

# Impacts of Land Clearing

on **Australian Wildlife**

in **Queensland**

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For his contribution to Australian herpetology Hal was awarded an AM by the Australian Government and an honorary Doctor of Science (DSc) from the University of Sydney. He was awarded honorary life membership of the Australian Society of Herpetologists and the American Society of Ichthyologists and Herpetologists. He is a recipient of the Whitley Medal of the Royal Zoological Society of NSW.

### Professor Hugh Ford

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In 1980, Hugh Ford and Dr Howe published a landmark study of the long term conservation status of birds in the Mount Lofty Ranges of South Australia, where only about ten per cent of the original 500 000 ha of native vegetation remains intact. Using island biogeography principles, they predicted that of the original terrestrial bird fauna of about 120 species, almost 50 would eventually become extinct. This was the first Australian study alerting us to the problem of an "extinction debt". The recently started Mount Lofty Birds for Biodiversity Regional Recovery Project aims to tackle this problem.

In 1993, Hugh Ford was awarded the Serventy Medal for "Outstanding Services to Ornithology in the

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### James Holman & Don Butler

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## EXECUTIVE SUMMARY

For the first time, recent land clearing rates have been used to calculate that in Queensland between 1997 and 1999, approximately 100 million native mammals, birds and reptiles die yearly as a result of the broad-scale clearing of *remnant* vegetation.

This includes:

- Over 2.1 million mammals, including an estimated 342,000 possums and gliders (about a third of which were feathertail gliders), 29,000 bandicoots and 19,000 koalas
- 8.5 million birds, comprising mostly woodland birds such as treecreepers, thornbills, robins and flycatchers, and
- 89 million reptiles, such as skinks and geckos.

**The average annual clearing rate of 446,000 ha of remnant vegetation in Queensland during 1997-99 also led to the loss of an estimated 190 million trees per year.**

This includes:

- 60 million trees per year in the brigalow (*Acacia harpophylla*) and gidgee (*A. cambagei*) open forests and woodlands
- 44 million trees per year from remnant areas of *Eucalyptus populnea* and *E. melanophloia* woodlands.

The highest annual rate of land clearing is occurring in the Brigalow Belt Bioregion, with a corresponding large impact on wildlife each year. This includes the estimated clearance of over 112 million trees and the estimated deaths of:

- over one million mammals, including an estimated 18,000 koalas and 110,000 possums and gliders
- over five million birds, and
- 52 million reptiles.

The study used the Queensland Herbarium's comprehensive analysis of change in remnant vegetation in Queensland for the period 1997-99, published as *Remnant Vegetation in Queensland: Analysis of Pre-clearing, Remnant 1997-99 Regional Ecosystem Information*.

The report dispels the common belief that when birds and other mobile wildlife lose their habitats they simply fly away or move on to locate new

habitat. The reality is starkly different: when native bushland is cleared and burnt, food and shelter habitats are destroyed, and displaced wildlife die immediately or soon after from starvation or by predation. Those that escape to nearby remnant vegetation usually survive only at the expense of other wildlife, which are displaced and die.

### Land Clearing and the Extinction Process

Broad-scale land clearing often leads to many species being propelled into a process of decline — a kind of ecological 'chain reaction' — that culminates in the elimination of local and regional populations. This extinction process follows a predictable path:

**1. Rapid Death of Individuals.** Animals and plants are killed when their habitats are cleared, or die soon after by starvation or by predation. Those mammals, birds and reptiles that reach intact remnant habitat typically find it to be occupied by similar species, which defend their territories against intruders, or with which the newcomers must compete for limited food and other resources. Even many mobile species (especially mammals) have very high levels of site attachment and instead of moving on, they linger and eventually die in degraded habitats no longer suited to them.

**2. Local and Regional Extinction of Populations.** Longer-term threats, such as habitat fragmentation and degradation, continue the path of decline. The richest habitats are typically cleared first and most extensively. Many mammal and bird species prefer these habitats, and even if the overall level of clearing is not high, their populations are rapidly depleted or even lost locally. For many other species, clearing leads to their fragmentation into small sub-populations in remnant patches of habitat that are vulnerable to catastrophic local environmental events (such as bushfires). Once lost, such sub-populations cannot be replaced by new immigrants of the same species because the patches are too isolated. Furthermore, the quality of habitat in remnants typically declines with their size leading to increased predation or reduced breeding success. The decline of some quite common species towards extinction in remnants of 100s to 1000s of hectares is now well documented in several regions.

**3. Total Extinction of a Species.** Over time, successive cycles of local impacts and habitat fragmentation lead to the decline, endangerment (through local or regional extinctions) and then the final and irreversible extinction of a species.

### Land Clearing and the Extinction Debt

A consequence of this extinction process is that it can take decades or more for the full effects of broad scale land clearing to appear. This time lag is often referred to as an extinction debt – we have “borrowed” rich habitats for short-term gains and reduced their diversity, adaptability and long term productivity through loss of species richness – the debt is paid by future generations when it falls due in 20, 50 or more years time as local extinctions gradually become regional until entire species are made extinct.

### The Extinction Debt

To avoid this predictable pattern of extinction, biodiversity conservation requirements must be the major factor in determining strong regional habitat retention targets. Other Australian states have retained insufficient habitat to avert significant regional extinctions. Queensland has the opportunity to learn from the lessons of the southern States and sustainably develop its own landscapes.

Sustainably developed landscapes place a premium on the role of wildlife in providing a wealth of ecosystem services, spanning the production of fresh air, clean water, and nutrients for crop growth, to pollinating crops. Most of these *currently* free and sustainable ecosystem services support economic activities. Farmers rely on small animals and microbes in the soil to recycle waste plant material, producing nutrients to assist the growth of the next crop. Native reptiles and birds help keep insects in check; and without this service producers would need to pay for additional pesticides, with their

consequent effects on community health. Most of these ecosystem services, however, continue to be undervalued by producers, economists and governments.

Preventing broadscale clearing of remnant vegetation of high biodiversity value is a cornerstone of sound natural resource management. This report highlights the large and direct impacts of land clearing on native wildlife, and reinforces the urgent need for more weight to be given in natural resource management policy and planning decisions to ensuring that adequate habitat is conserved to sustain wildlife and maintain the many services of our native ecosystems.

Australia is one of the world’s megadiverse countries, with more species (including mammals, birds, reptiles and trees) than most other nations. Consequently, given our comparatively small human population and research base the density (ie. number of individuals in a given area) of relatively few species has been determined with precision, and the species richness (ie. number of different species occurring in a given area or habitat) of few habitats are known in great detail. For this reason, nation-wide estimates of these values must be extrapolated from a relatively small number of detailed studies. Therefore the authors have deliberately employed highly conservative estimates in making their calculations. The true mortality figures are likely to be substantially higher than those estimated in this report.

While further losses of biodiversity are an inevitable outcome of Australia’s development, we must re-define acceptable levels of biodiversity loss in the context of long-term sustainability.

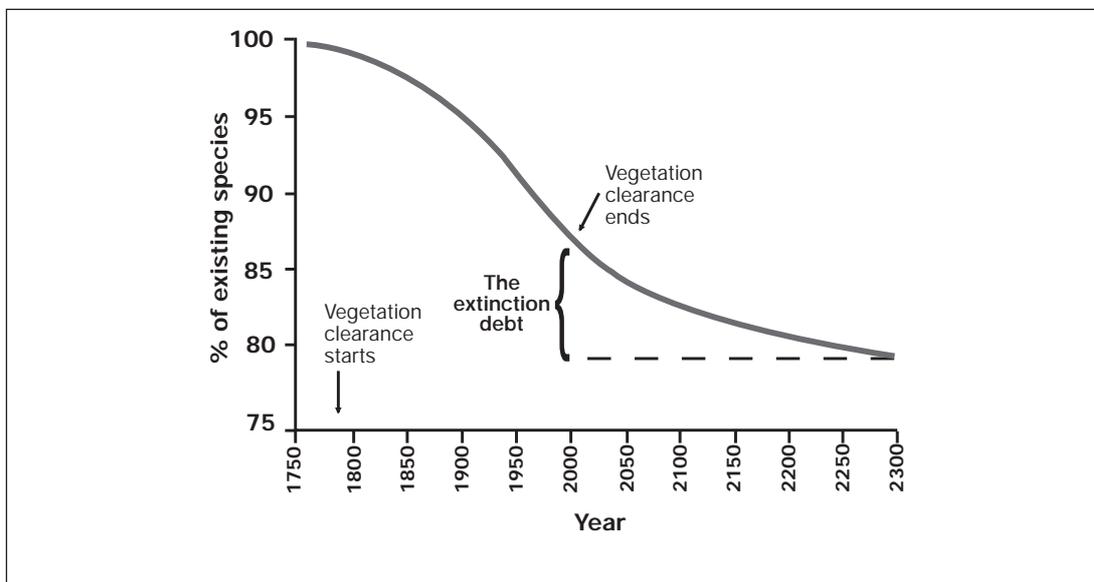


Figure 1: The extinction debt

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## INTRODUCTION

According to the 2001 national *State of the Environment Report*, land clearing is the biggest threat to Australia's wildlife. Currently, most wildlife is killed in Queensland, which accounts for over 80 per cent of the original and remnant vegetation being cleared in Australia each year.<sup>1</sup> Between 1997-99, an average of 446,000 hectares of remnant vegetation were cleared each year: a rate of over 50 hectares or 100 rugby football fields cleared every hour.

While the role of land clearing as the main cause of salinity is well known, the direct and indirect impacts of land clearing on wildlife are not widely understood.

Many people believe that when birds and other mobile species have their habitats cleared, they simply fly or move on to locate new habitat. The reality is starkly different.

This report outlines the direct and long-term impacts of land clearing on wildlife. For the first time, the estimated numbers of mammals, birds, and reptiles killed each year in Queensland has been calculated, as well as the number of trees cleared each year.

### Land Clearing and the Extinction Process

Broad-scale land clearing often leads to many species being propelled into a process of decline that culminates in the elimination of local and regional populations. This extinction process follows a predictable path:

#### 1. Rapid Death of Individuals.

Animals and plants are killed when their habitats are cleared, or die soon after by starvation or predation. With broad-scale clearing, smaller mammals and reptiles are unable to reach intact habitat, and probably starve or are killed by predators soon after clearing. Larger mammals and reptiles and birds may be able to reach intact habitat. However, many mobile species (especially mammals) have very high levels of site attachment and instead of moving on, they linger and eventually die in degraded habitats no longer suited to them. Those animals that do reach new habitat usually find that it is already occupied by similar species, many of which defend their territories

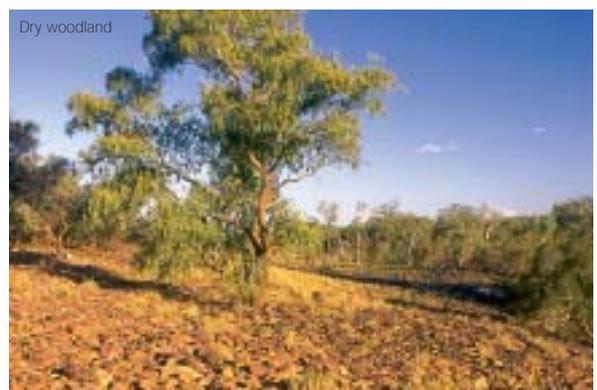
against intruders. It is improbable that many refugees from clearing settle into high quality sites - or if they do they may replace current occupants. Most end up in poor quality habitat, where food and shelter are inadequate, or where they are vulnerable to predators. Even if displaced animals do crowd into uncleared remnants they almost certainly do not survive for long, as the density of most species is no higher, and often lower, in those remnants compared with pre-clearing vegetation.

#### 2. Local and Regional Extinction of Populations.

Longer-term threats, such as habitat fragmentation and degradation, continue the process of decline. The habitats on fertile soils are typically cleared first and most extensively. Many mammal and bird species prefer these habitats, and even if the overall level of clearing is not high, their populations are rapidly depleted or even lost locally. For many other species, clearing leads to their fragmentation into small sub-populations in remnant patches of habitat that are vulnerable to catastrophic local environmental events (such as bushfires). Once lost, such sub-populations cannot be replaced by new immigrants of the same species because the patches are too isolated. Furthermore, the quality of habitat in remnants typically declines with their size leading to increased predation or reduced breeding success. The decline of some quite common species towards extinction in remnants of 100s to 1000s of hectares is now well documented in several regions (for example see box [below/next page]). The pattern of local extinctions of small, isolated populations may be compounded in extensively cleared landscapes so that species may disappear from an entire region.

#### 3. Total Extinction of the Species.

Over time, successive cycles of local impacts and habitat fragmentation lead to the decline, endangerment and then total and irreversible extinction of a species. The patterns of regional species loss in the wheatbelt of Western Australia, the Mount Lofty Ranges of South Australia, western Victoria and the New England region of NSW could be repeated throughout the range of many mammals, birds and reptiles if clearing continues at its present rate in NSW and Queensland, leading to the total extinction of some species. The relationship between landscape fragmentation and degradation and the general path to species extinction is diagrammatically set out in Figure 1.



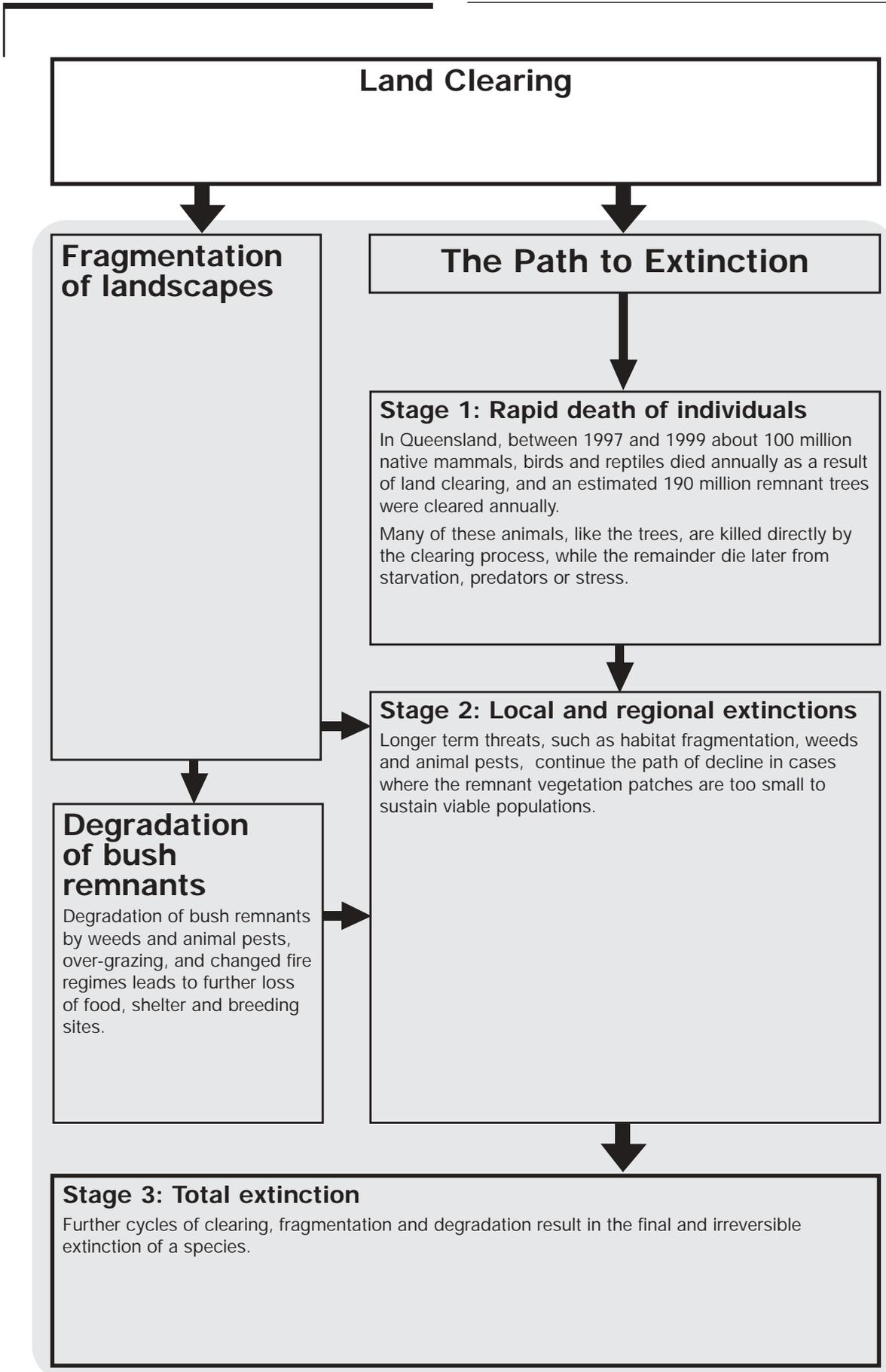


Figure 1: Land Clearing, landscape fragmentation and the path to extinction

**The Redundancy Argument**  
– should we worry about loss of biodiversity?

Ecosystems are intrinsically dynamic, non-linear and chaotic, making it very difficult to accurately predict the effects of any major disturbance on such systems, whether from local events such as fire or land clearing to planet-wide events such as global warming.<sup>2</sup>

However theoretical ecology suggests that for any ecosystem to be able to respond to the wide range of disturbances – perturbations – that it experiences over time, then at any point in time some components of the system (including species) must be redundant (ie. unnecessary) for maintaining the current health and services of that ecosystem. This has led some ecologists to argue that some species are redundant and so their loss, especially of those on which humans do not depend for sustenance, should not significantly affect ecosystem processes.<sup>3</sup>

The same ecological theory, however, that argues the case for redundancy also postulates that if redundancy is reduced in an ecosystem, so too is the ability of that system to respond to short- and

long-term disturbances. In other words, lowering the level of redundancy (rather than biodiversity *per se*) in a system may not have any immediate effects but results in lowered fitness of the system to be able to respond to change, so putting in jeopardy the long-term adaptability and viability of that system and the range of services it can provide – ie. its resilience is compromised. The greater a system's *resilience*, the greater is its insurance value.<sup>4</sup> Given current and anticipated levels of climate change, such reductions in fitness could seriously reduce our future options in sustainably utilising Australia's diverse ecosystems.



