Fire Risk Management Plans include lists of areas with threatened flora and fauna, treatment plans and maps identifying vulnerable populations and endangered species (NSW RFS, 2016b). The National Parks and Wildlife Service (NPWS) in designing hazard reduction burn plans in known koala habitat will factor in the species' requirements with respect to burn timing, intensity and retention of habitat trees (e.g. by raking around hollow trees to prevent burning) (NSW OEH, 2016c).

An OEH and NPWS fire regime study in 2010 concluded that crown fires arguably have the greatest impact, in the short to medium term (e.g. loss of canopy cover and tree death, especially of tall forest Eucalypt dominants), reduced survival of animals especially arboreal mammals and others with limited dispersal/flight capacity, and increased soil impacts such as sediment movement and loss of organic matter (Hammill, Tasker, & Barker, 2013). Smaller regular burns can however still directly affect individual koalas as they often remain in the trees when hazard reduction burns take place or through contact with burnt lower portions of trees. Regular controlled low intensity fires can promote fire-retardant shrubby species and reduced eucalypt growth (Clarence Valley Council, 2015), unfortunately reducing the habitat suitability for koalas.

In 2013-2014 the NPWS undertook 232 prescribed burns, during this period there were 342 wildfire incidents in national parks. There has been a downward trend over 20 years in the overall size of wildfires, due to planning and response time (NSW OEH, 2016c).

Mosaic pattern of prescribed burning treatment is undertaken across NSW (NSW RFS, 2016a). This patchwork pattern of prescribed burning aims to reduce the risk of a significant bushfire in parks and reserves and provide wildlife with safe refuge while the vegetation regrows (DEWNR, 2011).

Further research is needed into the effect on fauna. A barrier to understanding the impact of fire on koalas is that flora studies are much more prevalent than fauna studies in regard to monitoring effects of fire. In assessing the impact of mosaic prescribed fires Clarke (2008) raises concerns about monitoring studies being short-term, a lack of clear knowledge around patch size, proximity and connectivity and cautions that studies rely on flora responses to burns rather than fauna. Driscoll et al. (2010) highlights spatial arrangements and that species ability to persist under managed fire mosaic regimes is poorly understood and it cautions against reliance on traditional methods, given the modern changes that have created developed, fragmented or modified landscapes. Effective feedback and monitoring is key to understanding the effectiveness of patch mosaic burning as it increases in uptake in Australia as a practice (Parr & Andersen, 2006). Clarke identifies a need for broad-scale and/or long term studies of fauna in response to fire regimes (Clarke, 2008).

2.7 UNDERSTANDING THE ECONOMIC, SOCIAL AND ENVIRONMENTAL VALUE OF KOALAS

The most widely quoted figure on the economic value of koala tourism comes from a study by Hundloe and Hamilton (1997), valuing koala tourism at $1.8 billion. The study found that the income directly contributed $1.1 billion to the Australian economy and provides approximately 9000 jobs. The research into the economic value of the koala warrants being updated to reflect the current tourism value.

Nature-based activities, combined with Australia's unique flora and fauna, are a major source of tourism. The study by Hundloe and Hamilton (1997) conducted a survey of departing international foreign tourists, and provided the following insight: when asked which animals they particularly wanted to see in Australia, 72% of respondents nominated koalas, making them the most popular choice (followed by kangaroos at 66%).

South Australia acknowledges the valuable local opportunities koala eco-tourism provides (DEWNR, 2011) and Victoria recognises the need to manage populations to 'ensure that the species continues to flourish in the wild' as a 'major tourism drawcard' within its management strategy principles (DSE, 2004). NSW government could learn from the approaches of Victoria and South Australia and work with Destination NSW.

Within NSW, in 2006-07 the World Heritage Gondwana Rainforests drew $327 million of visitor expenditure, of which $145 million was value-added, and accounted for over 1600 jobs. A summary of several economic studies has shown protected areas in north-east NSW to have added $124 million to the local region, and to have supported almost 2000 jobs (Love & Sweeney, 2015).

3 MAJOR ISSUES NEEDING ATTENTION

3.1 GOVERNMENT AGENCIES CAN IMPROVE THE WAY THEY WORK TOGETHER TO MANAGE THREATS TO KOALAS

As outlined in Section 2.1 of this report, koalas are found across a wide range of habitats and locations. While koalas are recognised as threatened across two thirds of the species' range, the species is not uniformly threatened at all locations, with some populations in Victoria and South Australia even requiring a reduction in numbers (NRMMC, 2009a).

As presented in Section 2.4 of this report and in the work by McAlpine et al. (2015) and Santika et al. (2015), the threats to koala populations vary between and within different regions of NSW.

While additional information will help inform future threat management and mitigation, it is clear that there is sufficient evidence from which government can act now. This report recommends adopting a whole-of-government koala strategy for NSW, with the objective of stabilising and then starting to increase koala numbers.

Individual government agencies, and those outside government, are already pursuing measures to manage or mitigate impacts on koalas. The aim of the strategy should be to build on this base and provide a more strategic and coordinated way for government agencies to work together to identify and implement actions that have the greatest likelihood of reducing key threats to koala populations. It is also crucial that the strategy delivers information and tools that help the private sector and the community take actions as appropriate and make it easier to work with government.

To achieve this, the strategy needs to start from a strong evidence base including direct detection, mapping existing koala habitat, likelihood of occurrence data and threat mapping. The strategy should present this information as its base case or starting point. This information will also be critical to monitoring the effectiveness of actions taken and, more broadly, whether the objective of stabilising and then starting to increase koala numbers is being achieved. Over time it is hoped that information about genetic diversity can also be brought to bear to inform future management actions.

The strategy should identify key koala populations and analyse the state of and threats to those populations, with the expectation that this analysis will set:

- specific on-ground actions that government agencies, in combination with the private sector and the community, can take now at a local, regional and state-wide scale
- the direction for policy reform, such as considering specific changes to the planning framework and working with the Federal government to align assessment and monitoring methods.

Publishing the results of this analysis will also ensure that there is a clear and transparent rationale for directing where, what and at what scale actions and policy reforms need to be taken.

State-wide threats, such as habitat loss and the predicted likely increased incidence and severity of future droughts, require responses across the koala's range. Other threats, such as urbanisation in the Sydney Basin and on the north coast require actions specific to each area.

The strategy should make it clear which agency or agencies are responsible for which actions, set timeframes for those actions and specify how their success will be measured. A

strong model for local and regional level inter-agency collaboration is already used in relation to how agencies work together to implement Bush Fire Risk Management Plans. A similar approach could be established to support implementation of identified local and regional management and mitigation actions.

In establishing the need to act, the strategy should also make it clear where there is a need for policy reform. The strategy should outline reform areas and set accountabilities and timeframes. This will be important to ensuring that the systems designed to support healthy koala populations are effective.

To be successful, the strategy needs to recognise and provide opportunities for involvement of Aboriginal traditional owners and community members as traditional custodians of the land, the private sector and broader community. There is already a wealth of information about what works and what doesn't, as well as clear avenues for further research. The strategy should bring this information together and present it in a way that others can take informed decisions.

In developing a state-wide strategy, the deficiencies of past strategies and plans need to be recognised. Predavec (2008) and McAlpine et al. (2015) provide reviews of the National Koala Conservation and Management Strategy (NRMMC, 2009).

3.2 IMPROVING DATA ON KOALA NUMBERS AND HABITAT

The NSW koala strategy should prioritise gathering better data about the number, location and abundance of koalas, and their habitat, as the basis for better management and decision-making.

In particular, new sensor technologies and data analytics can be employed, in combination with data gathered through EISs, citizen science and traditional survey methods such as scat surveys, to build a much richer picture of koala occurrence. Data fusion techniques can bring this information together which can then be used to inform better models of population and habitat. The raw data should also be available in the SEED Environmental Data Portal (extended if necessary to include flora and fauna) for open access by government, community and researchers.

This should link with the Government's new investment in the NSW Smart Sensing Network. This initiative will develop and apply 'smart sensor' technologies to a range of complex issues, including monitoring technologies for native animals like koalas, and use ICT to identify and track species.

There are a number of other strands to the task of improving data which are outlined in the following sections.

3.2.1 Likelihood of occurrence and population trends: surveying and citizen science surveying

The report recommends that a program be developed to build on the koala likelihood of occurrence map (Predavec et al., 2015) by targeting gaps in data particularly in priority areas (e.g. where there are higher threats).

Surveying is essential to gathering important data on koalas. Undertaking surveys in priority areas will build on the current state-wide map of likelihood of koala occurrence. These data, in combination with the predictive habitat map, will help decision makers to protect koala habitat, better plan development in areas with koalas and undertake threat mitigation at a population and landscape scale.

More survey data also allows comparisons with previous surveys and for broad population trends to be discovered. Knowledge of whether a population is declining, stable or increasing is important for decision makers to determine whether interventions are working, or whether different interventions are required. Building a strong picture of koala occurrence in combination with trends (see below for more details) will allow confident, cross-tenure decisions across government to be made about koala management to secure koala populations across their broad geographical range (Adams-Hosking et al., 2016).

The 2006 state-wide koala survey was used to gather data to develop broad-scale maps of populations for the purposes of targeted management action (Lunney et al., 2009). This study showcases the importance of ongoing survey data and the way it is used to determine occupancy and trends. The information was used to inform the 2008 Koala Recovery Plan (DECC, 2008).

There are many methods to obtain survey data, including citizen science. Citizen science involves members of the community in data collection. Advances in technology, such as apps on smart phones, or interactive maps on websites, allow citizen scientists to record data, such as locations where koalas were seen or were absent, quickly and accurately. Data can also be uploaded instantly to wildlife databases and analysed far more cost effectively to determine changes in koala distribution.

The community gains an increased awareness of conservation issues and engagement in management outcomes by being involved in surveys. Previous citizen science surveys of koala distribution show that community-developed knowledge matches traditional science results on koala distribution (Lunney et al., 2009).

Citizen science surveys allow data to be gathered cost effectively over a long period of time and across a large geographical area, including private land. It also helps to boost data that has gaps and inconsistencies, such as koala presence and absence data. The state-wide koala surveys used citizen scientists to gather data during 1986-1987 and again in 2006 with success (Lunney et al., 2009). For those areas where citizens are not usually likely to survey, such as in bushland away from roads and urban areas, partnerships with local groups who will go to those areas are important.

It is important to ensure citizen science survey models are replicable, comparable and account for limitations in the data. Volunteer citizen scientists must be educated on the target species and trained in the standardised sampling protocol to safeguard against unusable data. To ensure the use of the reported data, precautions must be taken to minimise the risk associated with public-gathered data such as encouraging a photograph whenever possible. In addition volunteers may also be provided a range of example data collection sites representing all suitable habitat types. Importantly, participants must not report a false sighting if the target species was not sighted during their search, but instead report an “absence sighting”.

Combining the results of the surveys and predictive habitat modelling will provide a comprehensive landscape based picture of where koalas are, how they are faring across NSW, and allow government to manage koalas better and undertake threat mitigation at a population and landscape scale.

3.2.2 Population monitoring

In many cases, the reliance on traditional point-in-time surveys (such as scat surveys conducted according to licence conditions under IFOAs) has proven ineffective at providing data on population trends, as they are not designed for comparative or repeat surveying (Woosnam-Merchez, Cristescu, Dique, Ellis, Beeton, Simmonds, & Carrick, 2012; Slade & Law, 2016). A robust monitoring program is essential to understand the impact of interventions and activities at a landscape scale and at specific sites and how populations

respond over time. A targeted monitoring program is especially important in remote areas that may not be regularly visited by the public or researchers.

All major infrastructure projects and natural resource management activities have a local impact on the environment. However, further information is required on how this impacts the broader koala population over time. Monitoring is essential to manage a range of threats. It is also important that effective monitoring of actions is undertaken to ensure that management decisions are founded on 'best available science'.

The report recommends the development and implementation of a plan for systematic long-term population monitoring across tenures. This monitoring and the subsequent analysis of data should be well funded and undertaken annually. All data and metadata should be deposited in the SEED Environmental Data Portal. This monitoring plan will define clear objectives to assess and report on existing mitigation actions for koala conservation across all tenures and activities and include trigger points that specify the implementation of particular actions when thresholds are exceeded in line with an adaptive management approach.

An example demonstrating the value of a robust long-term regional monitoring program for koalas can be found in the Queensland Government's South East Queensland Koala Monitoring Program (Rhodes, Beyer, Preece, & McAlpine, 2015). This program has monitored the abundance and occupancy of koalas in South East Queensland over the past 20 years and has been critical for providing a strong evidence basis for policy development.

Given the lack of clarity on koala population status, especially in remote areas, a robust monitoring program should aim to provide the following benefits, including:

- assessing the effectiveness of koala policies across all land tenures
- information for informing future policy change
- provision of data to give managers, policy makers and the community better confidence in population and distribution trends over time
- provision of information that will assist and improve the development of policies that encourage increased koala protection and enhance their population
- better information to provide targeted areas in which to focus further research
- better information of the status and trends of koalas in timber production forests
- better information on the status and trends of koalas whose habitat is impact by major infrastructure and the impact this has on the wider koala population.

There are a number of monitoring methods, each with its own limitations, which can be used to research and monitor koalas across a variety of landscapes. Which survey techniques and sensor technology that can be employed are dependent on the purpose of the monitoring: for example, whether it is large-scale population monitoring, monitoring of site-specific mitigations or data on a specific individuals within a population. The technologies and sensors used for koalas could also be used simultaneously to monitor other species that share the same environment. Improved and novel technologies and techniques that are being investigated in a variety of studies and environments include those described below. The new NSW Smart Sensing Network will also generate new monitoring approaches.

Acoustic monitoring

Acoustic monitoring is capable of detecting koala presence. Male bellows are recorded during the breeding season with SongMeters (Ellis, Bercovitch, FitzGibbon, Roe, Wimmer, Melzer, & Wilson, 2011), presenting an innovative opportunity for monitoring individuals and populations over time. Combining results from acoustic monitoring with traditional monitoring methods and analytical tools such as the occupancy modelling framework would provide strong data across the landscape scale (MacKenzie, Nichols, Lachman, Droege, Royle, & Langtimm, 2002).

Remote monitoring and tracking
Current monitoring studies usually use GPS/VHF collars. This technology is not without limitations: Matthews et al. (2013) examined 24 studies that included 280 GPS collar deployments, and concluded that problems associated with collar design resulted in only a small proportion functioning reliably over the periods of study. Problems included 15% of collar deployments yielding no data, and 75% of the studies incurring additional costs as a result of unexpected locational accuracy.

Wireless identification (WID) tags are a novel technology that could increase our understanding of koala movements, in conjunction with traditional methods such as the GPS/VHF methods. WID tags are relatively small (under 10 g), can remain active for months/years (battery dependent), and replace standard plastic ear tags. For example, WID tags have been used by the Queensland Department of Transport and Main Roads in Moreton Bay area (TMR, 2016). The tags allow data to be obtained on koala movements, including the ability to ascertain their typical ranges and if they moved outside of these ranges. When a fatality occurs to a tagged koala, it also allows the individual to be located and, potentially, the cause of death to be determined and adaptive threat management to be implemented (Endeavour Veterinary Ecology, 2016; TMR, 2016).

Wireless identification tags, in combination with a data harvesting system and motion activated cameras, were used by researchers at Griffith University to monitor koalas using crossings over roads in south-east Queensland (Dexter et al., 2016). In their subsequent report, they indicated that the use of remote technology is still hampered by the trade-off between the different requirements of a project, the data required and the costs related with implementing and recovering the monitors.

Koala scat sniffer dogs
Population data can be hard to gain for species, such as the koala, that are characterised by low density and large home ranges, and whose behaviour makes visual identification difficult. For these species, indirect measurements such as scat (faecal pellets) surveys can be a useful indicator of the presence or absence of the species and how they use the environment (Phillips & Callaghan, 2011; Cristescu et al., 2015). Scat surveys have been used to inform some of the CKPOMs prepared under SEPP 44.

Using dogs specifically trained to detect koala scats is being investigated, particularly as scat surveys conducted by researchers can return a high false negative rate (Cristescu et al., 2015). Experimentally, off-leash dog trials returned a 100% detection rate and was 19 times more efficient than current scat surveys (Cristescu et al., 2015). This study concluded that detection dogs are more cost effective than other survey methods such as human-only detection, camera traps and hair analysis; and that using detection dogs for koalas increases the accuracy and reduces false negatives. Detection dogs will be utilised for the a large scale koala distribution survey on the Northern Tablelands (Northern Tablelands LLS, 2016).

3.2.3 Likely koala habitat: predictive habitat modelling

Important koala habitat areas in NSW are not currently identified state-wide and across all tenures. This hinders conservation of important habitat as agencies across government may not account for important koala habitat across the landscape when making decisions.

Adoption across government of a state-wide, cross-tenure predictive habitat map to guide decisions at government level and inform private land owners, is essential for koala habitat preservation. To produce a state-wide map, a suitable model must be developed.

The state-wide map will be important for managing threats at a population and landscape scale, as it will allow decision makers to see where koala habitat is likely to be and target those areas with additional ground-truthing.

In addition to assisting avoidance of threats related to development, the map will also help government to take further steps to understand threats impacting koalas in particular areas and mitigate these. If the predictive habitat map identifies habitat as suitable but ground-truthing identifies that habitat is not being used by koalas, government can take steps to determine why the habitat is not being used and then manage the threats and encourage koalas to the area. For example, a koala may not use habitat that has poor connectivity or has wild dogs.

In order to expand the model to the whole of NSW, improvements in some underlying environmental data, such as vegetation data are required. There have been significant developments in vegetation data that will be used to inform the model, such as plant community type vegetation data. Further developing plant community type data sets and combining this with browse tree species data and woody canopy data is important to identify koala habitat across the state.

3.2.4 Establishing a single repository for koala genetic information in NSW

Preventing the decline of genetic diversity in NSW is a key factor in protecting the resilience of our koala populations. This is particularly important when there are other population restricting factors present such as Chlamydia. Currently, it is not known if there are any populations free of Chlamydia in NSW. Local extinctions can occur where fertility loss due to Chlamydia and reduced recruitment from habitat fragmentation cause populations to decline (DECC, 2008).

As indicated by the translocated koala population experiences across South Australia and Victoria from a small base, it is valuable to recognise the consequences of low genetic diversity for the koala populations and take steps to avoid this happening in NSW. Low genetic diversity characteristics bring a range of consequences including "*reductions in fertility, survivorship, disease resistance, growth rates and adaptability to environmental changes*" (DECC, 2008). Both Victoria and South Australia now only employ translocation programs in response to the problems of over-browsing, with extremely strict protocols and after considerable consideration (e.g. where risk of death would be high) as it is expensive; has unpredictable success results; and is logistically highly complex (DSE, 2004; DEWNR, 2011).

Managing a number of populations as a meta-population allows for adequate gene flow amongst different sites to ensure that both genetic and demographic integrity of the focus species is maintained. A program of gathering genetic data would therefore strengthen understanding of the health and dynamics of NSW koala populations.

There are a number of different tools available to undertake this form of metapopulation management including molecular genetics, remote monitoring methods, and demographic and genetic modelling software.

To develop our understanding of koala genetics in NSW further, it is essential that the government establish a single repository for genetic material. The Australian Museum in Sydney, as a co-leader of the Koala Genome Consortium and home to the Australian Centre for Wildlife Genomics, is ideally placed to provide this repository where samples could be analysed, provided they were well supported by a genetic diversity sampling program funded by the government. Tissue samples could be taken by koala carers, researchers or veterinarians who deal with koalas that are injured or killed each year. Ecological consultants, licensed under the NPWS's Scientific Licensing arrangements, could also participate in this program.

To ensure its effectiveness, the program would need an administrator to coordinate and facilitate taking and delivering samples to the Australian Museum, and OEH would be well placed to take this role. The administrator's role would include developing appropriate protocols and funding for training of staff (both internal and external), veterinary support, transport arrangements and any other essential support processes. The koala carer guidelines produced by the NPWS (1997) should be amended to support this program, and a similar protocol put in place for ecological consultants. Data and metadata associated with these samples need to be deposited in the SEED Environmental Data Portal.

3.3 A LANDSCAPE APPROACH TO MANAGING AND MITIGATING THREATS

Koala populations need large areas of connected habitat to maintain their viability. Habitat loss and fragmentation has resulted in population decline and has been identified as a significant threat to the species persistence in NSW (DECC, 2008).

Reserves in modified landscapes can help reduce the stresses faced by some koala populations, for example, by limiting the impacts of climate change, vegetation clearing, road kill and in some instances domestic dog attack. Even small reserves can provide important 'stepping stones', connecting habitat and allowing koalas to move and disperse through more extensive but fragmented landscapes.

Formal protected areas, such as national parks, provide a network of lands where threats can be managed and mitigated in a coordinated and systematic manner, for example through the application of regional fire, weed and pest management strategies. National parks may also play an increasingly important role in enabling koala populations (and other threatened species) to adapt to the effects of climate change.

Protection measures on private lands, whether through formal arrangements such as biobanking or conservation agreements, or informally through information and educational initiatives such as Land for Wildlife, are critical to ensuring healthy koala populations can persist. The Saving our Species program is also intending to work directly with landholders and provide resources to restore and improve koala habitat on private land over the next few years.

The national parks estate provides a solid foundation for landscape conservation and has a key role to play in protecting koalas. However, there needs to be a network of other crown land (that may not be suitable for addition to the parks estate), Aboriginal land and other private freehold land that together provide large tracts of well-connected and managed koala habitat across regions.

To be effective, conservation efforts to protect koalas will require measures on private and public lands, with actions based around an understanding of the species' needs from a landscape perspective.

Habitat restoration and revegetation can offer the potential to restore habitat for koala populations. A study of young tree plantations on the Liverpool Plains showed that 4-7 year old plantations of River Red Gums (a known koala browse species) were preferentially used and koalas crossed farmed paddocks to use such areas (Kavanagh & Stanton, 2012). Occupancy of young eucalypt plantations and remnant patches by koalas was strongly influenced by the proximity of these sites to remnant vegetation, indicating that habitat restoration needs to be strategic not random and should consider connectivity in the landscape.

A more recent study demonstrated that koalas need taller trees, and non-feed species with shadier/denser foliage, to provide shelter from heat (Crowther, Lunney, Lemon, Stalenberg,

Wheeler, Madani, Ross, & Ellis, 2014). The planting of both food and shelter trees could connect existing taller mature trees, such as remnant paddock trees, to increase habitat area and connectivity across the landscape. Indeed, genetic analyses suggest that eucalypt timber plantations and regeneration of koala friendly habitat on farmland near Lismore has increased landscape permeability for koalas (Lee, Ellis, Carrick, Corley, Johnston, Baverstock, Nock, Rowe, & Seddon, 2013). However, koalas in commercial timber plantations incorporating browse species are recognised as highly problematic in South Australia. This should be taken into account in NSW (DEWNR, 2011).

3.4 CREATING A CONSERVATION NETWORK

Developing a cross-tenure approach to koala conservation will allow opportunities to be identified where a landscape scale management approach can be implemented that improves connectivity and resilience against key threats. By systematically applying data on the likelihood of koala occurrence, the predictive koala habitat model and threats, we can identify key areas to target for conservation management and action. OEH land managers and agencies with significant land portfolios could work together to develop cross-tenure conservation efforts where they are likely to be most effective for addressing threats.

3.4.1 Opportunities for conserving habitat on private land

One of the major barriers for private landholders to conserving koala habitat is the opportunity cost of forgoing their future development rights by permanently protecting habitat. Another barrier is that there can be actions landholders are required to take to manage habitat (e.g. erecting fences to keep dogs out, tree planting) which involve upfront costs to the landholder.

The Conservation Partners Program, OEH has been supporting conservation on private land for many years and provides some funding to landholders to manage their land for conservation. These funds typically covered the costs of works such as building fences and vegetation restoration but did not compensate the landholder for lost opportunity cost.

The Savings Our Species program and the recently announced Private Land Conservation Program has a budget of $240 million over five years with ongoing funding thereafter and will provide significant financial incentives for landholders to manage their land for conservation. Under these reforms, programs previously supported by the Conservation Partners Program will be incorporated into the Private Land Conservation Program. Under this program landholders will be able to enter into three agreement types. The different types of agreements have different biodiversity management needs and associated funding, and will be administered by the Biodiversity Conservation Trust.

A key initiative under a future koala strategy could be to use the resources of both the Saving our Species and Private Land Conservation programs for koala conservation on private land. A NSW koala strategy could also provide direction to the proposed Biodiversity Conservation Trust.

3.4.2 Opportunities for managing Crown lands for koala conservation

There are many instances across NSW where Crown lands, whether controlled and managed by state government agencies or councils, contain koala habitat or populations. There are opportunities under the current Crown lands reforms process for the government to identify lands that contain koala habitat and ensure that their future management arrangements will maintain both the koala habitat and any populations that exist on that land.

There are a number of government processes currently underway where these outcomes could be achieved. These include:

- ensuring that crown land with prime koala habitat currently held by the state is retained in state ownership either by the current land manager managing that land for koala conservation or by transferring to the national parks estate
- ensuring state government agencies that have land identified as excess to their needs should assess whether the land contains koala habitat prior to any sale or transfer, and, if so, transfer the land to another agency or council to manage for koala conservation
- as part of the review of the NSW Forest Agreements, Forest Corporation NSW work collaboratively with OEH on a state-wide process to identify uneconomic state forests with koala populations and habitat, and to transfer those parcels to OEH as a priority.

Due to size, location and other uses, public land with good quality koala habitat will not always be suitable for adding to the national parks estate.

3.4.3 Expanding the national parks estate to protect koalas

The national parks estate will continue to be a key component in the network of large tracts of protected habitat needed to sustain the koala in NSW. Under a landscape approach, strategic park additions could complement increasing protection of habitat on other crown land and private land over time.

Using existing information and models on koala habitat and populations, augmented by new information that would be generated under other recommendations in this report, the NPWS should include potential areas of high quality koala habitat in their long term acquisition program. That agency should focus on any areas identified as potential reserve additions or new reserves to align with other conservation efforts on private land, such as rehabilitation of habitats to create suitable corridors for koala movement. This approach should align with NPWS long term reservation strategies.

There is also strong community interest to engage in koala conservation at many levels, such as rehabilitating sick and/or injured animals for release, contributing to habitat rehabilitation, identifying areas for koala habitat protection and participating in koala survey, education and research.

NPWS should harness this community interest and engage with the community, highlighting important areas in the landscape (on both private and public land) and the range of initiatives in which the community can become involved. Areas of existing and proposed additions to the parks estate can be identified to invite community engagement and focus effort in the conservation of koalas.

3.5 EMBEDDING HABITAT INFORMATION INTO THE PLANNING SYSTEM WILL IMPROVE DECISION MAKING

A comprehensive predictive habitat map, combined with the koala likelihood of occurrence map embedded as a regulatory tool in both the local and state government planning system will help ensure that important koala habitat is preserved across the landscape in NSW. The map will influence policy decisions across agencies at early stages, such as the appropriateness of a development being undertaken at a particular location, as well as at a finer scale.

In addition to planning system tools, the map will help decisions to be made by a range of agencies, such as:

- identifying parcels of private land that contain high quality koala habitat, which can improve connectivity between areas of land managed for conservation values and provide refuge from key threats
- identifying management arrangements that would preserve the lands' value to koalas

- ensuring funding mechanisms are available, for example through biodiversity stewardship agreements and biodiversity stewardship payments under the government's Saving Our Species and Private Land Conservation program, to provide private land holders incentives to manage land in a way that benefits koalas
- identifying parcels of Crown land that support connectivity and/or are key to managing threats to a particular population
- transfer of parcels of Crown land to the national parks reserve system as appropriate
- identifying areas to target for dog control and other threat mitigation.

The map will also help private land holders to understand where koala habitat is on their land and in combination with an education program, protect the habitat.

4 RECOMMENDATIONS

The importance of the koala as an iconic species to the community should be formally recognised by government along with a commitment to acting, monitoring and continuously learning so that healthy koala populations can persist.

