Australia's biodiversity: status and trends

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Key messages

- Australia's biodiversity has been modified since human settlement by land clearing, habitat fragmentation, biological invasions, burning, harvesting of species from land and sea, and climate change.
- There are surprisingly few scientific data sets on how Australian biodiversity is faring; however, direct measures, such as numbers of extinct and endangered species, and indirect measures, such as extent of vegetation cover, show that biodiversity in both terrestrial and aquatic environments is declining. Our marine environments are in good condition, except near cities.
- Ecosystems near large population centres and on prime agricultural land have experienced the greatest declines; hence, most endangered species occur along the eastern coastline and in south-eastern and south-western Australia.
- Evidence from monitoring suggests that pressures on Australian biodiversity are increasing, despite the investments in management.
- Better monitoring of biodiversity is needed to boost the efficiency and effectiveness of management.

HOW IS OUR BIODIVERSITY DOING?

Australia's biodiversity has been modified since human settlement, both Indigenous and European, by burning, land clearing, agriculture, habitat fragmentation, the spread of non-native invasive species, and the harvesting of species from land and sea. These continuing pressures are now being joined by climate change.

Scientists refer to biodiversity 'status and trends'. The status of biodiversity refers to its condition at one point in time. As explained in Chapter 1, biodiversity is difficult to quantify and so any single measure is likely to be inadequate at some level of organisation or spatial scale. Scientists studying a region's biodiversity typically attempt to characterise species richness (the number of species – the simplest and commonest measure) and species diversity (a measure that reflects both the number of species and their relative abundance). These same measures can be calculated equivalently for the other two levels of biodiversity: genes and ecosystems.

Trends in biodiversity can be estimated by comparing measures of richness, diversity, or habitat condition across two or more time periods. Measures have to be able to detect long-term trends, often against a background of short-term variation, such as seasonal change. Future states can be predicted by coupling the past trend with knowledge of the strength and effect of the processes that may continue to modify biodiversity.

Many of us remember patches of vegetation from our childhood being replaced by suburbs or, as in Chapter 1, recall that the fishing in favourite locations seemed to be better when we were children. However, worryingly few scientific data sets are available to assess status and trends of biodiversity in Australia. Scientists are actively seeking accurate, consistent and meaningful measures. This chapter outlines our present knowledge and ideas for improving such monitoring.

WHAT DO WE KNOW, AND HOW DO WE KNOW IT?