Land clearing January 2003

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### LAND CLEARING AND THE EXTINCTION DEBT: A LESSON FROM THE SOUTHERN STATES

One of the reliable rules of modern ecology is that small areas of habitat support fewer species than large areas of the same habitat. From a conservation perspective the theory provides a fairly robust rule of thumb, that reducing habitat area to ten per cent of its former extent will eventually cause about 50 per cent of species dependent on natural habitat to disappear.<sup>5</sup>

The Mount Lofty Ranges of South Australia contain an "island" of relatively high rainfall (500mm-800mm) forest and woodland, isolated from similar areas in eastern Australia by much drier mallee habitat. Only about ten per cent of the original 500 000 ha of native vegetation remains intact. In a wake-up call, Ford and Howe (1980)<sup>6</sup> used the theory of island biogeography to predict that, of an original terrestrial bird fauna of about 120 species, almost 50 would eventually become extinct in the Mount Lofty Ranges.

Garnett and Crowley (2000)<sup>7</sup> list eight species that have already disappeared: King Quail, Swift Parrot, Glossy Black Cockatoo, Swamp Parrot, Azure Kingfisher, Rufous Field-wren, Regent Honeyeater and Barking Owl. While the loss of eight such remarkable species is lamentable, the loss of another 42 would be catastrophic. Now that vegetation controls have been implemented and habitat loss in the Mount Lofty Ranges almost ceased has the process of extinction been halted?

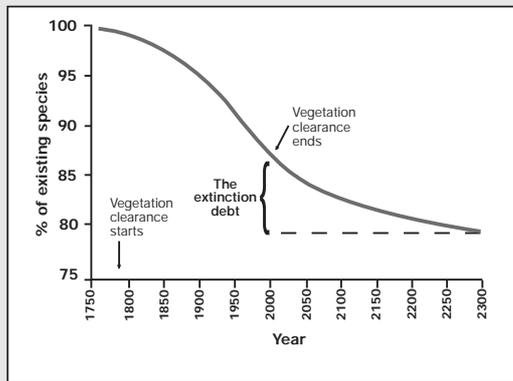


Figure 2: The extinction debt

### THE EXTINCTION DEBT

Unfortunately, another ominous prediction from the theory of island biogeography suggests that there is indeed still plenty to worry about.

Systems that become fragmented and reduced in area are expected to enter a long period of "relaxation" to lower levels of species richness.

Thus there will be a substantial time lag between the loss of habitat and the consequent loss of species. For long-lived species like birds, this time lag may be measured in hundreds of years. In short, our past actions, destroying 90 per cent of all the native vegetation, have incurred an extinction debt.

This extinction debt is the future loss of species

that is a consequence of past actions, which in this case may involve another 40 species of terrestrial birds. This debt will have to be paid as a result of past actions, but might be partly avoided by research and management in the short-term and large-scale habitat reconstruction in the long term. But if such actions are to be effective, it is critical they be targeted towards preserving the species most at risk. If 40 more species are likely to become extinct, then a key question is "which species will be next?"

### ALMOST OR ALREADY GONE IN MOUNT LOFTY RANGES

Eight species already have populations well below what we would consider viable levels: Square-tailed Kite, Bush Stone-curlew, Little Lorikeet, White-throated Gerygone, Spotted Quail-thrush, Olive-backed Oriole, Brown Quail and Flame Robin. In some cases they were possibly always rare. We predict that most of these species will be declared regionally extinct within 50 years. Their demise is predictable and will take the total loss to 16 species, 13 per cent of the original 120 species.

### THE LIVING DEAD

The conventional wisdom in population viability studies is that any species that has fallen below a total population size of 500 is more than likely to become extinct. Most of the species in this position in the Mt Lofty Ranges can still be easily found by an experienced observer, but their long-term persistence is unlikely unless their decline can be quickly reversed. Species whose populations are isolated and species that depend more heavily on natural habitat are more likely to disappear. Taking this into account, the wisdom of various South Australian ornithologists, our own survey data, and information summarised by Paton et al. (1994),<sup>8</sup> we believe that the following 16 further species are all likely to be gone within 200 years.

### MOUNT LOFTY

Brown Treecreeper

Southern Emu-wren

Tawny-crowned Honeyeater

Brush Bronzewing

Southern Whiteface

Tawny Frogmouth

Bassian Thrush

Beautiful Firetail

Black-chinned Honeyeater

Chestnut-rumped Hylacola

Grey Butcherbird

Painted Button-quail

Pallid Cuckoo

Restless Flycatcher

Shining Bronze Cuckoo

Singing Bushlark



Diamond Finch (Firetail)

© Reg Morrison/AUSCAPE

We can think of these as the “living dead”, species that would once have had secure populations but that are now almost certainly doomed. If their loss eventuates, the toll will have risen to 32 species (27 per cent of the original 120 species).

However, the most disturbing prediction of the theory is that as many as 20 more species will eventually disappear – perhaps species like the Scarlet Robin, Diamond Firetail, Crested Shrike-tit, Eastern Spinebill and Yellow-tailed Black Cockatoo – species that we currently consider relatively common. In the case of the Scarlet Robin, it seems already to be in decline, not only in the Mt Lofty Ranges, but elsewhere in its range. Will revegetation save these species? If so, where in the landscape should revegetation be focused so as to minimise the loss? With present knowledge, we are unable to answer such questions. However, obtaining answers is imperative, because evidence is mounting that birds are declining right across the agricultural zones of southern Australia (Ford *et al.* 2001).<sup>9</sup> We can and must use the experience gained in the Mount Lofty Ranges as a warning of what might happen across the remainder of Australia.

#### DO REGIONAL EXTINCTIONS REALLY MATTER?

While regional extinctions may diminish the quality of life of people living in that region, do they really matter? Surely only the complete loss of a species from the whole of its range is of concern? While none of the present and future extinctions in the Mount Lofty Ranges mean the loss of a full species, they do often represent the loss of a unique subspecies. Being inhabitants of an isolated area of wetter forest, many of the birds in the Mount Lofty Ranges are genetically quite distinct from others of their species occurring elsewhere. They are a fundamental component of biodiversity that represents within-species variation and this provides the potential for new speciation. In addition, the nation-wide declines in many species mean that they may soon be endangered in all parts of their range. Restoring habitat in the Mt Lofty Ranges may provide a critical refuge for populations of these species in the future. Furthermore, what we learn from our research and management of these beleaguered populations will be invaluable when we have to tackle similar declines elsewhere in Australia.

#### IMPLICATIONS FOR VEGETATION RETENTION

Information from South Australia provides an important lesson for other Australian states that are currently grappling with vegetation clearance controls. As we can see from the Mount Lofty Ranges situation, retaining only ten per cent of the native vegetation in a region will ensure significant local species loss. What about other parts of South Australia? The South-East of SA has about 13 per cent of the original vegetation and has suffered similar species loss to the Mount Lofty Ranges. Taking the theory and empirical evidence together, landscape and regional habitat targets need to set sufficiently high to avoid substantial loss of regional bird species. Queensland still has the opportunity to learn from South Australia’s mistakes, rather than repeating them.<sup>10</sup>

Source: Adapted from Professor Hugh Possingham, *et al* (2001)<sup>11</sup>

## DEFINITIONS AND METHODOLOGY

This study of the impact of land clearing on Queensland's wildlife is based on the Queensland Herbarium's definitions and analysis of clearing of remnant vegetation 1997-99 in Queensland. The report, *Remnant Vegetation in Queensland: Analysis of Pre-clearing, Remnant 1997-99 Regional Ecosystem Information*, provides the most robust and comprehensive analysis of recent clearing patterns of remnant vegetation in Queensland.<sup>12</sup>

### Definitions of Native Vegetation

The Queensland Herbarium defines Pre-clearing vegetation as the vegetation present before clearing. This has been determined from remaining vegetation, aerial photographs, and from existing knowledge of the ecology and history of remnant areas.

Remnant vegetation is defined as vegetation where the predominant layer of the vegetation is still intact, ie. has at least 50 per cent of the cover and more than 70 per cent of the height, and is made up of species characteristic of the vegetation's undisturbed predominant layer. This definition includes all woody structural formations as well as those dominated by shrubs, grasses and other life forms.

### Definition of Land Clearing

Land clearing consists of the destruction of the above ground biomass of native vegetation and its substantial replacement by non-local species or by human artefacts. It includes clearance of native vegetation for crops, pasture, plantations, gardens, houses, mines, buildings and roads.

### Definition of Broad Vegetation Groups

The Queensland Herbarium defines 18 Broad Vegetation Groups (BVGs) to summarise the extent of each group and current clearing rates.

The BVGs used in the Herbarium analysis encompass vegetation types that are frequently dominated by a single species, e.g. *Eucalyptus tetradonta* (BVG3), *Acacia aneura* (BVG12) or suite

of species, e.g. the *Acacia* spp. usually on residual ranges (BVG10) or Eucalypt woodlands on ranges (BVG1). Other groups are dominated by a structural formation, e.g. grasslands (BVG14) or rainforests and vine thickets (BVG15) or are defined by specialised habitats such as the intertidal areas (BVG17) and wetlands (BVG16). Botanical nomenclature here follows Henderson (2002),<sup>13</sup> and a list of frequently used common names is given in Appendix 3.

1. **Eucalypt woodlands on ranges.** Widespread across coastal and subcoastal regions, generally on steep hills and ranges with shallow rocky soils. Characteristic species include ironbarks (*Eucalyptus crebra*, *E. cullenii*, *E. decorticans*, *E. dura*, *E. fibrosa*, *E. shirleyi*), bloodwoods (*Corymbia citriodora*, *C. erythrophloia*, *C. intermedia*, *C. clarksoniana*, *C. leichhardtii*, *C. trachyphloia*), and a wide range of other species such as *E. cloeziana* and *E. acmenoides*.
2. **Eucalypt open forest.** Occurs mainly in higher rainfall coastal and to a lesser extent subcoastal regions and generally on hills and ranges with shallow soils. Main species include *Eucalyptus grandis*, *E. saligna*, *E. pilularis*, *E. microcorys*, *E. acmenoides*, *Corymbia citriodora*, *E. laevopinea*, *E. montivaga*, *E. propinqua* and *E. major*.
3. **Eucalyptus tetradonta woodlands – open forest.** Occurs on flat to undulating plains with deep sandy, often red soils, in Cape York Peninsula and adjacent parts of North Queensland. Associated species include *Corymbia nesophila*, *C. stockeri*, *C. clarksoniana*, *C. hylandii*, *E. miniata* and *E. phoenicea*.
4. **Eucalyptus similis and E. whitei woodlands.** Occurs on undulating plains with infertile red earth sandy soils in the Desert Uplands, Einasleigh Uplands and adjacent parts of surrounding regions. Associated species include *Corymbia setosa* and *E. melanophloia*.
5. **Eucalyptus populnea and E. melanophloia woodlands.** Generally occurs on flat to undulating plains and low hills usually with moderately deep, often texture contrast soils. This vegetation type is widespread in the Brigalow Belt, Desert Uplands and eastern part of the Mulga Lands bioregions. *E. brownii* replaces *E. populnea* approximately north of 23°S (with both species present in different habitats between 21°S and 23°S).
6. **Mixed eucalypt woodlands on flat to undulating plains and low rises often with sandy texture contrast soils.** Variable group which is widespread in all regions apart from the more arid Channel Country and Mulga Lands. Frequent dominant species include *Eucalyptus mollucana*, *E. microcarpa*, *E. crebra*, *E. organophila*, bloodwoods (*Corymbia clarksoniana*,

*C. dallachiana*, *C. polycarpa*, *C. plena*, *C. terminalis*, *C. papuana*, *C. tessellaris*), *E. conica*, *Angophora leiocarpa*, and in northern areas *E. platyphylla* and *E. chlorophylla*. This type includes Cypress Pine *Callitris* spp. dominated regional ecosystems that occur on sandy soils in the Brigalow Belt and western parts of the Mulga Lands bioregions.

7. **Eucalyptus microneura and other box woodlands.** Restricted to the Einasleigh Uplands, Gulf Plains and North-west Highlands bioregions. Associated species include *Eucalyptus chlorophylla*, *E. pruinosa*, *E. tectifera*, *Lysiphillum cunninghamii* and *Erythrophleum chlorostachys*.
8. **Eucalyptus leucophloia low open woodlands on ranges with shallow soils.** Associated species include *E. persistens*, *E. normantonensis* and *Corymbia* spp. *E. leucophylla* dominated regional ecosystems are widespread in the North-west Highlands and extend into adjacent parts of the Mitchell Grass Downs, Gulf Plains and Channel Country bioregions. *E. persistens* dominated regional ecosystems occur in the Brigalow Belt, Desert Uplands, Einasleigh Uplands and adjacent parts of neighboring bioregions.
9. **Riparian eucalypt woodland.** Wide range of regional ecosystems fringing drainage lines and spreading onto adjacent floodplains. Frequent in all bioregions except the Central Queensland Coast where rainforests usually fringe the drainage lines. *Eucalyptus tereticornis* is a common dominant along coastal drainage lines while *E. camaldulensis* is more frequent inland. Frequent dominants of western flood and alluvial plains include *E. coolibah*, *E. ochrophloia*, *E. microtheca* and *E. largiflorens*.
10. **Acacia spp. woodlands and shrublands.** Widespread on ranges with shallow, rocky soils in the Gulf Plains and all inland bioregions. Characteristic species include *Acacia catenulata* or *A. shirleyi*, and *A. stowardii* in more western regions.
11. **Acacia harpophylla or A. cambagei open forests and woodlands.** Occur on flat to undulating plains with fertile, clay soils. *A. harpophylla* communities occur mainly in the Brigalow Belt but also the moister parts of the more western bioregions. *A. cambagei* replaces *A. harpophylla* in the western parts of the Brigalow Belt and is widespread across the Desert Uplands, Mitchell Grass Downs, Mulga Lands and southern parts of the Gulf Plains bioregions. Associated or locally dominant species include *A. argyrodendron*, *A. melvillei*, *A. georginea*, *Casuarina cristata* and/or *Eucalyptus* spp. such as *E. populnea*, *E. cambageana*, and *E. thozetiana*.
12. **Acacia aneura woodlands and shrublands.** Generally occurs on flat to undulating plains with infertile red sandy earth soils in the Mulga Lands and adjacent parts of the Channel Country, Desert Uplands and Mitchell Grass Downs bioregions. Emergent eucalypts such as *Eucalyptus populnea* and *E. melanophloia* may be present in more eastern parts of its distribution.
13. **Triodia spp. hummock grasslands.** Occur on arid inland dunefields and sandplains which are most extensive in the Channel Country bioregion. Scattered shrubs and sometimes low trees can occur. *Zygochloa paradoxa* grasslands and *Crotalaria* forblands which occur on the dunefields in the Simpson Desert are included in this group.
14. **Native Grasslands.** Occur on flat to undulating plains with clay soils, usually derived from alluvium or sedimentary rocks. *Dichanthium* spp. characterise higher rainfall areas particularly in the Brigalow Belt and Gulf Plains, while *Astrebula* spp. tend to dominate in the Mitchell Grass Downs (where scattered tree species may be present), Mulga Lands and Channel Country bioregions. Areas seasonally dominated by short grasses (e.g. *Eragrostis*, *Aristida* spp.) or forbs (eg. *Asteraceae* and *Chenopodiaceae* spp.) are widespread on alluvial or gravelly plains the Channel Country, Mitchell Grass Downs and Mulga Lands. Grasslands in the coastal regions are dominated by other species such as *Themeda arguens*, *Imperata cylindrica* or *Sorghum* spp.
15. **Rainforests and vine thickets.** Best developed in the extensive areas of complex tropical and subtropical rainforests that occur in the Wet Tropics, Central Queensland Coast, South-east Queensland and Cape York Peninsula bioregions. The Brigalow Belt and Einasleigh Uplands bioregions support less complex and generally less diverse drier rainforest and vine thickets which often occur in small scattered pockets.
16. **Wetlands.** Occur in all bioregions although often of limited extent. There are a wide range of wetlands types including ephemeral to permanent lakes, billabongs and the northern floodplains supporting sedgeland or mixed sedge/grasslands on northern floodplains. Bare claypans and swamps supporting *Chenopodium auricomum*, *Eragrostis australasica*, *Muehlenbeckia florulenta* or samphire species (eg. *Halosarcia* spp.) communities occur in arid parts of the state. Includes Melaleuca (*M. argentea*, *M. fluviatilis*, *M. leucadendra*, *M. dealbata*, *M. quinquenervia*, *M. viridiflora*) swamps that occur in coastal regions.
17. **Mangroves and strand communities.** Occur along the entire coast on tidally inundated estuarine deposits. Frequent species include mangroves (eg. *Avicennia marina*, *Rhizophora* spp., *Ceriops tagal*), samphire species (eg.

