Conclusions

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Key messages

- Cultural and scientific values of Australia's biodiversity are globally significant.
- As the global demand for Australia's resources and agricultural products continues apace, and Australia's population continues to expand, pressure on all aspects of biodiversity will not diminish.
- Three key challenges stand out: science is still wrestling with the effective measurement of biodiversity; the undeniable evidence of significant biodiversity loss demands action; and managing biodiversity requires compromise because of the varied values that humans bring to their decisions.
- Science has a strong place in management, yet the scale and complexity of the challenge are such that biodiversity science is only just beginning to quantify ecological and social benefits and their interdependencies.
- In Australia, and globally, effective policy responses from governments to the inter-linked social and ecological aspects of biodiversity are still in the process of maturing.
- Five areas are identified where there is potential for substantial progress: fill key knowledge gaps; build community involvement; build national consensus on biodiversity priorities and establish performance measures for these in Australia's national accounts; institute a national program of biodiversity monitoring; and manage for resilience in the face of change.
- There are grounds for optimism in the face of these challenges, yet also a need for a greater effort to halt the decline in biodiversity.

AUSTRALIA'S BIODIVERSITY IN GLOBAL CONTEXT

Is Australian biodiversity unusual by world standards? The answer is yes and no! People here benefit economically from use of our biodiversity just as they do in other countries. Our society is also dependent upon the clean water, nutrient cycling and other forms of ecological life-support provided by ecosystems in similar fashion to nations elsewhere. And, like most other peoples, many of us cherish recreation in the bush. Given all that, though, it is evident that our biodiversity is distinctive for two reasons.

It is beyond doubt that our biodiversity is unusual by virtue of its unique scientific value to the world (Figure 12.1). This cargo of fellow Australians evolved to become what we see today during the tens of millions of years that the ancient continent of Gondwana was carried across the Indian and Pacific Oceans. On these grounds, Australia is truly special. For example:

- Australia is one of 17 'megadiverse' regions, among such naturally luxuriant countries as Brazil and the Congo.
- The heathlands and woodlands of south-western Australia comprise one of 34 biodiversity hotspots worldwide.
- Australia possesses more than 80 globally unique families of plants and animals.

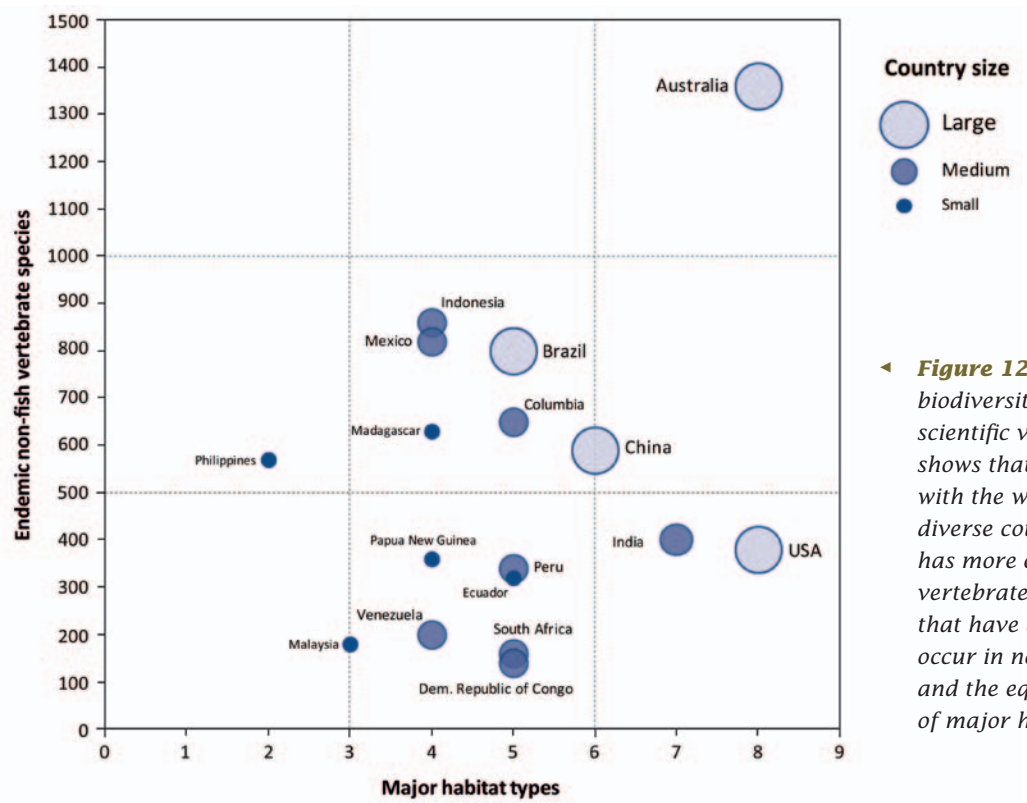


***Figure 12.1**: Australia's biodiversity is of global scientific value. This figure shows that, when compared with the world's 17 mega-diverse countries, Australia has more endemic non-fish vertebrate species (species that have a backbone and occur in no other country), and the equal greatest number of major habitat types.*[1]