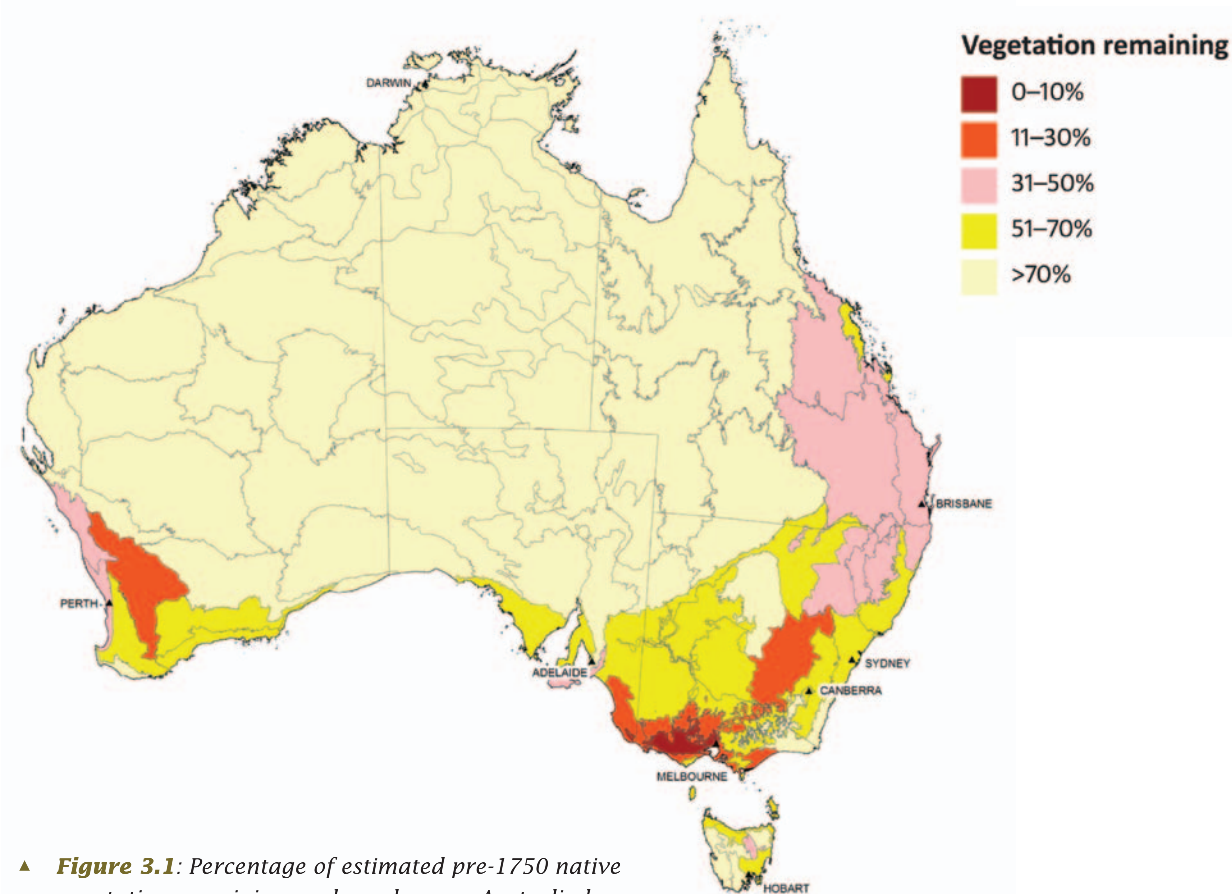
Australian ecosystems

Australia certainly is 'the lucky country'. We still have more relatively unaltered nature per head of population than any other country. Staring out from an aeroplane's window seat for hours on the way to Asia and beyond (the only chance many of us get to view much of our country) we see endless expanses of apparently undisturbed territory. Should we be concerned?

The short answer is – a qualified yes. The greatest clearing of native vegetation since European settlement has occurred in coastal zones adjacent to cities, in the Murray–Darling Basin, and in the wheat belt of Western Australia. Grassy woodlands in the east have been transformed to a remnant of their former selves, with southern eucalyptus woodlands being the most affected.[1]

In these regions much of the remaining native vegetation, including the remnants in agricultural landscapes, is confined to poorer soils in rocky country or in areas of low rainfall, as these have little agricultural value. On the other hand, large tracts of Australia away from the east coast have more than 70% of vegetation still remaining.

The Australian Government has developed a map of Australia broken down into 89 areas called bioregions, each consisting of several interrelated habitats.[2] Those bioregions along the east coast from Queensland to South Australia and in south-west Western Australia have lost more than 50% of their pre-1750 vegetation (Figure 3.1). Marine communities are generally in good condition by global standards, although there are areas of concern on the Great Barrier Reef and some other coastal regions.



▲ ***Figure 3.1**: Percentage of estimated pre-1750 native vegetation remaining uncleared across Australia by bioregion. Note that vegetation may be changed by grazing or altered fire regimes even if it remains uncleared.[2]*

Until 2000, land clearing for cropping in Australia was subsidised, and sometimes obligatory, at rates often exceeding 1 million ha a year. Much of the old-growth forest and woodland has been harvested. Since 2000, land-clearing has slowed dramatically due to legislative changes. Forest regrowth is now outstripping native forest clearing, although the regrowth may not have the same environmental value as the original vegetation.[3]

Broad-scale estimates are useful for reporting, but they obscure details about the state of biodiversity even when there is intact cover. Over 60% of Australia has been grazed by livestock, in many areas to the extent that the soil is degraded and the native herb layer is gone or made up of introduced plants.[3] Grazing by stock and feral animals causes losses of biodiversity not captured by measures of native tree cover. Considerable numbers of non-native species are now altering Australian ecosystems, including more than 3000 plants and 83 vertebrates, and many more invertebrate and marine non-natives.

Canefields adjacent to lowland rainforest, showing the change in land use following clearing. Photo: Dan Metcalfe, CSIRO.

Australia's vegetation types are estimated as declining in quality in State of Environment reports produced by the Australian and state governments, the major cause being increased fragmentation of habitat. Habitat fragmentation occurs when patches of vegetation become too small to sustain populations or too far apart for animals or plants to move between them. The effects may initially go unnoticed; a few long-lived trees could still be present, but declines in their pollinators and seed dispersers mean the patch of habitat is living on borrowed time.