An effective strategy for koala management should embody the following principles:

- **Act on evidence:** act on the best scientific evidence available, reducing threats based on current understanding while also measuring and monitoring outcomes
- **Recover:** aim to recover the koala by managing and mitigating threats to key koala populations in NSW, managing cumulative impacts in a regional context and improving connectivity across the landscape
- **Learn:** learn by continuously improving knowledge and understanding of how koalas are faring and adapt management approaches.

Several of the recommended measures, particularly those focussed on data and monitoring, will require additional, sustained and dedicated resources.

This review makes 11 recommendations to inform the development of a NSW koala strategy.

4.1 A WHOLE OF GOVERNMENT STRATEGIC APPROACH

Recommendation 1
That Government adopt a whole-of-government koala strategy for NSW with the objective of stabilising and then starting to increase koala numbers.

Government agencies should collaborate to develop a strategy based on the principles of on-ground action, ongoing monitoring and continuous learning. The strategy should identify the actions necessary to manage and mitigate priority threats to key koala populations.

The Office of Environment and Heritage ideally will have ongoing responsibility for the strategy with each agency formally agreeing to deliver the actions assigned to it. An inter-agency forum should periodically review implementation and report to the responsible Ministers about actions taken, outcomes achieved and future priorities. This reporting should be made public.

The strategy should:

- identify key koala populations and management areas which have the potential for long-term recovery and viability
- identify priority threats to key koala populations at the population scale, through mapping and establishing threat hierarchies
- define actions to manage and mitigate priority threats to key koala populations
- prioritise management actions, investment priorities and clearly assign accountabilities and timeframes
- review and align legislative and regulatory arrangements to improve outcomes for koalas across tenures
- establish a framework and specific mechanisms for on-going coordination and cooperation of land managers, policy makers, researchers and the community to deliver the defined actions
- build on the knowledge base in NSW by drawing on experience with koala population management in other jurisdictions, particularly Victoria and Queensland to learn from

past positive and negative experiences, and also learn from approaches and outcomes with other native species
- identify any knowledge gaps that may impede these actions and prioritise them for further research
- evaluate outcomes, consistent with the NSW Government Program Evaluation Guidelines, within five years of commencement of the strategy.

The strategy should specifically address the following recommendations to ensure action is taken to recover key koala populations.

4.2 PRIORITISE INFORMATION FOR BETTER PLANNING AND DECISION MAKING

Better outcomes for koalas will require fit-for-purpose data and monitoring to inform planning and decision-making. There are three priority areas:

- improving data on koala numbers and locations to inform decisions, for example, the prioritisation of areas to be targeted for conservation
- developing predictive koala habitat maps to inform regional planning outcomes and local zoning decisions, guide conservation planning and inform on-ground recovery and restoration
- monitoring koala trends to give confidence in population changes over time, assess the effectiveness of policies, and understand whether NSW is meeting its overall goal for koalas.

These priorities are described in the recommendations below.

Recommendation 2
That Government initiate a program to improve data on the number, location and occurrence of koalas in NSW, including trends over time, taking advantage of new sensor and communication technologies and data analytics within 12 months of receipt of this report.

The Government should act immediately to build a strong evidence base on the likelihood of koala occurrence at a suitable spatial scale across NSW. This program should build on the koala likelihood of occurrence map (Predavec et al., 2015) by targeting gaps in data particularly in priority areas (i.e. where there are potentially higher threats).

These and other available data and mapping should be used to inform management decisions contained in the strategy, such as the identification of areas to be targeted for conservation reserves (recommendation 7).

The Government should implement a plan for trend monitoring of koalas across all tenures at a landscape scale, based on a review of current literature and recent research. The monitoring plan and subsequent analysis should be undertaken annually and be implemented across tenure. The monitoring plan needs to define clear objectives to assess and report on existing mitigation actions for koala conservation across all tenures and activities, and include trigger points that specify the implementation of particular actions when thresholds are exceeded in line with an adaptive management approach.

Given the lack of clarity on koala population status, especially in remote areas away from the coast and in populated areas, a robust monitoring program should aim to provide the following:

- knowledge about the effectiveness of koala policies across all land tenures
- data to give managers, policy makers and the community better confidence in population and distribution trends over time

- information that will assist and improve the development of policies that encourage increased koala protection and enhance their population
- better understanding of the cumulative impacts of threats on key koala populations
- better information to identify targeted areas for further research.

All data collected should be entered into the SEED Environmental Data Portal (extended if necessary to include flora and fauna) so that it is available to government, the community, industry and researchers to use and inform broader actions that support preserving koalas.

Recommendation 3
That Government publish a state-wide predictive koala habitat map within three years of receipt of this report, with immediate priority given to improving coverage of the north coast.

This map will inform regional planning outcomes and local zoning decisions, guide conservation planning and inform on-ground recovery and restoration efforts as outlined in subsequent recommendations.

4.3 APPLYING OUR KNOWLEDGE TO IMPROVE OUTCOMES

Government and the community employ a range of regulatory and non-regulatory approaches to managing koalas, their habitat and threats. Many of the regulatory measures are or have been recently reformed or reviewed, for example, the land management and biodiversity conservation reforms and the SEPP 44 review.

Developing a koala strategy provides the opportunity to review and align the various regulatory approaches to improve outcomes for koalas across different land uses and tenures, using the improved data and mapping to inform better planning and decision-making. The strategy can also ensure that non-regulatory approaches such as incentives for private conservation are aligned with agreed priorities across all tenures.

The following recommendations outline a series of priorities.

Recommendation 4
That Government improve outcomes for koalas through changes to the planning system.

In addition to the current review of SEPP 44, within 12 months of receipt of this report Government should start a broader evaluation of the effectiveness of SEPP 44 as a planning tool and the Comprehensive Koala Plans of Management for protecting koalas and their habitat. This work should also consider how best to incorporate the state-wide predictive koala habitat map (Recommendation 3) and the koala likelihood of occurrence map (Recommendation 2) in combination with state-wide best practice guidelines to inform land-use planning and zoning and to guide development consent.

Recommendation 5
That Government improve outcomes for koalas through the Biodiversity Conservation Bill and associated Regulations.

This should be achieved by:
- ensuring that the koala habitat maps are suitable for use through the Bill and Regulations
- including koala habitat in Category 2 (Regulated Land) on the native vegetation regulatory map and identifying and implementing controls as appropriate
- including predictive koala habitat and likelihood of koala occupancy information in the Biodiversity Assessment Method (BAM) threshold sensitive values map

- considering including impacts on the best quality koala habitat as 'serious and irreversible impacts'.

Koalas should also be included in the monitoring programs to be established under the new Bills.

Recommendation 6
That Government investigate models for guiding and incentivising collaborative best practice for new development and ongoing land use occurring in areas of known koala populations across tenures, industries and land users.

Guidelines should be developed to improve the design of new developments in koala habitat and direct mitigation measures. It is also recommended that Government develop best practice principles for Koala Plans of Management for State Significant Development mining projects occurring in areas with known koala populations.

In addition to these guidelines and principles, Government should also investigate incentive models for industry implementation of best practice, encouraging and rewarding innovative approaches. For example, this could take the form of an accreditation or rating system for companies or developments that exceed expectations in Environmental Impact Assessments and for 'koala-friendly' design and development. This could apply to all major land use change that may impact koala habitat across all tenures, industries and land users.

Recommendation 7
That Government agencies identify priority areas of land across tenures to target for koala conservation management and threat mitigation.

The Office of Environment and Heritage should work with land managers and agencies with significant land portfolios to apply the likelihood of koala occurrence data systematically (Recommendation 2), the predictive koala habitat map (Recommendation 3) and regional scale threat information to identify priority areas to target for conservation management and threat mitigation.

Looking across all land tenures will allow opportunities to be identified where a landscape scale management approach can be implemented that improves connectivity and resilience against priority threats.

This work should commence with the north coast by:

- identifying parcels of public land that support connectivity and/or are key to managing threats to populations so that they are managed for conservation values
- identifying parcels of private land that contain koala habitat that can improve connectivity and provide refuge from priority threats and identifying voluntary land management arrangements that would preserve the lands' value to koalas.
  Private land holders should be incentivised to manage their land in ways that benefit the koala through funding mechanisms such as biodiversity stewardship agreements and payments under Saving our Species and Private Land Conservation programs
- identifying appropriate management arrangements for parcels of public land including through addition to the national parks reserve system or arrangements with Aboriginal Land Councils
- identifying priority areas of land for restoration
- identifying target areas for dog control and other threat mitigation.

The Office of Environment and Heritage should also work with Roads and Maritime Services and councils to identify koala road kill hotspots at a fine scale and determine the feasibility and likely effectiveness of preventive mitigation.

4.4 OPPORTUNITIES FOR THE SCIENTIFIC AND BROADER COMMUNITY TO DIRECTLY CONTRIBUTE

Community based action to address threats to koalas and their habitat will be essential for koala recovery. These actions come in many forms such as the work of koala carers and rehabilitation groups, local Landcare and habitat restoration groups, investment funding by Local Land Services, the work of non-government organisations and the on-ground works funded through the Saving Our Species Iconic Koala Project. Our research community and local councils are also important partners for meeting the goals of the strategy.

The following recommendations outline a series of actions for collaboration between Government, the community and researchers.

Recommendation 8
That Government, through the Office of Environment and Heritage, convene two symposia within 12 months of receiving this report: one for scientists active in koala research and land managers to develop a koala research plan; and one focussed on koala rehabilitation to identify actions to optimise the delivery of and support for the network of koala rehabilitation groups and carers.

The koala research plan should build on the koala research priorities identified in the strategy and provide seed funding to support researchers to build collaborative grants applications such as Australian Research Council and Environmental Trust bids.

A biennial symposium, organised and facilitated by OEH, should refresh the koala research plan and share research findings to feed back into the strategy's delivery. General outcomes of the symposium should be agreed upon and made available to community members and land managers in a suitable form to permit them to act on the best available science.

An immediate set of research priorities has been identified through this review. These include knowledge gaps relating to key koala populations:

- better understanding of the impact of managed and wild fire on koala habitat
- local population movements and viability in relation to connectivity, roads and dogs
- cumulative impacts on koala populations from pressures of native forest harvesting, fire and dogs
- effectiveness of offset and rehabilitation activities
- cumulative impacts on koala gene flow from fragmented habitat and populations
- results from the Koala Genome Consortium to better inform disease research including chlamydia and koala retrovirus (KoRV)
- climate change impacts and identification of climate refugia
- key socio-economic and institutional barriers to the effective implementation of koala conservation strategies
- effectiveness of management strategies to minimise impacts on koala populations including development consent for residential subdivision and mitigation activities for reducing mortality on roads.

Within six months of receipt of this report, it is recommended that a priority research project is commenced to better understand how koalas are responding to regeneration harvesting forestry operations on the mid-north coast of NSW. The project will assess the effectiveness of current and proposed prescriptions designed to mitigate the impacts of forestry operations on koalas in these areas.

The second symposium, also organised and facilitated by OEH, should focus on koala fauna rehabilitation to identify actions to optimise the delivery of and support for the network of koala rehabilitation groups and carers.

This would include:

- examining different models of operation and discussing challenges faced by the network of fauna rehabilitation groups and carers and how they might be overcome
- discussing how to maximise responsiveness, improve or standardise triage and clinical practices to increase survival and return to the wild rates
- standardising data collection so this information can be used as a metric in reporting the success of the koala strategy as well as being made available for scientific research purposes.

The symposium should include representatives of the Veterinary Association and scientists working on koala research to aid the continuous learning of these groups.

Recommendation 9
That Government establish the Australian Museum as a preferred repository for koala genetic samples in NSW, and all data and metadata associated with these samples should be deposited into the SEED Environmental Data Portal (extended if necessary to include flora and fauna).

Government should develop and fund a program to collect genetic information from tissue samples taken from all injured and deceased koalas across the state for analysis in accordance with an agreed protocol. The program should be administered and implemented by OEH and provide the necessary protocols, funding, training, veterinary support, transport arrangements and other necessary support for carers and researchers to take and deliver samples to the Australian Museum. The koala carer guidelines produced by the National Parks and Wildlife Service should be amended to support this program, and a similar protocol put in place for ecological consultants under the NPWS's Scientific Licensing arrangements.

Recommendation 10
That Government facilitate the exchange of information among land managers, local government, the research community and the broader community.

To allow an adaptive management approach to be used by land managers, information flow between researchers and government agencies should be facilitated in real time through the SEED Environmental Data Portal.

Access to the learnings from the koala symposium and the annual reporting on outcomes to the Minister will help the community to act on the best scientific evidence available. To promote the dissemination of these learnings, local koala field days should be held in key centres around NSW where information about koala conservation and management can be exchanged. These should be followed up with booklets, pamphlets and eLearning materials to allow the community to access an information tool kit so they can decide how to best manage their land for koalas and other threatened species.

Also, local councils should be supported to manage local threats to koalas better through the exchange of information.

Recommendation 11
That Government draws on knowledge and shares information with local community members through a program that supports localised engagement between liaison people and residents and industry.

Local knowledge and follow-through is vital. Local residents, Aboriginal traditional owners and community members, Aboriginal Land Councils, farmers, land managers and environmental consultants are holders of considerable detailed local knowledge about koala

populations, occurrence, and threats. Sharing information will be an important approach to developing the koala strategy, and communicating and delivering local initiatives.

Learning from other programs such as the South Australian *Cockies Helping Cockies* program which was developed by the Zoos South Australia to address South-eastern Red Tailed Black Cockatoo recovery (Zoos South Australia, 2015), could provide a way forward to implementing programs and sharing knowledge. The delivery of such a program for koalas in NSW could include employing local residents as the liaison for the discussions and two-way information sharing, as well as rolling out program initiatives.

REFERENCES

Adams-Hosking, C, Grantham, H.S, Rhodes, J.R, McAlpine, C, & Moss, P.T. (2011). Modelling climate-change-induced shifts in the distribution of the koala. *Wildlife Research, 38*(2), 122-130. doi: http://dx.doi.org/10.1071/WR10156

Adams-Hosking, C, McBride, M.F, Baxter, G, Burgman, M, de Villiers, D, Kavanagh, R, Lawler, I, Lunney, D, Melzer, A, Menkhorst, P, Molsher, R, et al. (2016). Use of expert knowledge to elicit population trends for the koala (Phascolarctos cinereus). *Diversity and Distributions, 22*(3), 249-262. doi: 10.1111/ddi.12400

AKF. (2015). Press release: Poor mapping allows projects to slip through NSW's approval processes. *Australian Koala Foundation.* Retrieved 18 July, 2016, from https://www.savethekoala.com/sites/default/files/NSWMAPPING.pdf

AKF. (2016). Land clearing & koalas. *Australian Koala Foundation.* Retrieved 18 July, 2016, from https://www.savethekoala.com/our-work/land-clearing-koalas

AMBS. (2012). *Investigation of the Impact of Roads on Koalas: Final Report*. Prepared by Australian Museum Business Services for the NSW Roads and Maritime Services.

Auerbach, N.A, Wilson, K.A, Tulloch, A.I.T, Rhodes, J.R, Hanson, J.O, & Possingham, H.P. (2015). Effects of threat management interactions on conservation priorities. *Conservation Biology, 29*(6), 1626-1635. doi: 10.1111/cobi.12551

Australian Government. (1999). *Environment Protection and Biodiversity Conservation Act 1999*. Retrieved from https://www.environment.gov.au/epbc.

Australian Government. (2013). EPBC Act - Frequently asked questions. Retrieved 22 November, 2016

Australian Government. (2014). *EPBC Act referral guidelines for the vulnerable koala* Prepared by the Australian Government, Department of the Environment Retrieved from https://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelines-vulnerable-koala.

Australian Government. (2015). *Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia*. Prepared by the Department of Agriculture and Water Resources.

Biolink. (2013). *Port Macquarie-Hastings koala habitat and population assessment*. Final report prepared by Biolink Ecological Consultants for Port Macquarie-Hasting Council.

Biolink. (2016). *Comprehensive Koala Plan of Management*. Prepared by Biolink Ecological Consultants for Campbelltown City Council Retrieved from www.campbelltown.nsw.gov.au/.../ckpom_ac_rw_bn_as_04052016.pdf.

Black, K.H, Price, G.J, Archer, M, & Hand, S.J. (2014). Bearing up well? Understanding the past, present and future of Australia's koalas. *Gondwana Research, 25*(3), 1186-1201. doi: http://dx.doi.org/10.1016/j.gr.2013.12.008

Briscoe, N.J, Kearney, M.R, Taylor, C.A, & Wintle, B.A. (2016). Unpacking the mechanisms captured by a correlative species distribution model to improve predictions of climate refugia. *Global Change Biology, 22*(7), 2425-2439. doi: 10.1111/gcb.13280

Brook, B.W. (2008). Synergies between climate change, extinctions and invasive vertebrates. *Wildlife Research, 35*(3), 249-252. doi: http://dx.doi.org/10.1071/WR07116

Brook, B.W, Sodhi, N.S, & Bradshaw, C.J.A. (2008). Synergies among extinction drivers under global change. *Trends in Ecology & Evolution, 23*(8), 453-460. doi: http://dx.doi.org/10.1016/j.tree.2008.03.011

Clarence Valley Council. (2015). *Comprehensive Koala Plan of Management for the Ashby, Woombah & Iluka localities in the Clarence Valley LGA*. Prepared by the Clarence Valley Council.

Clarke, M.F. (2008). Catering for the needs of fauna in fire management: science or just wishful thinking? *Wildlife Research, 35*(5), 385-394. doi: http://dx.doi.org/10.1071/WR07137

Close, R, Ward, S, & Phalen, D. (2015). A dangerous idea: that Koala densities can be low without the populations being in danger. *Australian Zoologist*. doi: doi:10.7882/AZ.2015.001

Commonwealth Department of the Environment and Energy. (2016). Australia's bioregions (IBRA) Retrieved 2 September, 2016, from https://www.environment.gov.au/land/nrs/science/ibra

Cristescu, R.H, Foley, E, Markula, A, Jackson, G, Jones, D, & Frère, C. (2015). Accuracy and efficiency of detection dogs: a powerful new tool for koala conservation and management. *Scientific Reports, 5*, 8349. doi: 10.1038/srep08349

Cristescu, R.H, Rhodes, J, Frére, C, & Banks, P.B. (2013). Is restoring flora the same as restoring fauna? Lessons learned from koalas and mining rehabilitation. *Journal of Applied Ecology, 50*(2), 423-431. doi: 10.1111/1365-2664.12046

Crowther, M.S, Lunney, D, Lemon, J, Stalenberg, E, Wheeler, R, Madani, G, Ross, K.A, & Ellis, M. (2014). Climate-mediated habitat selection in an arboreal folivore. *Ecography, 37*(4), 336-343. doi: 10.1111/j.1600-0587.2013.00413.x

Cumberland Ecology. (2013). *Watermark Coal Project: Koala Plan of Management*. Prepared by Cumberland Ecology for Shenhua Watermark Coal Pty Ltd.: Retrieved from https://majorprojects.affinitylive.com/public/8a284b3e94f1d837521048c1d21be675/43.%20Watermark%20Coal%20Project%20RTS%20-%20Appendix%20E%20-%20Revised%20Koala%20Plan%20of%20Management.pdf.

de Jesus, J. (2013). *Mitigation in impact assessment*. Prepared for the International Association for Impact Assessment.

DECC. (2008). *Recovery plan for the koala (Phascolarctos cinereus)*. Department of Environment and Climate Change: Retrieved from http://www.environment.nsw.gov.au/resources/threatenedspecies/08450krp.pdf.

DEWNR. (2011). *The South Australian Koala Conservation and Management Strategy*. South Australian Department of Environment, Water and Natural Resources Retrieved from http://assets.yoursay.sa.gov.au/production/2015/07/17/00_52_33_262_koala_conservation_management_sa_draft_strategy.pdf.

Dexter, C.E, Appleby, R.G, Edgar, J.P, Scott, J, & Jones, D.N. (2016). Using complementary remote detection methods for retrofitted eco-passages: a case study for monitoring individual koalas in south-east Queensland. *Wildlife Research*, -. doi: http://dx.doi.org/10.1071/WR15153

Didham, R.K. (2001). Ecological Consequences of Habitat Fragmentation *eLS*: John Wiley & Sons, Ltd.

Dique, D.S, Thompson, J, Preece, H.J, Penfold, G.C, de Villiers, D.L, & Leslie, R.S. (2003). Koala mortality on roads in south-east Queensland: the koala speed-zone trial. *Wildlife Research, 30*(4), 419-426. doi: 10.1071/wr02029

Doherty, T.S, Dickman, C.R, Nimmo, D.G, & Ritchie, E.G. (2015). Multiple threats, or multiplying the threats? Interactions between invasive predators and other ecological disturbances. *Biological Conservation, 190*, 60-68. doi: http://dx.doi.org/10.1016/j.biocon.2015.05.013

Driscoll, D.A, Lindenmayer, D.B, Bennett, A.F, Bode, M, Bradstock, R.A, Cary, G.J, Clarke, M.F, Dexter, N, Fensham, R, Friend, G, Gill, M, et al. (2010). Fire management for biodiversity conservation: Key research questions and our capacity to answer them. *Biological Conservation, 143*(9), 1928-1939. doi: http://dx.doi.org/10.1016/j.biocon.2010.05.026

DSE. (2004). *Victoria's Koala Management Strategy*. Victorian Department of Sustainability and Environment: Retrieved from http://www.depi.vic.gov.au/__data/assets/pdf_file/0014/220424/Koala.pdf.

Ecosure. (2015). *Koala conservation: managing a population in decline*. Retrieved from http://ecosure.com.au/wp-content/uploads/2015/08/MKG-PM.Capability_Statement_Ecosure_Koala_Conservation.pdf.

Ellis, W, Bercovitch, F, FitzGibbon, S, Roe, P, Wimmer, J, Melzer, A, & Wilson, R. (2011). Koala bellows and their association with the spatial dynamics of free-ranging koalas. *Behavioral Ecology, 22*(2), 372-377. doi: 10.1093/beheco/arq216

Endeavour Veterinary Ecology. (2016). *Koala Tagging and Monitoring Program Services for Moreton Bay Rail (NCHD 2834): Monthly Report (Part A)*. Prepared for the Queensland Department of Transport and Main Roads.

GHD. (2009). *South East Queensland Koala Habitat Assessment and Mapping Project*. Prepared by GHD for the Department of Environment & Resource Management, Queensland Government.

Goldingay, R.L, & Dobner, B. (2014). Home range areas of koalas in an urban area of north-east New South Wales. *Australian Mammalogy, 36*(1), 74-80. doi: 10.1071/am12049

Griffith, J.E, Dhand, N.K, Krockenberger, M.B, & Higgins, D.P. (2013). A retrospective study of admission trends of koalas to a rehabilitation facility over 30 years. *Journal of Wildlife Diseases, 49*(1), 18-28. doi: 10.7589/2012-05-135

Hammill, K, Tasker, L, & Barker, C. (2013). *The Invisible Mosaic: Fire Regimes in One of NSW's Most Iconic Conservation Areas*. Prepared for the NSW Office of Environment & Heritage.

Hanski, I, & Gilpin, M. (1991). Metapopulation dynamics: brief history and conceptual domain. *Biological Journal of the Linnean Society, 42*(1-2), 3-16. doi: 10.1111/j.1095-8312.1991.tb00548.x

Hesse, P, & Humphreys, G. (2001). Pilliga landscapes, quaternary environment and geomorphology. In J. Dargavel, D. Hart & B. Libbis (Eds.), *Perfumed Pineries: Environmental history of Australia's Callitris forests*. Centre for Resource and Environmental Studies, The Australian National University.

Hundloe, T, & Hamilton, C. (1997). *Koalas and Tourism: An Economic Evaluation (Discussion Paper Number 13)*. The Australia Institute.

IUCN. (2016). IUCN Red List of Threatened Species. Retrieved 2 September, 2016, from http://www.iucnredlist.org/

Jurkis, V, Rowell, D, & Ridley, D. (1994). *Survey techniques and aspects of the ecology of the Koala near Eden*. Prepared by Research Division, State Forests of New South Wales.

Kavanagh, R.P, & Barrott, E. (2001). Koala populations in the Pilliga forests. In J. Dargavel, D. Hart & B. Libbis (Eds.), *Perfumed Pineries: Environmental history of Australia's Callitris forests*.

Kavanagh, R.P, Debus, S, Tweedie, T, & Webster, R. (1995). Distribution of Nocturnal Forest Birds and Mammals in North-Eastern New South Wales: Relationships With Environmental Variables and Management History. *Wildlife Research, 22*(3), 359-377. doi: http://dx.doi.org/10.1071/WR9950359

Kavanagh, R.P, & Stanton, M.A. (2012). Koalas use young Eucalyptus plantations in an agricultural landscape on the Liverpool Plains, New South Wales. *Ecological Management & Restoration, 13*(3), 297-305. doi: 10.1111/emr.12005

Kavanagh, R.P, Stanton, M.A, & Brassil, T.E. (2007). Koalas continue to occupy their previous home-ranges after selective logging in Callitris–Eucalyptus forest. *Wildlife Research, 34*(2), 94-107. doi: http://dx.doi.org/10.1071/WR06126

Koala Hospital. (2016). Who We Are - Koala Hospital. Retrieved 1 September, 2016, from http://www.koalahospital.org.au/about-us/who-we-are

Koalas In Care. (2016). Koala problems. *Koalas In Care Inc.* Retrieved 18 July, 2016, from http://www.koalasincare.org.au/pages/habitat.htm

Kontos, E. (2015). Another dog attack, another koala dead. *South West Voice.* Retrieved 17 August, 2016, from http://www.southwestvoice.com.au/another-dog-attack-another-koala-dead/

Lee, K.E, Ellis, W.A.H, Carrick, F.N, Corley, S.W, Johnston, S.D, Baverstock, P.R, Nock, C.J, Rowe, K.C, & Seddon, J.M. (2013). Anthropogenic changes to the landscape resulted in colonization of koalas in north-east New South Wales, Australia. *Austral Ecology, 38*(3), 355-363. doi: 10.1111/j.1442-9993.2012.02414.x

Love, A, & Sweeney, O. (2015). *A Blueprint for a Comprehensive Reserve System for Koalas (Phascolarctos cinereus) on the North Coast of New South Wales*. Prepared for the National Parks Association of New South Wales Retrieved from http://www.koalapark.org.au/assets/blueprint_v2.pdf.

Lunney, D, Close, R, Bryant, J, Crowther, M.S, Shannon, I, Madden, K, & Ward, S. (2010). Campbelltown's koalas: their place in the natural history of Sydney *The Natural History of Sydney* (pp. 319-325). Royal Zoological Society of Australia.

Lunney, D, Crowther, M.S, Shannon, I, & Bryant, J.V. (2009). Combining a map-based public survey with an estimation of site occupancy to determine the recent and changing distribution of the koala in New South Wales. *Wildlife Research, 36*(3), 262-273. doi: http://dx.doi.org/10.1071/WR08079

Lunney, D, Crowther, M.S, Wallis, I, Foley, W.J, Lemon, J, Wheeler, R, Madani, G, Orscheg, C, Griffith, J. E, Krockenberger, M, Retamales, M, et al. (2012). Koalas and climate change: a case study on the Liverpool Plains, north-west New South Wales *Wildlife and Climate Change* (pp. 150-168).

Lunney, D, Gresser, S, O'Neill, L, Matthews, A, & Rhodes, J.R. (2007). The impact of fire and dogs on Koalas at Port Stephens, New South Wales, using population viability analysis. *Pacific Conservation Biology, 13*(3), 189-201.

Lunney, D, & Leary, T. (1988). The impact on native mammals of land-use changes and exotic species in the Bega district, New South Wales, since settlement. *Australian Journal of Ecology, 13*(1), 67-92. doi: 10.1111/j.1442-9993.1988.tb01417.x

Lunney, D, Lemon, J, Crowther, M.S, Stalenberg, E, Ross, K, & Wheeler, R. (2012). An Ecological Approach to Koala Conservation in a Mined Landscape. *Proceedings of Life-of-Mine Conference 2012*, 345-354.