- Australia is home to half of the world's marsupial species.
- The continent is a centre for globally important plant families such as the Myrtaceae, which contains the gum-trees.
- Our suite of unusual or unique ecosystems is recognised in 15 World Heritage sites.
- Southern coastal near-shore marine ecosystems show distinctively high endemism and richness.
- Australian tropical reefs form part of the rich and complex ecosystem known as the 'coral triangle' of the south-west Pacific Ocean.

It is also indisputable that the cultural values of our biodiversity are unique. Australians are stewards of an entire continent, one of few nations so privileged. The nation's culture is now diverse and cosmopolitan, yet it continues to derive strength from the beaches, reefs, rainforests, the bush and the outback. Furthermore, Australia possesses a distinguishing element in its Aboriginal traditional ecological knowledge embedded in a globally unusual philosophy (Chapter 6). Few nations possess such an Indigenous heritage and its resultant biocultural diversity; it gives to the Australian landscape a unique human lustre.

But Australia is now an important part of the global community, providing resources of energy, minerals and food to an increasingly densely populated planet. We are no longer the isolated continent that was Gondwana, where biodiversity could evolve in relative isolation and where until very recently in geological time there was virtually no human population to affect or prey upon it. Indeed our own population growth presents new and continuing challenges to decision-makers and to our own value judgments, as well as those of our financial and commercial entrepreneurs and political leaders.

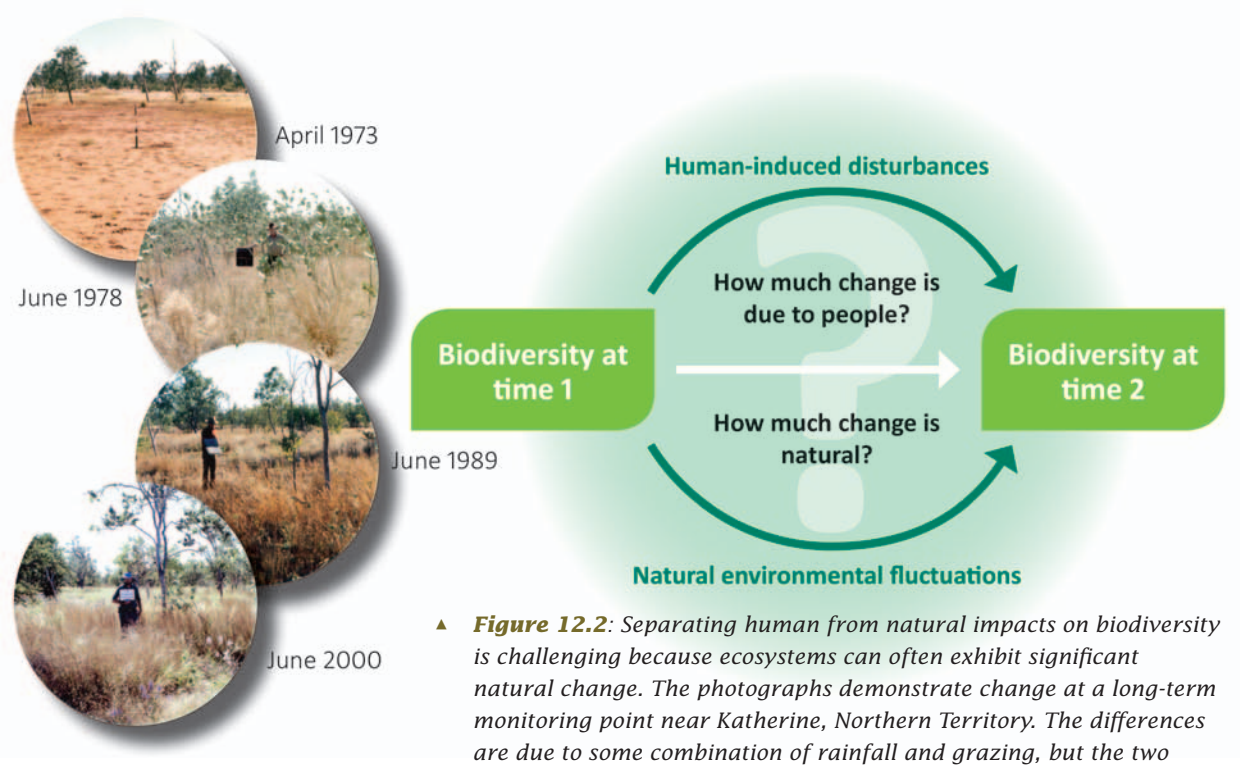
How then is the nation faring in its efforts to look after and build on these values of biodiversity?