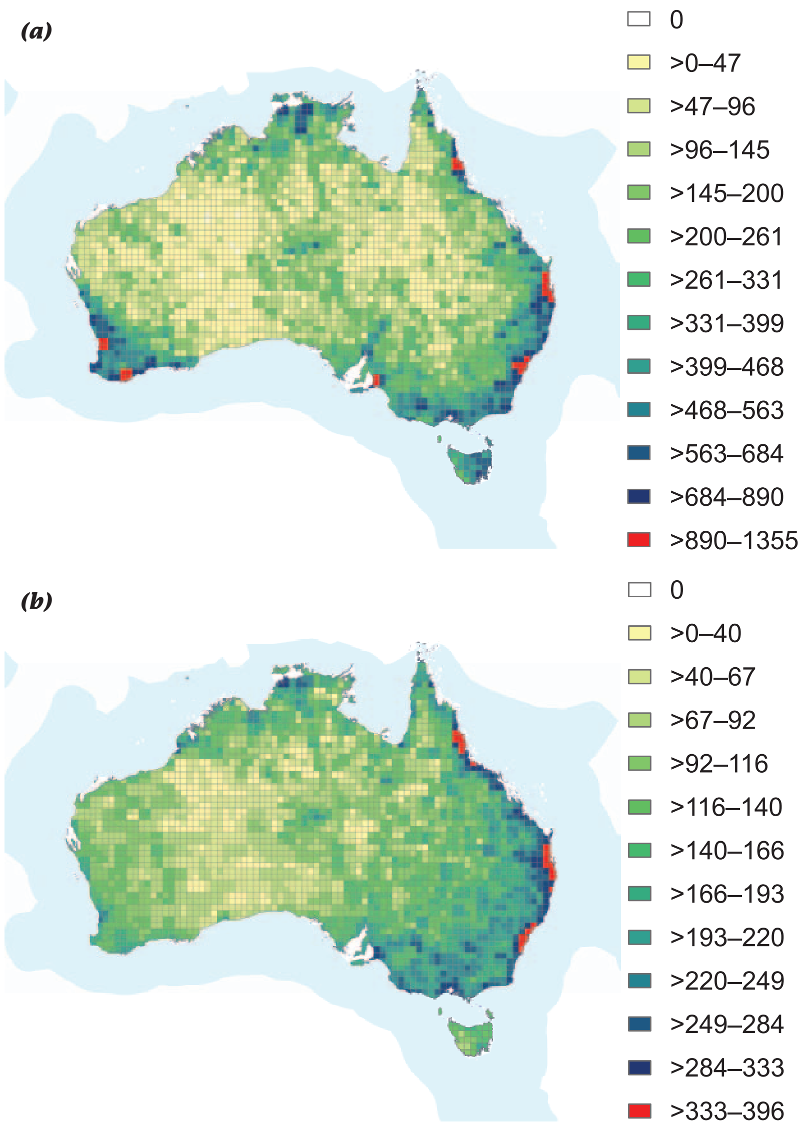
The number and distribution of species

Between 500 000 and 600 000 species of animals and plants currently inhabit the Australian landmass, but only around 25% have been formally named (Table 3.1).[4] Most vertebrate animals and flowering plants have been described. The remaining unnamed 75% are mainly small insects, nematodes, fungi and micro-organisms. Because their diversity and abundance are high they are challenging to measure, so assessments generally use larger organisms, or better-known groups such as ants, as surrogates (or proxies) for trends across all of the species that make up the breadth of biodiversity.

Table 3.1: The numbers of species formally documented by scientists versus the number of species thought to exist in Australia[4]

Group	Number of species described	Number of species estimated to exist	Percentage described
Mammals, birds, reptiles and frogs	2358	2470	95
Fishes	5000	5750	87
Insects	62 000	205 000	30
Other terrestrial invertebrates	52 000	115 000	45
Fungi	11 846	50 000	24
Flowering plants	18 706	21 000	89
Micro-organisms	4186	160 000	2.6

Consolidated databases such as the Australian National Heritage Tool and the *Atlas of Living Australia* have considerably improved understanding of species diversity (Box 3.1). Plants and vertebrate animals are richest along the east coast, in south-western Australia, and in the Top End of the Northern Territory (Figure 3.2). Within these regions, areas of high endemism (the extent to which a species is restricted to a particular area) occur along the central coast of New South Wales, the ranges bordering New South Wales and Queensland, the Wet Tropics around Cairns in north Queensland, and in south-western Australia. It is clear that areas of high species diversity and endemism often overlap with areas of intense land use for agriculture and urban development.



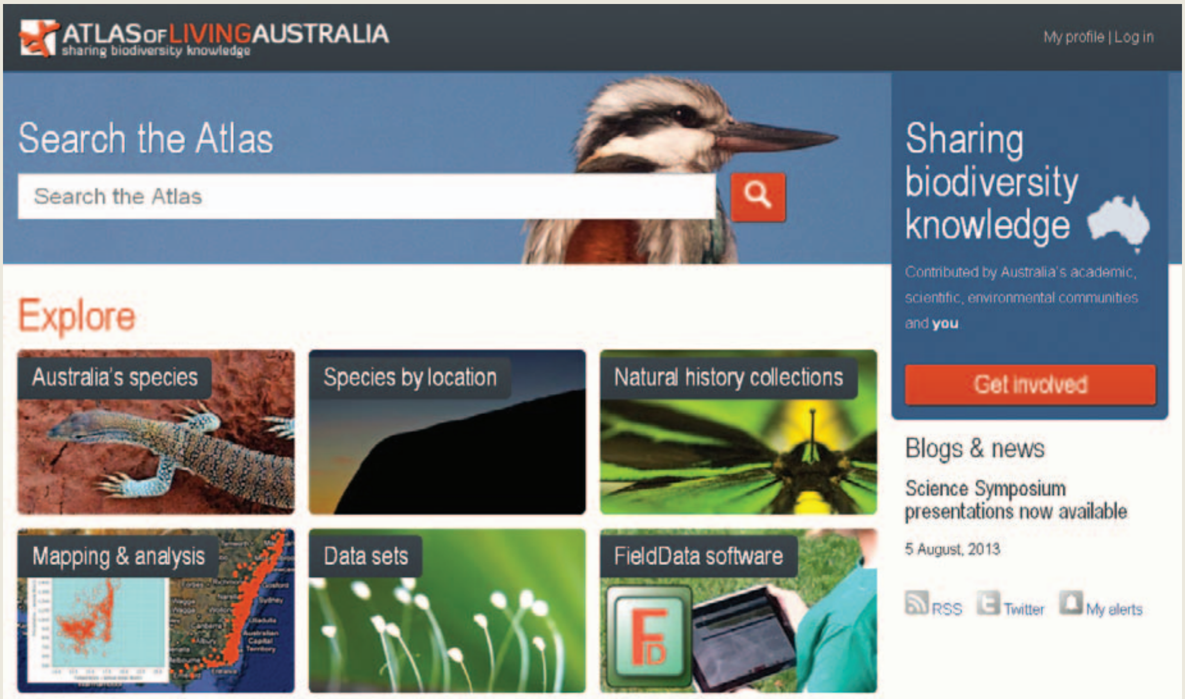
▲ ***Figure 3.2***: *Patterns of species richness for Australian* ***(a)*** *plants, and* ***(b)*** *birds; the higher the number, the more different species there are in that location.*[3]