Lunney, D, Predavec, M, Miller, I, Shannon, I, Fisher, M, Moon, C, Matthews, A, Turbill, J, & Rhodes, J.R. (2016). Interpreting patterns of population change in koalas from long-term datasets in Coffs Harbour on the north coast of New South Wales. *Australian Mammalogy, 38*(1), 29-43. doi: 10.1071/am15019

Lunney, D, Stalenberg, E, Santika, T, & Rhodes, J.R. (2014). Extinction in Eden: identifying the role of climate change in the decline of the koala in south-eastern NSW. *Wildlife Research, 41*(1), 22-34. doi: 10.1071/wr13054

MacKenzie, D.I, Nichols, J.D, Lachman, G.B, Droege, S, Royle, J.A, & Langtimm, C.A. (2002). Estimating site occupancy rates when detection probabilities are less than one. *Ecology, 83*(8), 2248-2255.

Mantyka-Pringle, C.S, Martin, T.G, Moffatt, D.B, Udy, J, Olley, J, Saxton, N, Sheldon, F, Bunn, S.E, & Rhodes, J.R. (2016). Prioritizing management actions for the conservation of freshwater biodiversity under changing climate and land-cover. *Biological Conservation, 197*, 80-89. doi: http://dx.doi.org/10.1016/j.biocon.2016.02.033

Mantyka-Pringle, C.S, Martin, T.G, & Rhodes, J.R. (2012). Interactions between climate and habitat loss effects on biodiversity: a systematic review and meta-analysis. *Global Change Biology, 18*(4), 1239-1252. doi: 10.1111/j.1365-2486.2011.02593.x

Masters, P, Duka, T, Berris, S, & Moss, G. (2004). Koalas on Kangaroo Island: from introduction to pest status in less than a century. *Wildlife Research, 31*(3), 267-272. doi: 10.1071/wr03007

Matthews, A, Ruykys, L, Ellis, B, FitzGibbon, S, Lunney, D, Crowther, M.S, Glen, A.S, Purcell, B, Moseby, K, Stott, J, Fletcher, D, et al. (2013). The success of GPS collar deployments on mammals in Australia. *Australian Mammalogy, 35*(1), 65-83. doi: http://dx.doi.org/10.1071/AM12021

McAlpine, C, Lunney, D, Melzer, A, Menkhorst, P, Phillips, S, Phalen, D, Ellis, W, Foley, W, Baxter, G, de Villiers, D, Kavanagh, R, et al. (2015). Conserving koalas: A review of

the contrasting regional trends, outlooks and policy challenges. *Biological Conservation, 192*, 226-236. doi: http://dx.doi.org/10.1016/j.biocon.2015.09.020

McAlpine, C, Melzer, A, Lunney, D, Foley, B, Adams-Hosking, C, Lawler, I, Whisson, D, Phillips, S, Kavanagh, R, Baxter, G, Gordon, G, et al. (2014). Working Group Workshop - Conserving koalas in the 21st century: synthesising the dynamics of Australia's koala populations. *Australian Centre for Ecological Analysis and Synthesis*.

Northern Tablelands LLS. (2016). Meet the Koala sniffer dogs at Tenterfield. Retrieved 24 August, 2016, from http://northerntablelands.lls.nsw.gov.au/resource-hub/media-releases/2016/meet-the-koala-sniffer-dogs-at-tenterfield

NPA NSW. (2016a). Great Koala National Park. *National Parks Association of NSW.* Retrieved 18 July, 2016, from http://www.npansw.org.au/index.php/campaigns/the-national-koala-park

NPA NSW. (2016b). Protecting natural areas from mining and gas. *National Parks Association of NSW.* Retrieved 18 July, 2016, from http://www.npansw.org.au/index.php/campaigns/supported-campaigns/protecting-natural-areas-from-mining-and-gas

NPA NSW. (2016c). Three levels of government guilty of failing to protect koalas. *National Parks Association of NSW*

Retrieved 18 July, 2016, from http://www.npansw.org.au/index.php/campaigns/the-national-koala-park/the-great-koala-national-park-news/297-three-levels-of-government-guilty-of-failing-to-protect-koalas

NRMMC. (2009a). *National koala conservation and management strategy 2009-2014*. Prepared by Natural Resource Management Ministerial Council under the Department of the Environment, Water, Heritage and the Arts.

NRMMC. (2009b). *National Koala Conservation and Management Strategy 2009–2014*. Endorsed by the Natural Resource Management Ministerial Council Retrieved from http://www.environment.gov.au/system/files/resources/165139fc-3ab5-4c96-8b15-d11a1ad882ab/files/koala-strategy.rtf.

NSW Department of Planning & Environment. (2016). Draft Koala Habitat Protection SEPP. Retrieved 1 December, 2016, from http://www.planning.nsw.gov.au/Koala-habitat

NSW EPA. (2016a). Act summaries. *Published by the NSW Environment Protection Authority.* Retrieved 22 November, 2016, from http://www.epa.nsw.gov.au/legislation/Actsummaries.htm#forestry2012

NSW EPA. (2016b). Coastal IFOA remake. *Published by the NSW Environment Protection Authority.* Retrieved 1 December, 2016, from http://www.epa.nsw.gov.au/forestagreements/coastIFOAs.htm

NSW EPA. (2016c). Koala Habitat Mapping pilot: NSW State Forests. Retrieved 29 November, 2016, 2016, from http://www.epa.nsw.gov.au/resources/forestagreements/koala-habitat-mapping-pilot-160038.pdf

NSW Farmer's Association. (2016). *Submission to the NSW Government Draft Biodiversity Conservation Bill 2016 and Local Land Services Amendment Bill 2016*. As published on the NSW Office of Environment & Heritage: Retrieved from http://www.environment.nsw.gov.au/biodiversitylegislation/publicsubs.htm.

NSW Government. (1979). *Environmental Planning and Assessment Act 1979 No 203*.

NSW Government. (1991). *Petroleum (Onshore) Act 1991 No 84*.

NSW Government (1991). *Protection of the Environment Administration Act 1991 No 60*.

NSW Government. (1992). *Mining Act 1992 No 29*. Retrieved from http://www.legislation.nsw.gov.au/#/view/act/1992/29.

NSW Government (1995). *State Environmental Planning Policy No 44—Koala Habitat Protection*.

NSW Government. (1995). *Threatened Species Conservation Act 1995 No. 101*. Retrieved from http://www.legislation.nsw.gov.au/#/view/act/1995/101.

NSW Government. (1997). Rural Fires Act 1997 No 65.

NSW Government. (1998). *Companion Animals Act 1998 No 87*.
NSW Government. (2003). *Native Vegetation Act 2003 No 103*.
NSW Government. (2012). *Forestry Act 2012 No 96*.
NSW Government. (2013). *Local Land Services Act 2013 No 51*.
NSW Government. (2014). *Koala Code of Practice: Forest Harvesting in New South Wales*. Prepared by the NSW Government's Forest Industries Taskforce.
NSW Government. (2016a). Biodiversity Reforms Overview. *Prepared by the NSW Government.* Retrieved 28 October, 2016, from https://www.landmanagement.nsw.gov.au/home/biodiversity-reforms-overview
NSW Government. (2016b). Submission Guide: Ecologically sustainable development. Retrieved 24 August, 2016, from https://www.landmanagement.nsw.gov.au/ecologically-sustainable-development/ecologically-sustainable-development-submission-guide/#cite_note-4
NSW Minerals Council. (2016). *Submission to the NSW Government Draft Biodiversity Conservation Bill 2016* As published on the NSW Office of Environment & Heritage: Retrieved from http://www.environment.nsw.gov.au/biodiversitylegislation/publicsubs.htm.
NSW OEH. (1997). *Guidelines and conditions for koala care in New South Wales*. Prepared by the NSW National Parks and Wildlife Services.
NSW OEH. (2010). *NSW Threat Abatement Plan: Predation by the red fox (Vulpes vulpes)*. Prepared by the NSW Office of Environment and Heritage Retrieved from http://www.environment.nsw.gov.au/resources/pestsweeds/110791FoxTAP2010.pdf.
NSW OEH. (2015). Act summaries. *Published by the NSW Office of Environment & Heritage.* Retrieved 22 November, 2016, from http://www.environment.nsw.gov.au/legislation/DECCActsummaries.htm
NSW OEH. (2016a). *2012–14 Koala survey report in coastal forests of south-eastern NSW – Bermagui/Mumbulla area. Corridors and core habitat for koalas*. Prepared by the NSW Office of Environment and Heritage Retrieved from http://www.environment.nsw.gov.au/resources/threatenedspecies/koala-survey-bermagui-mumbulla-160233.pdf.
NSW OEH. (2016b). Iconic Species. *Punblished by the NSW Office of Environment & Heritage.* Retrieved 22 November, 2016, from http://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/saving-our-species-program/threatened-species-conservation/iconic-species
NSW OEH. (2016c). *Koala Management in the NSW National Parks and Wildlife Service: Roles, responsibilities and priorities*. Prepared by NSW Office of Environment & Heritage.
NSW OEH. (2016d). *Media Release: NSW Government protects South Coast koalas and local timber industry*. Published by the NSW Office of Environment & Heritage Retrieved from http://www.environment.nsw.gov.au/news/nsw-government-protects-south-coast-koalas-and-local-timber-industry.
NSW OEH. (2016e). NSW Bionet, the website for the Atlas of NSW Wildlife, a whole-of-government system for flora and fauna sightings and information. Retrieved 2 September, 2016, from http://www.bionet.nsw.gov.au/
NSW OEH. (2016). Programs legislation and framework. *Published by the Office of Environment and Heritage.* Retrieved 22 November, 2016, from http://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/programs-legislation-and-framework
NSW RFS. (2016a). Bush Fire Risk Management Plans. Retrieved 3 August, 2016, from http://www.rfs.nsw.gov.au/resources/publications/bush-fire-risk-management-plans
NSW RFS. (2016b). Publications and Documents. Retrieved 25 August, 2016, from http://www.rfs.nsw.gov.au/resources/publications
NSW RMS. (2016). *Woolgoolga to Ballina - Pacific Highway Upgrade - Koala Management Plan - Sections 1-11*. Prepared by the NSW Roads and Maritime Services Retrieved

from http://www.rms.nsw.gov.au/documents/projects/northern-nsw/woolgoolga-to-ballina/w2b-koala-management-plan-sections-1-11.pdf.
NVI. (2016). Project koala. Retrieved July, 2016, from http://www.nvi.com.au/news/project-koala/
Parr, C.L, & Andersen, A.N. (2006). Patch Mosaic Burning for Biodiversity Conservation: a Critique of the Pyrodiversity Paradigm. *Conservation Biology, 20*(6), 1610-1619. doi: 10.1111/j.1523-1739.2006.00492.x
Phillips, S, & Callaghan, J. (2011). The Spot Assessment Technique: a tool for determining localised levels of habitat use by Koalas Phascolarctos cinereus. *Australian Zoologist, 35*(3), 774-780. doi: doi:10.7882/AZ.2011.029
Predavec, M. (2008). *Review of progress in implementing the 1998 National Koala Conservation Strategy*. Prepared by Parsons Brinckerhoff for the Commonwealth Department of the Environment, Water, Heritage and the Arts: Retrieved from https://www.environment.gov.au/system/files/resources/1471cfde-2ff1-4a63-afe0-0a25bd046684/files/review.pdf.
Predavec, M. (2016). *NSW koala population case studies*. Prepared for the Independent Review into the Decline of Koala Populations in Key Areas of NSW.
Predavec, M, Lunney, D, Shannon, I, Scotts, D, Turbill, J, & Faulkner, B. (2015). Mapping the likelihood of koalas across New South Wales for use in Private Native Forestry: developing a simple, species distribution model that deals with opportunistic data. *Australian Mammalogy, 37*(2), 182-193. doi: http://dx.doi.org/10.1071/AM15001
Redland City Council. (2016). Ground-breaking chlamydia vaccine trials begin for Redland koalas. from https://news.redland.qld.gov.au/2016/01/ground-breaking-chlamydia-vaccine-trials-begin-for-redland-koalas/
Reed, P, Lunney, D, & Walker, P. (1990). 1987 Survey of the Koala Phascolarctos cinereus (Goldfuss) in New South Wales and an ecological interpretation of its distribution. In A. Lee, K. Handasyde & G. Sanson (Eds.), *Biology of the koala*.
Rhodes, J, Beyer, H, Preece, H. J., & McAlpine, C. (2015). *South East Queensland Koala Population Modelling Study*. Prepared for the Queensland Department of Environment and Heritage Protection.
Rhodes, J, Ng, C.F, de Villiers, D.L, Preece, H.J, McAlpine, C.A, & Possingham, H.P. (2011). Using integrated population modelling to quantify the implications of multiple threatening processes for a rapidly declining population. *Biological Conservation, 144*(3), 1081-1088. doi: http://dx.doi.org/10.1016/j.biocon.2010.12.027
Roberts, P. (1998). Associations between koala faecal pellets and trees at Dorrigo. A thesis submitted in fulfillment of the requirements of the degree of Master of Resource Science at the University of New England.
RTA. (2009). *Use of fauna passage structures on RTA roads* Prepared by the RTA Environment Branch
Santika, T, McAlpine, C.A, Lunney, D, Wilson, K.A, & Rhodes, J.R. (2014). Modelling species distributional shifts across broad spatial extents by linking dynamic occupancy models with public-based surveys. *Diversity and Distributions, 20*(7), 786-796. doi: 10.1111/ddi.12189
Santika, T., McAlpine, C. A., Lunney, D., Wilson, K. A., & Rhodes, J. R. (2015). Assessing spatio-temporal priorities for species' recovery in broad-scale dynamic landscapes. *Journal of Applied Ecology, 52*(4), 832-840.
Seabrook, L, McAlpine, C, Baxter, G, Rhodes, J, Bradley, A, & Lunney, D. (2011). Drought-driven change in wildlife distribution and numbers: a case study of koalas in south west Queensland. *Wildlife Research, 38*(6), 509-524. doi: http://dx.doi.org/10.1071/WR11064
Shoebridge, J. (2016). Ecologist criticises Pacific Highway koala plan, finds flaws in estimated impact on animals. *ABC North Coast.* Retrieved 17 August, 2016, from http://www.abc.net.au/news/2016-04-21/ecologist-criticises-pacific-highway-koala-plan/7341682

Slade, C, & Law, B. (2016). The other half of the coastal State Forest estate in New South Wales; the value of informal forest reserves for conservation. *Australian Zoologist, 0*(aop), null. doi: doi:10.7882/AZ.2016.011

Smith, A. (2004). Koala conservation and habitat requirements in a timber production forest in north-east New South Wales. *Conservation of Australia's Forest Fauna, 2*, 591-611.

The Wilderness Society. (2015). We will stop Santos coal seam gas in NSW. Retrieved 2 September, 2016, from https://www.wilderness.org.au/campaigns/we-will-stop-santos-coal-seam-gas-nsw

Timber NSW. (2016). *Submission to the NSW Government Draft Biodiversity Conservation Bill 2016*. As published on the NSW Office of Environment & Heritage: Retrieved from http://www.environment.nsw.gov.au/biodiversitylegislation/publicsubs.htm.

TMR. (2016). Koala Tagging and Monitoring Program Services for Moreton Bay Rail. Retrieved 25 August, 2016, from http://www.tmr.qld.gov.au/Projects/Featured-projects/Moreton-Bay-Rail/Publications/Moreton-Bay-Rail-Koala-tagging-and-monitoring

Waugh, C, Khan, S.A, Carver, S, Hanger, J, Loader, J, Polkinghorne, A, Beagley, K, & Timms, P. (2016). A Prototype Recombinant-Protein Based Chlamydia pecorum Vaccine Results in Reduced Chlamydial Burden and Less Clinical Disease in Free-Ranging Koalas (Phascolarctos cinereus). *PLoS ONE, 11*(1), e0146934. doi: 10.1371/journal.pone.0146934

Wildcare Australia Inc. (2016). Wildcare Australia - Koalas. *Wildcare Australia Inc.* Retrieved 18 July, 2016, from http://wildcare.org.au/species-information/koalas/

Woosnam-Merchez, O, Cristescu, R, Dique, D, Ellis, B, Beeton, R, Simmonds, J, & Carrick, F. (2012). What faecal pellet surveys can and can't reveal about the ecology of koalas Phascolarctos cinereus. *Australian Zoologist, 36*(2), 192-200. doi: doi:10.7882/AZ.2012.030

Zoos South Australia. (2015). Zoos SA Supporting Red-tails. Retrieved 1 December, 2016, from http://www.redtail.com.au/news/93/72/Zoos-SA-supporting-Red-tails.html

Acronyms

AGS	Australian Group Selection
AMBS	Australian Museum Business Services
BAM	Biodiversity Assessment Method
CKPoM	Comprehensive Koala Plans of Management
DBH	Diameter at breast height (tree measurement)
DECC	Department of Environment and Climate Change
DEWNR	South Australian Department of Environment, Water and Natural Resources
DPI	NSW Department of Primary Industries
EP&A Act	Environmental Planning and Assessment Act 1979
EPA	NSW Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
FCNSW	Forestry Corporation of NSW
IBRA	Interim Biogeographic Regionalisation for Australia
IFOA	Integrated Forestry Operations Approval
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature and Natural Resources
KoRV	Koala Retrovirus
LGA	Local Government Area
LLS	Local Land Services
LLS Act	Local Land Services Act 2013
NPA	National Parks Association of NSW
NPWS	National Parks and Wildlife Services
NV Act	Native Vegetation Act 2003
OCSE	Office of the NSW Chief Scientist & Engineer
OEH	NSW Office of Environment and Heritage
PNF	Private Native Forestry
PVPs	Property Vegetation Plans
RFS	Rural Fire Service
RMS	NSW Roads and Maritime Services
SEEA	System of Environmental-Economic Accounting
SEED	Sharing and Enabling Environmental Data
SEPP	State Environmental Planning Policies
SSD	State Significant Development
SSI	State Significant Infrastructure
STS	Single Tree Selection
TSC Act	NSW Threatened Species Conservation Act 1995
WID	Wireless Identification Device

Glossary

Abundance a count of animals (i.e. population size, such as the size of the Australian [population of people is 23 million).

Absence data: information that shows areas where there is known koala habitat but have no recorded koala occurrences

Adaptive management: A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices.

Biodiversity: Biodiversity is the variability among living organisms from all sources (including terrestrial, aquatic, marine and other ecosystems and the ecological complexes of which they are part), at all levels of organisation, including genetic diversity, species diversity and ecosystem diversity.

Climate refugia: A refugium is an area that has escaped or will escape changes occurring elsewhere and continues to provide a suitable habitat for a species which would not be able to survive under prevailing conditions. Climate change refugia are used in reference to areas that may provide habitat for species displaced as the climate changes.

Connectivity: a management approach that focuses on the maintenance and restoration of functioning natural ecosystems across landscapes and marine areas, and requires systematic conservation planning that:

- identifies management responses at multiple scales
- uses whole-of-landscape or whole-of-seascape approaches
- takes into account the dynamics of climate change.

Cross-tenure: a consistent approach to land management regardless of ownership

Cumulative threats: when more than one threat is present with a potentially combined impact on a species

Defining 'secure' in the wild: the species is in a state (with or without active management) such that there is a 95% probability of having a viable population of the species in 100 years from the point of assessment. A viable population is likely one where: all deterministic threats are controlled; population size is sufficient to avoid demographic/genetic problems; population trajectory is stable or increasing; there is sufficient available habitat for the population to persist.

Environmental offset: measures that benefit biodiversity by compensating for the adverse impacts elsewhere of an action, such as clearing for development.

Endangered: refers to a species facing a very high risk of extinction in the wild in the near future (EPBC Act).

Forest Harvesting: involves cutting trees and delivering them to sawmills, pulp mills and other wood-processing plants. Its practical components include road construction, logging and log transportation.

Genetic diversity: refers to the variety of genetic information contained in individual plants, animals and micro-organisms.

Ground-truthing: information provided by direct observation as opposed to information provided by inference.

Habitat corridor: connections across the landscape that link up areas of habitat.

Habitat fragmentation: the process by which habitat loss results in the division of large, continuous habitats into smaller, more isolated remnants (Didham, 2001).

Healthy koala population: a healthy koala population is defined in the DECC Recovery plan (2008) as:

- "maintenance of existing populations (i.e. no local extinctions)
- improvement of the extent and quality of habitat and protection of priority habitats and sites
- an increase in the numbers of breeding females, together with a corresponding decrease in records of juvenile mortality
- an increase in the general health of animals in the wild (e.g. less overt signs of Chlamydia infection or other illness)
- an expansion in distribution and the presence of koalas in all areas of primary koala habitat
- an increase in community reports of koala sightings."

IBRA: The Interim Biogeographic Regionalisation for Australia provides a broad level break-up of the Australian landmass into 85 biogeographic regions and 403 subregions. The IBRA bioregions were derived by compiling information on climate, lithology/geology, landform, vegetation, flora and fauna. IBRA provides the national and regional planning framework for developing the National Reserve System.

Key koala populations: populations that have the potential for long-term recovery and viability.

Koala habitat: koala habitat can be defined as forests or woodlands containing koala food and shelter trees and other parts of the landscape that koalas use for movement.

Landscape scale: refers to a spatial scale beyond an individual site. Different scales are recognised in ecology including the patch level (e.g. individual patches and their variability), class level (e.g. forest, agriculture, urban), and the landscape level (all classes considered together). When linking animal movements and landscape structure, home ranges can be proxies to identify scales at which areas of interest (i.e. landscapes) can be defined

Likelihood of occurrence: the probability that a koala is actually present in a particular location.

Metapopulation: a set of local populations which interact via individuals moving among populations (Hanski & Gilpin, 1991).

Persist: refers to the continued existence of a koala population

Population density: a measurement of population per unit area or unit volume.

Presence data: information that shows where koalas have been recorded.

Revegetation: the re-establishment of vegetation in areas that have been cleared or highly modified. The mix of plant species may not be the same as that of the original vegetation.

Translocation: the movement of living organisms from one area with free release in another (DECC, 2008).

Vulnerable: refers to a species facing a high risk of extinction in the wild in the medium-term future (EPBC Act)

Wild dog: refers to all free-living dogs in NSW, including dingoes, feral dogs and their hybrids

APPENDICES

APPENDIX 1 TERMS OF REFERENCE

1. Aims and role of the committee

The Chair of the committee (Professor Mary O'Kane AC, NSW Chief Scientist & Engineer) has been asked to establish a committee to undertake a review into the decline of koala populations in key areas of NSW. Following completion of the review, the Chair will provide the Minister for the Environment a report that:

- sets out a framework for a whole of government approach to addressing pressures
- includes core learnings from other programs
- analyses successes/failures
- assesses policy options trialled to date
- considers key koala management policy settings
- identifies knowledge gaps
- recommends possible approaches to address the decline in koala numbers.

It is expected that the report will provide the Minister sufficient evidence from which a koala strategy for NSW can be prepared.

2. Membership

The Chair is requested to ensure that the koala advisory committee comprises at least the following, in addition to the Chair:

- two independent researchers
- members from the following NSW Government agencies:
    - Office of Environment and Heritage (OEH)
    - Environment Protection Authority (EPA)
    - Department of Planning and Environment (DPE)
    - Roads and Maritime Services (RMS)
    - Department of Primary Industries (DPI)
    - Department of Industry Division of Resources and Energy

3. Role of chair

The Chair is requested to:

- actively and regularly engage with the committee
- deliver a report to the Minister
- draw on advice beyond the koala advisory committee if required
- develop evidence-based options to address the decline of key koala populations
- facilitate consideration of the wide variety of agency interests
- apply robust business acumen to decisions
- liaise directly with Minister[s] on behalf of the committee when appropriate
- raise significant matters of concern directly with the Minister[s]
- act as a spokesperson for the committee as required.

While the Chair will consider input and evidence from the committee, the report to the Minister will be the Chair's report. The Chair does not require the committee's consensus or support for the report's recommendations.

4. Role of members

- The role of the members is at the discretion of the Chair.

5. Guiding principles

The Chair will develop options that consider:

- increasing regulatory efficiency, removing duplication and promoting consistency in approval requirements
- increasing upfront clarity and transparency in environmental standards
- minimising the private costs and maximises the public benefits of the options
- encouraging economic development, including by supporting regional and rural communities without devaluing koalas and their habitat
- building resilience to environmental hazards and risks.

6. Operating protocols

Meetings

Meetings will be held regularly (at least one each fortnight) at times to be determined by the Chair.

Agency support officers will have a standing invitation to attend meetings.

Meeting attendance in person should be preferred but may occur via teleconference or videoconference as arranged with the Secretariat.

Secretariat support

Secretariat support for the Chair (and committee) is provided by OEH. This will particularly be in terms of:

- administration including agendas, papers and minutes
- logistics including pre-briefs, meetings and workshops
- appointment of members
- coordination and information flow including between the Minister[s], chair, and members
- contribution to research, analysis, policy development and advice
- supporting stakeholder liaison, communication and engagement.

Committee membership

Name	Position	Agency
Professor Mary O'Kane	Chair, NSW Chief Scientist & Engineer	
Professor Kathy Belov	Professor of Comparative Genomics, Pro Vice-Chancellor	University of Sydney
Michael Crowley	Acting General Manager, Environment	Roads and Maritime Services
Steve Hartley	Director, Public Land and Aquatic Ecosystems Policy	Office of Environment and Heritage
Michael Hood	Principal Manager, Forestry	Environment Protection Authority
Dr Rebecca Johnson	Director, Australian Museum Research Institute	Australian Museum
Dr Brad Law	Principal Research Scientist	Department of Industry - Lands
Steve Murray	Executive Director, Regions	Department of Planning and Environment
Associate Professor Jonathan Rhodes	School of Geography, Planning and Environmental Management	University of Queensland
Susan Shaw	Manager, Cabinet and Parliamentary Services	Department of Industry – Resources and Energy
Paul Wells	Forestry Manager	Department of Industry - Lands
Stephen Wills	Group Director Infrastructure and Land Management	Department of Industry - Lands

APPENDIX 2 OVERVIEW OF LEGISLATION

Act	Purpose	Which agency / Minister administers	Relevance to Koalas
Threatened Species Conservation Act 1995 (TSC Act) Began 1 January 1996 **[Note: this Act is proposed for repeal as part of the biodiversity reforms. The sections of TSC Act that relate to listing of species as threatened will transfer to the new Act]**	The purpose of the TSC Act is to: • conserve biological diversity and promote ecologically sustainable development • prevent the extinction and promote the recovery of threatened species, populations and ecological communities • protect the critical habitat of endangered species, populations and ecological communities • eliminate or manage certain key threatening processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities • ensure that the impact of any action affecting threatened species, populations and ecological communities is properly assessed • encourage the conservation of threatened species, populations and ecological communities through cooperative management.	OEH Minister for the Environment	The Koala is listed under the Act as Vulnerable and three populations have been listed as Endangered. *"The TSC Act, through Part 8A of the NSW National Parks and Wildlife Act 1974 (NPW Act) prohibits the harming, picking, possessing, buying or selling of individual threatened species… The Act prohibits damaging their habitat and contains provisions to protect endangered populations and threatened ecological communities." (NSW OEH, 2016)* Section 91 of the TST Act provides for licences to pick, harm or damage the habitat of a threatened species in a range of contexts. Some of these licences issued under IFOAs (see Forestry Act) include particular provisions for protection of koalas. *"An environmental impact assessment may be required for a proposed development or activity before development consent is granted under the Environmental Planning and Assessment Act 1979 (NSW). The assessment will need to consider whether there is likely to be a significant effect on any threatened species, populations or ecological communities, or their habitats." (NSW OEH, 2016)* If a significant impact is likely, a more detailed assessment in the form of a species impact statement (SIS) may be required along with suitable ameliorative measures to address any impacts. Under the act, a recovery plan was prepared for the Koala that takes its objectives from the National Koala Conservation and Management Strategy. **Threatened Species Priorities Action Statement** The PAS has guided efforts to recover threatened species since 2007. PAS is a list of actions required to recover species, populations and communities listed under the Act. Before the PAS was implemented in 2007, the aim was to develop a recovery plan for every threatened species in NSW. However, the rate of recovery plan preparation was not keeping pace with the rate at which new species were listed. OEH reviewed the PAS in 2011 to evaluate its effectiveness. The review recommended a number of improvements including adopting an explicit management and prioritisation framework. Saving our Species delivers on all these recommendations, and its strategies and projects are designed to be the new PAS for NSW.