*Halosarcia* spp.), and the grass *Sporobolus virginicus*. Strand communities occur on beach or coastal sand dunes and include *Casuarina equisetifolia* woodlands, *Spinifex* spp. grasslands and a range of eucalypt woodlands and mixed shrublands

18. **Heath or mixed shrublands.** Generally occur on sandy infertile soils, predominantly in the coastal bioregions. Dominant species include *Asteromyrtus* spp., *Neofabricia* spp., *Micromyrtus* spp., *Acacia* spp. and *Leucopogon* spp. The ground layer is dominated by *Triodia* spp. in several regional ecosystems in this group. Includes shrublands and woodlands dominated by *Banksia* spp., *Eucalyptus* spp. or other species on coastal dunes and rocky headlands.

#### Methodology to Calculate Native Vegetation Change

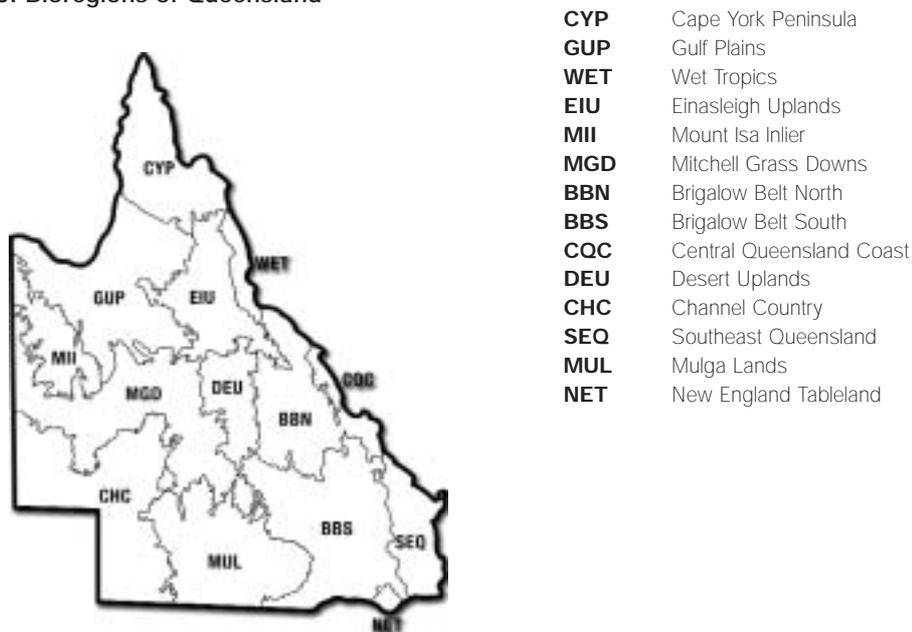
The Herbarium report provides reference information and statistics for Queensland's regional ecosystems based on the best available regional scale mapping (1:100,000 scale) generated by the Queensland Herbarium's vegetation and regional ecosystem survey and mapping program. The regional ecosystem information has been compiled at a scale of 1:100,000. At this scale, areas that are below the recommended minimum area of 20 hectares (or, if elongated, 27 hectares) for a map scale of 1:100,000, and areas of heavily disturbed and/or regrowth may not be included.

Queensland Herbarium mapping uses 1:80 000 scale aerial photography, flown in the 1960s, together with other historical data sources such as survey reports, and extensive field survey to produce maps of the pre-clearing extent of Regional Ecosystems. Remnant Regional Ecosystem maps are created by intersecting pre-clearing Regional Ecosystem maps with the distribution of remnant vegetation across the state delineated using rectified LANDSAT TM imagery and informed by field survey and aerial photography.

The report analyses the area of regional ecosystems using the same version of LANDSAT TM imagery used by the Statewide Landcover and Trees Study (SLATS, Queensland Department of Natural Resources and Mines) analysis of woody vegetation to provide complementary information. The definition of remnant vegetation used in the Herbarium report, however, differs from the definition of woody vegetation used in the Department of Natural Resources and Mines, SLATS project. The Herbarium definition of native vegetation includes grasslands and consequently their analysis records clearing of natural grasslands. The Herbarium report does not include clearing of non-remnant woody vegetation. Hence the figures reported in the Herbarium report do not match those of the SLATS reports.

A breakdown of clearing patterns by Broad Vegetation Type (BVT) and bioregion is provided in Table 1.

Figure 3: Bioregions of Queensland



Note: The broader Brigalow Belt bioregion comprises the Brigalow Belt South bioregion and the Brigalow Belt North bioregion

#### Methodology to Calculate Wildlife Impacts

The Queensland Herbarium analysis of clearing of remnant vegetation in Queensland in the period 1997-99 was used by the authors to calculate the impacts on mammals, birds, reptiles and trees over this period.

The data of clearing by Broad Vegetation Group (BVG) and/or bioregion used by the authors is set out in Table 1. The methodology used by each of the authors to determine wildlife densities in each BVG and/or bioregion and calculate wildlife impacts is set out in the respective sections of part 4.

One general assumption made in these calculations, based primarily on knowledge of the ecology of a wide range of species, as well as the absence of any evidence that remaining remnant vegetation supports higher densities of a wide range of species following adjacent land clearing, is that the vast majority of animals displaced by clearing will die – either immediately or after a short space of time. Deaths result primarily from physical injury, exposure to lethal conditions of temperature or lowered microclimatic humidity, predation, or lack of food.

There are several specific reasons for this:

1. Many species lack the mobility to move into uncleared remnants, and if they could move fast and far enough may not have the tolerance of highly disturbed habitat to allow them to cross it to reach remnants.
2. Many species (mammals especially) have very high levels of site attachment, and may not make the 'decision' to leave until it is way too late to make a successful move, even if they might have the physical capacity to do so. Instead they linger and eventually die in degraded habitats no longer suited to them. An example of this behaviour is exhibited by the response of woylies

(or brush-tailed bettongs) to fire in Western Australia where a radio-tracking study undertaken by Dr Christensen found that the attachment of individuals to their home areas is so strong that they double back through the fire front to remain in their home range, rather than continue to flee in front of the fire. As it happens, these animals are so skilled that most manage this without being burnt. They continue to survive for a while in their original habitat, but most are gradually killed by foxes in the open post-fire conditions.<sup>14</sup>

3. Even for those animals that might be able to escape into remnants (such as some birds), the prospects of surviving elsewhere are low, because in most undisturbed habitat, resources and space are fully utilised by residents and few additional animals can be packed in. Thus, although there might initially be an increase in density as a result of an influx of refugees, density dependent reductions in survival and reproduction as a result of increased pressure on resources such as food or shelter mean that density soon declines back to former levels - in short the extra numbers can't be absorbed. This was demonstrated in a classic study of birds in rainforest fragments in Brazil – clearing of surrounding forest produced a transient increase in density in uncleared patches, but density soon re-adjusted to former levels.<sup>15</sup>

After an area of native bushland has been cleared for cropping or grazing, some species of mammals, birds or reptiles will still be found on it. These remaining species may consist of some residual animals from the original assemblages found there prior to clearing (though usually in much reduced densities) or more likely be species not present in the original habitat but ones (such as grassland species) that move in to the new habitat created by the clearing process. In most studies to date, the total number of species present post-clearing ranges from about 5-20 per cent of the number originally present, but with usually less than ten per cent of the *taxa* originally present.

These residual original taxa fall well within the standard error ranges of the estimated mortalities, and so have not been specifically excluded from these conservative estimates of mortalities. In other words, in terms of the net effects of land clearing, it is assumed that for all taxa the number of individuals displaced by land clearing equals the number that die as a direct result of the clearing process.

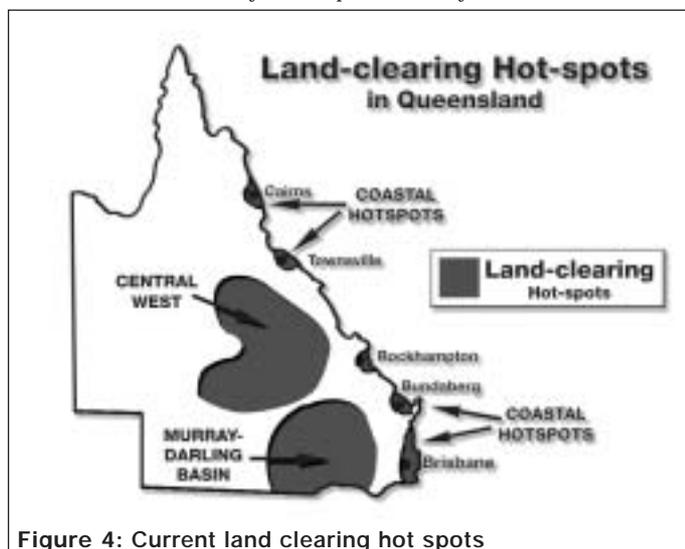


Figure 4: Current land clearing hot spots

## LOSS OF NATIVE VEGETATION SINCE EUROPEAN SETTLEMENT

Clearing of native vegetation has taken place for human settlement and agriculture mostly in the higher rainfall regions and on more fertile soils, generally excluding the arid interior and tropical far north.

Since European settlement, about 32 per cent of Australia's native vegetation has been cleared from the intensively used areas of Australia – largely in the higher rainfall areas of the south-east and far south-west of the continent.<sup>16,17</sup>

### Recent Clearing of Remnant Vegetation

Extensive clearing currently occurs mainly in Queensland, New South Wales, Tasmania and the Northern Territory.<sup>19</sup> While broadscale clearing for agriculture essentially ceased during the 1990s in

Western Australia, on-going clearing of remnant vegetation is significant due to high regional biodiversity and the fact that most of the native vegetation has already been cleared. In 1998, Queensland accounted for 81 per cent of the nation's remnant native vegetation converted to other uses.<sup>20</sup>

Between 1997-99, the Queensland Herbarium calculated that the average remnant vegetation clearing rate in Queensland was 446,000 ha/year.<sup>21</sup> This occurred on Freehold tenures (70 per cent), Leasehold tenures (29 per cent) and other tenures (1 per cent).

The areas with the highest remnant vegetation clearing rates were largely within the central and southern areas of the Brigalow Belt and the adjacent eastern area of the Mulga Lands bioregions. The majority of remnant vegetation cleared during this time was eucalypt open woodlands and woodlands dominated by poplar box (*Eucalyptus populnea*), coolibah (*E. coolibah*) or silver-leaved ironbark (*E. melanophloia*).

The highest remnant vegetation clearing rates were in the:

- Moonie River and Warrego River catchments;
- Brigalow Belt Central and Brigalow Belt Southern Regional Vegetation Management Plans (RVMP);
- Warroo, Balonne, Murweh and Jericho Shires.

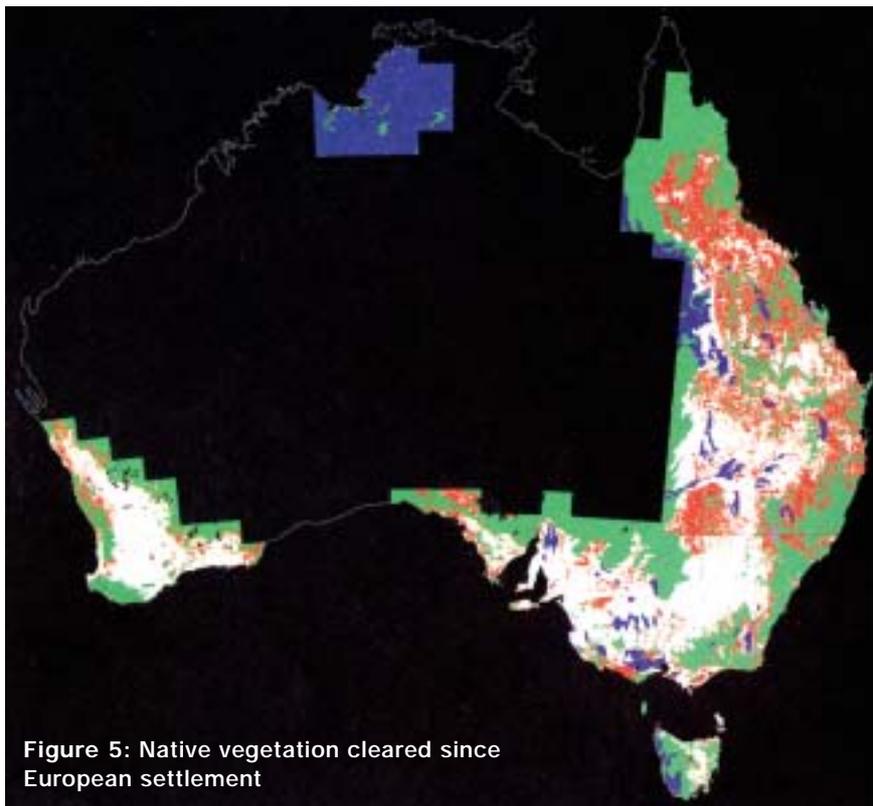


Figure 5: Native vegetation cleared since European settlement

Note: The classes and colour codes are: uncleared (green); thinned (brown); cleared (white); indeterminate (blue); and lakes (black).

Source: Graetz et al (1995:28)<sup>18</sup>

Table 1: Pre-clearing (km<sup>2</sup>) and 1999 remnant (per cent of pre-clearing extent) area and 1997 - 1999 average annual clearing (km<sup>2</sup>) by Broad Vegetation Group and Bioregion

Bioregion	Broad vegetation groups										TOTAL			
	1. Eucalypt woodlands on ranges	2. Eucalypt open forest	3. E. tetradiora woodlands / open forest	4. E. similis and E. whitei woodlands	5. Mixed eucalypt woodlands and other box woodlands	6. Riparian eucalypt woodlands	7. Acacia spp. woodlands / shrublands	8. <i>Acacia heterophylla</i> or <i>A. cambagei</i> open woodlands and shrublands	9. <i>Trochilodendron</i> spp. woodlands and shrublands	10. <i>Acacia</i> spp. hummock grasslands		11. Wetlands	12. Heath or mixed shrublands	
<b>Bioregion Brigalow Belt</b>	67,849	15,859	78,550	37,908	1,865	31,774	10,273	88,158	16,403	10,748	905	2,427	1,461	364,180
pre-clearing area	65	90	40	62	86	37	79	11	29	23	61	93	81	43.3
1999 remnant area (%)	247	53	903	281	5	323	98	516	124	35	6	3	8	2,602
annual clearing <sup>2</sup>														
<b>Channel Country</b>					4,170	9,921	37,005	13,402	20,892	43,009	89,880	19,868		238,146
pre-clearing area					100	100	100	98	100	100	100	100		100
1999 remnant area (%)					1	0	2	1	1	0	0	0		5
annual clearing <sup>2</sup>														
<b>Central Queensland Coast</b>														
pre-clearing area	7,294	246												
1999 remnant area (%)	79	98												
annual clearing <sup>2</sup>	13	0												
<b>Cape York Peninsula</b>														
pre-clearing area	4,102	629	59,216		9	344	121		4,189	6,208	22,378	5,021	7,870	121,673
1999 remnant area (%)	98	87	99		100	100	100		99	94	100	92	100	99
annual clearing <sup>2</sup>	0	0	0		0	0	0		0	0	0	0	0	0
<b>Desert Uplands</b>														
pre-clearing area	2,538		29,391		1,385	2,292	2,078	7,096	33	135	1,112		1,251	70,308
1999 remnant area (%)	97		92		95	91	97	61	99	91	97		91	87
annual clearing <sup>2</sup>	4		215		1	4	6	75	0	1	1		5	511
<b>Einiasleigh Uplands</b>														
pre-clearing area	71,801	1,228	2,679	114	6,969	14,153	3,538	800	8					
1999 remnant area (%)	98	100	100	92	100	95	97	97	100					
annual clearing <sup>2</sup>	7	0.5	0.5	2	1	5	3	0	0					
<b>Gulf Plains</b>														
pre-clearing area	3,367		25,612		8,129	21,412	8,243	19,596	143	43,466	5	42,627	7,231	220,000
1999 remnant area (%)	100		100		100	100	100	99	99	100	98	100	99	100
annual clearing <sup>2</sup>	0.5		2		5	1	2	0.5	5	2	0	1	0	21
<b>Mitchell Grass Downs</b>														
pre-clearing area			1,530	45	8,040	11,135	5,776	33,645	2,372	1,110				241,834
1999 remnant area (%)			97	100	100	99	99	72	97	100				95
annual clearing <sup>2</sup>			2	0	4	8	1	163	4	0				269