Box 3.1: Explore Australia's biodiversity and predict future trends

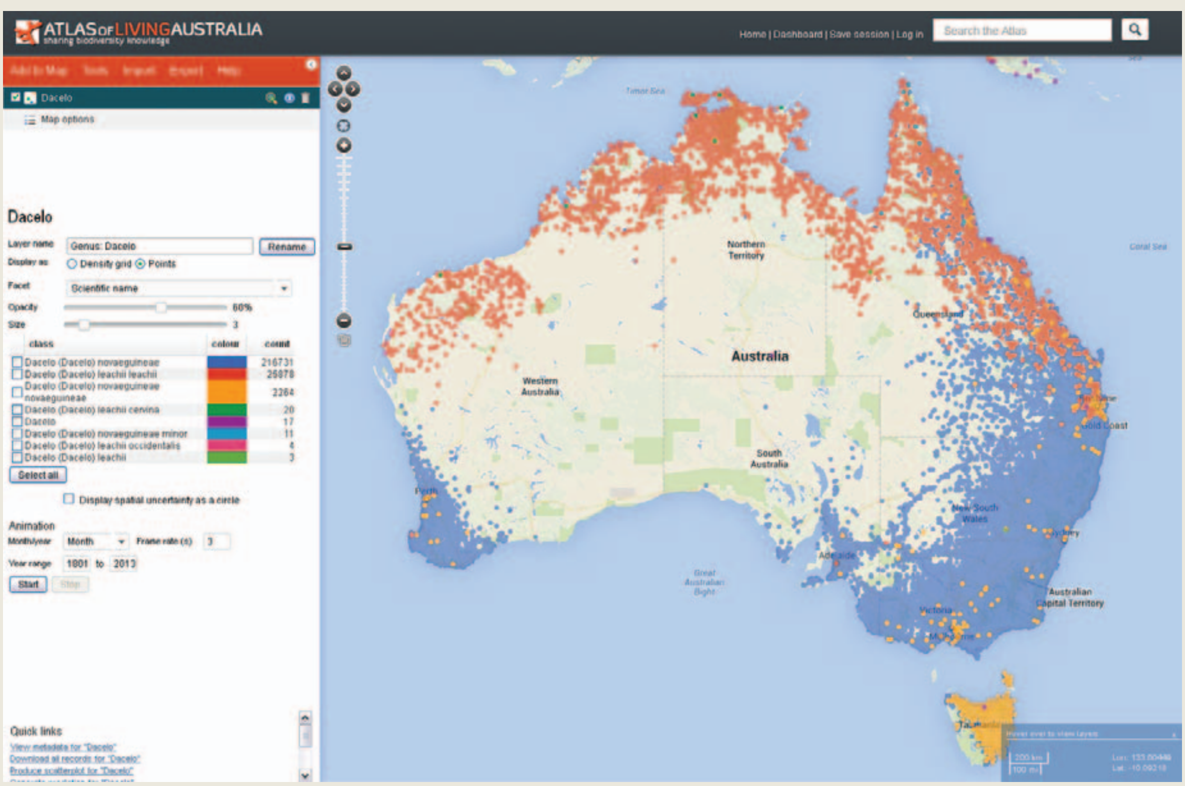
Information on location and conservation status of Australia's species, and tools to predict future trends, are in demand by scientists, decision-makers and community groups. In the past this information on Australia's biodiversity has been difficult to access and analyse as it has been fragmented across biological collections, institutions and government agencies.

The *Atlas of Living Australia* (www.ala.org.au) integrates and mobilises the country's biodiversity information, providing all Australians with free online access to a vast repository of information about Australia's plants and animals (Figure 3.3). The 40 million records in the *Atlas* span species occurrence records, images, molecular data, literature, maps and sound recordings. The *Atlas* is the most comprehensive and accessible data set on Australia's biodiversity ever produced. 'Citizen scientists' can also upload species sightings and photos to the *Atlas*, making these data, which would not normally be captured, available to the scientific community for further study.

The *Atlas* also features mapping and analysis tools to provide information about future trends. For example, the *Atlas* can be used to find out the climatic range of a species based on its current distribution (Figure 3.4), allowing predictions to be made about an animal's response to climate change, or whether a tree might be suitable for revegetation at a particular site.