			Saving our Species The Saving Our Species program aims to maximise the number of threatened species that can be secured in the wild in NSW for 100 years. It assigns threatened species to different management streams so the individual requirements of each species can be met. The koala is one of six iconic species addressed under the broader saving our species program. “Iconic species are important socially, culturally and economically, and the community expects them to be effectively managed and protected” (NSW OEH, 2016b). Management of iconic species is guided by existing recovery plans. Although there is no legislative power behind the program, the program directs government funding aimed at the conservation of threatened species. *Changes under the Biodiversity Conservation Bill* • Threatened plants and animals will continue to be listed. • It will continue to be illegal to harm threatened plants and animals and their habitat, unless you have specific approvals, such as development consent or a licence. • Under the proposed Biodiversity Conservation Bill, populations will now be defined as part of a species, to align with IUCN. A population of a particular species will only be eligible to be listed as threatened if its species is not already listed as threatened. • As populations are defined as part of species they will have the following threat categories: critically endangered, endangered or vulnerable (currently populations can only be listed as endangered under the *Threatened Species Conservation Act*) • The draft Bill allows for a conservation program for threatened plants and animals in NSW to be established, reflecting the approach taken by the Saving our Species program. • A tiered, risk-based approach to managing human-wildlife interactions will be introduced. This approach includes exempt activities (lowest risk), activities that comply with a code of practice (moderate activities), licensed activities (highest risk), and prohibited activities.

Native Vegetation Act 2003 (NV Act) Began 1 December 2005 **[Note: this Act is proposed for repeal as part of the biodiversity reforms]**	The purpose of the NV Act is: • to prevent broadscale clearing unless it improves or maintains environmental outcomes, and • to protect native vegetation of high conservation value having regard to its contribution to such matters as water quality, biodiversity, or the prevention of salinity or land degradation, and • to improve the condition of existing native vegetation, particularly where it has high conservation value	OEH Minister for the Environment	The NV Act requires impacts of clearing on threatened species to be avoided or offset in order to improve or maintain environmental outcomes. Koalas are considered in this due to being listed as vulnerable under the TSC Act. Clearing for certain purposes, such as routine agricultural management activities (RAMAs), do not require approval under the Act. However, it must only be undertaken to the minimum extent necessary and within the appropriate scope. This is done via Property Vegetation Plans (PVPs). In the case of Private Native Forestry (PNF), there is a code of practice that includes koala specific measures for PVPs. This includes: • not permitting activities in "core koala habitat" for the purpose of SEPP 44 • requiring 20m exclusion zones around trees that a certain number of koala scats have been found beneath • retention of feed trees species at particular rates where there is a record of a koala within 500m of the area or scats are found beneath feed trees. For non-PNF PVPs Threatened Species Assessment Tool allows for clearing where offsets would improve the habitat of specific threatened species to at least the same extent as the habitat values lost through the proposed clearing. The assessment does not allow clearing where impacts are unsustainable for a local population of a threatened species. *Changes under the Biodiversity Conservation Bill* • The new Native Vegetation Regulatory Map will underpin the new land management framework under the LLS Act. For native vegetation clearing, land is mapped as exempt (i.e. clearing can occur without approval), regulated (i.e. clearing is regulated either as an allowable activity, under a code of practice, or with approval under the LLS Act) or excluded (i.e. clearing is not covered under the land management framework). Clearing within core koala habitat does not qualify as 'code based' clearing. • Further detail - https://www.landmanagement.nsw.gov.au/ecologically-sustainable-development/ecologically-sustainable-development-submission-guide/ • A new Biodiversity Conservation Trust will enter into and administer private land conservation agreements with landholders. • The NSW Government has committed $240 million over five years to private land conservation and $70 million a year (escalated for inflation) ongoing thereafter, subject to performance reviews. • The Bill requires preparation of a Biodiversity Conservation Investment Strategy to target investment to priority areas.
National Parks and Wildlife Act 1974 (NPW Act) Began 1 January 1975	*"The NPW Act is a broad piece of legislation that covers a number of different areas including reserving lands, managing certain reserved lands, the protection of Aboriginal objects and places, the protection of fauna and the*	OEH Minister for the Environment	**Habitat:** includes habitat periodically or occasionally occupied by a species, population or ecological community. ***"Fauna:*** *The Chief Executive of the OEH is the authority responsible for the protection and care of fauna. Under the Act it is an offence to harm protected fauna. It is also an offence to harm threatened interstate fauna. In addition, the Act regulates the trade –*

	protection of native vegetation." (NSW OEH, 2015)		*including buying, selling, possession, import and export – of protected fauna. Protected fauna includes all fauna other than locally unprotected fauna, interstate threatened species, endangered populations, or endangered ecological communities. Unprotected fauna and threatened interstate fauna are specified in schedules to the Act. The Act allows for the issuing of licences to authorise a number of different activities relating to fauna. In some cases, such as where crown forestry activities are conducted in areas without an IFOA, a licence under S120 of the NPW Act is used. The holding of a valid licence and complying with the conditions of such a licence is a defence to prosecution under the Act." (NSW OEH, 2015)*
Environmental Planning and Assessment Act 1979 Began 1 September 1980	Objects of the Act includes: to encourage the *"protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats."(NSW Government, 1979)*	DPE Minister for Planning	Consent authorities must consider the impacts of actions on threat-listed species listed under the *Threatened Species Conservation Act 1995.* This is specified in the objects of the act and must be considered for all development assessments, but the Act also allows for issue-specific policies to be prepared, such as State Environmental Planning Policies (SEPPs). These require specialist consultation in regards to threatened species listed under the TSC Act. SEPP44 directly relates to koala conservation and is outlined below. The Act also includes provisions for Councils to prepare a planning proposal, including a Local Environmental Plans (LEP), which may include specific provisions relating to Koalas. The Act also establishes the development assessment and approval framework for all major projects. This is outlined under the Biodiversity Offsets Policy. The Framework for Biodiversity Assessment that underpins this policy sets out detailed guidelines for determining the location of threatened species in a proposed development site, and steps to be taken to minimise impact. **Exploration and mining activities** All new mining projects, and modifications to existing projects, require approval before they can commence. As part of this approval process, the proponent must prepare an Environmental Impact Statement, which covers a range of issues, including flora and fauna and landscape management. If a project is approved conditions may be imposed to minimise environmental impacts or require future rehabilitation. Compliance - Environmental Sustainability Unit (ESU) within the Department of Industry, Resources and Energy, to ensure compliance with environmental regulations under the EP&A Act and the *Mining Act 1992*. **Roads and Maritime Services** Roads and Maritime Services NSW (RMS) also has a responsibility under the EP&A Act when considering development projects. The majority of RMS's projects are assessed under part 5 of the Act. This assessment is often documented in a review of environmental factors. Projects that qualify as State significant infrastructure are assessed under part 5.1 of the Act. This assessment is documented in an Environmental Impact Statement (EIS). The agency has also developed best practice guidelines for Biodiversity to minimise impact on flora and fauna and habitats.

			SEPP 44 This SEPP encourages the conservation and management of areas of natural vegetation that provide habitat for Koalas, in order to ensure that permanent free living populations are maintained over their present range and to reverse the current trend of koala population decline. It requires the consideration of potential and core koala habitat before development consent can be granted. SEPP 44 applies to land greater than 1 hectare within the councils listed in Schedule 1 for which a development application has been made and Council is the determining authority. SEPP 44 does not apply to land listed under the *National Parks and Wildlife Act 1974*, or the *Forestry Act 1916* as State Forest or flora reserve, or to land where Council is not the determining authority. SEPP 44 also includes recommendations for Councils to prepare Comprehensive Koala Plans of Management (CKPoMs) and to include specific provisions in their LEPs. CKPoMs allow for the objectives of SEPP44 to be met, but remove the need for individual plans at the development application stage. **Definitions of koala habitats under SEPP 44 (NSW Government 1995):** *"Core koala habitat means an area of land with a resident population of koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population."* *"A potential koala habitat means areas of native vegetation where the trees of the types listed in Schedule 2 constitute at least 15% of the total number of trees in the upper or lower strata of the tree component."* **Changes under the Biodiversity Conservation Bill** • The biodiversity assessment method (BAM) will be used to assess biodiversity impacts of developments that need consent under the EP&A Act that are likely to have a significant impact on threatened species (i.e. above a 'threshold'). • The proposal for the threshold includes the concept of a 'sensitive values map' (i.e. if clearing is proposed within an area on the sensitive values map, the biodiversity assessment method would apply). This map has not yet been prepared. Core koala habitat could be included on the sensitive values map (i.e. clearing of core koala habitat would trigger assessment using the biodiversity assessment method). • The BAM is a metric-based tool that expresses biodiversity impacts in terms of 'biodiversity credits'. A biodiversity impact must be offset by retiring credits, in accordance with offset rules that will be set out in regulations. • Further detail - https://www.landmanagement.nsw.gov.au/ecologically-sustainable-development/ecologically-sustainable-development-submission-guide/
Rural Fires Act 1997	*"For the protection of infrastructure and environmental, economic, cultural,*	Rural Fire Service	*"Bush Fire Management Committees (BFMCs) are responsible for the preparation of bush fire risk management plans which outline strategies for the reduction of bush fire*

Began 1 September 1997	*agricultural and community assets from damage arising from fires"* (NSW Government, 1997) and the protection of the environment by requiring certain activities to be carried out having regard to the principles of ecologically sustainable development described in section 6 (2) of the Protection of the Environment Administration Act 1991.		*hazard. These plans may also identify areas where hazard reduction activities are prohibited or restricted on the basis of their likely impact on flora, fauna, cultural heritage or other assets. BFMCs are also required to prepare plans of operations which outline procedures for suppression of wildfire.* *For most threatened species (including koalas), adverse impacts resulting from hazard reduction are managed through general amelioration prescriptions. However, species-specific ameliorative measures have been developed for a selected list of threatened species that are particularly susceptible to hazard reduction" (DECC, 2008)* This includes all species listed as threatened under the TSC Act, as well as koalas. BFMCs are also required to act consistently with the provisions of recovery plans for threatened species.
Companion Animals Act 1998 Began 1 September 1998	*"To provide for the effective and responsible care and management of companion animals." (NSW Government, 1998)*	Office of Local Government	*"The Companion Animals Act 1998 requires that local councils identify management strategies for companion animals through strategic companion animals management plans. For example, councils can designate certain public lands as off-leash exercise areas and can identify other areas where dogs and cats are prohibited, including wildlife protection areas. The Act also enables council officers to manage stray and aggressive dogs and cats through enforcement(DECC, 2008)." (DECC, 2008)* This can assist with koala management by protecting possible koala habitats from disruption caused by domestic and stray animals, and in some cases may possibly prevent koala injury or death.
Forestry Act 2012 Began 1 January 2013	The Forestry Act integrates the regulatory regimes for environmental planning and assessment, to protect the environment and conserve threatened species. *"Parts 5A and 5B of the Act deal with Forestry Agreements and Integrated Forestry Operations Approvals (IFOAs) that were formally established under the Forestry and National Park Estate Act 1998. IFOAs apply to forestry operations in State forests and other Crown-timber lands, except in the national parks estate, and can be granted in areas covered by a forestry agreement." (NSW EPA, 2016a)*	DPE and DPI Parts 5A and 5B of this Act are administered by the Minister for the Environment. The remaining parts are administered by the Minister for Primary Industries.	The EPA regulates the Forestry Corporation of NSW (FCNSW) native forestry operations under Integrated Forestry Operations Approvals (IFOAs). Conditions in IFOAs make Forests NSW responsible for reducing the risks to koalas when they are conducting forestry operations. Some requirements include: • searching certain vegetation for koala use • applying exclusion zones where evidence of koala use meets certain thresholds. • retaining koala feed tree species at certain rates across areas where evidence of koala occur.

Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 Began 16 July 2000	• provide for the protection of the environment, especially matters of national environmental significance • conserve Australian biodiversity • control the international movement of plants and animals (wildlife), wildlife specimens and products made or derived from wildlife • promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources. (Australian Government, 2013)	Federal Environment Minister	***"Koala habitat:*** *any forest or woodland containing species that are known koala food trees, or shrubland with emergent food trees. This can include remnant and non-remnant vegetation in natural, agricultural, urban and peri-urban environments. Koala habitat is defined by the vegetation community present and the vegetation structure; the koala does not necessarily have to be present.* *The Department strongly encourages proponents to engage qualified specialists to carry out surveys prior to making an assessment of their action or submitting a referral, to provide adequate information on the following habitat attributes: Koala presence (and potentially abundance or density); Vegetation composition; Habitat connectivity; Existing threats to koalas; Recovery value." (Australian Government, 2014)* The combined Koala populations of Queensland, New South Wales and the Australian Capital Territory were listed as Vulnerable in 2012. An action that is likely to have a significant impact on a matter of national environmental significance (including species listed as Vulnerable under the Act), must be referred to the Commonwealth Minister for the Environment for assessment and approval. A recovery plan is currently being prepared for the Koala under the EPBC Act.
National Koala Conservation and Management Strategy (2009-2014) Began 5 November 2009	*"The National Koala Conservation and Management Strategy aims to conserve Koalas by retaining viable populations in the wild throughout their natural range." (NRMMC, 2009b)*	Federal Environment Minister	*"The strategy operates at several different geographic scales:* • *At the national and state scale, the strategy provides a framework for coordinated cooperation and strategic action amongst the wide range of stakeholders in Koala conservation. It sets priorities and focuses attention on the most important issues. The strategy also provides for the development of cost-effective tools to guide action at different scales.* • *At the local scale, the strategy aims to improve the awareness of communities and authorities that live with koalas, and to provide relevant support and assistance for devising and implementing effective conservation actions.* *The strategy does not provide any legislative powers. It is a policy document that provides priorities and directions for action." (NRMMC, 2009b)* The strategy has now expired and the intention is to replace it with the recovery plan that is due to be finalised by the end of 2016.

APPENDIX 1 Peter Williams

Peter Williams

SENIOR LECTURER, PLANNING - UG Teaching Staff, Planning, PG Teaching Staff, Planning

PhD (UOW), MEnvPlan (Macq), MPubPol (UNE), BSc (UNSW), BLegS (Macq), MPIA

CONTACT ME
Phone+61 2 9385 6829

Fax+61 2 9385 5270

Emailp.williams@unsw.edu.au

About

Peter Williams joined the School of Town Planning at UNSW in 1993 after 14 years in the private and public sectors, including the planning and urban research consultancy firm Plant Location International (Australia) Pty Limited, the Land Commission of NSW, National Parks and Wildlife Service, the Land and Environment Court and the Department of Mineral Resources. Peter set up the Master of Planning (MPlan) degree at UNSW in 2006 and was the Head of the degree fom 2007 - 2012. Peter was appointed Director of the Planning Program from 2009 - 2012, with responsibility for the Faculty's Bachelor of Planning and Master of Planning degrees. He is a regular contributor to *New Planner*, the journal of the NSW Division of the Planning Institute of Australia.

Research

Current research interests include environmental planning law and administration, natural resources planning and management, environmental studies, planning tools, open space management, affordable housing, sustainable urban development and spatial planning policy. In 2003 and 2005 Peter wrote the handbook for planning practitioners *Best Practice in Development Assessment for Local Government*, published by Landcom.

Integrating biodiversity in Australian cities

– managing urban growth and biodiversity in Sydney

Peter Williams

Planning and Urban Development Program

Faculty of the Built Environment University of New South Wales

Address: Faculty of the Built Environment UNSW SYDNEY NSW 2052

KEY COMMENT

To better integrate biodiversity conservation with managing the growth of Sydney, a hybrid framework which utilizes sound metropolitan planning, strategic or planning phase biodiversity certification, statutory-based regulation such as zoning, and market-based mechanisms including TDR and biobanking reinforced by conservation covenants or agreements, should be adopted.

Email: p.williams@unsw.edu.au

Keywords: Biodiversity; urban growth management; planning tools; property rights; Sydney Growth Centre. 3 Abstract: This paper examines the approaches taken to incorporate biodiversity conservation in the management of urban growth in Sydney.

Problems associated with managing Sydney's growth – particularly from the intersection of dealing with perceived property rights and the protection of natural resources such as biodiversity – are identified.

The issues are illustrated through significant State Government development decisions relating to the retention of biodiversity in the new growth areas of Sydney.

The singular reliance on traditional 'command and control' regulatory approaches as both a cause and ineffectual solution to the problems faced in biodiversity conservation is highlighted.

Newer 'market based' mechanisms which are being introduced (e.g. biobanking) or should be adopted (e.g. transferable development rights), as well as management at the strategic level (e.g. biodiversity certification), are considered.

This paper argues that to better integrate biodiversity conservation in Australian cities a mixed approach should be adopted in which a number of tools are utilised – and that this needs to occur in the context of a sound overarching strategic planning framework.

This constitutes a hybrid approach involving a 'fixed' strategic spatial plan informing statutory-based regulation primarily through zoning and other development controls, augmented by a range of market based tools implemented through statute and common law measures such as conservation covenants.

4 Introduction State and territory planning jurisdictions in Australia have relied primarily on a regulatorybased statutory planning framework, derived from the traditional British system, to implement planning and land use policy.

Australian planning systems are statutory-based in that they are prescribed by various state and territory legislation, including a dominant planning act (in New South Wales the Environmental Planning and Assessment Act 1979).

Such statutes in turn impose a series of controls or regulation through a system of land use zoning, development standards, building regulations, subdivision controls, heritage provisions etc.

The dominant source of government planning regulatory power is thus statutory law in the form of overriding planning legislation and subsequent delegated or subordinate legislation such as planning instruments, ordinances and regulations, although case law – particularly in the form of judicial interpretation of relevant legislation and judicial review of planning decisions – also plays a key role, given Australia's legal tradition as a common law country.

More recently however, planning approaches influenced by United States systems of financial and planning incentives have emerged to complement this traditional 'command and control' regulation hegemony. Part of a self-styled 'smart regulation' package, these seek to give Australian planning systems greater flexibility through the use of market-based mechanisms and financial incentives. These tools include planning bonuses, green offsets, and the acquisition of development 'rights' pertaining to realty. Often these also involve the utilization of traditional common law mechanisms such as covenants and easements.

One sphere of application of this hybrid mix of planning approaches and tools is the protection of biodiversity and other natural resource values in areas subject to urbanization

. A critique of the role of these approaches as applied to the integration of biodiversity and urban growth management within the framework of the NSW planning system and the context of 5 entrenched perceived property rights is presented in this paper.

Approaches which seek to work with property rights and the property market – transferable development rights and green offsets in the specific form of biobanking and at a strategic level biodiversity certification – in addition to the traditional tools of regulation such as zoning, are seen as pivotal and are advocated in this paper.

Context – City of Cities and the Growth Centres

The context of this analysis of the need for the utilization of an appropriate suite of tools to better integrate biodiversity conservation with continuing urbanization is the current metropolitan strategy for Sydney, City of Cities – A Plan for Sydney's Future, released in December 2005 (DoP, 2005a).

City of Cities, is "probably the most comprehensive planning strategy that Sydney has had since its first strategy" in 1951 (Searle, 2006: 553). However, it was arguably developer-led, being devised in response to heavy lobbying by the property industry, particularly the Property Council of Australia, for a new strategy (PCA, 2004).

It certainly bears the hallmarks of a blueprint to satiate developer desire for the further – and possibly the complete – urbanization of the Sydney basin, with the developer vision "writ large across the City of Cities strategy and its supporting documents" (Searle, 2006: 533).

All major Australian cities have released metropolitan strategic plans in recent years, and so the challenges examined in this paper are not unique to Sydney, and its findings have implications beyond Sydney. The City of Cities strategy is intended as the plan for Sydney over the 25 years between 2006 and 2031.

During this time the city's population is forecast to increase by 1.1 million people, from 4.2 million to 5.3 million.

To accommodate this predicted population growth and the anticipated fall in average household size, it is estimated that 640,000 new homes will be required.

This target translates to 445,000 new dwellings projected for the existing areas of Sydney, consistent with an ongoing policy of urban consolidation, and 195,000 in greenfield areas, 135,000 of which were to be located in the North West and South West Growth Centres (that is, two new urban release areas), and 60,000 in other greenfield areas (DoP, 2005a).

An additional 25,000 dwellings were originally projected to be built in the Growth Centres between 2032 and 2041, giving a total dwelling capacity in the Growth Centres of 160,000 dwellings; this was subsequently adjusted to 181,000 dwellings following the abandonment of proposed 'green zones' by the State Government in 2006 (further discussed below).

A pertinent action of the Metropolitan Strategy in relation to housing is the application of sustainability criteria for new urban development (Action C1.2). Here, proposed land release areas are to be assessed against sustainability criteria and infrastructure funding.

As a precursor, a general qualitative assessment of all land identified for release within the Growth Centres was provided by the then NSW Sustainability Commissioner, Professor Peter Newman in November 2004 (Newman, 2004).

This assessment was based on eight sustainability criteria, with a ranking assigned to each criteria ranging from 'Poor', 'OK', 'Good to Best', depending on how well the Sustainability Commissioner believed that the criteria "have been addressed in terms of global best practice for land development and also in terms of accepted practice in Sydney" (Newman, 2004: 1). Criteria 2: Environmental Protection, aims "to protect and enhance biodiversity, air, water and agricultural land." Within this criterion the biodiversity benchmark is to "save core biodiversity values and enhance natural ecosystem of the bioregion"; for water quality it is to 'maintain and improve

waterway health"; and for agricultural land to "ensure important agricultural land is conserved." For new land release areas this criterion rates as "'good' to 7 'best' practice as one of the major features of the area is the new ways that the environment will be protected however air and water quality limits are approaching so any development has to be very clean" (Newman, 2004: 4).

Despite the positive ratings of the sustainability criteria of natural resources and environmental protection, two points are of concern. First, in his report the Sustainability Commissioner "raises the question of whether the Land Release areas are needed at all.

Is it possible to somehow stop Sydney growing or at least prevent any further fringe growth?" (Newman, 2004: 4).

Second, it appears that additional urban development outside the identified Growth Centres may be approved if it meets the eight sustainability criteria, (Searle, 2006: 556), which would undermine the reason for the Growth Centres in terms of the objectives of the sustainability criteria such as minimizing Sydney's ecological footprint and to protect and enhance biodiversity, water and agricultural land.

Evidence of developer pressure for further land releases outside the designated Growth Centres release areas includes recent preliminary investigations by the Department of Planning into new releases, such as Macarthur South (Keneally, 2009).

This is a significant development and places heavy pressure to extend the apparently inexorable growth of Sydney. Policy failure, the demise of Sydney's green zones and smart regulation From the perspective of protection of areas of biodiversity value in and around Sydney's growth centres, the current Metropolitan Strategy and the tools drafted into its implementation arguably represent a dramatic example of policy failure in the face of perceived property rights. Failure of measured strategic spatial planning, and in its stead the formulation of ad hoc, reactionary 'policy on the run', was evident in the response by the NSW Government to the politics of property rights exerted by land owners and developers in the Growth Centres.

8 On 3 November 2005, a media release issued by the office of the New South Wales Minister for Planning, the Hon Frank Sartor MP announced the scrapping of two proposed 'green zones' in the SW and NW urban growth centres (Sartor, 2005). This 'green overlay', designed to preserve existing non-urban land for aesthetic, biodiversity conservation, recreation and agricultural purposes, covered 8,400 hectares in the land release areas, and a further 14,000 hectares outside the growth centres boundary. The decision to abandon these green zones or areas – formally described as Landscape and Rural Lifestyle Zone (LRLZ) under the Sydney metropolitan strategy – was taken, stated the media release, "following widespread public consultation". Reasons given for the decision were basically two-fold. First, the Department of Planning had received more than 3,000 submissions on the Growth Centres plans over a four-month exhibition period.

It was clear, stated the Minister, that "the proposed LRLZ caused widespread concern and confusion, with nine in ten written submissions objecting to the new zone, which affected more than 7,000 properties" (Sartor, 2005).

Many landowners complained about a perceived loss of property values and development rights (DoP, 2005c). Second, it was argued that the environmental benefits of the proposed green zones were limited, because 45% of the land identified for the LRLZ zone had already been cleared (Sartor, 2005). Putting aside the issue of the poor quality of Departmental mapping and lack of 'groundtruthing' resulting in the misidentification of appropriate quality green space, the clear

message was that public objection to the green zones was the primary reason for their demise, as both cleared and uncleared green areas were abandoned.

This public objection rested on the expectation (whether reasonable or otherwise) that landowners' land – whose current zoning was not residential – in an around the NW and SW Growth Centres would be 9 urbanised, with the windfall gain accruing to the property owners that this land use conversion process entails. As described in the news media at the time, the 'dumping' of the green zone on Sydney's fringe occurred after "a backlash from landowners angry their properties would not be considered for housing subdivisions" (Goodsir, 2005a: 3), with fears that "land values in some areas will plummet as a result…" (Goodsir, 2005b: 9).

One clear message from this episode is the role played by property rights and concomitant development expectations or rights in opposing – and ultimately determining – public policy designed to protect the environmental and natural resource values of the south-west and northwest fringe of Sydney.

This role was admitted by the Minister in an earlier media release (9 September 2005) when he announced a review of the LRLZ and stated that "the green zones were never intended to change people's existing land use rights" (DoP, 2005b). It should be pointed out however, that the green zone landowners were expecting more than their existing use rights. Rather, they wanted a right to develop or use their land in way that they were not presently entitled, that is, for residential purposes. This has two significant implications.

First, this right that was perceived to pertain to non-urban land does not exist even in land already zoned residential, since development consent is first required before residential subdivision and development can proceed.

Second, landowner insistence on, and State Government accedence to, such rights, can only lead to speculation in areas in and around the growth areas not zoned residential, which has indeed since occurred (Keneally, 2009). Recognition of these implications was acknowledged in the Sydney Morning Herald the next day when it reported:

Developers and groups representing thousands of aggrieved landholders yesterday applauded the State Government's decision to walk away from a green zoning proposal that had denied property owners the right to cash in on future housing estates. (Goodsir, 2005c: 11) 10 A further aspect of the State Government's decision in regard to the abandoned green zones was the announcement that it would attempt to retain some environmental aspirations by focusing on protecting the best sections of vegetation and waterways in the two Growth Centres.

This new approach, developed in consultation with the Department of Environment and Conservation, created four new zones into which land was classified: flood-prone, urbancapable, urban edge and conservation (Sartor, 2005).

Significantly, this approach focuses on biodiversity certification and relies on a new environmental offsets or biobanking scheme, under which developer payments are used to conserve areas of bushland, further discussed below. Planning implementation of the growth centres component of the Sydney metropolitan strategy was deferred to the making of a specific statutory plan in the form of a state environmental planning policy (SEPP), which finalised the release area boundaries and the constituent land zones and controls.

Work on a draft of this SEPP progressed throughout 2005, and major changes were made to its envisaged land use zones following the State Government's decision to abandon the proposed green zones

. A 'final' version of the draft SEPP – minus the now moribund green zones – was released in January 2006 for public exhibition and comment. Subsequently, on 28 July 2006 the Minister for Planning gazetted State Environmental Planning Policy (Sydney Region Growth Centres) 2006.

Yet the SEPP as gazetted was modified from that placed on public exhibition, following 750 submissions from members of the public, industry and State Government agencies (DoP, 2006a). Opinions on the nature of the modifications to the SEPP greatly diverged. On the one hand an update on the Sydney metropolitan strategy issued by the Department of Planning was emblazoned with the heading 'More Green Spaces for Western Sydney' (DoP, 2006b), whilst 11 on the other the Sydney Morning Herald more pessimistically – and accurately – reported that 'Housing eats our next park' (Davies, 2006). These two contrasting views are discussed in turn below.

The increase in green infrastructure in Western Sydney announced by the Minister involved the rezoning under the SEPP of a long-standing undeveloped 560 ha parcel of land owned by Airservices Australia, a Commonwealth Government agency.

Located at Shane's Park, in Sydney's north-west, the land is the site of a former international radio transmission station and about 80% was already listed on the Commonwealth's Register of the National Estate. The site was to be merely rezoned by the State Government from one open space designation to another. Conversely, the SEPP also sought to reduce by over one-half, the amount of land proposed for the Rouse Hill Regional Park. The park, which surrounds Rouse Hill House, one of Sydney's earliest properties, has been planned since 1989 and a further commitment to create the 115-hectare park was given in 1997.