Broad vegetation groups	Broad vegetation groups																		
	1. Eucalypt woodlands on ranges	2. Eucalypt open forest	3. E. tetradonta woodlands/ open forest	4. E. stilesii and E. whitei woodlands	5. E. populnea and E. melaleucla woodlands	6. Mixed eucalypt woodlands	7. E. microcarpa woodlands	8. E. leucophaea and other box woodlands	9. Riparian eucalypt low open woodlands	10. Acacia spp. woodlands	11. Acacia harpophylla woodlands	12. Acacia harpophylla or A. cambagei open woodlands	13. Acacia aneura woodlands & woodlands	14. Native grasses & woodlands	15. Rainforests and vine thickets	16. Wetlands	17. Mangroves and vine thickets	18. Heath or mixed shrublands	TOTAL
<b>Mulga Lands</b>																			
pre-clearing area					24,466	2,082													
1999 remnant area (%) <sup>1</sup>					43	72													
annual clearing <sup>2</sup>					327	20													
<b>New England Tablelands</b>																			
pre-clearing area	4,985	965			1,174	14													
1999 remnant area (%) <sup>1</sup>	29	57			42	12													
annual clearing <sup>2</sup>	14	2			1	0													
<b>North-west Highlands</b>																			
pre-clearing area			127			2,711	3,905	48,503	1,186	17	5,961	1,157	7,630	1,849	98				
1999 remnant area (%) <sup>1</sup>			100			100	99	99	99	100	99	100	99	100	100				
annual clearing <sup>2</sup>			0			4	1	16	0	0	12	0	5	0	0				
<b>South-east Queensland</b>																			
pre-clearing area	10,592	25,451			2,767	5,884													
1999 remnant area (%) <sup>1</sup>	34	53			17	31													
annual clearing <sup>2</sup>	7	34			0	16													
<b>Wet Tropics</b>																			
pre-clearing area	4,243	964	343			592	31	513											
1999 remnant area (%) <sup>1</sup>	85	53	70			97	15	46											
annual clearing <sup>2</sup>	5	1	1			0	0	0											
<b>TOTAL</b>																			
pre-clearing area	176,821	45,355	88,002	29,513	129,522	89,727	27,186	86,309	99,639	95,916	187,896	111,561	53,719	349,279	38,235	94,666	19,332	15,332	1,737,060
1999 remnant area (%) <sup>1</sup>	78	67	99	92	48	75	99	98	73	97	48	88	99	96	49	96	92	94	82
annual clearing <sup>2</sup>	298	91	4	217	1,425	336	7	33	370	130	856	353	21	231	44	25	8	16	4,460

1 Percentage (%) of pre-clearing area  
2 Calculated as an average annual rate of 2 years between 1997-1999

Source: Wilson et al (2002:33-35)<sup>10</sup>

4

## IMPACTS ON WILDLIFE MAMMALS

### 1. Overview

Australia is home to a strikingly unique range of mammals, and is the global centre of diversity for marsupials (pouched mammals) and monotremes (the egg-laying echidna and platypus).<sup>23</sup> The continent contains 156 species of marsupials and monotremes, only 12 of which can be found anywhere else (all of them in New Guinea and its islands). Similarly, the 64 species of Australian native rodents include only ten species that also occur outside Australia.<sup>24</sup>

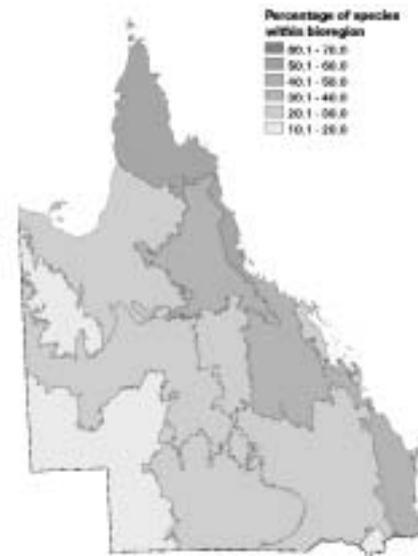
Queensland is the stronghold of mammal diversity in Australia: over half of the continent's marsupials and monotremes, and 78 per cent of its bats, are found in Queensland. Moreover, some highly distinctive elements of Australia's mammal fauna are concentrated in Queensland. For example, Queensland is the only state of Australia which has specialist rainforest mammals, and of Australia's 16 species of rock-wallabies, 12 are found in Queensland and nine of these are found nowhere else.<sup>25</sup>

Mammal diversity in Queensland is concentrated along the wet tropical coast and on Cape York

#### MAMMALS AT A GLANCE

- Australia has the highest number of endemic mammal species of any country in the world.<sup>26</sup>
- The conservation status of Queensland's mammals include five extinct, 12 endangered and 20 vulnerable species and sub-species.<sup>27</sup>
- The 163 native species of non-marine mammals in Queensland include 123 (75 per cent) that are found naturally only in Australia, and 35 (21 per cent) that occur only in Queensland.<sup>28</sup>
- The conservation status of Australian mammals includes 27 extinct, one critically endangered, 33 endangered and 51 vulnerable and one conservation dependent mammal species and sub-species.<sup>29</sup>
- The 305 native species of non-marine mammals in Australia include 258 (85 per cent) that are found naturally only in Australia.<sup>30</sup>

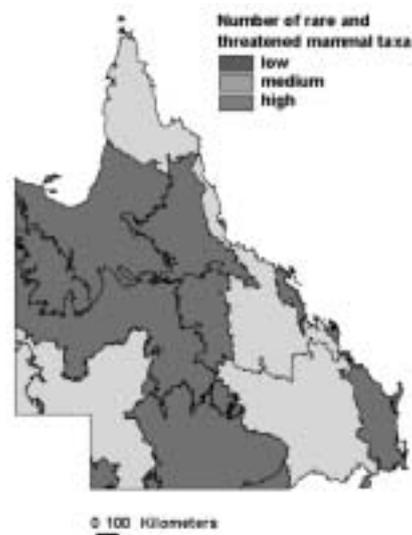
Figure 6: Diversity of native mammals by bioregion



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Peninsula, and these regions include some of the most distinct components of the fauna, such as the two species of Australian tree kangaroos and the spiny bandicoot. However, the majority of species occur in the large areas of sclerophyll forests and woodlands in the eastern half of the state, that are currently subject to high rates of land clearing. Many of these species originally had large geographic ranges that are now in the process of being reduced and broken up by extensive habitat destruction.

Figure 7: Rare or threatened mammals in each bioregion



Note: Figure derived from Table 7-19, Qld State of the Environment Report (1999)

## 2. Number of Mammals Killed by Land Clearing

- **More than 2.1 million mammals die in Queensland each year as a result of land clearing**

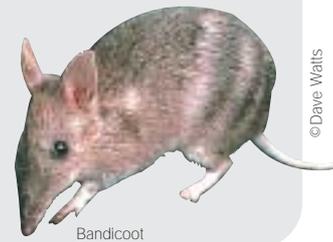
Over 2.1 million mammals are estimated to be killed by land clearing each year in Queensland. The true figure is likely to be much higher than this conservative estimate, which is based only on species for which abundance has been measured in the habitats that are subject to land clearing. These measures are available for all species of macropods, possums and gliders and bandicoots that are vulnerable to clearing, but for only eight of 23 species of small carnivorous marsupials and eight of 25 species of rodents. The figure does not include any estimate of the number of bats killed, because there is no information on population sizes of bats in these habitats. Land clearing reduces food resources for bats and destroys the roost sites of

many species. Species like flying foxes that are able to escape the immediate effects of land-clearing are forced to make increased use of fruit crops and other exotic vegetation, and this often puts them in conflict with people.<sup>31</sup>

Of the 342,000 possums and gliders killed annually, about half of the lost possums and gliders are common brushtail possums (*Trichosurus vulpecula*): common brushtails are still widespread in dry forests and woodlands in Queensland but are becoming less common in other parts of Australia. At least five other species are also seriously affected. The tiny feathertail glider (*Acrobates pygmaeus*) contributes about a third of the total number, and the remainder is made up of about equal numbers of sugar gliders (*Petaurus breviceps*), squirrel gliders (*P. norfolcensis*), greater gliders (*Petauroides volans*) and common ringtail possums (*Pseudocheirus peregrinus*).

**Table 2: Summary of total number of selected mammals killed annually in Queensland by land clearing**

Mammal Type	Total Number Killed
Koalas	19 000
Possums and gliders	342 000
Echidnas	Over 7 500
Macropods (kangaroos, wallabies and rat-kangaroos)	233 000
Bandicoots	29 000
Small carnivorous marsupials (dunnarts antechinus and others)	1.25 million
Rodents (native rats)	196 000



Bandicoot

**Table 3: Number of selected mammals killed annually in Queensland by land clearing (by bioregion)**

Bioregion	Annual clearing rate (ha/yr) <sup>32</sup>	Estimated (minimum) mammal density (individuals/ha) <sup>33</sup>	Number of mammals displaced killed/year
Brigalow Belt	260,200	3.93	1,022,586
Channel Country	500	10.26	5,130
Central Old Coast	2,600	42.12	109,512
Cape York Peninsula	0		0
Desert Uplands	51,100	3.48	177,828
Einiasleigh Uplands	2,800	1.42	3,976
Gulf Plains	2,100	0.58	1,218
Mitchell Grass Downs	26,900	2.86	76,934
Mulga Lands	85,400	2.87	245,098
New England Tablelands	1,800	45.11	81,198
North-west Highlands	3,800	0.16	608
South-east Queensland	7,400	51.24	379,176
Wet Tropics	1,300	50.46	65,598

<b>TOTAL</b>	<b>445,900</b>		<b>2,168,862</b> Rounded down to 2.1 million
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**Table 4: Number of selected mammals killed annually in Queensland by land clearing (by bioregion)**

Bioregion	Koalas (3)	Possums and Gliders	Bandicoots
Brigalow Belt	18,000	110,000	-
Channel Country	-	-	-
Central Old Coast	200	40,000	6,000
Cape York Peninsula	-	-	-
Desert Uplands	-	27,000	-
Einasleigh Uplands	-	1,500	-
Gulf Plains	-	-	-
Mitchell Grass Downs	-	-	-
Mulga Lands	-	-	-
New England Tablelands	-	28,000	3,000
North-west Highlands	-	-	-
South-east Queensland	600	115,000	17,000
Wet Tropics	-	20,000	3,000
<b>TOTAL</b>	<b>19,000<sup>(1)</sup></b>	<b>342,000<sup>(2)</sup></b>	<b>29,000<sup>(3)</sup></b>

Notes: 1 Totals are rounded to the nearest 1,000

2 The brigalow belt features prominently because of the large area being cleared, even though relatively few species occur there and at low density. Other regions, especially South-east Queensland are significant because although there is not such a high absolute rate of clearing it affects more species, many of them living at high density.

3 Some of the gaps reflect the judgement of the authors that although the target species occur there, they are at such low density or so patchy that numbers affected would be small, or impossible to estimate without fine-scale studies. This applies, for example, to koalas in the Desert Uplands.

#### Method Used to Calculate Impacts of Clearing of Remnant Vegetation on Mammals

Estimates of numbers of individual mammals killed by vegetation clearing were based on measurements of population density for each species. These species-specific estimates of population density were then extrapolated over the areas cleared, and estimates of numbers of individuals of each species were accumulated to arrive at a figure for the total number of individuals.

Measures of population density were taken from a database of abundances of Australian mammals compiled by Dr Chris Johnson<sup>34</sup>. Entries in this database consist of data from the published literature, unpublished reports and theses (a total of 112 literature sources), and from unpublished data supplied on request from mammal ecologists (24 personal sources). In each case the estimate of density represents a measurement produced by a detailed ecological study of a species in a defined locality.

The complete database for Queensland species consists of estimates of population density for 62 species. This includes data on all species of bandicoots, macropods (except for some species of rock-wallabies), and almost all species of possums and gliders occurring in the State. For many of these species density has been measured in multiple locations. Where many independent

estimates of density are available, their distributions are typically right-skewed; that is, most values are low or moderate but a small number are very high. Such rare high values have a large effect on the mean density for a species. To reduce this effect, means for each species were first calculated on log-transformed density measurements and were then back-transformed to produce normal values. There are substantial gaps in information on population densities of species of carnivorous marsupials, especially the smaller-bodied species (data available for only eight of 23 species in the State) and rodents (data available for only eight of 25 species). There are no estimates of population density of bat species in Queensland.

Only those species considered to be vulnerable to the effects of broad-scale vegetation clearance were included in the calculations. Species that were excluded were:

1. predominantly aquatic species (the platypus *Ornithorhynchus anatinus* and water rat *Hydromys chrysogaster*);
2. species with distributions restricted to small areas of rocky terrain (rock-wallabies, and the common rock-rat *Zyomys argurus*);
3. the red kangaroo *Macropus rufus*, a species of open plains that may have benefited to some extent from past land clearing;

4. species that are restricted to the rainforests of the Wet Tropics World Heritage Area; and
5. species with very small geographic ranges (some of these, such as the northern hairy-nosed wombat, are protected from the direct effects of vegetation clearing).

These exclusions are conservative, because some of these species may be indirectly affected by clearing of vegetation. For example, the core refuge habitats of rock-wallabies may not be destroyed by broad-scale vegetation clearance, but clearing may impede migration between populations and degrade habitats used for feeding.

The approach used here assumes that the densities measured by intensive ecological studies are representative of those pertaining in intact vegetation across whole bioregions. If past studies have tended to focus on sites and species where abundance is relatively high, this could result in over-estimation of the total number of individuals affected. The approach also suffers from the weakness that only species for which population density has been measured directly by detailed ecological study could be included in the estimates. It is for this latter reason that the final figure is considered to be probably an underestimate.

#### THE BLACK-STRIPED WALLABY: FROM COMMON TO THREATENED IN 30 YEARS ?

The black-striped wallaby (*Macropus dorsalis*) is a beautiful, medium-sized macropod that is widespread through the brigalow belt, south-east and central coast bioregions of Queensland. It is also found in north-eastern New South Wales, but past habitat destruction has made it a rarity in that State.



Black-striped wallabys

© Jean-Paul Ferrero/AUSCAPE

Range of the black  
striped wallaby –  
[Strahan 1995]

The species is most abundant in mixed brigalow/eucalypt woodland. It rests in dense thickets during the day, often in large groups, and it follows regularly-used paths to reach open patches or forest edges to graze at night.

The black-striped wallaby is a wary animal that likes to retreat deep into dense vegetation for shelter<sup>35</sup>. Clearing of vegetation destroys these refuges, and throughout much of its range the species is now restricted to isolated sites where dense woodland patches remain. It can be very abundant in such areas, and so is still considered by most people to be a common animal.

However, continued clearing of its habitat could place this species at risk in the near future. The total original area of suitable habitat for the black-striped wallaby in Queensland was approximately 247 600 km<sup>2</sup>. Only 84 154 km<sup>2</sup> (34 per cent) of this remained in 1999, and this is being cleared at a rate of about 1 865 km<sup>2</sup>/year. At this rate, the total population of this currently common species will be reduced to less than ten per cent of its original size by the year 2030.

### 3. The Future of Mammals

One in four Australian mammal species is now extinct or threatened with extinction.<sup>36</sup> Australia has the worst record of recent mammal extinctions of any country in the world; around half of all mammal extinctions globally in the last 200 years have been in Australia.<sup>37</sup> We have lost 17 mammal species and ten sub-species,<sup>38</sup> with four species becoming extinct in the last 50 years.<sup>39</sup> A further 85 species and sub-species species are classified as Critically Endangered, Endangered, or Vulnerable.<sup>40</sup> To date, most of the serious mammal declines have been concentrated in the southern half of the continent.

So far, only two species that originally occurred in Queensland have become extinct (the desert rat-kangaroo and the Darling Downs hopping mouse). Nineteen mammal species and one sub-species that occur in Queensland are classified as Critically Endangered, Endangered or Vulnerable.<sup>41</sup>

Queensland's mammals have fared relatively well because there are large areas of the state where rabbits and foxes have not established or where they occur in low numbers, because the extensive cattle grazing that is practised over much of inland Queensland is less damaging to the landscape than sheep grazing, and because more of Queensland's natural vegetation cover remains intact than in southern Australia. However, current rates of land clearing put many of Queensland's mammal species at risk.

Mammals are especially sensitive to the effects of habitat reduction and fragmentation. This is because they typically occur at low population densities, and individuals may require large areas of habitat for survival. As a result, remnant patches of vegetation must be large if they are to support viable populations for most mammal species. Moreover, for the majority of species that depend on vegetation cover for survival, movement through

the landscape is severely curtailed by land clearing. This means that populations in isolated fragments of habitat can not be replenished by dispersal from other areas. A study of mammal communities in woodland habitat in Victoria showed that macropods, possums and gliders were generally absent from woodland patches of less than ten ha, and that the number of species in a woodland patch declined with time since isolation of that patch by clearing of the surrounding vegetation.<sup>42</sup>

Although relatively few Queensland mammals are currently classed as threatened, many are classed as 'near threatened'; this currently applies to 20 of Queensland's marsupial species.<sup>43</sup> These are species not considered to be at immediate risk of extinction, but which have suffered substantial declines in the past and might soon become threatened with extinction if their environment deteriorates further. Continued land clearing has the potential to push many of these species into the higher threat categories making them more vulnerable to extinction.