▲ ***Figure 3.3***: *The* Atlas of Living Australia *website provides access to a vast repository of information about Australia's biodiversity.*[5]

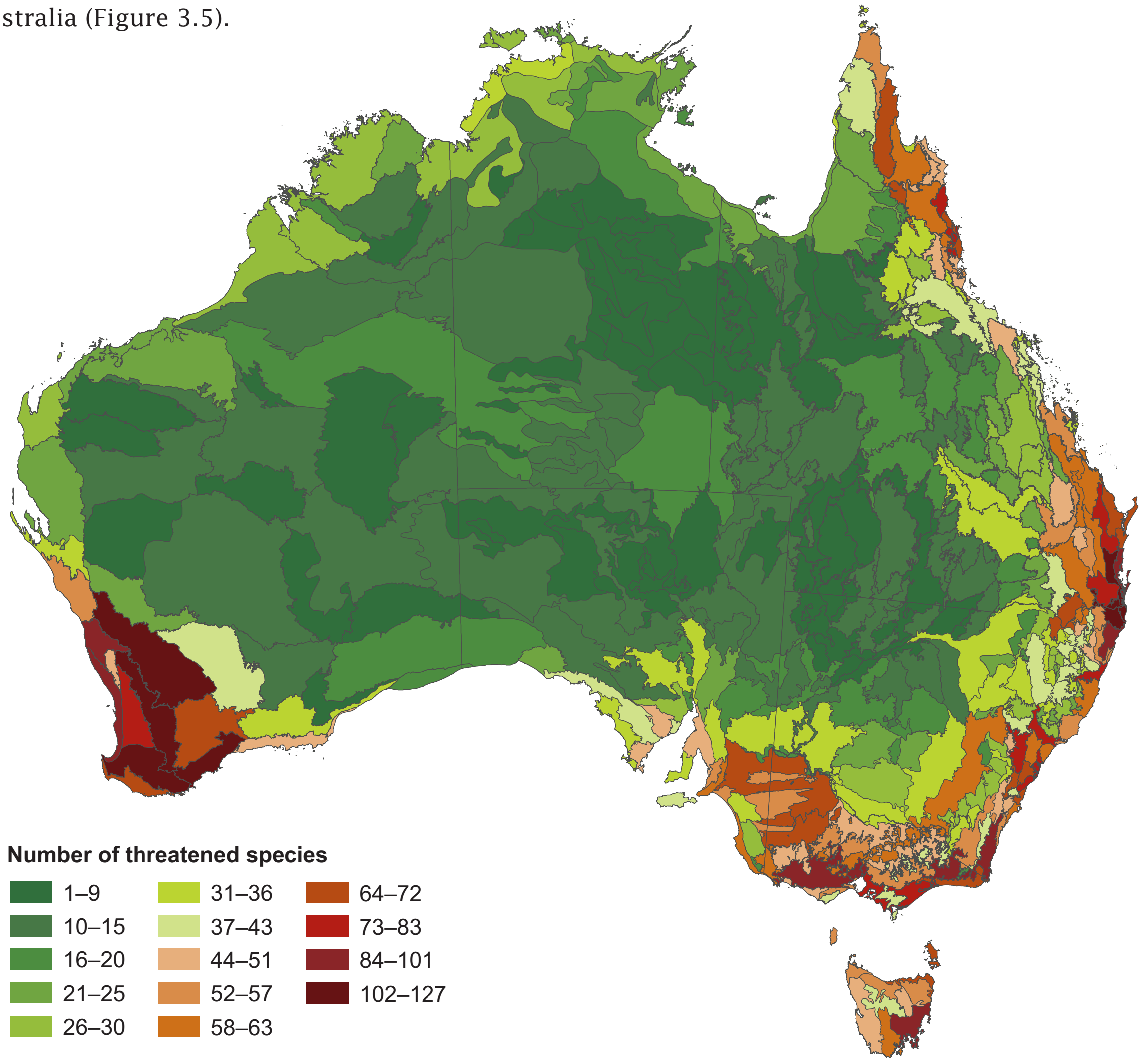


▲ ***Figure 3.4***: *A map showing the distribution of two species of kookaburras across Australia.*[5]

Rare, threatened and extinct species

Nearly 100 species of Australian organisms have become extinct since European settlement.[3] Twenty-six of these are mammals, such as the Tasmanian tiger; they account for 30% of the world's mammalian extinctions in the last few hundred years. Given that only 25% of Australia's organisms have been formally identified, and that rare species are hard to find, it is likely that additional extinctions have gone unnoticed.

All Australian states and territories, and the Commonwealth (under the *Environment Protection and Biodiversity Conservation Act 1999*) have formal processes for categorising terrestrial species according to extinction risk. The categories of risk are: of least concern, common, rare, vulnerable, endangered or extinct. Assessment of risk is based on scientific criteria on abundance and trend in their populations. Of the 1600 Australian species of plants and animals classified as rare or endangered, most are concentrated along the eastern seaboard and in southern and south-western Australia (Figure 3.5).



▲ ***Figure 3.5****: The number of species by bioregion across Australia currently listed as threatened (here meaning that they are rare, vulnerable, or endangered, but not yet extinct) under the* Environment Protection and Biodiversity Conservation Act 1999.[6]

Extinct Australian mammals and birds: ***(a)*** *pig-footed bandicoot,* Chaeropus ecaudatus*,* ***(b)*** *crescent nailtail wallaby,* Onychogalea lunata*,* ***(c)*** *paradise parrot,* Psephotus pulcherrimus*, and* ***(d)*** *Phillip Island parrot,* Nestor productus*. Source: Australian Museum.*

For plants, 25% of species in the best surveyed regions are rare, endangered or vulnerable. Victoria, with the most reliable records, has 49 species considered extinct, and 1826 (58%) species either rare, endangered, vulnerable, or under assessment. The number of rare, endangered or vulnerable plant species per state is correlated with the proportion of naturalised non-native plants because the land clearing, fragmentation and fire that cause loss of native species also allow weeds to spread, including those that can transform communities (Table 3.2).