In a decision that "outraged heritage experts, local councils and even the Government's own advisers on its metropolitan strategy", the State Government decided not to acquire Stage 2 of the park, with the Planning Minister arguing that the $120 million to be paid for the 81-hectare site "was too much to pay for views" (Davies, 2006).

Instead, the land was designated under the SEPP to be released for housing. Public opposition to this proposal was so intense however that the Minister quickly reversed his decision, announcing the entire area of the park would be protected by restoring its earlier open space zoning (DoP, 2006d).

Since the publication of City of Cities further potential for undermining of this plan has been evident in the form of developer pressure for land to be released for urban development outside the designated growth centres.

In particular, one major development company with 12 extensive land holdings in the Macarthur South/Appin has actively lobbied the NSW State Government for this land to be added to Sydney's release areas (Frew and Snow, 2008).

This is part of an area investigated for urbanisation under the 1988 Sydney metropolitan strategy Sydney Into Its Third Century (DEP, 1988) but subsequently deferred due to water and air pollution problems (DoP, 1993; Holliday, 1998; Vipond, 2001)

Clearly, such a release would also undermine a fundamental component of City of Cities of limiting Sydney's urban expansion to 2031 to the designated growth centres and hasten the urbanisation of the Sydney basin. Following initial consideration, the Government recently announced the deferral of further investigation of Macarthur South as its development is presently unviable due to prohibitive infrastructure costs (Keneally, 2009).

It should be pointed out that similar challenges are facing other Australian cities. For example, the recent and controversial expansion of Melbourne's urban growth boundary into its 'green wedge' areas (Buxton and Goodman, 2002; Buxton and Scheurer, 2007), has strong parallels with the Sydney situation.

This brief vignette reveals a number of key factors that must be taken into consideration in contemporary growth management on the rural-urban fringe of Australian cities and towns.

First is the deficiency, on their own, of traditional command and control mechanisms such as land use zoning and planning restrictions to guarantee the protection of non-urban land. Second is the apparent inevitability of continued urban sprawl unless appropriate growth management policy responses can be crafted and implemented to counter this apparent biodiversity-damaging form of urbanisation.

Third is the role – rightly or wrongly – that claims to property rights play in land use planning and development decisions.

Fourth is the reluctance of government to rely, otherwise than de minimus, on the public purse to protect non-urban land (for example, through land acquisition for the provision of green infrastructure).

The fifth factor – argued here to be an inevitable conclusion given the 13 previous four considerations – is the role that newer alternative mechanisms such as smart regulation and market-based instruments that operate within the context of property rights can play, particularly in the context of seeking to ensure that natural resource and environmental values are protected in the face of the pressure and expectations of continued urban expansion. It is in the context of these factors that some complementary mechanisms for planning policy implementation – specifically the integration of biodiversity conservation into managing the growth of Australian cities – are now considered with Sydney as a case study

Transferable development rights The concept of property rights is integral to schemes such as transferable development rights (TDR). TDR is described as a property rights-based tool since it recognizes, and seeks to work with, a development right which is perceived as one of a number of rights accruing from ownership or other interest in property (Wiggins, 1988).

Fundamental differences however, can be identified in the practical application and consequences of the concept of property rights.

Specifically property rights-based tools have, depending on the approach taken, been ascribed as constituting an example of a market-based or economic instrument, or alternatively a manifestation of free market environmentalism (Gunningham and Grabosky, 1998). Yet in essence, TDR is one type of planning tool that seeks to compensate landowners whose development rights have been restricted by regulation.

Compensation is achieved by allocating to those owners an amount of development that may be transferred from the restricted site to another site (Bindon, 1992). Fundamentally, development rights are severed from a parcel designated for protection ('sending area'), and the severed rights are transferred to a parcel in an area where additional development is permitted ('receiving area') (Johnston 14 and Madison, 1997: 365).

The scheme thus allows more development on the receiving parcel while reducing or preventing development on the donor parcel.

Under such a program, the development rights of the sending parcel may be either sold by that owner to the owner of the recipient parcel, or transferred directly from the donor to the receiving site if they are under common ownership. The number of development rights that can be transferred depends on how many development-rights 'credits' a planning authority allocates and how much it allows in areas designated for growth (Daniels, 1999: 224). Within the modern system of formalised land tenure the bundle of rights that constitute land ownership are often consolidated in the hands of a single 'owner'.

By allowing voluntary acquisition and conveyance of specific rights for specific uses, trading in partial interests offer this more flexible and refined alternative to a strictly regulatory approach or acquiring full ownership rights (Wiebe and Meinzen-Dick, 1998).

Development rights have been viewed as one of a number of rights embodied in the ownership interest in property. These development rights have been classified as a real property interest, which entitles the owner of a fee simple interest to deal with the land as the owner wishes, subject only to government regulation, principally through zoning (Arnold, 1992).

However, the right to transfer development rights is not ordinarily part of the bundle of rights that comes with land ownership: because in Australia at least there is no right to develop land except within the terms of planning instruments.

Government must therefore enact specific legislation to legalise the sending of a building right from one parcel to another (Daniels and Bowers, 1997).

Once legislatively sanctioned, an owner may separate and transfer one of the rights incidental to ownership whilst retaining the other rights (Arnold, 1992). In the US the acquisition and conveyance of partial interests to land has proven to be a popular, flexible and effective tool for land use and conservation policy. 15 TDR has several attractions to commend it – which revolve around its 'respect' for property rights. TDR is a (hybrid) market based mechanism under which developers pay for preservation in return for additional development potential. Where a TDR scheme is in place, a developer buys development rights, with zoning provisions identifying the number of additional units allowed in designated receiving areas.

TDR is therefore effective when the TDR option is more profitable than the non-TDR option for landowners and developers. The motivation for utilizing this scheme is the ability to sell and transfer development rights – thereby increasing residential densities in targeted sites – and yet retain land and appropriate uses in receiving areas.

Schemes such as the purchase or transfer of these interests or rights have allowed public agencies and private non-profit conservation groups to influence the use of public and private land without incurring the political costs of land regulation or the full financial costs of outright land acquisition (Wiebe and Meinzen-Dick, 1998)

. It is a voluntary approach to influencing land use, by offering landowners and farmers financial incentives for environmental conservation, restoration, and preservation. In Australia there is no such inherent right to develop land; rather a property owner may have the right to seek development consent, after the granting of which, development for the specific purpose approved can legally commence before the consent lapses after a prescribed period.

Nevertheless, in practice the Australian experience is that a landowner may have certain development expectations based on the applicable statutory planning controls. Implicit in the controls is a perceived probability of gaining approval for a certain type and quantity of development (Bindon, 1992).

As a consequence, the fundamental principles behind the US model has been recognised and adopted by several local councils in Australia that have established TDR systems (Williams, 2004).

These include heritage conservation in 16 Sydney, Adelaide, Melbourne and Brisbane (Ryan, 2004), protection of the Mount Lofty Ranges near Adelaide, provision of open space and conservation reserves in Gosford (NSW), urban growth management in Wellington (NSW) and protection of the Illawarra Escarpment near Wollongong (Williams, 2004).

Yet the apparent reluctance for more widespread use of TDR as a planning tool remains. This is despite TDR being identified as a tool worthy of consideration, for example, in the NSW Plan First planning system reforms a decade ago (DUAP, 2001).

Three reasons can be advanced to explain this situation. First, the utilization of market based tools is still relatively recent in Australia. There has been a tradition of reliance on 'command and control' regulation in Australia, which is quite different to the history of market based tools in the US and bargaining for planning gain/negotiated planning agreements in Britain.

Second, there is a lack of understanding of the TDR mechanism by planning decision-makers (both politicians and planners). Third, there is ongoing legal uncertainty and impediments surrounding TDR..

Evidence of the present legal impediments to the more widespread adoption of a TDR scheme in NSW include expression of doubt by the NSW Land Environment Court about the legality of TDR schemes (see for example Leighton Properties Pty Limited v North Sydney Council [1998] NSWLEC 39) concerns raised by a Commission of Inquiry regarding the transparency of Wollongong City Council's TDR for the Illawarra Escarpment (Commission of Inquiry, 1999), and ongoing reluctance by the NSW Parliamentary Counsels Office to support draft statutory plans produced by local councils that seek to include TDR provisions.

Biodiversity certification and biobanking Biodiversity certification and biobanking are two relatively new planning tools in NSW. Biodiversity certification was introduced with the passage of the Threatened Species 17 Legislation Amendment Act 2004 (NSW).

It is designed to integrate threatened species management into the strategic planning stage through the auspices of the formulation of environmental planning instruments (EPIs), rather than being mired within the 'trench warfare' of assessment under the development application process. Under this scheme, environmental biodiversity studies are required to be prepared up front, and planning options for development and conservation methods identified and evaluated.

A draft EPI is then prepared and forwarded to the Minister for Environment, Conservation and Climate Change who then decides whether to grant biodiversity certification. The outcome of the process is that a developer does not need to prepare a species impact statement, and biodiversity does not comprise part of the environmental assessment of the proposed development.

Significantly, the first EPI to receive biodiversity certification in NSW was State Environmental Planning Policy (Sydney Region Growth Centres) 2006 which contains the main statutory planning controls for Sydney's Growth Centres. Biobanking is an example of an offsets scheme.

Under an offset arrangement, industries or resource users are given the choice of either offsetting the damage they cause or paying an authority to do it on their behalf.

The provision of an offset is a mandatory requirement or condition of the granting of approval to undertake development with potentially adverse environmental impacts. The arrangements operate partly through regulatory mechanisms such as permits or approvals, and partly through a market-based system, which allows one property owner who undertakes some form of environmental restoration to sell offset credits to another owner or industry seeking approval to undertake development. Thus an offset arrangement is clearly a hybrid of regulatory and market-based instruments. 18 The NSW Biodiversity Banking and Offset Scheme was introduced under the Threatened Species Conservation Amendment (Biodiversity Banking) Act 2006 (NSW).

The scheme seeks to provide an additional, market-based, mechanism to assist in conservation management. It aims to achieve more predictable development and conservation outcomes by guiding development to appropriate places, and to promote private land conservation through income generating opportunities for landowners who provide biobank sites.

Landowners create credits by establishing biobank sites and earn income from managing land for conservation.

The scheme aims to be comprehensive – the biobanking provisions include requirements for biobanking statements, creation of biodiversity credits (calculated using published assessment methodology), detailed regulations (including cost recovery), establishment of a BioBanking Trust Fund, BioBanking public registers and enforcement provisions (DECC, 2007). The NSW BioBanking and Offsets Scheme seeks to address the loss of biodiversity by enabling landowners to establish biobank sites to secure conservation outcomes and offset impacts on biodiversity caused by development. Conceptually, this is achieved through the use of an 'improve or maintain' test for biodiversity values, which means avoiding significant biodiversity conservation areas and offsetting impacts in other areas (DECC, 2007: 4).

The offsets are measured in terms of credits, using the published BioBanking Assessment Methodology (DECC, 2009), and developers participating in the scheme are required to meet this improve or maintain test based on the impact of their proposed project. The BioBanking Scheme has four key components (DECC, 2009b): 1

. Establishing biobank sites on land through biobanking agreements between the Minister for Climate Change and the Environment and participating landowners. A 19 biobanking agreement is similar to a covenant and is attached to the land title. It runs with the land, and generally will have effect in perpetuity so as to offset the impacts of development on biodiversity values.

2. Creating biodiversity credits for management actions that are carried out, or proposed to be carried out, to improve or maintain biodiversity values on biobank sites. The biobanking assessment methodology is the tool used to determine the number of biodiversity credits that may be created for these management actions.

3. The trading of credits, once they are created and registered. 4. Enabling the credits to be used to offset the impact of development on biodiversity values. The assessment methodology is the tool that is used to determine the number and class of credits that must be retired to offset the impact of a development and ensure that the development improves or maintains biodiversity values.

BioBanking in NSW is still in its infancy – indeed at the time of writing no biobanking agreements had been listed publicly (DECC, 2009c) although several have been shortlisted as either biobank sites, development sites or joint biobank/development sites – and biodiversity certification has presently not extended beyond the Sydney Growth Centres (DECC, 2009d).

Nonetheless, some observations may be made in relation to both these biodiversity conservation tools. Both approaches require an 'improve or maintain' outcome for biodiversity values, which is difficult – if not impossible – to achieve given the high conservation value of the remaining biodiversity and ecological communities in the Sydney Region.

Disagreement exists in relation to the identification of appropriate offset ratios – i.e. the ratio of conservation land to offset developed land – with this generally well in excess of a simple 1:1 ratio.

Problems have also arisen with using biobanking and biodiversity 20 certification to justify the loss of areas of high biodiversity – something which DECC seeks to avoid and the Land and Environment Court has had to adjudicate in the case of specific residential developments in Sydney (see for example Sanctuary Investments Pty Ltd & Ors v Baulkham Hills Shire Council [2006] NSWLEC 733). Concerns have also been expressed by some local councils in the Sydney Region about the location of biodiversity offsets.

Such councils have argued that the offset sites should be located in the same local government area that the development is occurring, whereas some State Government agencies believe that the funds generated under the BioBanking Scheme could be better used to conserve larger areas of land outside the Sydney Region, where land acquisition costs are cheaper.

Further, problems have arisen in situations where developers have sought to offset the loss native vegetation on development sites with biobank sites containing ecological communities of inferior conservation status, contrary to the principles of the BioBank Scheme (DECC, 2009e).

Finally, the attraction of offering biodiversity offsets – generally as individual land dedication agreements outside the formal Biobank Scheme – has been used as a bargaining chip by developers to persuade State Government to give favourable consideration to unscheduled urban releases, particularly in the Lower Hunter region of NSW (Creagh and Munro, 2007).

One such land dedication agreement which attracted significant media attention involved the brokering of the agreement, and subsequent granting of planning approvals, by a former Minister for Planning for proposed residential developments at Catherine Hill Bay and Gwandalan in the Lower Hunter.

The Ministerial approvals were subsequently quashed by the Land and Environment Court on the grounds of apprehended bias and reliance on irrelevant considerations (Gwandalan Summerland Point Action Group Inc v Minister for Planning [2009] NSWLEC 140).

Pertinently, the invalidated approvals relied on land 21 dedication agreements that were outside the framework of the Government's own BioBanking and Offsets Scheme.

Conclusion

Faced with the rising influence of the property rights movement (along with the contemporary problem of 'down-zoning' land as witnessed in the proposed green zones in the Sydney Growth Centres), the challenge to land use managers and planners has been to devise planning mechanisms which respect the integrity of private property on the one hand, and yet still achieve planning policy objectives on the other.

It is in this context that more creative mechanisms such as TDR and biodiversity certification and biobanking need to be considered as urban growth management tools. In the case of TDR the issue of the lack of understanding of this mechanism by decision-makers (including planners) and the present legal uncertainty surrounding its application need to be resolved – the latter by legislative action.

In the case of biodiversity certification and biobanking the main issue relates to the untended consequences of these tools.

This includes their use to gain approval for inappropriate development in terms of undermining both the promotion of orderly land releases and the protection of areas of high biodiversity value within the Sydney Region.

Part of the reason for these problems lie in the fact that market based tools are still very much in their infancy in the NSW planning system.

To better integrate biodiversity conservation with managing the growth of Sydney, a hybrid framework which utilizes sound metropolitan planning, strategic or planning phase biodiversity certification, statutory-based regulation such as zoning, and market-based mechanisms including TDR and biobanking reinforced by conservation covenants or agreements, should be adopted.

At the Senate Environment Committee hearing yesterday Senator Cameron requested information about my expertise in Koala management. I did not have an opportunity to respond at the time so I have attached a brief CV which I hope will suffice. I have also attached a pdf of my paper on the history of Koala management in Victoria.

Peter Menkhorst
Contract Ecologist
Arthur Rylah Institute for Environmental Research
Department of Sustainability and Environment

Peter Menkhorst BSc (Zoology and Botany)

Ecological Consultant and author

Peter has over 35 years experience as a scientist with Victorian Government environment agencies (including Museum Victoria, Parks Victoria and Department of Sustainability and Environment or their predecessors). He has worked throughout Victoria in the fields of biodiversity survey, wildlife research, threatened species management and conservation policy development. He is a recognised authority on Victorian mammals and was editor and primary contributor to the authoritative book on that subject (item 8 in the list below). He has also written a field guide to Australian mammals and edited a field guide to Australian birds. Peter has a strong interest in threatened species recovery and has been a leader, since the 1980s, of several high profile and complex recovery programs in Victoria, including those for the Orange-bellied Parrot, Helmeted Honeyeater, Regent Honeyeater, Mountain Pygmy Possum and Brush-tailed Rock Wallaby. A 10-year stint in the Threatened Species Policy and Programs section of DSE, including a period as Manager, has given Peter a clear understanding of the legislative and policy contexts for achieving recovery of threatened species.

Peter's expertise in management of the Koala derives from his role in coordination of Koala management and conservation activities in Victoria for 12 years between 1995 and 2007. This included playing a central role in the development of the National Koala Conservation Strategy (Commonwealth of Australia 1998) and Victoria's Koala Management Strategy (DSE 2004), and representing the Department on Victoria's Koala Technical Advisory Committee. In these roles Peter was instrumental in leading the significant changes made during the last 15 years to the management of over-abundant and unsustainable populations of the Koala in Victoria. Following successful field trials of contraceptive implants in the Koala (see item 5 below), the Victorian Government has now adopted the technique in its Koala Management Strategy. Large-scale population control programs based on levonorgestrel implants have now largely replaced the previous, ethically-questionable translocation program in Victoria. As well as providing an ethically and financially suitable solution to a serious ecological problem, this work has overcome an intractable political issue for the Victorian Government.

Peter now works part-time as a consultant at the Arthur Rylah Institute for Environmental Research (DSE) on a number of projects relating to biodiversity monitoring, accounting for the needs of fauna in the development of planned fire regimes and ecology and monitoring of waterbirds. He is also part of a team preparing a new field guide to Australian birds for CSIRO Publishing.

Ten career best scientific publications (selected from more than 80 scientific publications). Those directly related to Koala management are indicated with an asterisk.

1. Smales, I. J., Quin, B., Menkhorst, P. W. and Franklin, D. C. 2009. Demography of the Helmeted Honeyeater (*Lichenostomus melanops cassidix*). *Emu* 109: 352-359.

Analysis of a long-term population dataset, providing important insights for management of this critically endangered taxon. Maintaining funding for this research project over an 18 year time period is a major achievement.

2. *Menkhorst, P. 2008. Hunted, marooned, re-introduced, contracepted: A history of Koala management in Victoria. Pages 73-92 in 'To Close for Comfort. Contentious issues in

human-wildlife encounters', edited by D. Lunney, A. Munn and W. Meikle. Royal Zoological Society of New South Wales, Mosman, New South Wales.

Reviews and documents Australia's longest-running and most intensive wildlife management program, including significant recent advances in the regulation of over-abundant Koala populations.

3. N.L. McKenzie, A.A. Burbidge, A. Baynes, R.N. Brereton, C.R. Dickman, G. Gordon, L.A. Gibson, P.W. Menkhorst, A.C. Robinson, M.R. Williams, J.C.Z. Woinarski. 2007. Analysis of factors implicated in the recent decline of Australia's mammal fauna. *Journal of Biogeography* 34: 597-611.

Assessed the explanatory value of eight faunal and environmental factors thought to have contributed to Australian mammal extinctions on a continental scale. Provides an explicit basis for setting conservation priorities amongst regions and species.

4. *Baxter, P. W. J., McCarthy, M. A., Possingham, H. P., Menkhorst, P. W. and McLean, N. 2006. Accounting for management costs in sensitivity analyses of matrix population models. *Conservation Biology* 20: 893-905.

Uses Victoria's Koala and Helmeted Honeyeater management programs, both of which I led for extended periods, to explore methods for including financial costs of proposed management actions in models designed to assess efficacy of management options.

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

Provided a cost-effective and ethically-acceptable means of controlling over-abundant Koala populations. Now routinely applied to the Koala populations in Victoria where Koala over-browsing is the greatest problem.

6. *Melzer, A., Carrick, F., Menkhorst, P., Lunney, D. and St John, B. 2000. Koala distribution and abundance: an overview, critical assessment and conservation implications. *Conservation Biology* 14: 619-628.

A global conservation and management assessment of this high-profile and contentious species.

7. Franklin, D., Smales, I., Quin, B. and Menkhorst, P. 1999. The annual cycle of the Helmeted Honeyeater: a sedentary inhabitant of a predictable environment. *Ibis* 141: 256-268.

Based on detailed study of a marked population, provides a rare level of insight into population processes in an endangered species, particularly the relationship between breeding, moult and dispersal.

8. Menkhorst, P.W. (Ed). 1995. *'Mammals of Victoria: Distribution, ecology and conservation'*. Oxford University Press, Melbourne. 359 pages.

The most comprehensive review of the mammals of any Australian region, based on the records of the Atlas of Victorian Wildlife and a comprehensive review of the literature. Still has a high citation rate 15 years after publication.

9. Menkhorst, P.W., Weavers, B.W. & Alexander, J.S.A. 1988. Distribution, habitat and conservation status of *Petaurus norfolcensis* (Marsupialia: Petauridae) in Victoria. *Australian Wildlife Res*earch 15:59-71.

An early and important contribution to knowledge of this poorly-known (at the time) species.

10. Menkhorst, P.W. 1984. The application of nest boxes in research and management of possums and gliders. Pp. 517-525 in '*Possums and Gliders*' ed. by A.P. Smith and I.D. Hume, Australian Mammal Society, Sydney.

Stimulated many studies using nest boxes as a tool to gain access to hollow-using fauna.

Hunted, marooned, re-introduced, contracepted: a history of Koala management in Victoria

Peter Menkhorst

Biodiversity and Ecosystem Services Division, Department of Sustainability and Environment, PO Box 500 East Melbourne VIC 3002.

Email: peter.menkhorst@dse.vic.gov.au

Current address: Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, PO Box 137 Heidelberg VIC 3084.

ABSTRACT

The management history of the Koala *Phascolarctos cinereus* in Victoria is unique and spectacular. Management of Koala populations began in Victoria in about 1910, at which time the species was undergoing a severe decline in population number and distribution. The fortuitous transfer of small numbers of Koalas to two coastal islands in the late 19th Century allowed intensive conservation management to begin in 1923, and it has continued almost unabated for the subsequent 84 years. Initially, Koalas were marooned for conservation purposes on four other large coastal islands, and several smaller ones, including two in the Murray River. These island populations were then used to re-introduce the species to remaining habitat across the former natural range of the species in Victoria and south-east South Australia. In the process intractable over-browsing problems were inadvertently created at ten sites. Since about 1985, the sole reason for translocation has been to protect natural values from the impacts of Koala over-browsing. Since 1995, considerable research effort has been directed at finding suitable in-situ population control mechanisms. During the 84 year program more than 24 000 Koalas were translocated to about 250 release sites and Koala populations have been successfully re-established in most areas of suitable habitat in Victoria. The genetic costs of using inbred populations as the source of animals for re-introduction are perhaps yet to be fully realised.

Key words: Koala, *Phascolarctos cinereus,* wildlife management, over-browsing, marooning, re-introduction, fertility control

Introduction

Koala conservation – perception and reality

The Koala *Phascolarctos cinereus* is amongst the most widely recognised and loved animals in the world. Its beguiling appearance and apparently docile nature result in a level of attraction and affection afforded to few other wild animals (Le Souef and Burrell 1926; Barrett 1937; Pratt 1937; Phillips 1990; Martin and Handasyde 1999). The annual benefit of this attraction to the Australian economy, via the role of the Koala as a tourism icon, was estimated in 1996 to total $1.1 billion (Hundloe and Hamilton 1997). Yet, it is not widely understood that, in parts of southern Australia, the Koala is responsible for one of the most intractable wildlife management problems, consuming a significant proportion of the wildlife management budgets of the Victorian and South Australian Governments.

Amongst the Australian public there is a widespread perception that the Koala is threatened with extinction. This is largely the result of a campaign run by a single special interest group, the Australian Koala Foundation (AKF), over a twenty year period. The AKF believes that the Koala can 'raise huge sums of money for conservation' (Tabart 1996). The effectiveness of the Koala as an 'icon' for conservation would be enhanced if it was officially listed as a threatened species. However, the reality is that two nominations (in 1995 and 2004) to have the Koala listed under Commonwealth legislation have failed because it did not meet the listing criteria at the national level (DEH 2006)[1]. This is not to say that the conservation of the Koala is assured – declines in Koala population numbers and distribution are still occurring in parts of coastal eastern Australia in the face of intensive agricultural and urban developments which result in the loss and fragmentation of forest and woodland cover (Melzer *et al.* 2000; US Fish and Wildlife Service 2000). Consequently, the Koala is listed as vulnerable in New South Wales and in the Southeast Queensland Biogeographic Region. Elsewhere throughout its extensive range, Koala populations remain in a reasonably sound conservation state (ANZECC 1998; Melzer *et al.* 2000; DEH 2006), although, like most taxa of Australian flora and fauna, there are good reasons for concern about future population trends, and for adopting a conservative approach.

[1] The 1995 submission failed despite the inclusion of gross under-estimates of the total Koala population and the numbers in each State. The real population figures for Victoria in 1996 were probably at least an order of magnitude greater than the 10 000 -15 000 claimed in the submission (for example, Martin (1997) estimated that the Koala population on the Strathbogie Plateau alone was in excess of 100 000 animals.)

Important conservation issues for the Koala in Victoria are the continuing incremental loss of mature trees through deliberate felling associated with land development and land-use change, and the declining health of remnant trees in rural landscapes. The potential for increased frequency of wildfire associated with climate change is also a serious concern for the Koala.

Koalas rely solely on the foliage of *Eucalyptus* trees for food. Further, they show distinct preferences for the foliage of a small number of tree species at a given site (Hindell and Lee 1991), and often prefer the foliage of individual trees over other individuals of the same species (Hindell and Lee 1991). Consequently, the number of Koalas that a given area can support is a function of the density of preferred browse tree species and the frequency of palatable or nutritious individuals of those species.

Koalas are long-lived – in Victoria many individuals reach 12-15 years of age (Martin and Handasyde 1999) and a few tagged and translocated animals are known to have lived for over 20 years (DSE unpublished data). Koalas are also highly fecund with many southern Victorian females producing a single young in most years of their 8-10 year breeding life (Martin and Handasyde 1999). Further, predation now plays only a very minor role in population regulation. Consequently, populations can increase rapidly. Populations that are free of Chlamydiosis, which can cause infertility in females, may double every three years; populations in which Chlamydiosis is active can still have a doubling time of about 12 years (Martin and Handasyde 1991). As a result, in southern Australia, populations of Koalas in patchy or isolated habitat have a history of reaching unsustainable densities leading to over-browsing of forage trees, widespread tree death and, in extreme cases, mass starvation of Koalas (Kershaw 1915, 1934; Anon 1944; McNally 1957; Warneke 1978; Martin 1985a; Martin and Handasyde 1999) (Figures 1A-1D).

The dichotomy in the reality and perception of the conservation status of the Koala, and the value of the Koala as a 'flagship species', has generated fierce debate and distracted wildlife managers and concerned members of the public from tackling the important issues facing the Koala, for example continuing incremental loss of trees and habitat fragmentation, (e.g. Martin 1997; Tabart 1997; ANZECC 1998; Phillips 2000).

In this paper I describe the history of active management of the Koala in Victoria, including the management of over-browsing, and the evolution of management responses as the conservation status of the Koala changed through the 20th Century. Finally, I provide an assessment of the achievements of 84 years of active Koala management in Victoria.

Figure 1. Examples of over-browsing damage (all photographs by the author). A – Coastal Manna Gum *Eucalyptus viminalis* ssp *pryoriana,* Snake Island, 22 June 2000. B – Manna Gum, Framlingham, April 2001. Acacias, River Red Gum *Eucalyptus camaldulensis* beside the Hopkins River and Messmate *E. obliqua* in the far distance are unaffected. C – Pure stand of Manna Gum, Framlingham, September 1998. D – a mixed woodland of Coastal Manna Gum and Saw Banksia *Banksia serrata* has been converted to an open woodland of Saw Banksia by Koala over-browsing of the Manna Gum, Raymond Island, September 2004.