The Great Barrier Reef, an ecosystem with globally significant values. Photo: Marie Davies.

BIODIVERSITY SCIENCE AND MANAGEMENT – EXTRAORDINARY COMPLEXITY AND CHALLENGE

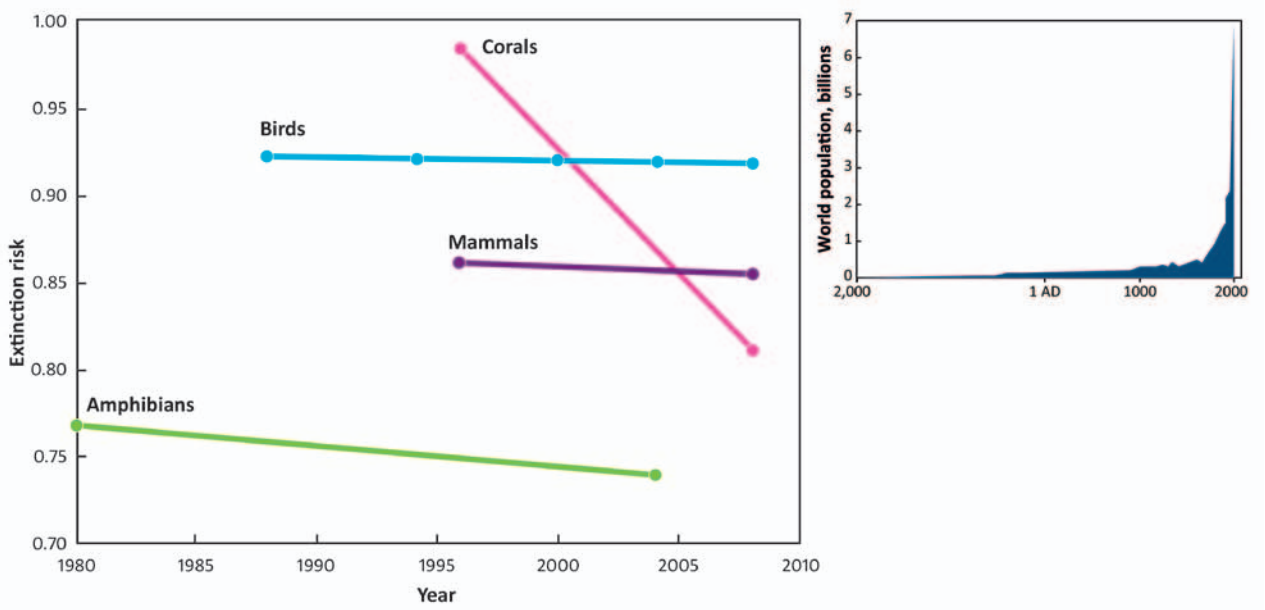
The scientific and management challenges in teasing out and making operational the concept of biodiversity are huge. Let us consider the objectives of biodiversity scientists and managers, and the hurdles that they face:

1. The first step is to describe and measure the full variety of life. Such an ambition is colossal. Calculations suggest that some 7–10% of the nine million species on Earth are found in Australia. Taxonomists are continuously discovering previously unrecognised species even among the flowering plants, birds and mammals, groups that are relatively well known. Among the vast arrays of insects, crustaceans and micro-organisms (just three poorly understood groups out of hundreds), myriads of species remain to be discovered (see Chapter 2). Within each species is a further level of genetic diversity that, in theory, would need to be outlined if biodiversity were to be comprehensively measured. Furthermore, this diversity ranges across land and sea in varying patterns to form ecosystems, which ecologists are still striving to categorise and measure in a scientifically systematic and repeatable way.
2. The desire to describe biodiversity is not an end in itself: the real objective is to understand its ebb and flow through time, so as to distinguish its response to human-induced disturbances from natural, background changes. The difficulty is that the natural world is far from stable. The 'balance of nature' is rare indeed; rather, ecosystems are mostly in constant flux. Separating natural fluctuations unambiguously from human influences is often difficult (Figure 12.2).