Bilby



© Jean-Paul Ferrero/AUSCAPE

## BIRDS

### 1. Overview

Queensland has the highest number of native bird species of any Australian State.<sup>44</sup> The southern brigalow belt of Queensland and northern NSW, for example, is home to 328 species of birds, almost half of those that live in Australia.<sup>45</sup>

Australia's eucalypt forests and woodlands contain the highest number of bird species of any ecosystem in Australia. About 85 bird species are found in highest densities in eucalypt forests, while 149 species mostly occupy eucalypt woodlands. Almost all these birds are found only in Australia, or at most are also found in small areas of New Guinea. Numerous species, for example the Speckled Warbler and Diamond Firetail, have ranges that span the woodland belt along and inland from the Great Dividing Range where clearing was most intense last century, and continues to this day in Queensland and NSW.<sup>46</sup>



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#### BIRDS AT A GLANCE

- Australia has the second highest number of endemic bird species of any country in the world, after Indonesia.<sup>47</sup>
- The conservation status of Queensland's birds includes one extinct, 11 endangered and 22 vulnerable bird species and sub-species.<sup>48</sup>
- 615 native bird species are found in Queensland.<sup>49</sup>
- The conservation status of Australian birds include 23 extinct, five critically endangered, 34 endangered and 62 vulnerable bird species and sub-species.<sup>50</sup>
- The 825 native bird species in Australia include 45 per cent that are found naturally only in Australia.<sup>51</sup> Of these, about 535 are breeding non-marine species.<sup>52</sup>

Figure 8: Diversity of bird species by bioregion

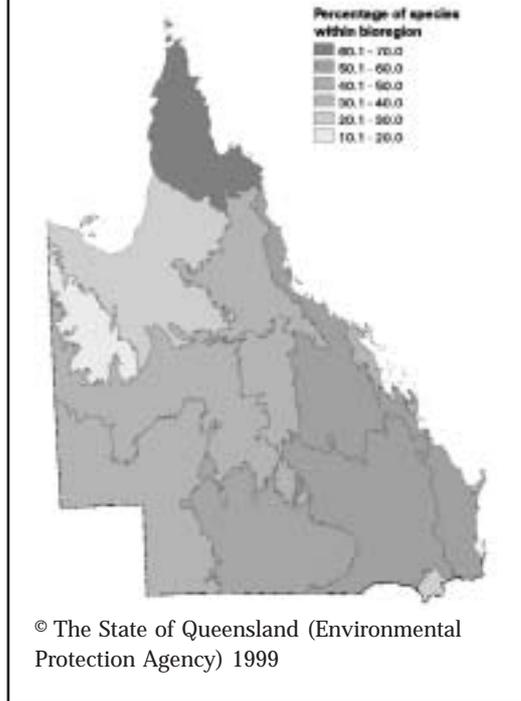
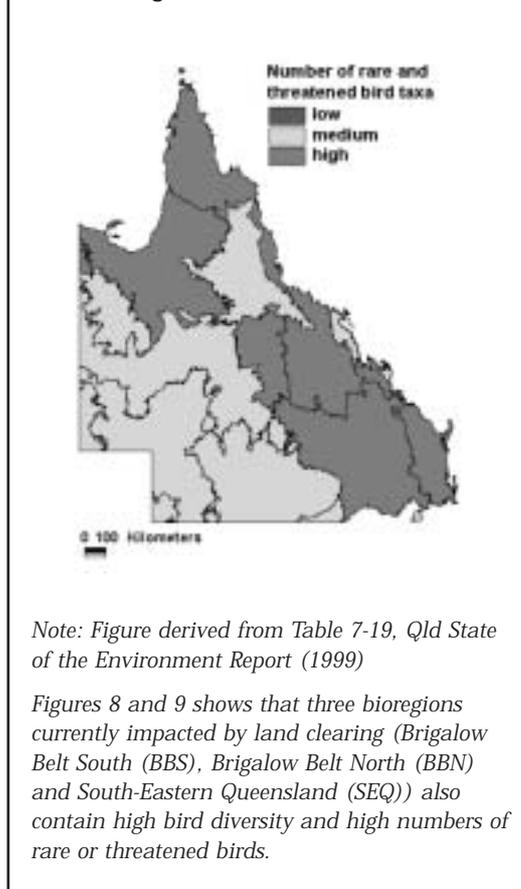


Figure 9: Rare or threatened birds in each bioregion



## 2. Number of Birds Killed by Land Clearing

- At least 8.5 million birds die in Queensland as a result of land clearing each year

At least 8.5 million birds are estimated to die in the short to medium term due to land clearing in Queensland every year. The biggest casualties are woodland bird species, particularly those in eucalypt woodlands where 6.2 million birds were killed yearly (see Table 5). The birds of the Brigalow Belt bioregion were most impacted – where over five million birds die as a result of land clearing each year. These include bellbirds, honeyeaters, robins, parrots, finches and wrens (see Table 7).



**Table 5: Number of birds killed annually in Queensland by land clearing (by general vegetation type)**

General vegetation type	Broad Vegetation Type (BVT) Number <sup>53</sup>	Average annual clearing rate (ha/yr) <sup>54</sup>	Mean bird density (birds/ha)	Number of birds displaced/year
Tablelands woodland	1	29,800	18.9	563,220
Open Forest	2	9,100	31.0	282,100
Eucalypt Woodlands	3,4,5,6,7,8,9	239,200	26.0	6,219,200
Acacia Woodlands	10,11,12	133,900	10.2	1,365,780
Grassland	13,14	25,200	1.3	32,760
Rainforests	15	4,400	33.0	145,200
Wetlands	16	2,500	?	?
Mangroves	17	800	?	?
Heathlands/mixed shrublands	18	1,600	?	?
<b>TOTAL</b>				<b>8,608,260</b> rounded down to 8.5 million

Table 5 relates the number of birds that die to general vegetation types derived from the Queensland Herbarium's 18 Broad Vegetation Types (BVTs). The number of birds that die as a result of the clearance of wetlands, mangroves and heathlands cannot be calculated due to the lack of bird density information for these vegetation types. The figure of at least 8.5 million would be significantly higher if the number of birds that die from the clearing of these three vegetation types could be included, since, for example, wetlands have relatively high bird densities.

### Method Used to Calculate Impacts of Clearing of Remnant Vegetation on Birds

There have been many estimates of the density of birds in eucalypt woodlands and forests. Riparian woodland and open forest, typically with river oak, tends to be especially rich in birds. Density of birds may vary seasonally with the arrival and departure of migrants and the production of young. It also varies between years being appreciably lower towards the end of severe droughts, though it may be increased by the arrival of nomads from inland Australia. Furthermore, the most commonly used methods of estimating bird numbers - fixed-width transects - under-estimate the density of birds. Other estimates are based on the number of pairs of each species. Most conservatively these can be doubled, but more realistically because so many



birds have helpers and there is a small floating residue of non-breeders, a multiplier of three or more should be used. By the end of the breeding season young birds are added, conservatively adding another individual to the pair. Consequently, in this analysis the number of pairs were multiplied by four to estimate density of birds. Some of the information on density of birds in a range of habitats in NSW and Queensland is given in Table 5. Although most of the data on density of birds are from New South Wales studies, most vegetation communities (habitats) cross the Queensland state border and densities of birds are generally similar in both states. The mean density for each habitat has been calculated from the mean densities in each of the studies listed in Table 5.

Hence, the overall estimate is that at least 8.5 million birds will be displaced from their habitat. They or the birds they subsequently displace die in the short to medium term, due to clearing in Queensland every year at current rates of clearing. Note that the biggest losses in both area of habitat and birds is from eucalypt and acacia woodlands. The authors only found one estimate of density of birds in acacia woodland and none from brigalow. This habitat is typically a mix of acacia, eucalypts and other trees, often with considerable structural diversity. It is likely to contain quite high bird densities.

**Table 6: Estimates of the density of birds from a variety of habitats.**

Habitat	Region	Density - Birds/ha	Reference	Notes
Broad Vegetation Group - 1		Mean = 18.9		
Tablelands Woodland	New England	21.5-23.6	Ford and Bell 1982 <sup>55</sup>	Large remnant
Tablelands Woodland	New England	9.7	Ford et al. 1985 <sup>56</sup>	Same as above but after severe drought
Tablelands Woodland/Open Forest	New England	18.2 breeding, 32.5 winter	Howe 1984 <sup>57</sup>	Continuous forest
Tablelands Woodland/Open Forest	New England	16.1 breeding, 16.6 winter	Howe 1984 <sup>58</sup>	Remnants
Tablelands Woodland	S NSW	16.4-20	Recher and Holmes 1985 <sup>59</sup>	
Tablelands Open Forest	S NSW	15-27.6	Recher and Holmes 1985 <sup>60</sup>	
<b>Broad Vegetation Group - 2</b>		<b>Mean = 31.0</b>		
Open Forest and Woodland	SE Queensland	9.9 summer, 25.5 winter	Catterall et al. 1998 <sup>61</sup>	
Dry Sclerophyll Forest	Coastal NSW	23.6-51.3	Milledge and Recher 1985 <sup>62</sup>	
Wet Sclerophyll Forest	Coastal NSW	36.8-54.1	Milledge and Recher 1985 <sup>63</sup>	
Dry sclerophyll Forest	Coastal NSW	31.5	Shields et al. 1985 <sup>64</sup>	
Wet Sclerophyll Forest	Coastal NSW	25.9-35.5	Shields et al. 1985 <sup>65</sup>	
Open Forest	Sydney	23.3	Keast 1985 <sup>66</sup>	
<b>Broad Vegetation Groups - 3, 4, 5, 6, 7, 8, 9</b>		<b>Mean = 26.0</b>		
Open Forest	NW Slopes of NSW	42.8	Oliver et al. 1999 <sup>67</sup>	
Poplar Box	Central Queensland	9.2	Gilmore 1985 <sup>68</sup>	Number of pairs x 4
Open Forest	Pilliga Scrub	25.9	Date, pers comm	
<b>Broad Vegetation Groups - 10, 11, 12</b>		<b>Mean = 10.2</b>		
Gidgee	Central Queensland	10.2	Gilmore 1985 <sup>69</sup>	Number of pairs x 4
<b>Broad Vegetation Groups - 13, 14</b>		<b>Mean = 1.3</b>		
Grassland	New England	0.8	Ford and Bell 1982 <sup>70</sup>	Native grassland, scattered trees
Grassland	New England	1.9	Barrett 1995 <sup>71</sup>	Native or Exotic Pasture, Scattered Trees
<b>Broad Vegetation Group - 15</b>		<b>Mean = 33.0</b>		
Rainforest	Coastal NSW	33.0	Shields et al. 1985 <sup>72</sup>	

Notes: 1 Broad Vegetation Groups 16, 17 and 18, bird densities not calculated – only small areas cleared.

2 Broad Vegetation Groups are from Appendix 3 and have been grouped together into more general habitat types, for which there are data on bird density.

**Table 7: Reductions in recording rates between the First (1980) and the Second Bird Atlas (2000) for a selection of species**

Species	Decline in Australia	Decline in NSW
Emu		39%
Bush Stone-Curlew		63%
Flame Robin	51%	56%
White-browed Woodswallow	38%	61%
Black-faced Woodswallow	36%	65%
Scarlet Robin	31%	55%
Dusky Woodswallow	28%	41%
Hooded Robin	27%	41%
Crested Shrike-tit	25%	18%
Masked Woodswallow	22%	46%
Jacky Winter	19%	21%
Restless Flycatcher		32%
Varied Sittella		44%
Diamond Firetail		39%
Brown Treecreeper		16%
Noisy Miner		Increase of 15%
Pied Currawong		Increase of 11%
Common Myna		Increase of 140%
Grey Butcherbird		Increase of 33%

*Notes: Figures are National and NSW only (no analysis has yet been completed for Queensland)*

*Sources: Blakers et al. (1984)<sup>73</sup> and G.W. Barrett, Birds Australia, pers. comm.<sup>74</sup>*

### DECLINE OF AUSTRALIA'S WOODLAND ROBINS

Australia's robins are a well-known and colourful part of Australia's birdlife.<sup>75</sup>

Birdwatchers have suspected for over 25 years that some robins have disappeared from their regular haunts.<sup>76,77</sup>

Scientists have now documented the local extinction and dramatic decline of robins in the WA wheatbelt, the Mount Lofty Ranges of SA and Victoria; regions where most of the clearing took place long ago.

The Second Bird Atlas, conducted by Birds Australia, has assessed the national decline of robin species over the last 20 years. The number of surveys in which Flame Robins were sighted has fallen by 51 per cent, while sightings of Scarlet Robins fell by 31 per cent and Hooded Robins by 27 per cent. The pattern in NSW, where clearing has been intense from the 1970s to the 1990s, showed declines of 50 per cent or more for several species (Table 7). Now the greatest rate of clearing is in Queensland and if this continues we can expect the dramatic declines of robins and other birds to spread north during this century.

Although robins may venture into open, partly cleared country in winter they need woodland, with some understorey for breeding. Clearing for agriculture deprives them of breeding habitat. A recent study of the impact of tree clearing in central Queensland found that the abundance of robins declined significantly in cleared areas.<sup>78</sup>



Flame robin

© Roger Brown/AUSCAPE

Following clearing, there are many examples of robin species disappearing from remnant vegetation – in some cases even from patches that are 100s or 1000s of hectares in area. Reasons include increased predation of young, decreased food due to grazing pressure, and smothering of nesting and hiding sites by weeds and exotic grasses.

What is apparent is that clearing followed by habitat degradation can trigger a downward spiral for robins resulting in regional extinctions and state-wide declines of these beautiful birds.

### 3. The Future of Birds

One in five Australian bird species is now threatened with extinction,<sup>79</sup> and scientists predict that if current threats are not reversed soon, half of the nations birds, or over 250 land bird species, will become extinct by 2100.<sup>80</sup> Recent studies from throughout the temperate woodlands have found that dozens of woodland birds are still declining in total numbers and distribution. Many of these declines are happening rapidly, and placing currently common birds onto the path of extinction.

The decline of woodland birds in the southern woodlands of Australia is well documented, where the pattern of decline and range contraction generally follows the historical pattern of broad-scale clearing. Queensland has so far retained relatively more of its native vegetation than southern States, and consequently may not have yet experienced the same decline in woodland birds.

Consequently, Queensland can learn from the southern States and also play an important role in conservation by providing a final stronghold for Australia's woodland bird community. For example Grey-crowned Babblers are still common in Queensland but they are now extinct in south-eastern South Australia, very rare in Victoria and are declining at the edges of their range in NSW. Many other woodland birds are showing similar patterns.

This final stronghold is now being breached. The southern brigalow belt woodlands, home to 328 species of birds, now have three species listed as endangered and a further 21 species listed as vulnerable or rare. At least three more species are extinct from the southern half of their former range: the Squatter Pigeon, Star Finch and the Black-throated Finch.

Short- to medium-term impacts on specific bird groups were monitored in a recent study on the impacts of tree clearing in Central Queensland. It shows that the abundance of insect eating birds (such as treecreepers, thornbills, robins and flycatchers) and fruit eating birds declined significantly in cleared sites. Birds that forage in the canopy and middle layers of eucalypt woodlands were noticeably absent. Additionally, within the small patches left to provide shade for cattle and other uses, the species composition is changing with larger generalist birds (such as the Australian Magpie and Noisy and Yellow-throated Miner) displacing the smaller insect and fruit feeding birds.<sup>81</sup>

The immediate effect of clearing habitats is obvious. The relationship between the area of an island or patch of habitat and the number of species is one of the most robust in the science of ecology. Reduction of an ecosystem by 90 per cent will lead to about a halving in the number of

species of most species groups, including birds. This level of clearing has been reached or exceeded in the Western Australian wheatbelt, Mount Lofty Ranges of South Australia, and many regions in Victoria and southern NSW.

However, an end to broad-scale clearing is only the first step required to arrest and ultimately reverse the decline of woodland birds.<sup>82</sup> Habitat loss leads to fragmentation with small populations in remnants being at a high risk of extinction. When remnants are a long way from each other, young birds are unable to disperse to find breeding territories and mates. This effect is now well understood for Brown Treecreepers in NSW and Blue-breasted Fairy-wrens in the WA Wheatbelt.<sup>83,84</sup> Fragmented habitat suffers degradation by exposure to more extreme weather, by invasion of weeds, exotic pasture grasses and open country animals across edges. Furthermore, heavy grazing, changes to the fire and water regimes, removal of firewood, and tidying up further degrade and simplify the woodland habitat. A few bird species may increase in abundance - Noisy Miners, which aggressively exclude other birds<sup>85</sup> and Pied Currawongs, which are major nest predators.<sup>86</sup>

What is abundantly clear is that habitat loss, fragmentation and degradation are key threats for one half of birds in Australia.<sup>87</sup> Our birds are being pushed down a path to extinction similar to the one last century that led to Australia holding the unenviable record of losing more mammal species than any other country since 1500.<sup>88</sup> Urgent action is required to reverse this trend, starting with an end to broad scale land clearing.