Methods

Information sources

In my role of coordinating Koala policy and management in Victoria since 1996, the published literature on Koalas and their management was extensively reviewed, as were files and other records of the Victorian Government wildlife agency in its various guises. Information on individual translocation events was taken from Appendix 1 of Martin (1989) for the years 1923-1988 and from departmental databases for subsequent years.

Definitions

In this document the following definitions are adopted for describing the purposes of moving wildlife from one point to another: translocation is a generic term to describe the deliberate movement of an organism from one place with free release at another. Thus, translocation covers 1) introduction, where the release site is outside the historically-known range of the taxon, 2) re-introduction where an attempt is made to establish a taxon in an area that was once part of its historic range, but from where it has been extirpated, and 3) re-stocking which involves the addition of individuals to an existing population (also known as re-enforcement). Important localities mentioned in the text are mapped in Figures 2Aand 2B.

Results

Development of a policy and knowledge-base for Koala management in Victoria

Management of the Koala has been a major component of the wildlife management program in Victoria since the 1920s, but there appears to have been little documentation of the aims, strategies, effort or cost. Consequently, it is difficult to gain a clear understanding of the work undertaken in Koala management before the 1950s, although several authors have provided broad outlines (Lewis 1934, 1954; McNally 1960; Warneke 1978; Martin 1989; Phillips 1990; Menkhorst 1996; Martin and Handasyde 1999).

For the first 50 years of Koala management in Victoria a clear policy statement about its aims and strategies seems to have been lacking. A wildlife policy statement covering Koala management and procedures was drafted in October 1976 (Fisheries and Wildlife Department 1976) but was never promulgated. In 1988, in recognition of the need for a stronger scientific basis and improved coordination for Koala management, the Department of Conservation, Forests and Lands contracted Roger Martin to prepare a management plan for the Koala in Victoria. Although never formally adopted, this plan helped focus attention on the need to develop new approaches to the control of over-browsing, and placed

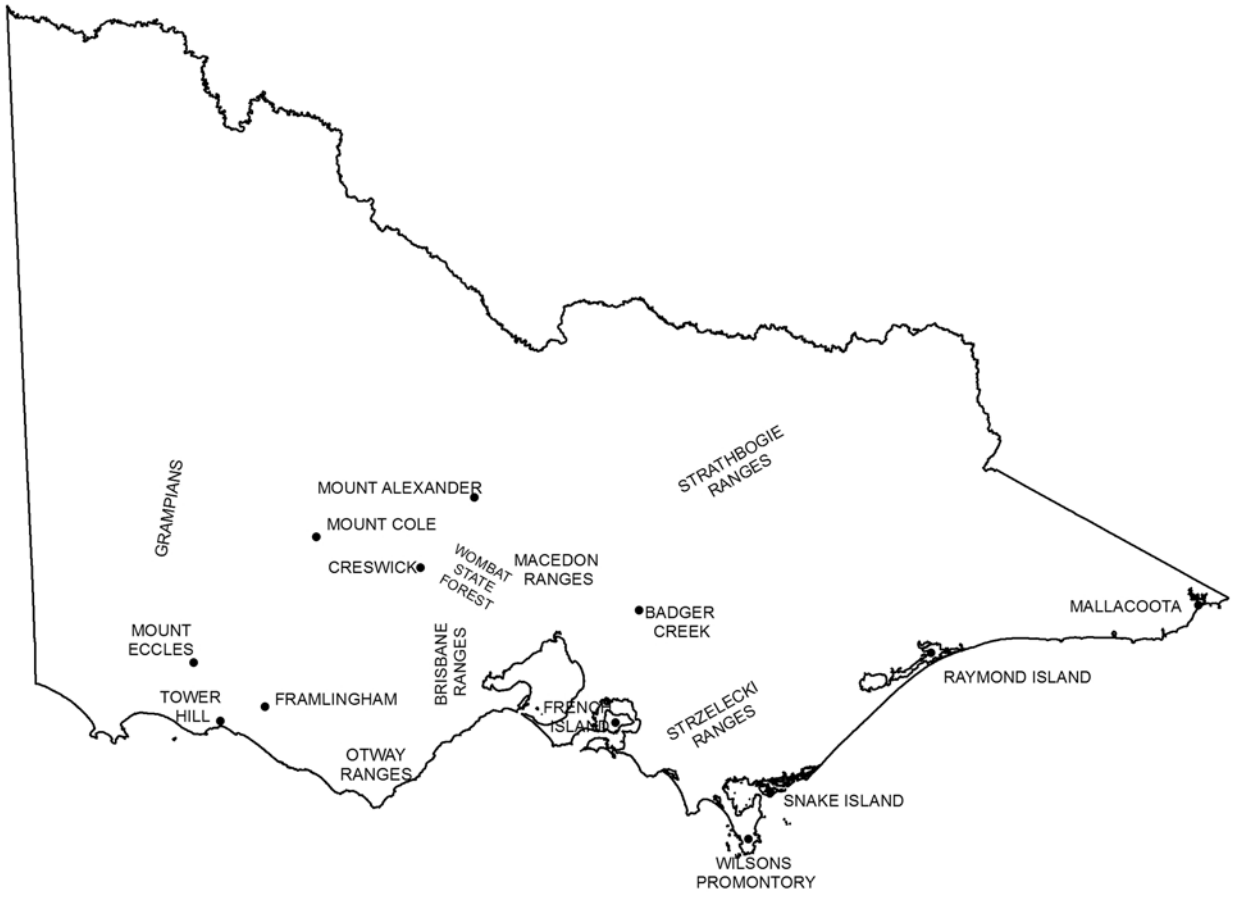

Figure 2.A - Localities of important places mentioned in the text.

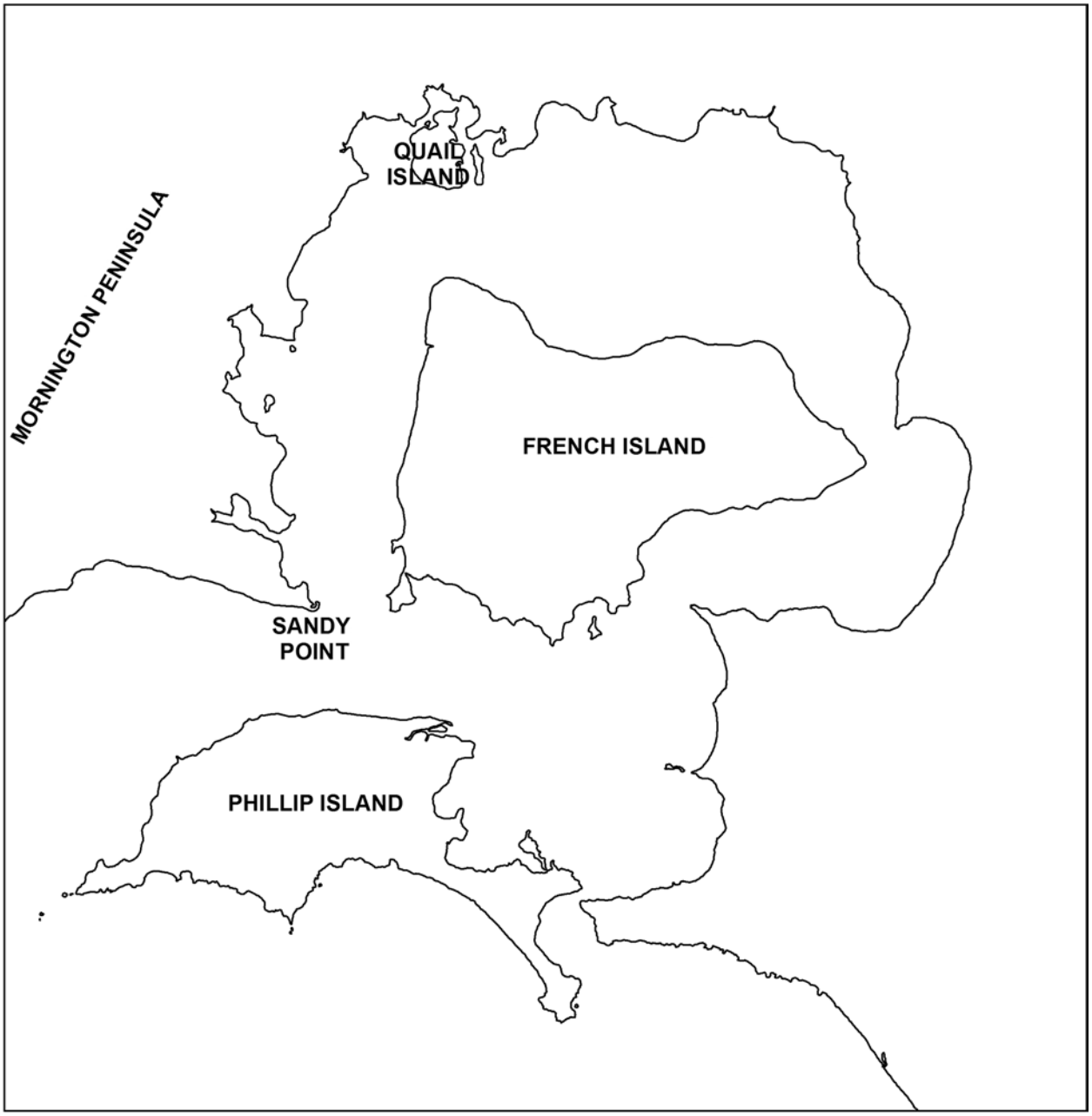

Figure 2. B - Key Koala sites around Western Port.

other issues, including the disease Chlamydiosis, and the genetic consequences of the translocation program, into a more scientific perspective (Martin 1989). Another very important contribution made by Roger Martin was to extract from departmental records information about all Koala translocations, allowing for the first time an appreciation of the full magnitude of this remarkable wildlife management program (see below) (Appendix 1, Martin 1989).

In 1996 the Commonwealth Government formed a National Koala Network charged with preparing a national conservation strategy for the Koala (ANZECC 1998). It was not until 2004, 80 years after active management of Koalas began, that the Victorian Government formally adopted and published a Koala management plan (Menkhorst 2004), as required under the national conservation strategy.

There was a similar lack of a scientific basis for Koala management in Victoria until the second half of the 20th century. John McNally was employed as a Wildlife Management Officer during the 1950s and, during the course of major translocation programs from French Island, undertook the first scientific study of a wild Koala population in Victoria (McNally 1957). The period from about 1977 to 1990 was very productive for research into the biology and ecology of the Koala. For southern Australian Koalas, this research was led by Professor Tony Lee from the Zoology Department at Monash University and included post-graduate studies by Roger Martin (population dynamics, over-abundance, Chlamydiosis, translocation to new habitat), Peter Mitchell (social behaviour, diseases), Mark Hindell (feeding behaviour and food preferences), and Kathrine Handasyde (reproductive physiology, population dynamics, Chlamydiosis). Subsequent studies which have influenced Koala management include those by Handasyde

and her students at the University of Melbourne, notably Natasha McLean (population demographics) and Emily Hynes (fertility control), by John Emmins of the Department of Pathology and Immunology at Monash University (immunology, genetics, Chlamydiosis), and by Flavia Santamaria at the University of Ballarat (fate of translocated Koalas). Combined, this work has provided a strong foundation for the development of current Koala management programs.

The 1990s saw increased pressure to better manage over-abundant Koala populations and the beginning of research into methods of in-situ population control for Koalas to replace the increasingly problematic translocation program (Menkhorst *et al.* 1998; Middleton *et al.* 2003; Duka and Masters 2005).

A brief history of Koala management in Victoria since European colonisation

From a review of the published literature and examination of departmental files, I discern four sequential themes in the management of Koalas in Victoria – the first, in line with the prevailing attitudes towards wildlife, characterised mostly by neglect and exploitation, the second by the concept of establishing refuge populations on islands or inside fenced 'safe havens', the third by re-introduction to suitable habitat in its former range, and the fourth by the search for cost-effective means of in-situ control of population growth. The approximate duration of these four phases of Koala management is shown in Figure 3.

1. Neglect and exploitation – the early decades of European settlement

The occupation of Victoria by European settlers began in the 1830s and accelerated through the 1850s when the discovery of gold across a wide area of central Victoria resulted in a dramatic influx of people to Melbourne and regional areas. By the 1860s, most of the State had been explored and much of the country suitable for the grazing of sheep or cattle had been 'taken up' by European squatters (Dingle 1984). During that period surprisingly few reports of Koalas were documented in the historical literature (Warneke 1978). The frequency of sightings increased dramatically in some regions from about the 1860s (e.g. Parris 1948) and there seems little doubt that Koala populations increased through the last decades of the nineteenth century (Warneke 1978; Strahan and Martin 1982; Lunney and Leary 1988; Phillips 1990). It has been postulated that hunting of Koalas by Aboriginal people had previously held Koala populations at low levels, but following the dramatic decline in Aboriginal populations, and the breakdown of their traditional hunting patterns, Koala populations rapidly increased (Parris 1948; Warneke 1978; Strahan and Martin 1982; Lunney and Leary 1988; Phillips 1990). The widespread poisoning of another predator, the Dingo *Canis lupus dingo* (Menkhorst 1996), would also have reduced predation pressure on Victoria's Koalas (Strahan and Martin 1982).

This increase in Koala population levels was of a magnitude that allowed the development of a major industry based on killing Koalas for their fur (Pratt 1937; Troughton 1941; Phillips 1990; Hrdina and Gordon 2004). A mammalogist at the British Museum, Robert Lydekker, wrote in 1894 that 'the Koala must be an abundant animal since from 10 000 to 30 000 are annually imported into London, while in 1889 the enormous total of 300 000 was reached' (Lydekker 1894). Many thousands of Koala skins from Victoria were amongst the millions exported from Australia (Warneke 1978).

The Koala was given legislative protection in Victoria in 1898 when it was proclaimed Native Game under the Game Act 1890, so providing a legal mechanism to declare a closed season for it (Seebeck 1988). In this case, the 'season' was closed permanently. However, this protection came too late and by the early 1900s a combination of habitat destruction, hunting, wildfire and probably disease (Le Souef 1925; Le Souef and Burrell 1926; Troughton 1941) had caused a drastic population decline. The hunting industry collapsed during the early 1900s (Phillips 1990; Hrdina and Gordon 2004) and by the 1920s there was concern that the Koala had been almost wiped out in Victoria (Le Souef 1925; Barrett 1937; Troughton 1941; Lewis 1954; Warneke 1978). Remnant populations are claimed to have occurred only in parts of the south-west, the Mornington Peninsula and South Gippsland (Lewis 1934), including Wilsons Promontory (Kershaw 1915; Kershaw 1934), but Koalas probably also persisted in East Gippsland, contiguous with those in south-eastern New South Wales, as remnant populations still do today.

2. Island Populations to the Rescue – Phase 1, Marooning

Fortunately for the future of the Koala in Victoria, small numbers of Koalas had been introduced by local people to Phillip Island in the 1870s and to French Island in 1890s (McNally 1960; Martin and Handasyde 1999). In contrast to the population on Phillip Island, that on French Island was free of the disease Chlamydiosis, presumably because the founder animals were sub-adult and had not been infected with this sexually-transmitted disease prior to their release on the island (Martin and Handasyde 1999). Thus, the French Island population quickly achieved a rapid rate of growth and, in the early 1920s, settlers reported high population densities of Koalas, including complaints of defoliation of trees left as windbreaks around their houses (Lewis 1934; McNally 1957).

Exploitation & neglect	×	×	×								
Marooning on islands or mainland 'safe havens'			×	×	×	×					
Re-introduction to mainland habitat					×	×	×	×	×		
Translocation to protect habitat								×	×	×	×
In-situ. fertility control										×	×
Decade	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s

Figure 3. Timeline illustrating the sequence of responses to Koala over-browsing in Victoria.

Coincidently, in the early 1920s, the Chief Inspector of Fisheries and Game, Fred Lewis, initiated community-based surveys to establish the distribution of remnant Koala populations in Victoria. He did this by writing to bush schools, sawmills and other rural workplaces asking whether Koalas persisted in the district. The results of these surveys highlighted the magnitude of the decline of the Koala over most of its Victorian range and emphasised the role that extensive bushfires had played in that decline. Lewis concluded that only about 500-1000 Koalas remained in Victoria (Lewis 1934; Barrett 1937). While this population estimate is likely to have been a significant underestimate, it is clear that a drastic population decline and range contraction had occurred across most of the Koala's Victorian range. The surveys also emphasised the conservation value of the introduced population on French Island. From this information grew a plan to create further island 'safe havens', free from the threat of wildfire and disease. Requests from the French Island community for permission to cull Koalas were refused. Instead, the Victorian Government set about developing a Koala translocation program.

The practice of introducing populations of threatened species to islands where the threats operating on the mainland do not apply, known as marooning (Williams 1977), has been used successfully for many threatened species in New Zealand and for several species of mammal in Western Australia and South Australia (Abbott 2000). The earliest documented case of deliberate marooning of a threatened species took place in New Zealand in the 1890s when the New Zealand Government purchased three islands that were free of introduced predators and employed two men to capture and transfer Kakapo and other rare birds to them (Butler 1989).

Another, far less well-known, early case of marooning for conservation outcomes was the transfer of Koalas from the thriving colony on French Island to other Victorian islands and to Kangaroo Island in South Australia beginning in 1923 (Appendix 1A). At this time there was great pessimism about the ability of the species to survive on mainland Victoria due to fire and forest removal (Lewis 1934; Barrett 1937; Pratt 1937).

'*On the mainland of Victoria, I feel certain, the Koala is doomed to early extinction, and will never be re-established, excepting perhaps in some reserves which may be specially set apart for its protection and conservation, such as the Badger Creek Sanctuary, near Healesville. Such reserves however must be securely fenced to prevent the animals escaping.*' (Lewis 1934).

That the island to island translocations can be considered examples of conservation marooning is clear from the contemporary literature –

'*....it is hoped that on the three islands in Western Port the Koalas will have a safe home where the species will be preserved indefinitely*' (Lewis 1934).

Quail Island with about 3000 acres of Manna Gum *Eucalyptus viminalis* forest was considered to be a suitable 'retreat' (Lewis 1934).

'*Phillip Island and certain other islands off the coast are maintained as reservoirs of Koalas*' (Fisheries and Game Department 1956).

In a similar vein, the Fauna and Flora Protection Board of South Australia wrote to the Director of the National Museum of Victoria, Charles Kershaw, in 1923 offering the Flinders Chase Reserve on Kangaroo Island as a suitable site for the establishment of Koalas (Robertson 1978). This request was acted upon immediately by Fred Lewis; to the great cost of South Australian wildlife management some 70 years later (Koala Management Task Force 1996; Masters *et al.* 2004; Duka and Masters 2005). There is no evidence that Koalas occurred naturally on any of these coastal islands (Warneke 1978; Menkhorst 1996) so the maroonings should be considered introductions rather than re-introductions.

In reality, none of the three Western Port islands (French, Phillip and Quail Islands) provided adequate protection for Koalas, for differing reasons, and significant management intervention became necessary for each of them.

On French Island during the early 1930s there was considerable habitat degradation caused by vegetation clearing, fires lit by local farmers, and defoliation of eucalypts (Lewis 1934). Lewis ascribed the defoliation to insect attack and frequent fires, but it may well have been at least partly due to Koala browsing. This situation led Lewis to conclude that French Island could not act as the sole refuge for Koalas.

' *it became necessary then, in order to preserve the Koala, to select some other place for it, and the Fisheries and Game Department chose Quail Island, a Government reserve and sanctuary of about 3000 acres in the northern portion of Western Port Bay. To this retreat some 200-300 Koalas have now been transferred. There is an abundance of* Eucalyptus viminalis *on this island* …' (Lewis 1934).

Within a mere ten years the Quail Island population had increased to the point where the entire eucalypt canopy on the island was seriously degraded and a disastrous Koala population crash ensued (Anon 1944, 1945). This unfortunate event proved to be a watershed in public concern for Koalas, not least because of a failure of the Fisheries and Game Department (notably Fred Lewis) to acknowledge that the defoliation was caused by over-abundant Koalas rather than insect attack (Anon 1944, 1945; Martin and Handasyde 1999). As a result of public outcry, a major translocation program took place in 1944 aimed at removing all Koalas from Quail Island. Over 1300 surviving Koalas were removed and released into selected mainland habitat – the beginning of the re-introduction phase of Koala management in Victoria.

Meanwhile, Koala numbers on French and Phillip Islands were also increasing, resulting in eucalypt decline and necessitating removals of Koalas. Perhaps as a result of learning from the Quail Island experience, 865 Koalas were removed from Phillip Island in 1944, the same year as the huge Quail Island program, and a further 583 in 1945 – a remarkable achievement in wartime Australia where labour, fuel and other resources were in short supply. In the mid-1950s, efforts were also made to remove most Koalas from French Island because it was considered to have become unsuitable as a holding area due to 'closer settlement and frequent fires' (McNally 1960). A total of

2235 Koalas were removed from French Island between 1954 and 1957 and a further 883 from Phillip Island in 1957-58 (Appendix 1B, Figures 4A-4D).

Despite the over-browsing problems encountered on the three Western Port islands, and the re-introduction program being well established by the mid-1950s, the Fisheries and Game Department still considered that island 'holding areas' were essential to provide stocks for re-introduction. Other unsettled coastal islands were investigated to assess their suitability to replace French Island and Phillip Island as key holding areas. This led to the introduction of Koalas to Snake Island (1945) and Raymond Island (1953). Islands were also chosen as sites to assess the suitability of River Red Gum *Eucalyptus camaldulensis* forest as Koala habitat, leading to the release of Koalas onto two islands in the Murray River – Goat Island near Swan Hill (1952) and Loch Island at Mildura (1957). Conversely, Koalas were removed from two small islands, Chinaman Island in Western Port (1952) and Wartook Island in Wartook Reservoir, The Grampians (1957-1965), presumably to curtail incipient over-browsing problems.

The Department did acknowledge that there would be 'a constant need to remove surplus animals' from these island holding areas (McNally 1960), and instigated annual assessments of Koala numbers and tree condition on French Island. Presumably, it was considered that the value of the holding areas as reservoirs of Koalas for re-introduction outweighed the costs of monitoring and controlling the size of island populations.

The suggestion was even made that Quail Island be replanted and restocked. Two small plantations of Manna Gums were established in 1945 and an ecological burn was applied in 1946 to promote regeneration of Manna Gum and disadvantage bracken (Braithwaite *et al*. 1980). These efforts, along with natural recovery of the surviving Manna Gums, must have produced remarkable results because in April 1947, only three years after the Quail Island debacle, another 32 Koalas were released there. These animals from the Chlamydia positive Phillip Island population had lower fecundity than the original French Island stock and the population did not flourish. Koalas were last reported on Quail Island in 1978 (Braithwaite *et al*. 1980) and the population now seems to have died out (author, unpublished information).

Figure 4. Koala translocation, 1950s style (photographs from J. Cooper collection, Department of Sustainability and Environment). A – catching Koalas, French Island. B – transporting captured Koalas in sacks. C – loading Koala crates at Tankerton jetty, French Island, for transportation to the mainland. D – Phillip Island Koalas which had known only woodland of Coastal Manna Gum and Messmate, such as depicted in Figures 4A and 4B, being released into tall wet forest of Mountain Grey Gum *Eucalyptus cypellocarpa* and Manna Gum at Grey River, eastern Otway Ranges, 1958 (current release protocols do not allow the release of more than one animal into a tree (Menkhorst 2004)). This region now supports a large, high-density population of Koalas (Figure 9).

The Koala population on Phillip Island has been in steady decline since the 1970s due to declining fertility caused by Chlamydiosis combined with the impacts of a burgeoning human population (habitat loss, predation by dogs, and road deaths) (Backhouse and Crouch 1991). In contrast, and despite the gloomy predictions of Lewis and McNally, the French Island Koala population has remained free of Chlamydia and has continued to flourish – the island is sparsely settled and the road system is not conducive to high speeds. Consequently, the Koala population has a high rate of growth – doubling time roughly 3 years (Martin and Handasyde 1991) – and it is necessary to continuously remove Koalas from French Island. Since 1977 translocations have been undertaken in all but two years, at an average of 192 animals per year (n 27, range 36-591) (Appendix 1B).

3. Island populations to the rescue – phase 2 – re-introduction

With the need to remove large numbers of Koalas from Phillip and Quail Islands during the mid-1940s, the strategy for Koala conservation underwent an important shift – to a re-introduction program to mainland habitat that had remained vacant following the population decline in the early 1900s. It was hoped that this program would result in the 'partial re-establishment of the Koala in Victoria' (McNally 1957).

Firstly, mainland 'islands' were established to house Koalas in protected areas. These 'islands' were fenced areas of habitat at the Badger Creek Sanctuary [now Healesville Sanctuary, a zoo], and the Creswick and Mt Alexander 'Koala Parks'. The rationale for releasing Koalas into fenced enclosures is not clear and may have been driven as much by hopes of encouraging tourism to regional Victoria as by concern about protecting the Koalas from undefined threats.

The Mt Alexander Koala Park is the best documented (Widdowson 1947) – in 1941 a 50 acre fenced reserve was established in Manna Gum forest at about 600 m altitude on Mt Alexander, 10 km north-east of Castlemaine, and 54 Koalas from Phillip Island were introduced. The project was heavily supported by the Castlemaine Publicity and Tourist Association and local community service clubs raised money by public subscription. By 1944 the area of the enclosure had been doubled and a further 152 Phillip Island animals were introduced. In 1947 it became necessary to begin a program of applying metal bands to the trunks of over-browsed trees to prevent Koala access (Figure 5), and moving the band to a different tree after the original tree had recovered. Eventually, it became necessary to reduce the population within the enclosure and 100 Koalas were liberated into the surrounding forest. A similar structure was established at Creswick in 1942 and it was stocked with animals from Phillip Island in 1942 and 1943, and from Quail Island in 1944.

Little appears to have been recorded about the history of these two fenced enclosures, or about their effectiveness as tourist drawcards. Neither was entirely effective at retaining Koalas within the fenced area and some visitors expressed disappointment at not being able to find Koalas within the Mt Alexander enclosure. Both Koala Parks generated surplus animals that were released into the surrounding forest and further afield (Appendix 1C). The fence at the Mt Alexander Koala Park is still being maintained, although the density of Koalas on this high and exposed site is lower than that needed to satisfy tourists wishing to see Koalas.

Figure 5. Remains of a tree band applied to a Manna Gum in the Mt Alexander Koala Park during the 1940s (photographed in March 2007, author).

The Koala Parks became obsolete with the switch to a full-scale re-introduction program precipitated by the very large numbers of Koalas that needed to be rapidly removed from Quail and Phillip Islands beginning in 1944 (Appendix 1B). The sheer numbers of Koalas requiring translocation meant that a large number of suitable release sites needed to be found. Fisheries and Game Inspectors across Victoria were asked to identify potential release sites according to specific criteria that included the presence of suitable browse tree species, the area of available forest cover, and security of tenure and management, including a capacity to respond to wildfire (McNally 1960). The last criterion meant that State Forests were favoured as release sites because the Forests Commission had primary responsibility for control of wildfire and was best equipped to perform that role.

By the early 1950s the island populations were seen as on-going sources of surplus Koalas that would provide animals for the re-introduction program:

'*Phillip Island and certain other islands off the coast are maintained as reservoirs of Koalas*' (Fisheries and Game Department 1956).

'*these island populations have since provided the holding areas for koalas from which surplus animals are transported to restock suitable localities on the mainland of Victoria*' (McNally 1960) (Figure 6).