▲ ***Figure 12.2****: Separating human from natural impacts on biodiversity is challenging because ecosystems can often exhibit significant natural change. The photographs demonstrate change at a long-term monitoring point near Katherine, Northern Territory. The differences are due to some combination of rainfall and grazing, but the two forces are not readily separable.[2] Photos: Gary Bastin, CSIRO.*

3. Next, scientists must present policy and management options to meet diverse expectations from society, so as to provide means of maximising benefits to people while minimising risks associated with biodiversity loss. Here, science is aiming to understand human dependencies on ecosystem services, and to find measures representing those benefits that will be useful for decision-makers. Although there are numerous examples of advances in biodiversity science, some of which are highlighted in this book, in this kind of measurement it has so far often fallen short.[3] Scientists too rarely have come to agreement on achievable and useful measures of biodiversity and its benefits because of the technical difficulties of such a complex challenge. The full concept of biodiversity is too rich to be lashed down by plain numbers, and yet aspects of it will have to be simplified and counted in order for us to understand what is going on.
4. The first three steps are challenging enough, yet they are being played out in a world undergoing a crisis of biodiversity decline. Biodiversity is partly a conceptual notion, an assertion encompassing diverse human values evident in the natural world. Nevertheless, the concept includes real things, among which there is undeniable evidence of a real problem of significant global and Australian decline. The rise in human population globally from 2 to 7 billion in just 100 years has caused this effect, directly or indirectly (Figure 12.3). Australian ecosystems have not been spared despite our relatively low human population. The continent has experienced, as Chapter 3 explains, the highest recent extinction rate among mammals of any country – 27 species in the last 200 years. This extinction process is a dismal by-product of land-use change and movement of species resulting from the conversion of natural to human-dominated ecosystems as people go about their lives. While there may be nothing inherently wrong in that process of conversion, we have made lots of irrevocable mistakes and have learnt that the benefits are also associated with risks. Indeed, the human species is now so dominant that the trade-off between our activities and the health of the natural world is becoming apparent to all. Future projections are also revealing that climates are likely to change so much and so fast that many species may not be able to persist where they currently live. Australia's biodiversity loss will probably not stabilise, therefore, and continuing change appears inevitable.
5. Finally, and in summary, the science and management of biodiversity are embedded in the inherently complex world of natural resource management. These endeavours have never been solely technical matters, because their emphasis is determined by the values that humans bring to their decisions – and with biodiversity the linkage between people and nature is especially critical. The chain of consequence may be summarised as follows.
   - Use of natural resources for human benefit causes alterations in an ecosystem.
   - Some species in that ecosystem decline and some ecosystem functions alter too; biodiversity, therefore, is usually seen to deteriorate from the viewpoint of one value system or another.



▲ ***Figure 12.3**: Growth in the human population (right graph) is leading, through resource use, to a global decline in biodiversity, known as the 'sixth great extinction event' in geological time. In the left graph, proportional declines in broad groups of plants and animals are estimated from a starting point of 1980. A value of 1 on the axis of 'extinction risk' indicates that all species in the group are assessed as being at little risk of going extinct in the near future; an index of 0 would mean that all species are extinct. If the lines on the graph were found to be sloping upwards after repeated assessment through time, then the rate of biodiversity loss would be reducing. However, most groups show a downward slope of increasing loss.*[4]

- Rarely is there an obvious point of ecological change, a threshold, at which particular values of biodiversity are at fatal risk (except sometimes for individual species).
- Resource use generates short-term returns: the benefits can be realised quickly, restoration is much more expensive, and the costs of biodiversity decline become obvious and occur only slowly.
- Science struggles to measure the changes in biodiversity effectively and concisely.
- Different members of society differ in their judgments of the appropriate balance between benefit and loss.
- Policy makers must then use imperfect information to compare apples (e.g. loss of spiritual benefits) with oranges (e.g. economic prosperity) to arrive at a compromise between the benefits of resource use and the disadvantages of change in biodiversity.