Threatened Australian plants and animals. ***(a)*** *Hill zieria,* Zieria collina; ***(b)*** *bridled nailtail wallabies,* Onychogalea fraenata; *and* ***(c)*** *the Lord Howe Island stick-insect,* Dryococelus australis. *Photos: (a) Murray Fagg, Australian National Botanic Gardens, (b) W. Lawler, Australian Wildlife Conservancy, and (c) Rohan Cleave, Melbourne Zoo.*

Table 3.2: Proportions of rare and threatened plant species, and of non-native species, among Australian states and territories

State or territory	Total native species	Number of rare, endangered or vulnerable species (and as % of total native species)	Number of naturalised non-native species (and as % of native species)
QLD[7]	8344	202 (2)	1191 (14)
NSW[8]	6152	609 (10)	1665 (27)
VIC[9]	4418	348 (8)	1158 (26)
SA[10]	3400	828 (24)	1400 (41)
NT[11]	4183	65 (2)	455 (11)
TAS[12]	2498	500 (20)	716 (29)
WA[13]	12 257	405 (3)	1050 (9)

Table 3.3: Reductions in the ranges of selected Australian mammals, from Lindenmayer[14]

Mammal	Historic range (km^2)	Current range (km^2)	Reduction (%)
Banded hare-wallaby	490 000	600	> 99
Burrowing bettong	4 370 000	600	> 99
Greater stick-nest rat	1 325 000	600	> 99
Rufous hare-wallaby	1 962 000	1215	> 99
Bridled nailtail wallaby	1 100 000	10 000	99
Long-tailed dunnart	1 175 000	15 500	99
Northern hairy-nosed wombat	106 000	1500	99
Brush-tailed bettong	1 772 000	53 500	97
Hastings river rat	270 000	7500	97
Numbat	1 925 000	59 000	97
Dusky hopping mouse	900 000	42 500	95
Heath rat	236 000	15 000	94
Smoky mouse	151 000	12 700	92
Tasmanian bettong	512 000	48 000	91
Dibbler	99 000	10 300	90
Leadbeater’s possum	44 000	5200	88
Red-tailed phascogale	176 000	29 000	84
Greater bilby	5 296 000	946 000	82

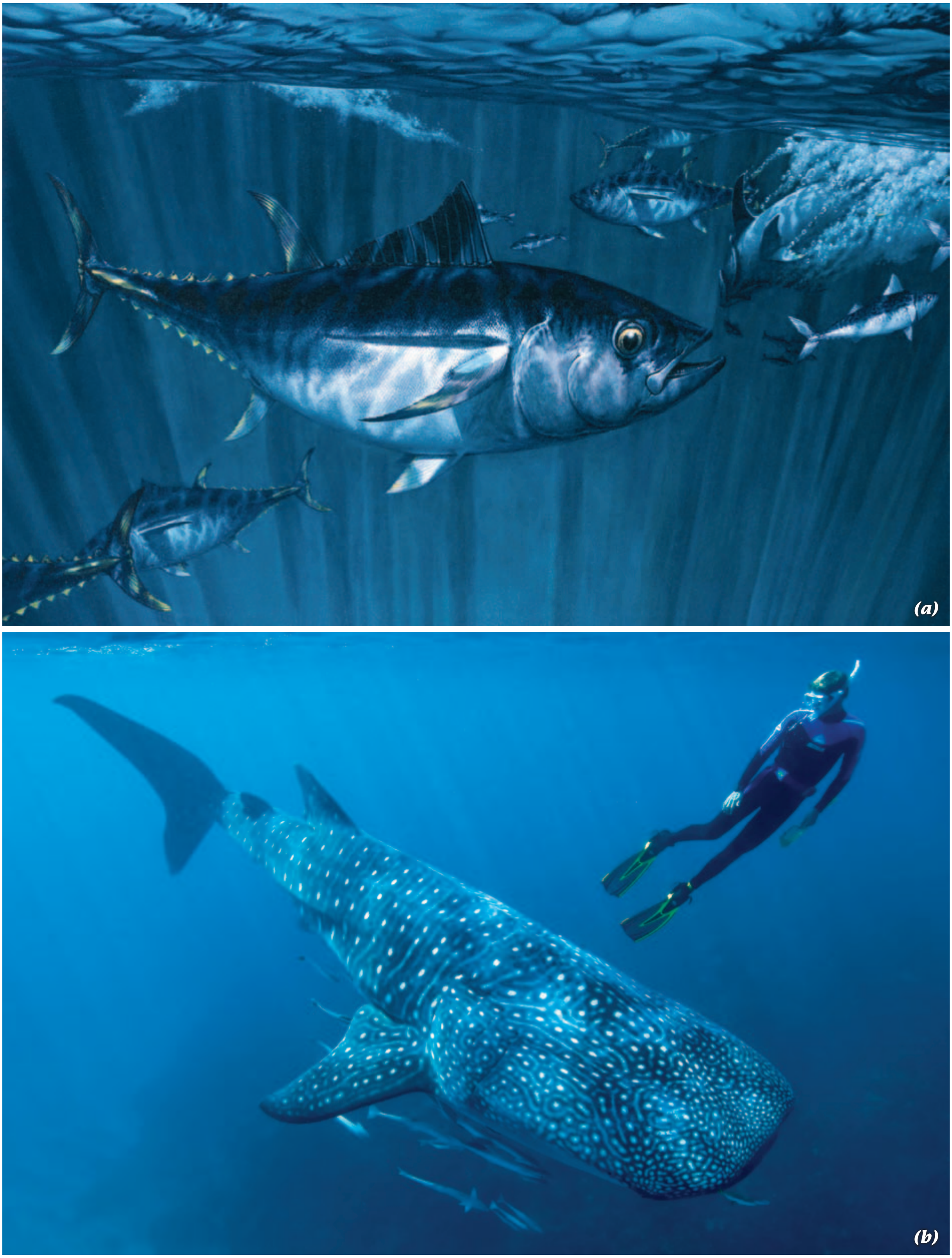
The number of sightings of many woodland birds has declined between 11 and 51% over the past two decades.[14] Numbers of eastern Australian waterbirds in general, and some resident shorebirds in particular, have also fallen significantly.[15] Many Australian rare and threatened mammal species appear to be trending towards extinction, with their original ranges (the geographical area within which the species can be found) reduced between 80 and 99% since European settlement (Table 3.3), and remaining populations are often low in density and more fragmented.