C. Andrew Henley/AUSCAPE

## REPTILES

### 1. Overview

With a total of at least 850 species of reptiles (including 820 non-marine species), Australia has nearly ten per cent of the world's known reptiles. Moreover, some 87 per cent (92 per cent of non-marine species) of Australia's reptiles are found nowhere else, so that the survival of these species, globally, depends entirely upon the actions of Australians.

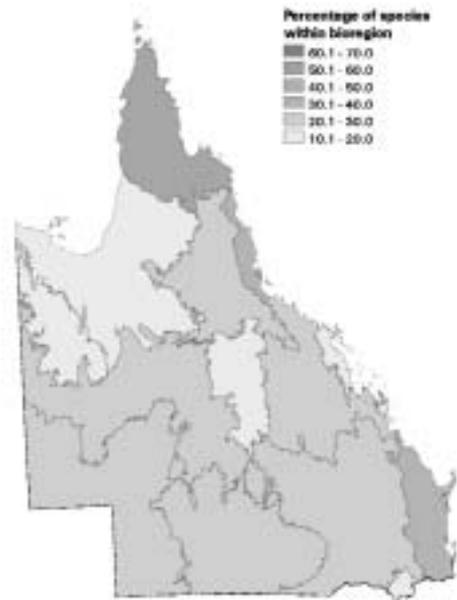
Queensland is one of Australia's most diverse States for reptiles. Of Australia's 820 non-marine reptile species, 51 per cent (421 species) are found in Queensland – about the same number as in Western Australia but nearly twice the number found in NSW.<sup>89</sup> Queensland has national hotspots of exceptionally high species richness for several major groups of reptiles such as skinks, geckos and snakes.<sup>90</sup>



#### REPTILES AT A GLANCE

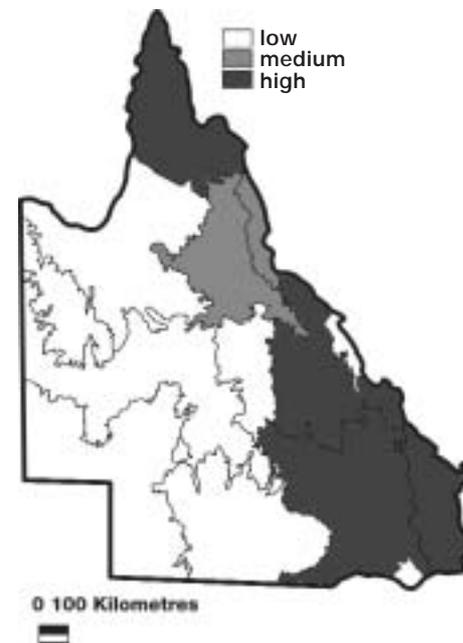
- Australia possesses nearly ten per cent of the world's reptile species.<sup>91</sup>
- Australia has the world's highest number of endemic reptile species.<sup>92</sup>
- The conservation status of Queensland's reptiles includes four endangered and 15 vulnerable species and sub-species.<sup>93</sup>
- Of the 421 native non-marine reptile species found in Queensland, 35 per cent are found naturally *only* in that State.<sup>94</sup>
- The conservation status of Australian reptiles includes 12 endangered and 38 vulnerable reptile species and sub-species.<sup>95</sup>
- Of the 820 native non-marine reptile species found in Australia, 92 per cent are found naturally *only* in Australia.<sup>96</sup>

Figure 10: Diversity of reptile species by bioregion



© The State of Queensland (Environmental Protection Agency) 1999

Figure 11: Rare or threatened reptiles in each bioregion



Note: Figure derived from Table 7-19, Qld State of the Environment Report (1999)

## 2. Number of Reptiles Killed by Land Clearing

- **An estimated 89 million reptiles die in Queensland as a result of land clearing each year**

An estimated 89 million reptiles are being displaced from their habitat every year due to clearing of native vegetation in Queensland and will die in the short term and not be replaced. The highest losses will be in the brigalow belt where more than 52 million reptiles were killed each year in a region that has already lost about 57 per cent of its original extent and is still losing, annually, 1.8 per cent of what remains. At current rates, only 39 per cent would remain in 20 years time, during which time an estimated 1.04 billion reptiles would have been permanently eliminated from Queensland's rich wildlife resource base.

**Table 8: Number of reptiles killed annually in Queensland by land clearing**

General vegetation Type/bioregion	Average annual clearing rate (ha/yr)	Number of reptiles killed (millions)
Brigalow Belt	260,200	52.04
Desert Uplands	51,100	10.22
Mitchell Grass Downs	26,900	5.38
Mulga Lands	85,400	17.08
South-east Queensland	7,400	1.48
All other areas	14,900	2.98
<b>TOTAL</b>		<b>89.18 million rounded down to 89 million</b>

### Method Used to Calculate Impacts of Clearing of Remnant Vegetation on Reptiles

The estimate of reptile impacts is based on a methodology previously developed by Drs Harald Ehmann and Hal Cogger.<sup>97</sup>

This method involved an examination of the known range of densities for the few species of Australian reptiles that have been studied in detail, and then, using mallee as a typical mid-range habitat, estimating a mean species-richness across Australia.

The range of reptile species richness in Australian habitats ranges from about five species (in some stony deserts) to about 100 species in a variety of tropical environments. Individual species densities in a variety of reptilian families ranged from less than 5/ha to more than 300/ha.

Applying this method to reptiles alone,<sup>98</sup> it was concluded that a conservative estimate of the density of reptiles across a wide range of Australian native habitats could be obtained by assuming that:

- the mean number of species of reptiles in native Australian habitats is about 20;
- collectively, these individual species have a mean density of about ten per hectare; and
- these figures translate into an estimate of a mean density throughout native vegetation in Australia of 200 reptiles per hectare.

In summary, it was *conservatively* estimated that:

- Australia has a "standing crop" or carrying capacity of about 154 billion reptiles;
- Every year, approximately 20 per cent of the standing crop - 31 billion reptiles - die naturally and are replaced by young born in that year;
- At least 4.4 million reptiles die each year on Australia's roads ("roadkills"); and
- At most, about 15,000 reptiles are taken from the wild each year for museum collections, research and keeping as pets.

These estimates were informed by a variety of studies, including a study by Dr Peter Rawlinson that showed in native habitat, such as mallee in Victoria, clearing for cereal production resulted in a reduction in resident reptiles from 30 species to four (a permanent reduction of 77 per cent).<sup>99</sup> In mallee in central western NSW, studies by Dr Cogger showed that a reduction from 35 to nine (74 per cent reduction), but this variation was not strongly correlated with remnant size suggesting that other factors such as distance from other areas, vegetation structure and floristics were also important. On the other hand, the number of species surviving in land cleared for agriculture was inversely correlated with the size of the area cleared. More recently, research by CSIRO scientists in central NSW has also shown that many reptile species found in native habitats in the region are absent from adjacent areas cleared for agricultural production.<sup>100</sup>

Great desert skink



©Steve McAlpin

#### REPTILES IN THE QUEENSLAND BRIGALOW

Of the 148 reptile species found in Queensland's brigalow belt, in 1998 scientists found that 13 species are virtually restricted to the region, while a further 14 species have most of their range located within the region.<sup>101</sup> When these 27 species were assessed against international threatened species criteria,<sup>102</sup> one was ranked as critically endangered (and may well be extinct), one as endangered, ten as vulnerable and two as near-threatened.

This includes the Yakka Skink (*Egernia rugosa*), listed as vulnerable under both Queensland and Commonwealth legislation, which is found in relatively small numbers from south-east Queensland to the lower eastern parts of Cape York Peninsula. It is a large, well-built lizard growing to a total length of nearly half a metre. It is a relatively shy, basking lizard that retreats into its burrow at the slightest disturbance, and so is not often seen.

Its burrows are usually associated with rocky outcrops or tree root systems in a range of habitats from open forests to woodlands and shrublands. Land clearing results in extirpation of the lizard by removing its cover and exposing its burrows to destruction by farm machinery and grazing sheep and cattle.

Yet despite the threat to so many species, only two per cent of the region had been set aside in reserves – an area not much larger than that cleared during each and every year of the previous decade. A further four per cent consisted of State forests and Timber Reserves offering some protection into the future. Of 163 regional ecosystems identified in the brigalow belt by plant ecologists, 33 were classified as endangered and 32 as being of concern. All of this in an area occupying nearly 20 per cent of Queensland.

So even when the major threat to maintaining the rich diversity of animals and plants of the brigalow belt – the clearing of native vegetation - had been clearly identified, nothing was done to stem the loss. Indeed, high rates of land clearing continue.

The authors of this study concluded that the brigalow belt in Queensland "...is a fine example of how to diminish diversity – encourage clearing of native forests, through taxation and other incentives; fail to secure in conservation reserves representatives of all vegetation types in the region; recognise late, after several species have become extinct or are in decline, that a major problem in maintaining diversity exists; and proceed with plans for further development even though diversity is already known to be assailed."<sup>103</sup>

Unfortunately this story is being repeated every day, on different scales but with similar outcomes, in many parts of Australia. Biodiversity, like water, can be degraded and overexploited to the point where whole ecosystems and their services – clean air, clean water, erosion control, moderation of climate and recreational facilities - eventually collapse.

### 3. The Future of Reptiles

One in four of Australia's 850 reptile species are in significant decline. Of these, Queensland has the highest number (84 or 41 per cent) of the 204 reptile species currently threatened.<sup>104</sup> It also comes second (after Western Australia) in the number of species falling into the two highest categories of threat – endangered and vulnerable. Of the major threats contributing to the decline of the 52 species assessed nationally<sup>105</sup> as endangered or vulnerable, land clearing was the threat most often implicated, followed by (but well ahead of) the degrading processes of overgrazing and cropping.

For a variety of reasons – small size, secretive habits, fewer researchers – and despite their greater diversity, the ecology and distribution of reptiles is much less well known than that of either mammals or birds. The majority of reptiles are declining in numbers, but those at the greatest risk of extinction are those whose declines are driven largely by clearing of native vegetation and the consequent fragmentation of their populations.

The problem with land clearing is that the great majority of the reptiles displaced die immediately or soon after clearing takes place, *and are never replaced*. If the land is allowed to revegetate over time, some reptiles will eventually re-establish themselves, but if the cleared land is replaced by crops then the original reptiles – in their millions – are lost forever.

But other primary production activities, such as grazing by livestock, also seriously degrade natural ecosystems and dramatically reduce their capacity to support the diversity and densities of reptiles that were originally present. Even rough estimates of these effects are difficult to determine on a national scale, but as lands used for grazing are primarily woodlands, open woodlands and shrublands,<sup>106</sup> and as these vegetation associations together made up

some 84 per cent of Australia's original vegetation cover (now about 79 per cent), even modest degradation of such lands results in a dramatic loss of reptilian diversity.

Few species of reptiles have had their populations monitored for long-term changes in health and numbers. Such monitoring programs as exist are usually confined to already endangered species with small numbers and well-documented declines. So we have no idea of the state of health of most of our 820 species of non-marine reptiles. Similarly, there have been virtually no studies conducted in Australia of reptile communities or assemblages in which reliable estimates have been made of both species richness *and* population numbers of each of the species present. Consequently estimates of the numbers of reptiles affected by land clearing are extrapolated from a very limited database. Nevertheless the method used is essentially conservative in its assumptions.

Quite apart from the permanent loss resulting from the annual slaughter of millions of reptiles through land clearing and related activities, the contribution of these lost reptiles to ecosystem services and functions, and the consequent loss of the land's productivity, remain unmeasured. Most reptiles are insect eaters, and using the example of Queensland's brigalow belt cited above, the 520 million reptiles killed by land clearing during the past decade would otherwise have consumed a conservatively estimated 100 billion insects annually during that period. Given other interdependencies and links in the complex ecology of woodlands and forests, the loss of reptile numbers and diversity is capable of seriously compromising the long-term viability (in terms of ecosystem services) of the affected land.

*Many of the lizards and other reptiles that survive the initial clearing of remnant bush take refuge in the wood rows of cleared vegetation. Many of these die when the woodrows are burnt.*

## REMNANT TREES

### 1. Overview

Australia has a diverse and distinctive flora dominated by eucalypts and acacias. Our native higher plants include 15,638 species, of which about 80-95 per cent are endemic.<sup>107,108</sup>

Queensland supports more higher plant species than any other Australian state.<sup>109</sup> Plant diversity is highest in coastal areas of the state, and is most concentrated in the Wet Tropics and south-east Queensland,<sup>110</sup> which represent two of Australia's nine centres of vascular plant endemism.<sup>111</sup> These two areas, which were productive and species rich, were extensively cleared by the 1960s.

During the 1990s about 80 per cent of Australia's land clearing occurred in Queensland.<sup>112</sup> Within Queensland, tree clearing has moved from the highly productive and fertile land types, for example coastal and alluvial areas, to more marginal ecosystems with lower fertility and/or rainfall.<sup>113</sup> This trend reflects legislative protection of the more heavily cleared ecosystems and the fact that the most productive land types have already had more than 90 per cent of the remnant native vegetation cleared.

#### AUSTRALIA'S VEGETATION AT GLANCE

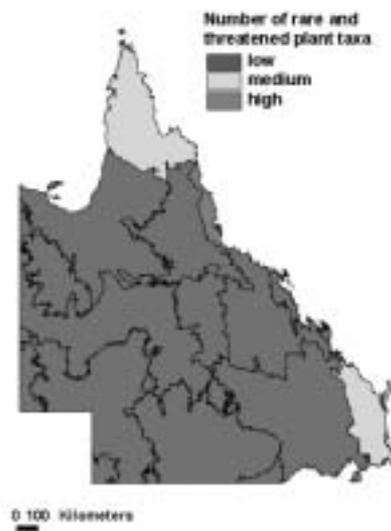
- Australia is the fifth ranked country in the world for endemic higher plant species.<sup>114</sup>
- The conservation status of Queensland's flora includes 21 extinct, 81 endangered and 243 vulnerable plant species and sub-species.<sup>115</sup>
- The 8,329 native species of vascular plants in Queensland include 2,582 (31 per cent) that are found naturally *only* in Queensland.<sup>116</sup>
- The conservation status of Australian flora includes 62 extinct, 35 critically endangered, 489 endangered and 656 vulnerable plant species and sub-species.<sup>117</sup>
- The 15,638 native species of higher plants in Australia include more than 13 000 that are found naturally only in Australia.<sup>118,119</sup>

Figure 12: Diversity of plant species (including naturalised plants) by bioregion

MAP  
TO  
COME

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Figure 13: Rare or threatened plants in each bioregion



Note: Figure derived from Table 7-19, Qld State of the Environment Report (1999)

## 2. Number of trees cleared from remnant woodlands

- **190 million trees were cleared from remnant areas in Queensland each year**

The annual clearing rate of 446,000 ha of remnant vegetation in Queensland during 1997-99<sup>120</sup> represented a loss of 190 million trees a year (estimate does not include clearing of non-remnant areas (ie. regrowth), Table 9). The greatest numbers of trees cleared from remnant areas occurred in the "Brigalow (*Acacia harpophylla*) or Gidgee (*Acacia cambagei*) open forest and woodlands" broad vegetation group (Table 9). Clearing in remnant areas of this broad vegetation group killed an estimated 60 million trees a year and accounted for about one third of all trees cleared from remnant vegetation in Queensland during two years (1997-99). Since the 1950's brigalow and gidgee communities have been targeted for tree clearing in Queensland,<sup>121</sup> mainly because of their clay soils and relatively low agricultural productivity in remnant condition. Brigalow and gidgee communities are very poorly represented in Queensland's conservation reserves.

As productive areas of native vegetation have become exhausted or protected from clearing, so clearing rates have accelerated in more marginal ecosystems such as the drier eucalypt woodlands.<sup>122</sup> For example, the clearing of an estimated 44 million trees a year from remnant "*Eucalyptus populnea* and *E. melanophloia* woodlands" accounted for the second largest proportion (23 per cent) of trees cleared from remnant areas in the 1997-99 period. In 1999, 48 per cent of these woodlands remained in a natural state.<sup>123</sup>

The two most impacted bioregions were the Brigalow Belt and the Mulga Lands where an estimated 112.32 and 34.89 million trees were cleared respectively. Of all trees cleared in Queensland in the years 1997-99, nearly six out of every ten trees cleared (58.8 per cent) were in the Brigalow Belt Bioregion (see Table 10).

**Table 9: Number of trees cleared annually from remnant areas of Queensland's broad vegetation groups (1997-99)**

Broad Vegetation Group (BVG)	Mean tree densities (trees/ha) <sup>(4)</sup>	Estimated no. of trees cleared (millions/yr)	percent of total trees cleared
1. Eucalypt woodlands on ranges.	397	11.34	6
2. Eucalypt open forest.	457	4.07	2
3. <i>Eucalyptus tetradonta</i> woodlands / open forest.	466	1.02	1
4. <i>Eucalyptus similis</i> and <i>E. whitei</i> woodlands.	231	3.66	2
5. <i>Eucalyptus populnea</i> and <i>E. melanophloia</i> woodlands.	325	43.70	23
6. Mixed eucalypt woodlands.	421	15.97	8
7. <i>Eucalyptus microneura</i> and other box woodlands.	340	1.78	1
8. <i>Eucalyptus leucophloia</i> low open woodlands.	235	1.91	1
9. Riparian eucalypt woodland.	303	11.34	6
10. <i>Acacia</i> spp. woodlands and shrublands.	1022	12.77	7
11. <i>Acacia harpophylla</i> or <i>A. cambagei</i> open forests & woodlands.	590	60.15	31
12. <i>Acacia aneura</i> woodlands and shrublands.	523	17.06	9
15. Rainforests and vine thickets.	959	2.97	2
16. Wetlands.	798	2.67	1
17. Mangroves and strand communities.	916	0.60	<1
<b>TOTAL</b>		<b>190<sup>(3)</sup></b>	<b>100</b>

Notes: 1 The broad vegetation groups 13, 14 and 18 were excluded from this analysis.