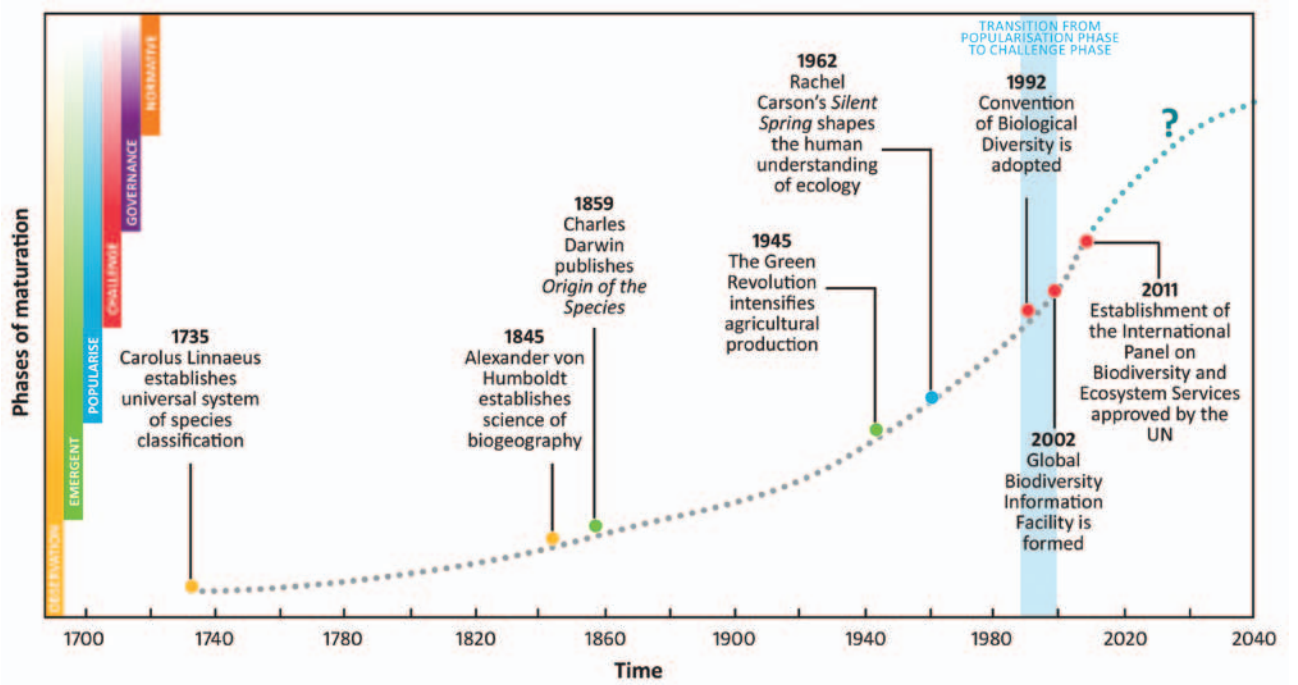
This sequence of events plays out often, all over the world. The authors of this book believe that we can do better at managing the consequences.

WAYS FORWARD

Humans are questing, striving animals: we will not abandon our ceaseless search for further advantage from resource use, and we will continue thereby to affect the planet and its biodiversity. The fact that Earth has entered an epoch of human domination is reflected in the coining by some scientists of a term, the 'Anthropocene', by analogy with Pleistocene and Pliocene ('anthropo' meaning human – the idea being that an observer in the far future looking at the geological and fossil record of the present times will find universal signals of human activity). Under these circumstances, biodiversity is almost certain to continue declining. The question is: 'How much loss will be acceptable according to the various values placed upon biodiversity among our community?'

The Anthropocene, the human-dominated world. Photo: Willem van Aken, CSIRO.

Many of the biodiversity challenges outlined in this book are the legacy of past decisions on the exploitation of natural resources, some of them ill-informed. It ought now to be clear that current decisions will similarly influence, often profoundly, the biodiversity to be inherited by our descendants. In the 21st century, we have the benefits of hindsight and of much greater scientific understanding of potential consequences of our decisions. This increases the urgency while raising the social and political costs of delay, and frequently causing contest and disagreement. The progress of the global societal response to major challenges through policy and management may be tracked through several generalised phases towards political maturation (Figure 12.4).[5] Biodiversity is at a critical juncture where society is not yet sufficiently convinced that biodiversity has been so severely compromised that action is demanded, with the result that corrective responses remain patchy.



▲ ***Figure 12.4**: The trajectory of biodiversity through six generalised phases by which policy and management respond to a topic of major social concern. The challenge of biodiversity decline has come through the first phase of observation, and then another of emergence into the social debate. Now it is part of popular discussion, but has not challenged societies sufficiently to proceed further into a phase where governance responses have significant impact. Other social developments, such as gender equality or workplace health and safety, have proceeded likewise through such phases, and when complete become part of the normal way in which things are done.*[5]

Nevertheless, growing concerns have led to establishment of an Intergovernmental Platform on Biodiversity and Ecosystem Services, an international body that will play a role analogous to the Intergovernmental Panel on Climate Change. In elucidating and reporting on biodiversity status and risks from change, it seeks to be a bridge between science and policy. Along with many nations Australia has also committed to the Convention on Biological Diversity, which has a specified set of objectives known as the 'Aichi Biodiversity Targets':[6]

Strategic Goal A. Address the underlying causes of biodiversity loss.