Aquatic and marine environments

In southern Australia, where water has been extracted for agricultural or urban use and natural river flows have been altered, significant biodiversity declines have been a consequence. In the Murray–Darling Basin, there has been a 90% reduction in the area of wetlands. Native fish are found in only 43% of the rivers where they should occur.[3] For much of northern and remote inland Australia, such as the Lake Eyre Basin, watercourses are unaffected by water extraction so ecosystems may remain relatively intact, though there is limited monitoring to allow estimation of biodiversity trends. To assist with these challenges the recent *Groundwater Dependent Ecosystems Atlas* helps managers determine which aquatic ecosystems are linked, and how impacts might be minimised throughout a catchment.[16]

Generally, the condition of the marine environment appears good.[3] However, near-shore marine areas adjacent to large population centres have experienced significant impacts. Some large marine species in Australian waters – Australian sea lions, southern bluefin tuna and the whale shark – were harvested heavily earlier in our history, but despite protection show no signs of recovery. The numbers of turtles, dugongs and coastal dolphins have also declined since European settlement. On the positive side, no-take areas, together with controls on catch, are leading to the recovery of some reef fishes, such as coral trout, that were threatened by over-fishing.

The climate is changing. In coming decades it is likely that sea levels will rise; extreme weather events are expected to increase in incidence and severity, ocean acidification to increase and ocean currents to change. To accommodate these changes, different organisms will evolve and shift in distribution in different ways, and so the composition and dynamics of ecosystems will also change. Along the south-eastern coast, some species of macroalgae, microalgae, zooplankton, invertebrates and many fish are already extending their ranges southward. The Great Barrier Reef is particularly vulnerable to climate change, with declining water quality from catchment run-off and coastal development, fishing, and poaching compounding the effects (Box 3.2).[17] Coral bleaching, due to the symbiotic microalgae leaving the coral under conditions of higher water temperatures, has become more frequent as the ocean warms.[18] Under such conditions, information on both status and trend is vital for effective management.



(a) *Southern bluefin tuna and* ***(b)*** *a whale shark, two species affected by heavy harvesting.*
Photo: (a) CSIRO, (b) Wayne Osborne.

A satellite image showing a flood plume as sediment flows from the Burdekin River, Queensland, out towards the Great Barrier Reef. Photo: NASA, GeoScience Australia, CSIRO.

Box 3.2: Crown-of-thorns starfish

Crown-of-thorns starfish, *Acanthaster planci*, occur naturally throughout the Indo-Pacific region.[19] They are a normal part of healthy reefs. Occasionally, though, they have devastating population outbreaks. Scientists estimate that coral cover on the Great Barrier Reef has halved over the past 27 years, due at least partly to starfish.

Each female starfish produces millions of larvae. Most do not survive; but increased water nutrients, such as from flooding linked to agricultural run-off, can fuel an increase in their food supply of phytoplankton. A small increase in the survival of larvae can produce a huge increase in starfish numbers.

Once an outbreak has begun it can propagate to new reefs not exposed to high nutrient levels – the starfish move southward on ocean currents over about a 15-year period. Reefs can recover over 10–20 years, but additional stresses, such as coral bleaching or cyclones, can delay recovery. Reducing agricultural run-off and therefore nutrient inputs to reef waters is thought to be the best means of control, and so oceanographic models are being developed to provide snapshots of the impacts of flooding.

The crown-of-thorns starfish illustrates the interdependence of ecosystems with the surrounding social and economic systems. Decisions made by farmers regarding fertiliser application can indirectly influence the reefs and the fishing and tourist industries that depend on them.