Through the 1940s, large numbers of Koalas from Phillip and Quail Islands (Appendix 1B) were released in the Daylesford area, Macedon Range, Mt Alexander, Brisbane Ranges (specifically the Durdiwarrah Water Reserve) and Strathbogie Ranges. During the 1950s most translocations were from Phillip and French Islands (Appendix 1B, Figure 4) and favoured release areas included the Grampians, Mt Cole, Wombat State Forest, the eastern slopes of the Otway Range (Figure 4D), and riverine forests along the Murray River. All these districts now have well-established Koala populations (Menkhorst 1996, Figure 7) though the population around Halls Gap in the Grampians crashed in the 1970s due to infertility caused by Chlamydiosis and that in the Macedon Range has declined since the late 1970s, commensurate with a surge in housing development. By 1960 the Department felt confident enough to claim that the 'future of the Koala in Victoria is assured' (McNally 1960), a claim that has stood the test of time (Menkhorst 1996) (Figure 7).

Small numbers of Koalas were also translocated to other States but the documentation of these is often poor. Kershaw (1934) states that some of the surplus Koalas from Wilsons Promontory in the early 1900s were sent to New South Wales, South Australia and Western Australia, but there appears to be no further record of this. French Island Koalas were also released along the Murrumbidgee River at Narrandera, where a population persists (Parsons 1990), but there is no official record of this in Victorian departmental files. Finally, and most bizarrely, Koalas from the Mt Alexander Koala Park were used to found a colony in Yanchep National Park, Western Australia.

Despite the efforts of the Victorian wildlife agency to prevent severe over-browsing and Koala suffering, there were regular outbreaks during the late 20th Century, on islands and in isolated patches of coastal Manna Gum forest on the mainland (Table 1). Severe defoliation, tree deaths and Koala population crashes occurred at Sandy Point in the mid 1980s, on Snake Island in the mid 1990s (Figure 1A), at Framlingham in 1997-98 (Figures 1B, 1C) (Martin and Handasyde 1999), and at Raymond Island in 2004 (Figure 1D). In recent years, timely management interventions in the form of initial population reductions by translocation followed by the application of hormone-based contraception have prevented severe defoliation at Tower Hill Game Reserve and may do so Mt Eccles National Park, where more than 6000 ha of Manna Gum forest is threatened.

In the 83 years between 1923 and 2006, over 24 600 individual animals were translocated to over 250 release sites across Victoria (Appendix 1A, B, and C), probably the most sustained and extensive wildlife re-introduction program ever undertaken.

4. In-situ population control to protect other natural values

Although the conservation of the Koala had been a primary aim of the translocation program since 1923, it was usually not the sole reason because prevention of tree death caused by over-browsing was frequently an additional concern. However, the re-introduction program was effectively complete by about the mid-1980s

Figure 6. Display prepared for the Royal Melbourne Show, 1957, indicating Koala 'holding areas' (French Island and Phillip Island) and major 're-stocking areas' (Grampians, Mt Cole, Castlemaine [Mt Alexander], Stony Rises, Brisbane Ranges, Mornington Peninsula) (photograph from J. Cooper collection, Department of Sustainability and Environment).

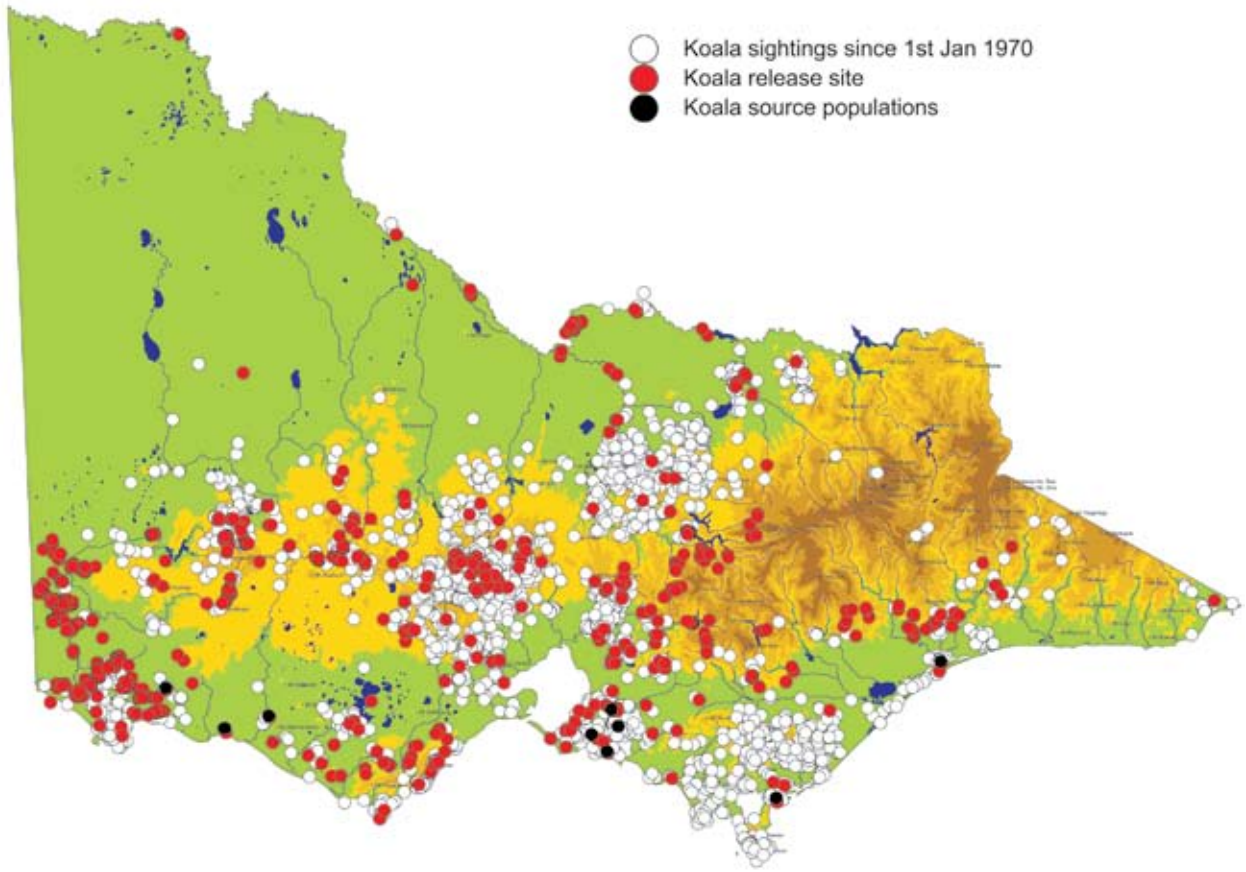

Figure 7. Distribution of principal source populations (black dots), all documented release sites (red), and post 1970 Koala sighting records (white). From west to east the source populations are: Mt Eccles National Park, Tower Hill Game Reserve, Framlingham forest, Sandy Point, Phillip Island, Quail Island, French Island, Snake Island, Raymond Island. Data from Atlas of Victorian Wildlife database, Department of Sustainability and Environment.

and it was clear that translocation could no longer be the sole solution to Koala over-browsing (Martin 1989). Further, there was increasing public concern over the animal welfare aspects of Koala over-browsing and the translocation program. Despite these factors, translocation has continued until the present because it is the only politically acceptable and practicable means of rapid population reduction. Most of the translocations since the mid 1980s should be considered re-stocking rather than re-introduction because there were few release areas that did not already support a Koala population. The recommendation of Martin (1989) that animals

Table 1. Over-browsing events that have required active management in Victoria.

Area	Years	Management response
Wilsons Promontory	1905-1910	Translocation locally and interstate, cull
French Island	1923-present	Translocation (marooning and re-introduction), research into physiological and behavioural effects and effectiveness of 3 different hormone implants in females, and vasectomy of males.
Phillip Island	1941-1978	Translocation (marooning and re-introduction).
Quail Island	1944-1945	Translocation (marooning and re-introduction).
Sandy Point	1985-2000	Translocation (re-stocking).
Snake Island	1992-present	Translocation (re-stocking) of surgically sterilised animals, trial of immunocontraception (2000-2003).
Tower Hill	1996-2003	Translocation (re-stocking) followed by in-situ fertility control via hormone implants.
Framlingham	1997-1999	Translocation (re-stocking) of intact females and surgically-sterilised males.
Mt Eccles	1999-present	Translocation (re-stocking) of surgically sterilised animals, in-situ fertility control via hormone implants.
Raymond Island	2004	Translocation, trial of commercial hormone implant.
Eastern Otway Ranges	2002-present	May not be practicable – population very large, rugged topography, very tall trees.

from Chlamydia negative populations not be released into areas where Chlamydia is present is unable to be met because Chlamydia is now known to be endemic and widespread through Victorian Koala populations (Emmins 1996). Further, the habitat at the three known Chlamydia-free populations (French Island, Tower Hill Game Reserve and Framlingham) is already in a state of decline due to over-browsing, and artificially increasing those populations would be counter-productive. However, clinical cases of Chlamydiosis are rare in most Victorian Koala populations and the disease is thought to have no epizootic potential (Emmins 1996).

Lethal methods of population reduction are widely used on other marsupial species throughout Australia (for example various species of kangaroo and wallaby, Common Brushtail Possum, and Common Wombat). Shooting would likely be the most cost-effective means of rapidly reducing Koala populations (Martin 1997, Tyndale-Biscoe 1997; Duka and Masters 2005), however, lethal means of population control have not been authorised for the Koala since the 1920s because of its iconic status and public image. At a meeting of the Australian and New Zealand Environment and Conservation Council (a forum of State, Commonwealth and New Zealand Environment Ministers) held in May 1996, culling was rejected as a management tool. Consequently, it was not considered during preparation of the National Koala Conservation Strategy published in 1998 (ANZECC 1998).

Counter balancing concerns for individual animal welfare is the increasing concern amongst land managers and conservationists about the ecological damage resulting from Koala over-browsing (Koala Management Task Force 1996; ANZECC 1998; Masters *et al.* 2004; Menkhorst 2004).

The search for an alternative to translocation began in earnest in 1995 when the Department of Natural Resources and Environment commissioned a review of fertility control options (Middleton 1996a). The outcome of the review was a recommendation to conduct separate field trials of the effectiveness of two techniques – slow-release implants of a progestin hormone or oestradiol to females, and vasectomy of males (Middleton 1996b). Implementation began in late 1996, despite opposition from some quarters because it was feared that the program would divert money away from other urgent wildlife research and management programs, and because of doubt about the efficacy of male sterilisation (eg. Anderson 1996). So began a decade of intensive research and adaptive management trials by the Victorian and South Australian wildlife management agencies to develop methods for in-situ population control (Table 2).

In Victoria, these trials have been guided by an expert advisory committee, the Koala Technical Advisory Committee, convened jointly by the two Government agencies with primary responsibility for

Table 2. Fertility control trials and population management programs other than translocation undertaken on Koalas in Victoria and South Australia.

1. Population reduction by translocation followed by hormone implant contraception of remaining females	Tower Hill 1996-2003 (Middleton *et al.* 2003, DSE and EcoPlan Australia unpublished)				
2. Male sterilisation followed by release at capture site	French Island 1996 to 1998 (Menkhorst *et al.* 1998, DSE and EcoPlan Australia unpublished))				
3. Surgical sterilisation followed by translocation	Kangaroo Island 1997 to 2001 (Duka and Masters 2005)	Snake Island 1999 (Parks Victoria 2003b)	Mt Eccles National Park 1999 (both sexes)-2000 (females only) (Parks Victoria 2003a)	Framlingham 1998 (males only) (DSE and EcoPlan Australia unpublished)	French Island 2000 (females only) (Parks Victoria unpublished)
4. Surgical sterilisation followed by delayed translocation	Snake Island 2000 to present (Parks Victoria unpublished)				
5. Immunocontraception	Snake Island 2000-2003 (Kitchener *et al.* in prep)				
6. Hormone implants to females followed by release at capture site	Mt Eccles National Park 2004-present – levonorgestrel (Parks Victoria unpublished)	French Island 2004-2007 – levonorgestrel and etonogestrel (E. Hynes, University of Melbourne unpublished), 2006-present – Suprelorin (A. Greenwood, University of Melbourne unpublished)	Raymond Island 2006-present – Suprelorin (A. Greenwood, University of Melbourne unpublished)		

Koala management, the Department of Sustainability and Environment and Parks Victoria. The committee's role is to advise the two Government agencies on technical matters relating to Koala management. Its primary focus in recent years has been to advise on adaptive-management trials to assess a range of fertility control techniques for their efficacy, ethics and cost-effectiveness.

A six-year field trial of subdermal implants containing either the synthetic progestin levonorgestrel, or low doses of oestradiol, applied to female Koalas, began at Tower Hill Game Reserve in 1997. This trial indicated that a contraceptive rate of 100% could be maintained for up to six years using levonorgestrel implants, representing at least 60% of the reproductive life of a female Koala (Middleton *et al.* 2003; DSE unpublished data). A trial of the impact of vasectomy of male Koalas was also conducted at Red Bill Creek on French Island between November 1996 and October 1998. By vasectomising all males captured on the study site (the proportion of treated males on site varied over time because the population was not a closed one) this program reduced the proportion of females carrying pouch young from 87% at the beginning of treatments to 36% over two breeding seasons (DSE unpublished data).

Meanwhile, severe over-browsing problems were emerging on Snake Island and at Mt Eccles National Park. Because the hormone implant trials had not been completed, surgical sterilisation of females, by transection and bipolar cautery of the distal oviduct, as undertaken by the South Australian Government on Kangaroo Island (Masters *et al.* 2004; Duka and Masters 2005), was initiated on Snake Island in 1999, and at Mt Eccles National Park the following year. In both these Victorian cases it was found that the combination of surgical sterilisation and immediate translocation could result in high levels of mortality (up to 90% in one treatment group) (Parks Victoria 2003a) and the practice was abandoned. On Snake Island surgical sterilisation of males and females has continued but sterilised animals are released on the island and are translocated off the island when captured in subsequent years (Parks Victoria 2003b). The aim of removing all Koalas from Snake Island, part of the Nooramunga Marine and Coastal Park, is now within sight after eight years of intensive effort in which over 1100 male and over 1600 female Koalas have been surgically sterilised. Most of these sterilised animals have also been removed from the island to adjacent mainland habitat (Parks Victoria unpublished data).

Based on the results of the hormone implant trial (Middleton *et al.* 2003), and the animal welfare concerns associated with surgical sterilisation, a large-scale trial of the efficacy of hormone implants at the population level was begun at Mt Eccles National Park in 2004. The Koala population there was estimated at 11 000 animals (Wood 2004) with a sex ratio a little below parity and female fertility rate of 38% (Chlamydia is present in the population) (McLean 2003). Therefore, it was estimated that there were about 2100 fertile females present. Over the three years to 2006, 2450 females were implanted (Figure 8), a level of treatment that is approaching the 75% of fertile females required to produce a significant population decline (N. McLean unpublished). This trial gives hope that most of the Koala populations currently causing significant defoliation can be held at sustainable population densities via a determined contraception program using levonorgestrel implants. Fortunately, three of the four current over-browsing populations (Tower Hill Game Reserve, French Island, Raymond Island) are considerably smaller than that at Mt Eccles. The Mt Eccles program also included the development of a koala-forest model to help evaluate the long-term consequences of different levels of fertility control on both the Koalas and their food supply (the Manna Gum forest) (Todd et al. in press). The model allows the assessment of the most ecologically and financially desirable target population size for the National Park (1000 adults).

There is currently no practicable response available, within the levels of resourcing provided for wildlife management in Australia, to manage larger populations that are causing serious over-browsing, such as those on Kangaroo Island (SA) (estimated 30 000 Koalas) and in the eastern Otway Ranges (Figure 9) and Strathbogie Ranges (Victoria) (population sizes unknown but likely to be many tens of thousands in each).

The potential of an anti-fertility vaccine was also investigated at Snake Island between 2000 and 2003 using as antigens both porcine zona pellucida and a constituent protein of the zona pellucida from the Common Brushtail

Figure 8. Veterinarian inserting sub-dermal, slow-release hormone implant between the shoulder blades of sedated female Koala, Mt Eccles National Park, October 2004 (photograph – author)

Possum. Immunisation with porcine zona pellucida led to a significant reduction in fertility in female Koalas with antigen-specific antibody still detected 33 months after initial immunisation treatment (Kitchener *et al.* in prep).

In 2004, a bid for funding under the Australian Research Council's Linkage Grant program resulted in funds for a five-year program of research into the efficacy, on large populations, of a commercially-available contraceptive implant developed for the pet industry, the GnRH super agonist Suprelorin (Peptech Animal Health Pty Ltd). A potential advantage of Suprelorin is that, as a liquid rather than a powder, it may be amenable to remote delivery via a darting system. This project will also assess the impact of fertility control on population genetics in the Koala (Herbert 2007).

Figure 9. Tourists drive through severely over-browsed forest dominated by Southern Blue Gum *Eucalyptus globulus* along the Great Ocean Road near Kennett River, eastern Otway Ranges, January 2008. Numerous Koalas can be readily viewed from the roadside, descendents of animals released nearby in the Grey River Reserve in 1958 (Figure 4D), 1977 and 1982.

Figure 10. Over-browsing at Wilsons Promontory, approx. 1905-1910, the first documented case of Koala over-browsing (from Barrett 1937).

DISCUSSION

Causes of over-browsing by the Koala

The capacity for Koalas to cause serious over-browsing of preferred food trees was first documented by members of an expedition to Wilsons Promontory conducted by the Victorian Field Naturalists Club in 1905. This expedition preceded the declaration of Wilsons Promontory as Victoria's first national park (Garnett 1971) and, although hunting parties had shot hundreds of Koalas for their pelts during the preceding winters (Kershaw 1934), the interior of the promontory was uninhabited, difficult to access and rarely visited. At Red Hill at the foot of the Yanakie Isthmus, the field naturalists found a dense population of Koalas that were noted to be in poor condition, in an area of Swamp Gum *Eucalyptus ovata* which had been seriously defoliated. Some years later the dead Swamp Gums were still plainly evident (Kershaw 1915) (Figure 10). Likewise, in the valley at Oberon Bay, the 1905 party attributed the decline in health of Manna Gums to Koala over-browsing (Kershaw 1934) and remedial action in the form of relocation of Koalas to other parts of the Promontory and interstate, and some culling, was instigated in about 1910-12 – the first Koala management for conservation purposes (to protect the community of flora and fauna that was threatened by Koala over-browsing).

Koala over-browsing is confined to southern Australia. It is not known to occur on Queensland islands to which the Koala has been introduced (A. Melzer, Central Queensland University pers. comm.). Most cases of Koala over-browsing have three characteristics:

1) they involve one of the coastal subspecies of the Manna Gum *Eucalyptus viminalis* ssp *pryoriana* or ssp *cygnatensis*, or the Swamp Gum, and often other palatable species of eucalypt growing nearby are ignored, or eaten only as a last resort, for example Messmate *E. obliqua* at Framlingham and on Snake Island.
2) Koala population densities are high, at least 2 per ha.
3) they occur either on islands, or in situations with poor habitat connectivity and therefore with limited dispersal opportunities[2].

This last characteristic has led to claims that over-browsing could be overcome by increasing connectivity of habitat. While increased connectivity is to be welcomed, there is ample evidence that, even in the absence of barriers to movement, Koalas are incredibly reluctant to leave favoured stands of trees – the first documented case of Koala over-browsing on Wilsons Promontory had ample habitat connectivity but trees were still killed (Figure 10) before the Koalas chose to disperse, and the current situation around Kennet River and Grey River in the eastern Otway Range (Figure 10) has contiguous forest habitat over more than 140 000 ha of the Great Otway National Park and Otway Forest Park. Therefore, lack of connectivity of habitat is not a pre-requisite for over-browsing to occur – although it has been the usual situation through the twentieth century. This may be an artefact of the translocation program combined with the extensive habitat fragmentation that has occurred in Victoria since the late 1800s.

Observations of over-browsing in a natural population at Wilsons Promontory in 1905 (Figure 9), and by Martin (1985a, b) in another natural population in South Gippsland during the early 1980s, refute recent claims that over-population, and consequently over-browsing, are products of the social disruption caused by translocation (Phillips 2000). These observations support the hypothesis

[2]Koalas are actually quite accomplished travelers and are capable of crossing many km of inhospitable habitat such as cleared farmland and pine plantations (e.g. Lee *et al.* 1991, Santamaria 2002, Parks Victoria 2003a).

that Koala populations may naturally have undergone population fluctuations in their patchy preferred habitat (Martin 1985b). Of course, fragmentation of habitat has greatly exacerbated the impact of these fluctuations on the habitat and on Koala populations by limiting the capacity to disperse, thereby increasing the necessity to take effective management action.

Outcomes of the translocation program

Koalas are now widespread in coastal and lowland forests and woodlands across southern, central and north-eastern Victoria, roughly south of the 500 mm isohyet and below about 700 m altitude (Menkhorst 1996) (Figure 7). Populations also extend into the drier Riverina region in narrow corridors of riverine forest along the Goulburn and Murray Rivers, downstream to the Swan Hill area (Menkhorst 1996; M. Rohde pers comm). This distribution probably approximates the distributional range of the Koala at the time of European settlement (Warneke 1978; Martin 1989). However, the current distribution is far more fragmented due to extensive clearing of forest and woodland for pastoral and agricultural industries.

The claim that the translocation program has been a major conservation success is made from a population conservation perspective rather than the individual animal welfare perspective frequently adopted by its critics. It is acknowledged that large numbers of Koalas would have suffered considerable discomfort and an unknown number did not survive the translocation and release process. In most cases little or no monitoring of translocated individuals took place – it was generally impractical to do so, especially before the development of radio-telemetry technology during the late 1970s. The standard level of monitoring consisted of two follow-up visits to the release site – one and two weeks after release – to search for debilitated animals. Few were found, but no conclusions about the fate of the translocated individuals can be drawn from such unstructured and qualitative assessments. However, the fact that Koala populations have been re-established virtually throughout the remaining suitable habitat across the former range of the species indicates that enough animals survived for population establishment. Further, there can be no doubt that far greater distress and mortality would have resulted from a strategy of allowing isolated populations to crash, as clearly shown at Quail Island in 1944, Sandy Point in 1986, and Framlingham in 1997.

Studies of the fate of translocated animals have generally shown high levels of survivorship, even when released into entirely unfamiliar forest communities and forest structure (Lee *et al.* 1991; Santamaria 2002; Parks Victoria 2003b; DSE unpublished data from Raymond Island). However, there have been some exceptions, notably in south-west Victoria in 2002 (Parks Victoria 2003a). Important factors in determining the survivorship of translocated Koalas have been identified as habitat quality at the release site, the physical condition of the individual animal (M. Lynch, Veterinarian, Zoos Victoria unpublished data), avoidance of cold and wet weather during capture, translocation and release, and minimisation of time between capture and release (Martin 1989; Menkhorst 2004).

Fertility control trials

Since the mid 1990s the Koala over-browsing problem has stimulated significant research into methods of in-situ fertility control in marsupials (Middleton *et al.* 2003, Duka and Masters 2005, Herbert 2007). Large-scale field trials of progestin hormone implants conducted in Victoria at Tower Hill (Middleton *et al.* 2003) and Mt Eccles National Park (Parks Victoria unpublished data) suggest that this technique is practicable, though costly (exact costings are not available but a reasonable estimate of the cost of a large-scale hormone implant program is around $200 per treated animal). It is now proposed that progestin hormone implants will become the principal fertility control method for over-abundant Koala populations in Victoria (Menkhorst 2004).

Genetic issues

Unfortunately, the stock used to found the French Island population in about 1898 probably comprised only a few animals (Houlden *et al.* 1996), thereby creating a severe genetic bottle-neck. The founders for the Phillip Island population were more numerous and from a greater geographical range, but never-the-less also represent a significant genetic bottleneck. The genetic bottle-neck effect was then amplified when subsets of these populations were marooned on other islands, resulting in significant inbreeding.

An unforeseen consequence of using these populations to restock the Victorian mainland is likely to have been the genetic swamping of any remnant populations by the restricted and inbred island gene pool. Thus, the level of genetic variation in Victorian Koala populations established through translocation is significantly lower than that found in the major relict Victorian population (South Gippsland) and across comparable areas in NSW and Qld (Emmins 1996; Houlden, *et al.* 1996, 1999). Therefore, there is a higher threat of inbreeding depression in Victorian Koala populations than in Koala populations further north (Emmins 1996).

Although genetic theory predicts that populations with low genetic variation will have lower survival prospects, there is currently no evidence that the population growth potential of Victorian Koalas is being constrained by their genetic history. On the contrary, many populations derived from island stock are flourishing, for example in the eastern Otway Ranges. However, given the finding that a higher than normal proportion of male Koalas on French Island exhibit testicular aplasia (Seymour *et al.* 2001), it would be prudent to be alert to signs of inbreeding depression in Victorian Koalas (Sherwin *et al.* 2000).

In South Gippsland, including the Strzelecki Ranges, remnants of the original gene pool survive, thanks to a strong remnant population and few releases of island stock (Emmins 1996). For this reason, Koala management strategies have recommended against translocation into South Gippsland (Martin 1989; Menkhorst 2004). It is also probable that Koalas east of the Snowy River, except those immediately around Mallacoota township, are largely unaffected by the translocation program (see Figure 7).

Assessing the effectiveness of the translocation program

Any fair assessment of the success of the translocation program using modern criteria and standards (IUCN 1998) should give due regard to the original aims of the program, and how these changed through time. It is also important to have regard for the knowledge available at a given time and the prevailing attitudes towards wildlife. In 1923, the science of genetics was in its infancy, and the concepts of inbreeding and small founder size were not well articulated. Therefore, it is perhaps not fair to point to the genetic consequences of the re-introduction program as evidence of a failure of the program. That criticism can be more fairly applied to management from about 1970 onwards when alternatives to translocation could have been more vigorously pursued.

Table 3 presents a qualitative assessment of the degree to which the important considerations in planning a re-introduction program (as defined by IUCN 1998) were considered during the three phases of management of Koalas in Victoria. Given that the program preceded the IUCN guidelines by up to 70 years, and that the science of conservation biology has developed only since about 1980, the program stands up well against these modern criteria.

The marooning phase succeeded in establishing populations on all the coastal islands to which Koalas were taken and these island populations provided ample stock for the re-introduction program. However, significant management problems were created: the on-going management of population levels on all of the islands has consumed a major component of Victoria's wildlife management budget ever since; the ecological cost to the island's indigenous floral and faunal communities has never been properly investigated or documented, but is likely to have been serious in all cases (for example Figure 1); severe genetic bottle-necks were created, and the animal welfare cost has been significant.

The re-introduction phase was clearly successful because populations have persisted and expanded over several decades (up to six) in most regions where releases took place (Figure 7). There are now many times more Koalas in Victoria than there were in 1944 when the re-introduction phase began. However, neither the animal welfare cost, nor the financial cost, was ever adequately documented, and the genetic cost is, perhaps, yet to become clear. The habitat protection phase has been successful at some sites, such as French Island, where an adequate and timely translocation program has been in place for over 50 years, but has been less successful at sites where translocations were too limited or too late, for example Sandy Point (1985), Snake Island (1992) and Framlingham (1997).

Initiation of research to develop acceptable alternatives to translocation came too late to allow a seamless transfer from translocation to in-situ population control. After a decade of research it is still not certain that a practicable method that meets animal welfare standards and expenditure targets will be found. Sub-dermal, slow-release hormone implants containing levonorgestrel provide the most promising means of limiting population growth, but, on their own, will not produce a rapid population reduction. Therefore, this technique needs to be applied long before unsustainable population densities are reached. Continuing exploration of other avenues of population control is essential.

Table 3. Assessment of consideration given to relevant criteria during each phase of the translocation program. n – little or none; p – partially considered; y – considered; na – not applicable.

Consideration	Phase		
	Marooning	Re-introduction	In-situ
Stakeholder approvals	P	Y	Y
Commitment of long-term financial and political support	P	P	P
Access to technical advice	P	P	Y
Appropriate taxon – close genetic relationship to original stock	Y	Y	NA
Intra-specific variation considered	N	P	NA
Critical needs understood	P	P	NA
Potential ecological impacts understood	N	P	P
Optimal number and composition understood	N	P	P
Assured long-term protection of release areas	Y	P	Y
Habitat adequate	N	P	NA
Threats controlled	Y	P	P
Impacts on donor population assessed	N	P	NA
Veterinary screening process established	N	N	Y
Monitoring and success indicators agreed	N	N	Y
Decision process for revision, rescheduling, discontinuation	N	N	Y
Transport plan developed	Y	Y	NA
Release strategy in place	?	P	NA
Policy on interventions agreed	?	N	P
Collection and investigation of mortalities	N	P	Y
Documentation of outcomes	N	P	Y

Despite the cost and the threat of problems caused by reduced genetic variation, the re-establishment of the Koala in almost all remaining habitat across most of its original Victorian distribution can be considered the most successful wildlife management program undertaken in that State. It can also reasonably be claimed to be a successful threatened species recovery program, one of very few ever achieved in Victoria, and it would not have been possible were it not for the fortuitous creation of two introduced island colonies (Warneke 1978), and the decision in 1923 to create more of them.