Strategic Goal B. Reduce the direct pressures on biodiversity and promote sustainable use.

Strategic Goal C. Improve biodiversity by safeguarding ecosystems, species and genetic diversity.

Strategic Goal D. Enhance the benefits to all from biodiversity and ecosystem services.

Strategic Goal E. Enhance implementation through participatory planning, knowledge management and capacity building.

There are several consequences of the struggle to arrive at effective societal responses. In the first place, the idea that there should be no further species losses locally and regionally is an impossible dream (although it seems sensible to strive for this outcome at the continental scale). There will always be winners and losers among species, ecosystems and values of biodiversity.

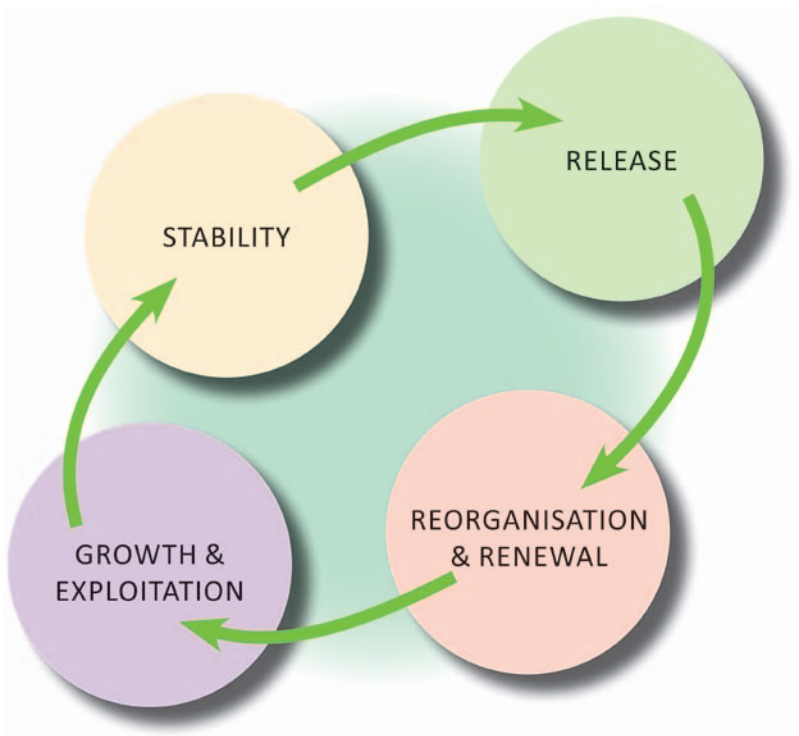
Science can also inform society about the probability of losing a species here or gaining more there, but rarely if ever can it say whether that result would be a 'good' or a 'bad' outcome across *all* the values that are represented in biodiversity. Nor should it, for this is a judgment that only society itself can make, through all the diverse mechanisms of democracy.

One option does not seem wise, though. Some land-based conservation activity springs from the assumption, whether spoken or not, that the goal is to recreate or to protect ecosystems as they were in a 'pristine' state in 1770, when Captain Cook arrived. The word 'pristine' is of limited meaning anyway, given the interaction between Aboriginal people and the continent's biodiversity in the millennia leading up to that moment in time. Nor will a 'pristine' baseline provide much guidance as climates change, probably irreversibly (Chapter 4). Our advice, rather, is that Australians embrace responsibility for deciding what we wish to achieve in various parts of our country. This recommendation emphasises the social aspect of biodiversity: it is up to us as Australians to ask ourselves what it is we wish our homeland to look like, with science helping to identify the options and understand how preferred options can be achieved most efficiently and with acceptable risk.

This book emphasises the concept of 'social technologies' as a method of reaching better decisions about how we manage biodiversity: which actions should be taken where and when in the land- or sea-scape, and in what form they are acceptable to society. Forms of structured decision-making (Chapter 4) can help solve the problem of allocation of effort between potential actions. Future progress rests upon having deeper conversations about societal goals for biodiversity, because achievement of a single goal will rarely satisfy all expectations. Approaches focused only on what ecosystems can do for humans in an economic sense would have no place for ecosystems or species without an immediate contribution to human wellbeing, and would leave Australia a poorer place culturally, recreationally and scientifically. Approaches that ignored economic need by emphasising primacy of the cultural and spiritual could likewise lead to poorer communities. Like many nations, we are trying to achieve a balance among values in our decision-making.