2 Estimates include only those trees cleared from remnant areas, as defined by the Queensland Herbarium. i.e. the estimate does not include cleared regrowth.

3 Rounded down to 190 million

4 Mean tree densities for BVGs from Queensland Herbarium (2002)<sup>124</sup>

**Table 10: Annual tree clearing in Queensland by bioregion (1997-1999)**

Bioregion	Estimated no. of trees cleared (millions/yr)	Portion of total trees cleared (%)
1. Northwest Highlands	2.00	1.0
2. Gulf Plains	9.19	4.8
3. Cape York Peninsula	0	0
4. Mitchell Grass Downs	9.51	5.0
5. Channel Country	0.31	0.2
6. Mulga Lands	34.89	18.3
7. Wet Tropics	0.77	0.4
8. Central Queensland Coast	1.38	0.7
9. Einasleigh Uplands	3.66	1.9
10. Desert Uplands	13.00	6.8
11. Brigalow Belt	112.32	58.8
12. Southeast Queensland	3.27	1.7
13. New England Tableland	0.66	0.3

Notes: 1 Annual clearance rate from dataset used by Wilson et al. (2002)<sup>125</sup>

2 Mean tree densities for Regional Ecosystems from Queensland Herbarium (2002)<sup>126</sup>

3 Estimates include only those trees cleared from remnant areas, as defined by the Queensland Herbarium. i.e. the estimate does not include cleared regrowth.

#### Method Used to Calculate Impacts of Clearing on Remnant Trees

##### Data sources

Two data sources were used for this analysis:

1. Mean tree densities for Queensland's Regional Ecosystems and Broad Vegetation Groups<sup>127</sup> (Refer to Appendix 1 for methodology, Appendix 2 for a summary of the Herbariums results). At each CORVEG site (COVEG is the name of the Queensland Herbarium's vegetation site database), the Queensland Herbarium calculated stem densities of mature trees that were present in the Emergent, Tree one and Tree two layers.
2. Clearing rates for Queensland's regional ecosystems during 1997-99.<sup>128</sup>

##### Calculation process

A two-step process was required to calculate the approximate number of trees cleared from Queensland's remnant Broad Vegetation Groups (BVGs) during the two year period (1997-1999). This analysis estimated only those trees cleared from remnant areas, and did not include trees that have been cleared from areas of regrowth. The Queensland Herbarium defines remnant as "vegetation where the predominant stratum of the vegetation is still intact, i.e. has at least 50 per cent of the cover and more than 70 per cent of the height, and is composed of species characteristic of the vegetation's undisturbed predominant stratum.

This definition includes all woody structural formations as well as those dominated by shrubs, grasses and other life forms".

While this report presents information for broad vegetation groups, the Queensland Herbarium maps sub-units of these groups called regional ecosystems. Regional ecosystems are vegetation communities in a bioregion that are consistently associated with particular combinations of geology, landform and soil. The first step in calculating the number of trees cleared from broad vegetation groups was to estimate the number of trees cleared from remnant areas in each regional ecosystem for the two-year period. To calculate this, the mean stem density for each regional ecosystem was multiplied by the area cleared from that regional ecosystem. The Herbarium's tree density data was based on vegetation sites from their CORVEG database. Regional ecosystems that were not well represented in the CORVEG database (i.e. < 3 CORVEG sites, 844 regional ecosystems) were assigned the average stem density for their specific broad vegetation group, and this density was multiplied by the area cleared from that specific regional ecosystem cleared.

The second step was to calculate the number of trees cleared from the remnant areas with the broad vegetation groups. To calculate this, the number of trees cleared in the regional ecosystems that constitute a particular broad vegetation group were summed.

The Queensland Herbarium did not provide tree densities for the *Triodia* spp. hummock grasslands (13) and native grassland (14) broad vegetation groups, due to potential sampling bias (Refer to Appendix 1). These groups were therefore excluded from the analysis. The Heath or Mixed shrubland (18) broad vegetation group was excluded from the analysis as shrubs may have been included in tree layers and therefore would inflate stem densities. The effect of excluding these broad vegetation groups from the analysis results in an underestimation and thus conservative figure for the actual total number of trees cleared in Queensland in 1997-99.

The calculation process outlined above rests on two basic assumptions:

- The tree layers (Emergent, Tree layer 1, Tree layer 2) in the CORVEG dataset did not include shrubs (Refer to Appendix 1). The inclusion of shrubs would inflate the estimate of trees cleared.
- There were sufficient CORVEG sites in each regional ecosystem to accurately describe tree densities.

The estimated number of mature trees cleared is expected to be conservative due primarily to two limitations in the methodology:

- Only trees cleared from areas defined by the Queensland Herbarium as remnant were included in this analysis. The Queensland Herbarium defines remnant as “vegetation where the predominant stratum of the vegetation is still

intact, i.e. has at least 50 per cent of the cover and more than 70 per cent of the height, and is composed of species characteristic of the vegetation’s undisturbed predominant stratum. This definition includes all woody structural formations as well as those dominated by shrubs, grasses and other life forms”. The inclusion of ‘regrowth’ trees would have increased estimates significantly.

- Three broad vegetation groups (13, 14 and 18) were not included in the analysis.

The broad vegetation groups *Eucalyptus microneura* and other box woodlands. (BVG 7) and *Acacia aneura* woodlands and shrublands (BVG 12) were poorly represented by site data, with only one and four CORVEG sites respectively (see Table 10). The low numbers of CORVEG sites for these broad vegetation groups means average stem densities calculated are based on a low sample size, however these groups also account for small proportions of the numbers of trees cleared. The majority of the broad vegetation groups contained regional ecosystems that had  $\geq 3$  CORVEG sites and therefore average stem densities were based on larger sample sizes.

The regional ecosystem 11.4.8 (Description: *Eucalyptus cambageana*, *Acacia harpophylla* and/or *A. argyrodendron* woodland on Cainozoic clay plains had the greatest number of trees cleared from remnant areas for the two year period (see Table 12).

**Table 11: Number of Regional Ecosystems (REs) in each Broad Vegetation Group (BVG) (Summary of QLD Herbariums data, 2002).**

Broad Vegetation Group (BVG)	RE's with <3 CORVEG sites	RE's with $\geq 3$ CORVEG sites	Total RE's	CORVEG SITES
1. Eucalypt woodlands on ranges.	118	41	159	290
2. Eucalypt open forest.	52	18	70	111
3. <i>Eucalyptus tetradonta</i> woodlands / open forest.	26	20	46	273
4. <i>Eucalyptus similis</i> and <i>E. whitei</i> woodlands.	5	5	10	48
5. <i>Eucalyptus populnea</i> and <i>E. melanophloia</i> woodlands.	32	17	49	109
6. Mixed eucalypt woodlands	75	20	95	142
7. <i>Eucalyptus microneura</i> and other box woodlands.	15	0	15	1
8. <i>Eucalyptus leucophloia</i> low open woodlands	42	4	46	17
9. Riparian eucalypt woodland.	57	9	66	81
10. <i>Acacia</i> spp. woodlands and shrublands.	33	5	38	68
11. <i>Acacia harpophylla</i> or <i>A. cambagei</i> open forests and woodlands.	87	12	99	100
12. <i>Acacia aneura</i> woodlands and shrublands.	33	0	33	4
15. Rainforests and vine thickets.	143	18	161	131
16. Wetlands.	85	10	95	101
17. Mangroves and strand communities.	41	7	48	109
<b>TOTAL</b>	<b>844</b>	<b>186</b>	<b>1030</b>	<b>1585</b>

**Table 12: Ten Regional Ecosystems (RE's) with the greatest number of remnant trees cleared during 1997-99**

Regional Ecosystems	Bioregion	Description	BVG	Annual Clearance rate (ha/yr)(1) for 1997-99	Trees cleared 1997-99 (million)	RE rank for trees cleared
11.4.8	Brigalow Belt	<i>Eucalyptus cambageana</i> , <i>Acacia harpophylla</i> and/or <i>A. argyrodendron</i> woodland on Cainozoic clay plains.	11	4918.89	13.87	1
11.7.2	Brigalow Belt	Monospecific stands of <i>Acacia</i> forest/woodland on Cainozoic lateritic duricrusts. Species include <i>Acacia shirleyi</i> , <i>A. catenulata</i> , <i>A. burrowii</i> , <i>A. sparsiflora</i> , <i>A. crassa</i> , <i>A. blakei</i> and <i>A. microsperma</i> . Hill slopes and scarp retreat zones. Emergent eucalypt species may be present: eg. <i>Eucalyptus thozetiana</i> , <i>E. decorticans</i> and <i>E. exserta</i> .	10	6591.3	13.61	2
11.5.5	Brigalow Belt	Woodland of <i>Eucalyptus melanophloia</i> , <i>Callitris glaucophylla</i> +/- <i>E. chloroclada</i> , <i>E. populnea</i> , <i>Corymbia tessellaris</i> , <i>E. intertexta</i> , <i>Angophora melanoxylon</i> , <i>Acacia aneura</i> on Cainozoic sand plains. <i>Triodia</i> sp. sometimes in understorey in places.	5	7694.37	11.80	3
11.5.13	Brigalow Belt	<i>Eucalyptus populnea</i> +/- <i>Acacia aneura</i> +/- <i>E. melanophloia</i> shrubby woodland on Cainozoic sand plains. Deep red earths.	5	13602.1	11.37	
11.4.3	Brigalow Belt	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> +/- scattered eucalypts (eg. <i>Eucalyptus pilligaensis</i> , <i>E. populnea</i> , <i>E. cambageana</i> , <i>E. thozetiana</i> and <i>E. largiflorens</i> ) +/- <i>Brachychiton rupestris</i> , open forest usually with <i>Geijera parviflora</i> and <i>Eremophila mitchellii</i> in understorey on Cainozoic clay plains. Cracking clays often gilgaied. <i>Melaleuca bracteata</i> often present in low-lying areas.	11	6243.89	9.47	
11.3.2	Brigalow Belt	Woodland to open woodland of <i>Eucalyptus populnea</i> on Cainozoic alluvial plains. Understorey grassy but low trees and shrubs may be present. Scattered low trees sometimes present eg. <i>Acacia salicina</i> , <i>Lysiphillum</i> spp., <i>Cassia brewsteri</i> and <i>Eremophila mitchellii</i> . <i>Acacia aneura</i> in south-west of bioregion. Texture contrast, deep uniform clays and sometimes cracking clay soils.	5	15738.96	9.04	4
11.5.1	Brigalow Belt	Woodland or open forest with <i>Eucalyptus crebra</i> , <i>Angophora leicarpa</i> , <i>Allocasuarina luehmannii</i> , <i>Callitris glaucophylla</i> and <i>C. endlicheri</i> +/- <i>E. populnea</i> +/- <i>E. pilligaensis</i> (in south of bioregion) on Cainozoic sand plains, especially outwash from weathered sandstones. Duplex soils with loamy sandy surface texture.	6	6259.81	8.27	5
11.9.5	Brigalow Belt	<i>Acacia harpophylla</i> +/- <i>Casuarina cristata</i> shrubby open forest on Cainozoic to Proterozoic consolidated, fine-grained sediments. Lowlands. Deep texture-contrast soils and cracking clays, often gilgaied. <i>Geijera parviflora</i> and <i>Eremophila mitchellii</i> in understorey. Understorey can also include semi-evergreen vine thicket species. <i>Melaleuca bracteata</i> often present along watercourses.	11	7032.34	8.27	
6.5.13	Mulga Lands	<i>Acacia aneura</i> +/- <i>Eucalyptus populnea</i> +/- <i>E. melanophloia</i> +/- <i>Brachychiton populneus</i> low woodland on Quaternary sand plains over Tertiary surface. Red earth soils.	12	7879.3	8.25	
11.3.1	Brigalow Belt	Open forest of <i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> with low trees <i>Geijera parviflora</i> , <i>Eremophila mitchellii</i> +/- emergent <i>Eucalyptus</i> spp. Eg. <i>E. coolabah</i> , <i>E. populnea</i> , <i>E. pilligaensis</i> on Cainozoic Alluvial plains. Cracking clay soils.	11	3949.72	7.72	

Note: 1) Annual clearance rate from dataset used by Wilson et al. (2002).<sup>130</sup>

2) Estimates include only those trees cleared from remnant areas, as defined by the Queensland Herbarium. i.e. the estimate does not include cleared regrowth.

### COOLIBAH WOODLANDS – A DISAPPEARING AUSTRALIAN ICON

*“Once a jolly swagman camped by a billabong under the shade of a Coolibah tree.”*

Queensland’s picturesque grassy Coolibah (*Eucalyptus coolibah*) country is in significant decline due to tree clearing. Coolibah woodlands, which are part of the broad vegetation group classified as “Riparian eucalypt woodland”, were once widespread in Queensland and have featured prominently in Australian art and literature. These woodlands are now rapidly giving way to pasture, crops and dams.

Riparian eucalypt woodlands was the broad vegetation group with the second fastest clearing rate in Queensland between 1997 and 1999.<sup>131</sup> About 11 million trees were cleared within two Coolibah dominated regional ecosystems. This represents about half of all trees cleared from remnant areas within the riparian

eucalypt woodlands. Less than 30 per cent of the original extent of these Coolibah ecosystems remains.<sup>132</sup>

Since Coolibah woodlands are a major element of riparian vegetation, their loss through clearing can be considered as a contributing factor to the decline of riparian systems in Queensland.<sup>133</sup> The quality of these remnant woodlands is also threatened through weed invasion, grazing and cultivation.<sup>134</sup>

### 3. Future of Queensland’s native vegetation

Land clearing is the primary threat to biodiversity. Native plants are at greater risk of extinction as a consequence of clearing, whereas weeds and exotic plants are becoming common. This pattern can be seen across Queensland and is most obvious in heavily cleared regions such as the south-east and Wet Tropics.

New vegetation management legislation was enacted in Queensland late in 2000. As a result, ‘endangered’ regional ecosystems (defined as having less than ten per cent remaining of pre-cleared extent) are protected by legislation from broad scale clearing on most tenures. ‘Not Of Concern’ regional ecosystems (more than 30 per cent remaining) are protected from clearing at a threshold of 30 per cent remnant area. ‘Of Concern’ regional ecosystems (10-30 per cent remaining) are protected from clearing on leasehold land, however on freehold land, clearing is still permitted to the lower ten per cent threshold. Of Queensland’s 1,160 Regional Ecosystems, 45 (< 4 per cent) are Endangered and 675 (58 per cent) Of Concern.<sup>135</sup>

Species that have been threatened by recent tree clearing need to be identified and listed as threatened to be afforded protected under state and Commonwealth legislation. The Brigalow Belt bioregion is a likely place to look for such species because of the particularly intense recent clearing. Broad scale tree clearing has accelerated in the Brigalow Belt since the 1950s,<sup>136</sup> so that by 1999 remnant vegetation was reduced to 43 per cent of its pre-clearing extent.<sup>137</sup> The species most threatened by tree clearing are presumably those restricted to severely cleared ecosystems. The most

severely cleared regional ecosystems (REs) in the Brigalow Belt are Semi-evergreen Vine Thickets (softwood scrubs, 7 REs), brigalow communities (14 REs) and grasslands (4 REs). In total these account for 25 of the 29 Endangered regional ecosystems in the bioregion. It is these ecosystems that need to be carefully examined to identify species requiring nomination as threatened, even though the ecosystems are now protected from tree clearing. For example, Ooline (*Cadellia pentastylis*) and Burncluith gum (*Eucalyptus argophloia*) are vulnerable trees from brigalow and softwood communities, which have been threatened by tree clearing, however others that are also threatened by tree clearing are yet to be identified.

Fragmentation is also a major threat to biodiversity.<sup>138</sup> The fragmented and reduced extent of regional ecosystems leaves them very susceptible to other relatively uncontrolled and less understood threats, such as weed invasion, grazing and altered fire regimes. The protection of fragmented and endangered ecosystems from clearing may not ensure the long-term protection of biodiversity. Mitigating the impact of threats to biodiversity requires proactive approaches to land management for maximising biodiversity, particularly in ecosystems already severely compromised by historical tree clearing.

The knowledge is available and the opportunity exists to avoid the repetition of costly land management errors. The cost of preventing clearing is a minute fraction of the cost of attempting to repair or rehabilitate destroyed ecosystems. Indeed, such ecosystems can never be fully restored to their original complexity and diversity.