Conclusion

The Koala in southern Australia provides a unique wildlife management challenge. It is declining in some regions yet is prone to extreme over-abundance in others. It causes serious ecological damage and animal welfare crises when population levels exceed food availability, yet attracts enormous public support and concern. The management of these issues by the Victorian Government over 80 years has provided valuable lessons in wildlife management. It represents a unique, long-term conservation management trial that has succeeded on one level, but has inadvertently generated several intractable population management issues which are yet to be fully resolved. The management of over-abundant Koalas has highlighted a public expectation that non-lethal control methods can be effective to manage wildlife populations. The development of practicable, ethically-acceptable and cost-effective means of meeting this expectation remains a major challenge for wildlife managers.

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References

Abbot, I. 2000. Improving the conservation of threatened and rare mammal species through translocation to islands: case study Western Australia. *Biological Conservation* **93**: 195-2001.

Anderson, I. 1996. First catch your koala… *New Scientist* (Australian edition), 28 September 1996.

Anonymous 1944. Last scene of all… *Wild Life* 6: 278-279.

Anonymous 1945. The tragedy of the koala bear. *Picture Post*, March 10 1945:16-17.

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

Backhouse, G. B. and Crouch, A. 1991. Koala management in the Western Port region, Victoria. Pp. 313-317 in *Biology of the Koala* ed. by A. K. Lee, K. A. Handasyde and G. D. Sanson. Surrey Beatty and Sons, Chipping Norton, NSW.

Barrett, C. 1937. *Koala: the story of Australia's native bear*. Robertson and Mullens, Melbourne.

Braithwaite, R. W., Lumsden, L. F. and Dixon, J. M. 1980. A short history of Quail Island. Pp. 44-48 in *Sites of Zoological Significance in the Westernport Region, Interim report 'Top of the Bay Area'*. National Museum of Victoria, Melbourne.

Butler, D. 1989. *Quest for the Kakapo: The full story of New Zealand's most remarkable bird*. Heinemann Reed, Auckland.

Department of Environment and Heritage, 2006. Advice for the Minister for the Environment and Heritage from the Threatened Species Scientific Committee on amendments to the list of threatened species under *Environment Protection and Biodiversity Conservation Act* 1999. 1. *Phascolarctos cinereus* (Koala). Accessed from http://www.environment.gov.au (biodiversity/threatened/species/pubs/koala) on 27 February 2007.

Dingle, T. 1984. *The Victorians: Settling*. Fairfax, Syme and Weldon, Sydney.

Duka, T. and Masters, P. 2005. Confronting a tough issue: Fertility control and translocation for over-abundant Koalas on Kangaroo Island, South Australia. *Ecological Management and Restoration* 6(3): 172-181.

Emmins, J. J. 1996. *The Victorian Koala: Genetic heterogeneity, immune responsiveness and epizootiology of Chlamydiosis*. Unpublished PhD thesis, Department of Pathology and Immunology, Monash University, Melbourne.

Fisheries and Game Department, 1956. *The Koala in Victoria*. Roneoed pamphlet, 2 foolscap pages, issued May 1956.

Garnett, J. Ros, 1971. National Parks and Nature Conservation Reserves in Victoria. Pp. 151-159 in *The Last of Lands* Ed by L. J. Webb, D. Whitelock and J. Le Guy Brereton. Frederick Warne and Co., London.

Herbert, C. A. 2007. From the urban fringe to the Abrolhos Islands: management challenges of burgeoning marsupial populations. Pp 129-141 in *Pest or Guest: the zoology of overabundance*, edited by D. Lunney, P. Eby, P. Hutchings and S. Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.

Hindell, M. A. and Lee A. K. 1991. Tree preferences of the Koala. Pp. 117-121 in *Biology of the Koala* ed. by A. K. Lee, K. A. Handasyde and G. D. Sanson. Surrey Beatty and Sons, Chipping Norton, NSW.

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

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

Hrdina, F. and Gordon, G. 2004. The koala and possum trade in Queensland, 1906-1936. *Australian Zoologist* **32**: 543-585.

Hundloe T. and Hamilton C. 1997. *Koalas and Tourism: An economic evaluation*. Discussion paper 13. The Australia Institute, Canberra.

IUCN 1998. *Guidelines for Re-introduction*. Prepared by the IUCN/SSC Re-introduction Specialist Group. IUCN, Gland, Switzerland.

Kershaw, J. A. 1906. Excursion to Wilson's Promontory – General Zoology (except Mollusca). *Victorian Naturalist* **22**: 197-203.

Kershaw, J. A. 1915. Excursion to National Park, Wilsons Promontory. *Victorian Naturalist* **31**: 143-152.

Kershaw, J.A. 1934. The koala on Wilson's Promontory. *Victorian Naturalist* 51: 76-77.

Koala Management Task Force. 1996. Final report. Unpublished report to the Government of South Australia, November 1996.

Lee, A. K. and Martin, R. W. 1988. *The Koala: A natural history*. University of New South Wales Press, Sydney.

Lee, A. K., Martin, R. W. and Handasyde, K. A. 1991. Experimental translocation of Koalas to new habitat. Pp. 299-312 in *Biology of the Koala* ed. by A. K. Lee, K. A. Handasyde and G. D. Sanson. Surrey Beatty and Sons, Chipping Norton, NSW.

Le Souef, A. S. 1925. The Australian native animals. How they stand today and the cause of the scarcity of certain species. Pp. 175-184 in Barrett, Sir J. (Ed) '*Save Australia: A plea for the right use of our flora and fauna*'. McMillan and Co., Melbourne.

Le Souef, A. S. and Burrell, H. 1926. *The Wild Animals of Australia, embracing the mammals of New Guinea and the nearer Pacific Islands*. George G. Harrap and Co., Sydney.

Lewis, F. 1934. The Koala in Victoria. *Victorian Naturalist* 51: 73-76.

Lewis, F. 1954. The rehabilitation of the Koala in Victoria. *Victorian Naturalist* 70: 197-200.

Lunney, D. and Leary, T. 1988. The impact on native animals of land use changes and exotic species in the Bega district, New South Wales, since settlement. *Australian Journal of Ecology* 13: 67-92.

Lydekker, R. 1894. *A Handbook to the Marsupialia and Monotremata*. W. H. Allen and Co., London.

Martin, R.W. 1985a. Overbrowsing and decline of a population of the koala, *Phascolarctos cinereus*, in Victoria. I. Food preference and food tree defoliation. *Wildlife Research* 12: 355-365.

Martin, R.W. 1985b. Overbrowsing and decline of a population of the koala, *Phascolarctos cinereus*, in Victoria. III. Population condition. *Wildlife Research* 12: 377-385.

Martin, R.W. 1989. Draft management plan for the conservation of the koala (*Phascolarctos cinereus*) in Victoria. *Arthur Rylah Institute for Environmental Research Technical Report Series* Number 99, Department of Conservation, Forests and Lands, Melbourne.

Martin, R.W. 1997. Managing over-abundance in koala populations in south-eastern Australia – future options. *Australian Biologist* 10: 57-63.

Martin, R. and Handasyde, K. 1991. Population dynamics of the Koala (*Phascolarctos cinereus*) in southeastern Australia. Pp. 75-84 in *Biology of the Koala* ed. by A. K. Lee, K. A. Handasyde and G. D. Sanson. Surrey Beatty and Sons, Chipping Norton, NSW.

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

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

McLean, N. 2003. *Ecology and management of overabundant koala (Phascolarctos cinereus) populations*. Unpublished PhD thesis, Department of Zoology, The University of Melbourne.

McNally, J. 1957. A field survey of a koala population, *Proceedings of the Zoological Society of New South Wales*, 1955-56: 18-27.

McNally, J. 1969. Koala management in Victoria. *The Australian Museum Magazine* 13(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: 619-628.

Menkhorst, P.W. (Ed.) 1996. *Mammals of Victoria: Distribution, ecology and conservation*. Second, revised edition. Melbourne, Oxford University Press.

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

Menkhorst, P., Middleton, D. and Walters, B. 1998. Managing over-abundant Koalas (*Phascolarctos cinereus*) in Victoria: A brief history and some potential new directions. In Managing Marsupial Abundance for Conservation Benefits. *Occasional Papers of the Marsupial* CRC No. 1. Proceedings of a symposium held at the Society for Conservation Biology Conference, Sydney, July 1998. Pp. 19-29.

Middleton, D. 1996a. *Fertility control in the management of free-ranging populations of the koala (Phascolarctos cinereus) in south-eastern Australia. Part One. Fertility Control Options, Techniques and Recommendations*. Unpublished report to Department of Natural Resources and Environment, Victoria by Ecoplan Australia, Lilydale.

Middleton, D. 1996b. *Fertility control in the management of free-ranging populations of the koala (Phascolarctos cinereus) in south-eastern Australia. Part Two. Fertility control trials, plan for implementation*. Unpublished report to Department of Natural Resources and Environment, Victoria by Ecoplan Australia, Lilydale.

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

Parks Victoria, 2003a. *Post-release monitoring of surgically sterilised and relocated Koalas, Mt Eccles National Park, Victoria*. Unpublished report, Parks Victoria, Melbourne.

Parks Victoria, 2003b. *The impact of relocation on the health and survival of sterilised adult female Koalas* (Phascolarctos cinereus) *at Snake Island and Gellions Run, Nooramunga Marine and Coastal Park*. Unpublished report, Parks Victoria, Melbourne.

Parris, H. S. 1948. Koalas on the lower Goulburn. *Victorian Naturalist* **64**: 192-193.

Parsons, G. 1990. Narrandera koala colony: a brief history of the Koalas in the Narrandera Nature Reserve. P. 69 in *Koala Summit: Managing Koalas in New South Wales* ed by D. Lunney, C. A. Urquhart and P. Reed. New South Wales National Parks and Wildlife Service, Sydney.

Phillips, S. 2000. Population trends and the Koala conservation debate. *Conservation Biology* 14: 650-659.

Phillips, W. 1990. *Koalas: the little Australian we'd all hate to lose*. Australian National Parks and Wildlife Service, Canberra.

Pratt, A. 1937. *The Call of the Koala*. Robertson and Mullen, Melbourne.

Robertson, A. C. 1978. The Koala in South Australia. In: T.J. Bergin, Ed. *The Koala: Proceedings of the Taronga Symposium*. Sydney, Zoological Parks Board of NSW. Pp. 132-143.

Santamaria, F. 2002. *Outcomes and implications of a Koala translocation in the Ballarat region*. Unpublished PhD thesis, University of Ballarat, Ballarat, Victoria.

Seebeck, J. H. 1988. *The Victorian mammal fauna: development of a conservation perspective*. Unpublished MSc thesis, Department of Zoology, The University of Melbourne.

Seymour, A. M., Montgomery, M. E., Costello, B. H., Ihle, S., Johnsson, G., St John, B., Taggart, D. and Houlden, B. A. 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., Timms, P., Wilcken, J. and Houlden, B. 2000. Analysis and conservation implications of Koala genetics. *Conservation Biology* **14**: 639-649.

Strahan, R. and Martin, R. W. 1982. The Koala: Little fact, much emotion. Pp 147-155 in *Species at Risk: Research in Australia*. Ed. by R. H. Groves and W. D. L. Ride. Australian Academy of Science, Canberra.

St John, B. 1997. Risk assessment and Koala management in South Australia. *Australian Biologist* 10(1): 47-56.

Tabart, D. 1996. The Australian Koala Foundation's role in Koala conservation. Pp 178-184 in *Koalas – research for management*. Proceedings of the Brisbane Koala Symposium, 22-23 September 1990.

Tabart, D. 1997. Why the Koala should not be culled, when the real problems are poor land management and land degradation. *Australian Biologist* 10(1): 40-46.

Todd, C. R., Forsythe, D, M. and Choquenot, D. in press. Modelling the effects of fertility control on koala-forest dynamics. Journal of Applied Ecology.

Troughton, E. 1941. *Furred Animals of Australia*. Angus and Robertson Ltd, Sydney.

Tyndale-Biscoe, H. 1997. Culling Koalas with kindness. *Search* 28: 250-251.

US Fish and Wildlife Service. 2000. Final determination of threatened status for the Koala. *Federal Register* 65(90): 26762-26771.

Warneke, R.M. 1978. The status of the koala in Victoria. Pp. 109-114 in *The Koala: Proceedings of the Taronga Symposium*, edited by T.J. Bergin. Sydney, Zoological Parks Board of NSW.

Widdowson, P. E. 1947. Koalas thrive in new home. *Wildlife*, Aug: 299-302.

Williams, G. R. 1977. Marooning – a technique for saving threatened species from extinction. *International Zoo Yearbook* **17**: 102-106.

Wood, M. 2004. Mt Eccles National Park Koala population survey, September 2004. Unpublished report to Parks Victoria by Australian Ecological Research Services, Portland.

APPENDIX 1

Appendix 1A. Releases of Victorian Koalas onto Islands

Release island	Source population	Year	Number	Notes
French Is.	Corinella area	1898?	? 2 ♀	
Phillip Is.	West Gippsland, Mornington Pen.	Late 1800s	?	
Phillip Is.	French Is.	1923	50	
Kangaroo Is.	French Is.	1923	6	South Australia
Kangaroo Is.	French Is.	1925	12	South Australia
Quail Is.	French Is.	1930	45	All (1308) Koalas removed in 1944
Chinaman Is.	French Is.	1930	15	
Quail Is.	French Is.	1931	30	
Chinaman Is.	French Is.	1931	30	All Koalas removed 1952
Quail Is.	French Is.	1932	60	
Quail Is.	French Is.	1933	30	
Snake Is.	Phillip Is.	1945	69	
Snake Is.	French Is.	1945	64	
Quail Is.	Phillip Is.	1947	32	
Wartook Is.	Creswick Koala Res.	1947	12	Island in Wartook Reservoir, The Grampians. All (74) Koalas removed 1957-1965
Wartook Is.	Phillip Is.	1948	16	
Goat Is.	Chinaman Is.	1952	4	Island in Murray River at Swan Hill. All remaining animals removed to Pental Island in 1976.
Raymond Is.	Phillip Is.	1953	32	
Chinaman Is.	French Is.	1957	48	
Loch Is.	French Is.	1957	6	Island in Murray River, Mildura. Population did not establish.
Hallstrom Is.	Stony Rises	1962	4	Island in Lake Eucumbene, NSW.
Loch Is.	Wartook Is.	1963	6	
Total			573 +	

APPENDIX I

Appendix 1B. Numbers of Koalas translocated from Victorian islands

Year	French	Phillip	Quail	Chinaman	Wartook	Snake	Raymond	totals
1923	56							56
1925	12							12
1927	1							1
1928	11							11
1930	62							62
1931	66							66
1932	60							60
1933	30							30
1935	38							38
1938	6							6
1939	33							33
1940	28							28
1941		114						114
1942		74						74
1943		97						97
1944		865	1308	6				2179
1945	96	583						679
1947		32						32
1948		16						16
1951		38						38
1952		106		39				145
1953		160						160
1954	711							711
1955		12						12
1956	41							41
1957	1483	425			38			1946
1958		458						458
1960	268							268
1963					6			6
1965	111(min.)				30			141
1969	6							6
1970	166							166
1971		8						8
1972	74 (min.)							74
1973		180						180
1974		29						29
1975		30						30
1976		20 (min.)						20
1977	294	121						415
1978		70						70
1979	110							110
1980	111							111
1981	241							241
1982	591							591
1983	36							36
1985	182							182
1986	76							76
1987	203							203
1988	87							87
1989	208							208
1990	226							226
1991	147							147

APPENDIX I

Year	French	Phillip	Quail	Chinaman	Wartook	Snake	Raymond	totals
1992	137					46		183
1993	134							134
1994	111					82		193
1995	134							134
1996	158							158
1997	234					562		796
1998	195							195
1999	212					204		416
2000	203					66		269
2001	170					242		412
2002						446		446
2003	170					50		220
2004	416					185	371	972
2005	250					441		691
2006	156					283	11	450
Totals	8551	3438	1308	45	74	2607	382	16405

Appendix 1C. Translocations of Koalas from Victorian mainland habitat. There were no translocations from mainland habitat between 2003 and 2007. Ckp – Creswick Koala Park; Mt A – Mt Alexander Koala Park; SR – Stony Rises; BR – Brisbane Ranges; SP – Sandy Point and surrounds; Fram – Framlingham; TH – Tower Hill; Mt E – Mt Eccles.

Year	Ckp	Mt A	SR	BR	SP	Fram	TH	Mt E	Totals
1946	30								30
1947	31	102							133
1948		6							6
1950		9							9
1952	6								6
1955		20							20
1962			4						4
1966		12							12
1969				16					16
1985					23				23
1986					44				44
1987					136				136
1988					228				228
1989					263				263
1990					217				217
1991					167				167
1992					33				33
1993					45				45
1994					46				46
1995					67				67
1996					55	59	199		313
1997					59		147		206
1998					44	1077	41		1162
1999					45	130		850	1025
2000					47			683	730
2001					3			1193	1196
2002								1528	1528
Totals	67	149	4	16	1522	1266	387	4254	7665

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Twenty-three road bridges and underpasses in Sydney's west will need to be upgraded or rebuilt to enable the Bankstown rail line to be converted to carry metro trains, posing significant disruption to already congested streets during construction.

The overhaul of the bridges will add to the upheaval on local roads from extra buses required to transport thousands of commuters while a 13.5-kilometre stretch of track between Sydenham and Bankstown is closed for construction.

Progress: 0%

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Gayle: "Very, very happy" with verdict

Cricketer Chris Gayle spoke to reporters outside court after winning his defamation case against Fairfax Media, likening the result to winning a "Triple century"

Residents along the rail corridor have also been warned they will be affected by noise and vibration, some of which will occur at night during the four-year construction period. Marrickville, Dulwich Hill and Bankstown will be among the suburbs worst affected by noise because of the closeness of homes to the line.

Under the latest plans for the project, 18 bridges, five underbridges and three footbridges along the line will require work to bring them up to scratch, much of which will happen at night and during weekends when traffic tends to be lighter.

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The bridge work is deemed necessary to meet "current design standards", operation specifications for the metro railway and changes to the alignment of the rail track at some locations.

It underscores the scale of the undertaking to convert the line for new single-deck metro trains, and comes amid plans for about 35,000 new high-rise dwellings to be built near stations between Sydenham and Bankstown over the next two decades.

"We're going to have a triple whammy – a high-rise and railway construction nightmare alongside a railway line taken out of service," said Peter Olive from the Sydenham to Bankstown Alliance, which is opposed to the conversion of the rail line.

Commuters will be forced to catch buses for up to two months each year for five years from 2019 to allow for the rail line's conversion. That is in addition to a shut -down of up to six months towards the end of the construction phase in late 2023.

About 66,000 vehicles pass over the Stacey Street overbridge at Bankstown each day. Photo: Wolter Peeters

The work on the bridges will range from construction at weekends and nights for up to eight months, to several days of full or partial closures, according to an assessment of the environmental impact of the project. It includes strengthening, maintenance, protection works and construction of retaining walls.

The bridges and underpasses act as crucial thoroughfares for residents to drive from one side of suburbs to another.

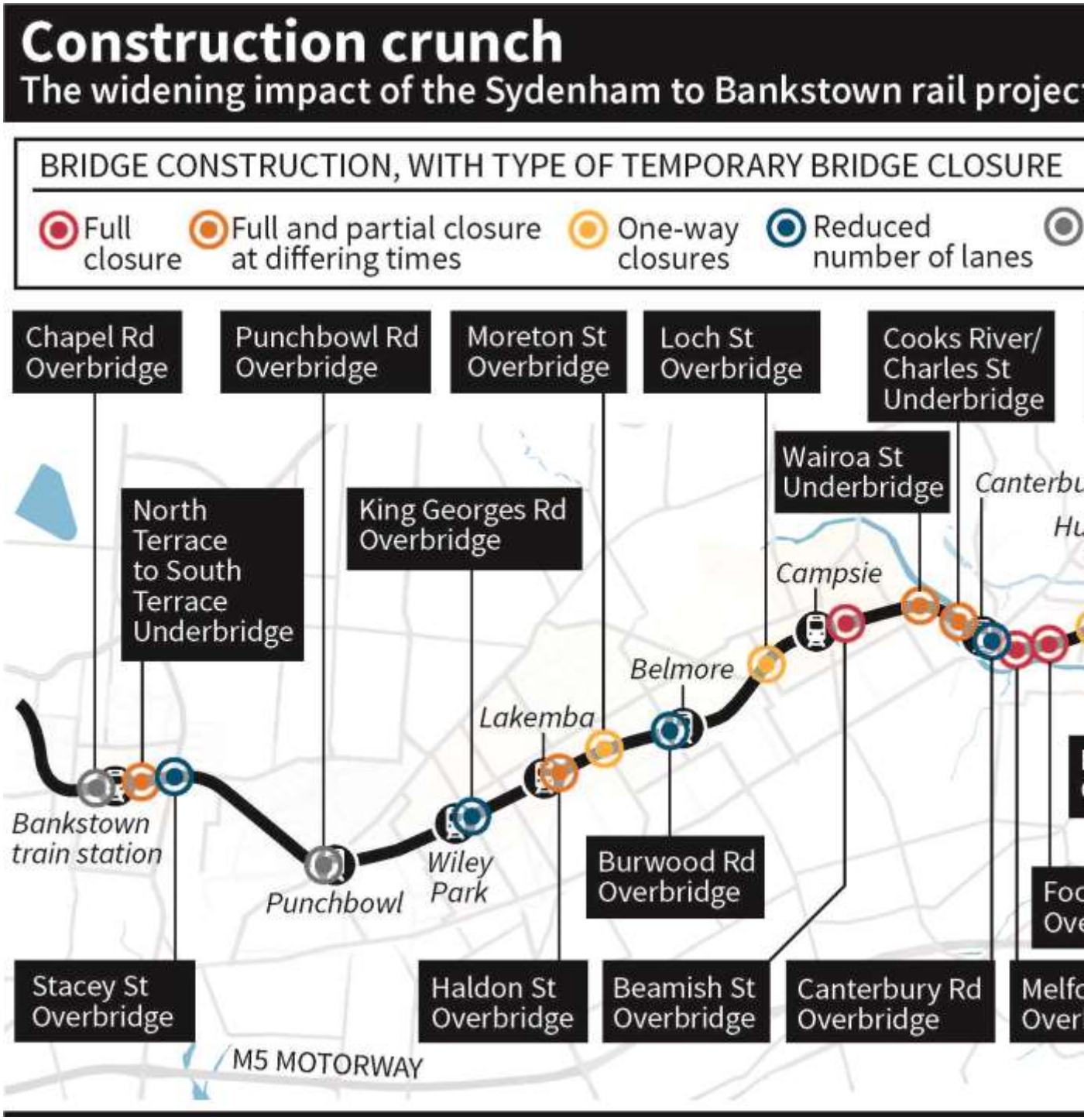
The King Georges overbridge at Wiley Park is the busiest of those needing work. Photo: Wolter Peeters

The busiest bridge needing work is the 31-metre King Georges overbridge at Wiley Park, over which almost 97,000 vehicles pass each day. Southbound lanes on the bridge will need to be reduced from four to three lanes for three weeks.

At Bankstown, the 90-metre long Stacey Street overbridge will be reduced from three to two lanes for four weeks, and at weekends and nights over a six-month period. That bridge has daily traffic volumes of 66,000 vehicles.

The busy Canterbury Road overbridge, near Canterbury Station, will be cut from two to one lanes during weekends and at nights for an eight-month period.

Two bridges on the rail corridor will also need to be completely replaced: the Illawarra Road overbridge at Marrickville, and the Albemarle Street bridge at Dulwich Hill.



Transport Minister Andrew Constance said some level of disruption was unavoidable for a major project such as the construction of a metro railway but the government would "listen to the community and minimise the impacts where possible".

"The end result of some short-term pain will be a congestion-busting metro that will revolutionise public transport in our city," he said.

"The Bankstown Line will remain open during the majority of construction, and our priority is to inconvenience as few customers as possible."

The conversion of the 120-year-old rail corridor is part of the second stage of the $20 billion metro train line from Sydney's north west to Chatswood, the CBD, and on to Sydenham and Bankstown. Upgrades to the 11 stations between Sydenham and Bankstown will each take about two years.

An existing 13-kilometre line between Epping and Chatswood in Sydney's north will also be closed for seven months from late next year to allow for completion of the first stage of the metro rail project known as Sydney Metro Northwest.

PRIORITY PRECINCTS - and built density solutions

The criticism of Angelo Candelapas, a Professor of Architecture at a public meeting held in Campsie/Canterbury Area in Oct 2017 is even relevant to the Northern Beaches.

In his talk, he briefly explained density models, with tall towers and mid-rise structures.

The argument for the priority precincts is they appeared under Rob Stokes MP's period as NSW Planning Minister. Both Ingelside, and Frenchs Forest are Priority Precincts.

In the Canterbury area the ratio of open space to housing areas is 5 % but 15% in the north shore area. But if your LGA has historically native fauna habitat, then refusing to cater for the Sustainable Habitat needs, may imply " long-term mis-management " , especially if converting lands, that could be good environmental habitat, to Urban Residential as a justification about " Plan to Grow Sydney " . So the proposals in Warriewood Valley need a more detail review. Within Angelo's Examples are options, that the Town Planning Association, of A. J. Small could have adopted, before Mark Ferguson became the CEO, of Northern Beaches Council. Now different models can provide the " density of humans " for the regional area. So the " defective Mona Vale Town Centre Plan" is not a " justification " for more urban density on Golf Course Lands in Bayview Golf Course.

One of Angelo's images, showed declining car use, so this implies better use of sustainable transport options (Electric Bicycles) but is there a LACK of SAFE PATHWAYS for Electric Bicycles ? .

The declining car use could mean greater use of " Mass Transport " solutions, and the " under-design " of the B-line was pointed out to me at a Meeting at Newport Beach recently.

The criticism of the number of Units being built along Cantebury Road, was about the Road Network not being able to cope, and the " Upgrade of the Rail Line " in the area being defective in "Logic" basically, as it does not significantly increase capacity.

In Canterbury, they are upset that the Racecourse is to become Urban Housing instead of increasing the % of open-space / playing fields/ etc.

So translated to the Northern Beaches, the TRANSPORT option should include costing a better B-line analysis (with sub-options like Light Rail) rather than just focussing on the BEACHES TUNNEL. The traffic congestion in Mosman has 4 lanes moving 2,000 cars per hour. The Congestion point may be the Harbour Bridge ? So using more Space Efficient Vehicles may assist. This implies better public Transport is part of the Solution, in the Northern Beaches area, and in the Campsie/Canterbury area.

Returning the Military Road into a more " local area street ' may be the local residents wish, but hard to achieve under the " Harvey Rose " vision for the B-line. Saving TRAVEL TIME thru Mosman and over the Harbour Bridge may help reduce the overall travel time from Upper Northern Beaches.

Or Vice Versa in peak recreation or holiday times.

As both City of Sydney and Inner West Council oppose the West Connex improving the Public Transport travel times from the upper Northern Beaches to CBD may decrease the Road Congestion, in a City that is to grow to 8 million, or by 80%. In the early 1950's the population target was 2 mill and the northern city boundary was bounded by a Green Belt that included Narrabeen Lakes . Warriewood Valley and Ingelside may have been "GREEN BELT "lands under the Cumberland Plan.

Tod Dickenson's Report earlier this year does not deal adequately with impacts of " Green Belt " lands of Warriewood Valley, and abandonment of Green Belt Area, and the supply of Minimum Sustainable Habitat areas for the listed Threatened Species in the LGA, and Habitat connection.