Community members debate options for natural resource management. Photo: Fiona Brown, CSIRO.

As biodiversity is a significant component of social–ecological systems, its management is likely to benefit from the emerging science of resilience thinking.[7] Resilience is the capacity of a system to absorb disturbance while retaining its functions and structure. Throughout this book it is argued that ecosystems are both complex and subject to unpredictable change. Such difficulties are even more pronounced in the social–ecological systems that end up defining the values of biodiversity around which we are striving to make decisions. To paraphrase the great philosopher of science JBS Haldane, social–ecological systems may not only be more complex than we imagine, they may be more complex than we *can* imagine. Under these conditions, resilience thinking suggests that we would do better by not trying to stabilise ecosystems, but rather to accept and work with the inevitable change (Figure 12.5).



▲ ***Figure 12.5****: The cycle of growth, stability, release, and reorganisation undergone by social–ecological systems.*[7]

Resilience thinking rests upon the proposition that it is not possible to learn fully about nature without carrying out 'experiments'. Observations are important, of course, but they will not confidently tell us about cause and effect. And it is virtually impossible to do experiments at ecosystem scale without interacting with some form of human resource use. 'Adaptive management' is an approach that consciously approaches management decisions and actions *as an experiment*, with hypotheses, a design capable of producing data that may test the hypotheses, and an expectation that we will manage the system differently following the cycle of testing and understanding. Resilience thinking and adaptive management are essential ways forward.

A related approach is to use scenarios to explore potential futures, supported by computer models that reflect the dynamics of different systems and the interactions between systems. Exploring scenarios encourages the posing of important 'what if' questions while avoiding the temptation of imagining that the future will necessarily be like the recent past.[8] It is useful to be able to peer decades into the future and ask, for example, 'What kind of things could

happen to biodiversity if Australia's human population continues to grow at the same rate and intense climate change occurs globally?', or 'What would it take to reverse declines in Australia's ecosystems while increasing agricultural output?' CSIRO is currently developing the modelling tools and expert systems for such approaches (Chapter 5), thereby highlighting the interdependence of biodiversity with society's changing demands for energy, water, food and reduced carbon emissions.[9] It would be foolish to suggest that scenarios make precise predictions of the future – that is not the aim. Instead, such modelling aims to understand the range of outlooks for Australian biodiversity and, thereby, to improve the quality of debate about what actions to take.

AUSTRALIA'S PERFORMANCE IN BIODIVERSITY MANAGEMENT

The *State of Environment Report 2011* confirmed that management of biodiversity in Australia is patchy:[10]

- Most of the pressures on biodiversity that arise directly or indirectly from human activities are still strong and will continue to be so in future years.
- Despite promising developments, pressures are not being substantially reduced nor the decline arrested.
- Climate change, population growth, economic development and consumption of natural resources must be managed better if the decline is to be arrested.
- Human activity has the potential to generate negative feedbacks that could harm the quality of life for Australians.

Impetus for improving management may be gained by focusing on the bright spots, five of which deserve attention. Each of these results from societal recognition, through an increasing acceptance of what science is telling us about the state of the environment, that there is a problem and that as a socially and technologically advanced society we can do something about it. Progress is being made.

The first is the improvement achieved through government leadership: broad-scale land clearing has been phased out, and processes have been set in place to restore high-biodiversity ecosystems as carbon sinks in anticipation of an increasingly carbon-based economy. State and Commonwealth governments are investing in community-driven, evidence-based natural resource management, and building strategies for biodiversity conservation on a vision of contributions by as many Australians as possible.

Second, in the last decade many global corporations and Australian companies have begun to mitigate the environmental impacts of their activities.[11] Businesses have as much potential to influence the course of events as governments, and in future will be fundamental to societal response to the decline in biodiversity. An exciting new opportunity is represented by the agricultural banking sector in Australia, which is exploring the contribution of biodiversity assets to the long-term sustainability and risk-management of farms.

Third is the quiet achievement of the expanding National Reserve System (Chapter 5), not only through government investment, but also increasingly with the growth in philanthropy through an increasing number of non-government conservation organisations supported by the public.[12]

Fourth, Australian marine management is world-leading. Fisheries management and spatial planning for marine reserves are among the best in the world.[13] Australia has pioneered the idea of adaptive management founded on conservation; despite the difficulties, the successes mean that our methods are in use worldwide (Chapter 9). Australia has contributed strongly in international marine policy, for example in managing the introduction of non-native marine species by shipping, and managing shared, migratory fish stocks on the high seas beyond national jurisdiction.[14]

A non-government conservation manager: Bush Heritage ecologist, Jim Radford, conducting a fauna survey at Boolcoomatta Reserve, north of Yunta, South Australia. Photo: Annette Ruzicka, Bush Heritage Australia.