MONITORING FOR BIODIVERSITY STATUS AND TRENDS

Effective management requires rigorous understanding of the status and trends of biodiversity. This in turn rests upon our ability to monitor biodiversity through time.[20] Monitoring can be effective in two ways: as a routine surveillance activity to assess overall change; or targeted to evaluate the performance of particular interventions. Monitoring underpins the implementation of the *Environment Protection and Biodiversity Conservation Act* by triggering listing of a species or ecosystem as threatened, or de-listing. It is also identified as a priority in the State of the Environment Report[3] and in the National Biodiversity Strategy.[21] Unsurprisingly, disagreement about how to manage is caused by disagreement about what the poor-quality monitoring data are actually telling us.

Despite its importance, however, little effective ecological monitoring is conducted in Australia. Among the relatively successful efforts is the use of diversity of vegetation cover as a surrogate for ecological condition, but monitoring usually requires on-ground visits to many sites. Meeting such requirements is time-consuming and expensive (Box 3.3).

So far, monitoring in Australia can be more accurately characterised as a series of independent local studies, and many programs suffer from poor design, inadequate funding or a failure to contribute to management or policy.[22] Australia has had some successful long-term monitoring programs across national parks. Many local programs have also assessed status and trends of species or ecosystems, or the intensity of threats, and successfully incorporated results into management. Species-based programs have been successful for the eastern bristlebird in New South Wales and the red-tailed black cockatoo in Victoria and South Australia. The most comprehensive national program is perhaps the *Atlas of Bird Life Australia*. Coordinated volunteers collect millions of records, providing a long-term picture of abundance and distribution of birds across the continent.

Given multiple demands on resources, the reasons for monitoring must be compelling. The information must provide insight into threats and allow management to assess the effectiveness of its actions. Even when good monitoring programs are in place, timely responses may be lacking, as occurred in the recent extinction of a bat, the Christmas Island pipistrelle, *Pipistrellus murrayi*.

Scientists are striving to design more cost-effective and coordinated monitoring programs at larger scales. The Terrestrial Ecosystems Research Network's recently established long-term ecological monitoring sites across Australia, based on a common set of methods, infrastructure and data management, and a commitment to make the information publicly available, is a step in this direction.[23] Similar marine programs exist, run by the Australian Institute of Marine Science on the Great Barrier Reef.

The issues confronting Australian biodiversity require sampling far more broadly than at present, and new cost-efficient technologies such as sensor networks and metagenomics (see Chapters 9 and 10). We need monitoring activities at local and national scales, and an agency

Box 3.3: National Flying-fox Monitoring Program

Australians have an ambivalent relationship with flying-foxes. Concern is focused on the impact of flying-foxes on agriculture as well as noise, smell and diseases from urban camps. Concern about population declines led to the listing of the grey-headed and spectacled flying-foxes, *Pteropus poliocephalus* and *P. conspicillatus*, as threatened. A conflict of values means that decisions about flying-foxes are invariably contested, the debate not being helped by a lack of scientific information. The National Flying-Fox Monitoring Program was established in 2012 to establish population trends through time.[24]

Flying-foxes are hard to monitor because they are highly mobile, regularly moving tens to hundreds of kilometres in short periods and clocking up thousands of kilometres over weeks. The monitoring program has been designed to account for these movements. With the help of volunteers, roughly 500 camps over 3500 km between Adelaide, South Australia, and Cooktown, in far north Queensland, are visited within the same period each quarter, with each monitoring event completed in just three days. This minimises the possibility of missing or double-counting parts of the population.

It has been estimated that because of natural year-to-year variation in population size, 14 years of data will be required to identify any human-induced change with statistical confidence.[24]

Monitoring even just a couple of species, such as these flying-foxes, can be a time-consuming and expensive process. Photo: David Westcott, CSIRO.

to take responsibility for the storage, management and accessibility of those data. The recent development of the National Plan for Environmental Information, which aims to boost connections between monitoring effort and Australian Government policies and programs, is a vital step in this direction.[25]

A CSIRO technician installing meteorological instruments on top of a 75 m tower, which forms part of the Terrestrial Ecosystem Research Network's OzFlux Facility. The Facility is a network of towers across Australia that continuously measures the exchanges (flux) of carbon dioxide, water vapour and energy between terrestrial ecosystems and the atmosphere. It is an example of long-term, large-scale monitoring that is helping inform Australian biodiversity management. Photo: Gregory Heath, CSIRO.

CONCLUSION

The main pressures on Australia's biodiversity – habitat fragmentation, altered fire regimes, invasive species (both non-native and native), harvesting of species, and climate change – are increasing, and the rate of species decline is not slowing down. Australia continues to set itself challenging targets. The *Australian Biodiversity Conservation Strategy (2010–2030)*[21] aims to increase the area managed for conservation by 600 000 km^2. To achieve these targets an effective long-term monitoring program is required. The management and scientific challenges may be large, but so too will be the environmental and social benefits.

Drawing on international activities will also support our national effort. A global system of biodiversity observation networks called GEOBON was started in 2008 for detection of change using both on-site measurements and remote sensing techniques.[26] The Intergovernmental Platform on Biodiversity and Ecosystem Services, established in 2012, also aims to provide an independent, scientifically sound, uniform and consistent framework to enable scientific knowledge on biodiversity to be translated into policy action. Australia is well placed to benefit from such global initiatives in responding effectively to the challenge of biodiversity decline.

FURTHER READING

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