5

## FUTURE OF AUSTRALIA'S WILDLIFE

Over the past decade, in a succession of reports and submissions made to Governments – both State and Commonwealth – Australia's leading scientists have emphasised what has long been recognised by ecologists: that the management of natural systems in this country has failed to recognise the value of the services they provide to Australia's health and wealth, and that we have consistently exploited those resources on an unsustainable basis. In 2002, two major reports<sup>139,140</sup> specifically warned the Australian Government of the dangerous consequences of current rates of broad-scale clearing of native vegetation.

In this document we have presented a different perspective on one particular aspect of land clearing – its direct impacts on the wildlife occupying the land that is cleared.

We have pointed out that when any area of native bushland is cleared it is widely assumed that, though a few animals may be killed by bulldozers or falling trees, most of the resident wildlife is simply "displaced" – that it will spread out to find new homes in nearby areas. But in reality, the vast majority of animals will die. Most will die quickly, but others survive for a time before dying from starvation or predation. Many reptiles and mammals may also survive for a while in the piles of cleared vegetation, only to be incinerated when those piles are burned prior to preparing the land for agriculture or grazing. Pre-and post-clearing surveys show dramatic declines in numbers and diversity – usually of the order of 70-90 per cent, but with no compensating increases in surviving bushland.

And so multi-millions of land vertebrates – mammals, birds and reptiles – are killed each year through local and broad-scale clearing of native forest and woodlands in Australia. They are not replaced over time. They are *permanently* removed from the Australian landscape.

While further losses of biodiversity are an inevitable outcome of Australia's development, we must re-define acceptable levels of loss in the context of sustainability. Unsustainable use of resources invariably leads to system

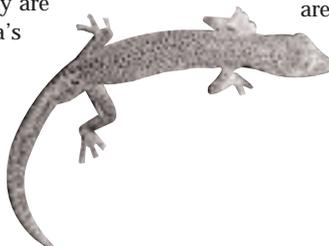
declines and failures – salination, loss of soil and soil fertility, inability to recover rapidly from natural disasters, eutrophication and toxification of rivers and wetlands, and the inevitable decline and extinction – first at local and regional levels, later at national levels – of uniquely Australian species.

There are many compelling reasons for conserving our wildlife. Not the least of these, apart from self-interest, is that Australia has more endemic species – species found nowhere else in the world – than most other countries. Declines and extinctions reflect our failure as custodians of our own country. Furthermore, our vertebrate wildlife represents a key element in the attraction of Australia as a global tourist destination.

There is also increasing evidence that the decline and extinction of species reflects declining ecosystem health. This is a complex process, with broad-scale land clearing not only impacting immediately on the animals and plants present when it occurs, but impacting more subtly over time through the slower-acting effects of habitat fragmentation and degradation.

Thus, the full effects of land clearing today may not be felt for many years. We are building up a debt – an extinction debt – that will cost future generations dearly. It will fall due in 20, 50 or perhaps 100 year's time when the full effects of today's actions are realised. In the meantime, local extinctions gradually become regional until entire species are extirpated. And with each passing year the prospects of mitigating the outcomes decreases while the cost escalates. Because of this lag time, if we stop clearing now we have a relatively narrow window of opportunity in which to take action to recover this debt and to start reconstructing Australian landscapes to maintain our wildlife, changed but nevertheless with most of its diversity intact.

Australia has now reached a point in its history when the management of the entire country demands a more holistic approach. Just as we must reclaim our rivers by breaching personal and political boundaries, so we must conserve our remaining biodiversity on a sustainable basis. This does not mean stopping the development clock, but of balancing development needs with the need to maintain the many services of natural ecosystems, including the reconstruction and restoration of seriously degraded systems. Biodiversity loss, the effective management of exotic animal and plants pests, and the recovery of our rivers and wetlands are the major environmental threats to a healthy and productive Australia.



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## APPENDICES

### Appendix 1:

Methodology used by Queensland Herbarium to estimate tree densities in the Broad Vegetation Groups (BVG) found in Queensland (Qld Herbarium 2002)

#### Database

The CORVEG database (Queensland Herbarium) was used to derive stem densities for mature trees. Within each CORVEG site, trees were defined as those that were present in the tree layers, which included the Emergent layer, Tree layer 1, Tree layer 2. CORVEG sites that were not assigned to a Regional Ecosystem (RE) were intersected with Queensland Herbarium 1:100,000 mapping of Bioregional Ecosystems using GIS (ARCVIEW). Regional ecosystems were then assigned to the Broad Vegetation Groups (BVGs) as described by Wilson *et al.* (2002). The *Vegetation Management Act* (1999) defines a regional ecosystem as a vegetation community in a bioregion that is consistently associated with a particular combination of geology, landform and soil.

#### Mean stem density for Queensland Regional Ecosystems

Mean tree densities (stems/ha) for the regional ecosystems were calculated by averaging the tree densities of CORVEG sites within a regional ecosystem. Data validation of CORVEG sites involved plotting the mean tree densities obtained at each CORVEG site against their respective regional ecosystem. CORVEG sites that were outliers within a regional ecosystem were examined

for errors. This involved assessing whether the vegetation description for the CORVEG site reflected their regional ecosystem. If the vegetation description for the CORVEG site did not reflect the regional ecosystem, the site was re-assigned to the correct regional ecosystem for its bioregion, or alternatively was deleted from the analysis.

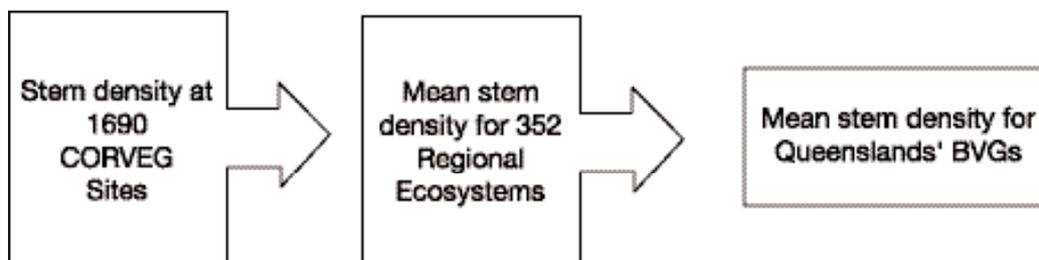
Further data validation involved comparing mean stem densities for the broad vegetation groups (derived from CORVEG sites) to the dataset used in Fensham *et al.* (2002). This comparison between datasets could not be conducted for all broad vegetation groups and was limited to the broad vegetation groups that include 1, 2, 3, 5, 6, 9, 10, 11 and 12. When the Fensham *et al.* dataset was limited to DBH > 5cm, comparable stem densities were obtained.

#### Mean stem density for Queensland Broad Vegetation Groups (BVGs)

The average tree density (stems/ha) was calculated for regional ecosystems that were sampled by  $\geq 3$  CORVEG sites. Regional ecosystems that were sampled by < 3 CORVEG sites were assigned the mean stem density calculated for their respective broad vegetation group using the total dataset.

Mean stem densities for each broad vegetation group were calculated by averaging stem densities obtained for all regional ecosystems within each broad vegetation group. The broad vegetation groups *Triodia* spp. hummock grasslands (13) and native grasslands (14), were excluded from the analysis, as stems densities may be inflated because of possible bias in plot location for these CORVEG sites. The final dataset used to calculate the average stem densities of the broad vegetation groups used 1672 CORVEG sites and represented 352 regional ecosystems (Refer to Figure 1).

Figure 1 Information flow chart for calculating stem densities



### An estimate of pre-clearing and remnant trees (1999) present in Queensland

To calculate an estimate of pre-clearing trees contained in the regional ecosystems sampled by  $\geq 3$  CORVEG sites, the mean stem density for the regional ecosystem was multiplied by the pre-clearing area. Regional ecosystems that were not well represented in the CORVEG database (i.e.  $< 3$  CORVEG sites) were assigned the average stem density for their specific broad vegetation group, and this density was multiplied by the pre-clearing area. To estimate the number of remnant trees present in 1999, stem densities for the regional ecosystems were multiplied by the 1999 regional ecosystem area.

### References

- Wilson, B. A., Neldner V. J., Accad, A. 2002 The extent and status of remnant vegetation in Queensland and its implications for statewide vegetation management and legislation. *Rangeland Journal* 24(1): 6-36.
- Fensham, R. J., Fairfax, R. J., Holman J. E. 2002 Quantitative assessment of vegetation structural attributes from aerial photography. *International Journal of Remote Sensing* 23: 2293-2317.



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### Appendix 2: Mean density of trees for sixteen of the Broad Vegetation Groups (BVG) found in Queensland

Broad Vegetation Group	Mean trees/ ha	SE	n
1. Eucalypt woodlands on ranges.	397	30	64
2. Eucalypt open forest.	457	51	27
3. <i>Eucalyptus tetradonta</i> woodlands / open forest.	466	39	26
4. <i>Eucalyptus similis</i> and <i>E. whitei</i> woodlands.	231	60	8
5. <i>Eucalyptus populnea</i> and <i>E. melanophloia</i> woodlands.	325	33	26
6. Mixed eucalypt woodlands	421	39	35
7. <i>Eucalyptus microneura</i> and other box woodlands.	340	N/A	1
8. <i>Eucalyptus leucophloia</i> low open woodlands	235	46	5
9. Riparian eucalypt woodland.	303	38	18
10. <i>Acacia</i> spp. woodlands and shrublands.	1022	73	5
11. <i>Acacia harpophylla</i> or <i>A. cambagei</i> open forests & woodlands.	590	79	30
12. <i>Acacia aneura</i> woodlands and shrublands.	523	104	3
15. Rainforests and vine thickets.	959	106	37
16. Wetlands.	798	118	23
17. Mangroves and strand communities.	916	135	20
18. Heath or mixed shrublands.	600*	91	24

(From Qld Herbarium 2002)

\* May include shrub species in tree strata. n represents the number of regional ecosystems contained within the broad vegetation groups.

Standard error (SE) calculated for regional ecosystems contained with broad vegetation groups.

### Appendix 3: Botanical name - common name list

Common names vary greatly within interest groups, eg. standard trade names are used by foresters, while different common names may be used by naturalists. Common names may vary in different localities, and any one plant may have a number of common names. The species included are mainly trees and shrubs that dominate and characterise the various broad vegetation groups. Derived from Bean *et al.* (1998) and Brooker and Kleinig (1994).

Botanical name	Common Names
<i>Acacia aneura</i>	mulga
<i>Acacia argyrodendron</i>	blackwood
<i>Acacia cambagei</i>	gidgee
<i>Acacia catenulata</i>	bendee
<i>Acacia georginea</i>	Georgina gidgee
<i>Acacia harpophylla</i>	brigalow
<i>Acacia melvillei</i>	Melville's wattle
<i>Acacia shirleyi</i>	lancewood
<i>Acacia stowardii</i>	bastard mulga
<i>Angophora leiocarpa</i>	apple, rusty gum, smooth-barked apple
<i>Astrebla species</i>	Mitchell grass
<i>Avicennia marina</i>	grey mangrove
<i>Callitris species</i>	cypress pine
<i>Casuarina cristata</i>	belah
<i>Casuarina equisetifolia</i>	beach casuarina, coast she-oak, beach she-oak
<i>Ceriops tagal</i>	yellow leaved spurred mangrove
<i>Corymbia citriodora</i>	lemon-scented gum, spotted gum
<i>Corymbia clarksoniana</i>	Clarkson's bloodwood
<i>Corymbia dallachiana</i>	Dallachy's gum
<i>Corymbia erythrophloia</i>	gum-topped bloodwood, variable-barked bloodwood
<i>Corymbia hylandii</i>	Hyland's bloodwood
<i>Corymbia intermedia</i>	pink bloodwood, red bloodwood
<i>Corymbia leichhardtii</i>	rustyjacket, yellowjacket
<i>Corymbia nesophila</i>	Melville Island bloodwood
<i>Corymbia papuana</i>	ghost gum
<i>Corymbia plena</i>	bloodwood
<i>Corymbia polycarpa</i>	long-fruited bloodwood
<i>Corymbia setosa</i>	rough-leaved bloodwood
<i>Corymbia stockerii</i>	blotchy bloodwood
<i>Corymbia terminalis</i>	desert bloodwood, western bloodwood
<i>Corymbia tessellaris</i>	carbeen, Moreton Bay ash
<i>Corymbia trachyphloia</i>	brown bloodwood
<i>Erythrophleum chlorostachys</i>	Cooktown ironwood
<i>Eucalyptus acmenoides</i>	yellow stringybark, white mahogany
<i>Eucalyptus brownii</i>	Reid River box
<i>Eucalyptus camaldulensis</i>	river red gum
<i>Eucalyptus cambageana</i>	Dawson gum, blackbutt, coowarra box
<i>Eucalyptus chlorophylla</i>	box
<i>Eucalyptus cloeziana</i>	Gympie messmate, yellow messmate
<i>Eucalyptus conica</i>	fuzzy box
<i>Eucalyptus coolibah</i>	coolibah
<i>Eucalyptus crebra</i>	narrow-leaved ironbark
<i>Eucalyptus cullenii</i>	Cullen's ironbark
<i>Eucalyptus decorticans</i>	gum-topped ironbark
<i>Eucalyptus dura</i>	gum-topped ironbark
<i>Eucalyptus eugenioides</i>	thin-leaved stringybark, white stringybark
<i>Eucalyptus exserta</i>	Queensland peppermint, bendo
<i>Eucalyptus fibrosa</i>	broad-leaved ironbark
<i>Eucalyptus grandis</i>	flooded gum, rose gum
<i>Eucalyptus laevopinea</i>	silvertop stringybark
<i>Eucalyptus largiflorens</i>	black box

<i>Eucalyptus leucophloia</i>	snappy gum
<i>Eucalyptus leucophylla</i>	Cloncurry box
<i>Eucalyptus longirostrata</i>	grey gum
<i>Eucalyptus major</i>	grey gum, mountain grey gum
<i>Eucalyptus melanoleuca</i>	Yarraman ironbark
<i>Eucalyptus melanophloia</i>	silver-leaved ironbark, silver ironbark
<i>Eucalyptus melliodora</i>	yellow box, yellow jacket
<i>Eucalyptus microcarpa</i>	grey box
<i>Eucalyptus microcorys</i>	tallow wood
<i>Eucalyptus microneura</i>	Gilbert River box
<i>Eucalyptus microtheca</i>	coolibah
<i>Eucalyptus miniata</i>	Darwin woollybutt
<i>Eucalyptus moluccana</i>	gum-topped box, grey box
<i>Eucalyptus montivaga</i>	Queensland ash
<i>Eucalyptus normantonensis</i>	Normanton box
<i>Eucalyptus ochrophloia</i>	Yapunyah
<i>Eucalyptus orgadophila</i>	mountain coolibah
<i>Eucalyptus persistens</i>	box
<i>Eucalyptus phoenicea</i>	scarlet gum
<i>Eucalyptus pilularis</i>	blackbutt
<i>Eucalyptus platyphylla</i>	poplar gum
<i>Eucalyptus populnea</i>	poplar box, bimble box
<i>Eucalyptus propinqua</i>	grey gum, small-fruited grey gum
<i>Eucalyptus pruinosa</i>	silver box
<i>Eucalyptus racemosa</i>	scribbly gum
<i>Eucalyptus resinifera</i>	red mahogany
<i>Eucalyptus saligna</i>	Sydney blue gum
<i>Eucalyptus shirleyii</i>	silver-leaved ironbark
<i>Eucalyptus similis</i>	Queensland yellowjacket
<i>Eucalyptus tectifera</i>	Darwin box
<i>Eucalyptus tereticornis</i>	blue gum, forest red gum
<i>Eucalyptus tetradonta</i>	Darwin stringybark, messmate
<i>Eucalyptus thozetiana</i>	mountain yapunyah
<i>Eucalyptus whitei</i>	White's ironbark
<i>Imperata cylindrica</i>	blady grass
<i>Lysiphyllum cunninghamii</i>	bauhinia
<i>Melaleuca argentea</i>	silver-leaved paperbark
<i>Melaleuca dealbata</i>	swamp tea-tree, paperbark
<i>Melaleuca fluviatilis</i>	paperbark
<i>Melaleuca leucadendra</i>	broad-leaved tea-tree
<i>Melaleuca quinquenervia</i>	swamp paperbark, paper-barked tea-tree
<i>Melaleuca viridiflora</i>	broad-leaved ti-tree, broad-leaved paperbark
<i>Muehlenbeckia florulenta</i>	lignum
<i>Sporobolus virginicus</i>	saltwater couch
<i>Triodia species</i>	spinifex
<i>Zygochloa paradoxa</i>	sandhill cane grass

## REFERENCES

- Bean, A.R., Sparshott, K.M., McDonald, W.J.F. and Neldner, V.J. (eds.) 1998. Forest ecosys mapping and analysis of south-eastern Queensland biogeographic region. A. Vegetation survey and mapping. Report for Queensland CRA/RFA steering committee. Queensland Herbarium and Environment Australia: Brisbane.
- Brooker, M.I.H. and Kleinig, D.A. 1994. *Field guide to eucalypts. Volume 3. Northern Australia.* Inkata Press: Sydney.

Dry woodland of Coolbah Eucalyptus