Finally, the introduction of Native Title has provided opportunities for Indigenous Australians to return to their Country. Nearly 100 Indigenous ranger groups exist today, and more than 50 Indigenous Protected Areas contribute to the National Reserve System (Chapter 5). Close to a third of Australia's landmass is likely to be under Indigenous management by 2030.[15] The Commonwealth Government's long-term support for management of biodiversity in an Aboriginal framework is a visionary response to one of the cultural values highlighted at the beginning of this book, and is also helping improve Indigenous livelihoods.

In short, Australia has much to be pleased with, yet has extensive challenges to be concerned about. How might the future best be approached?

INTO THE FUTURE

One signal feature concerning the future stands out. Biodiversity will continue declining until Australian society acts to turn around the forces creating the problem. On the plus side, our society has considerable experience in conducting the social dialogue necessary for effective interaction between the community, policy-makers and science to such ends. Pointing out this positive feature of our national life does not imply that we always conduct the debates effectively or get the decisions right. There is a healthy level of discussion, though: a level of desire among governments to seek better balance between human activities and the breadth of values of biodiversity, and substantial national scientific expertise. There is good reason to believe that if any nation can mitigate the decline in biodiversity through social negotiation, it could be Australia. We are still very much the 'lucky country'.

Our population is small relative to the size of the continent, meaning that the financial base from which to resource this mitigation and restoration is also inherently limited. But, on the other hand, Australia has vast areas of healthy habitat and is starting to use its first-world capacity to combat errors of the past. We have a head start, and now practical programs, science and, increasingly, novel technical solutions will continue with the long-term task of maintaining functional ecosystems.

A further reason for optimism is that Australian research is at the global forefront in many relevant areas. We are leaders in rapid biodiversity assessment, remote sensing and sensor network technologies, spatial biodiversity analysis, fire management, restoration and rapid decision-making in the face of multiple values and limited data. We are also ahead of the game in landscape management, species reintroduction and translocation. Hence, Australia has increasing ability to provide effective management.

In light of these features – rapid and ongoing biodiversity decline, experience in social dialogue, and substantial national scientific expertise – this book offers the following suggestions for big steps forward. They emerge from our experiences at working in biodiversity science and in writing the book: five top potential advances that seem to offer the greatest promise.

1. Fill key knowledge gaps. Quantify Australian species and their interactions before threats are too widespread, and especially develop better understanding of the potential impacts of climate change on biodiversity values at land and sea.[16]
2. Strengthen community involvement. Dialogue will allow communities to make better environmental decisions in matters such as biodiversity transactions, incentives and market instruments such as offsets, bio-banking and stewardship programs.
3. Build national consensus on biodiversity priorities and establish performance measures for these in Australia's national accounts. If environmental resources and ecosystem services, including biodiversity, were to be measured and tracked in a similar manner to our economy, then more effective management and accountability would follow.

4. Institute a national program of biodiversity monitoring. If biodiversity assets are to become part of the national accounts, then monitoring must occur, just as with economic data; the many automated technologies being developed will assist.
5. Manage for resilience in the face of change. We will need innovative adaptive management of vital ecosystem functions, given that biodiversity will progressively alter within our lifetimes due to climate change and existing long-standing pressures.

In closing, we write briefly from our perspectives as scientists whose value systems emphasise the ecological life-support benefits of biodiversity in addition to the scientific treasures that, obviously, we cherish. The challenges we have outlined are real indeed. Australia is on a trajectory of continuing declines in biodiversity (in line with most countries of the world), as the sweeping changes bringing about the Anthropocene create a new world. The country inherited by future citizens could reflect merely a haphazard collection of opportunistic species if our present actions are unplanned. On the other hand, we have the potential to choose a future for our biodiversity – to 'design' our landscapes – if we put our collective minds to it and act with caution. It is in this sense that every decision on natural resource management is a choice, as explained in Chapter 4. Sometimes, too, looking after biodiversity would not be that hard financially given the science we have available, if that was our priority. We write with a sense of urgency that these matters be debated in society and acted on. In our view, society needs to move into the normative stage of recognising that managing biodiversity for the long term is a core activity of our culture (Figure 12.4).

This book is based on the proposition that societal support for future choices will be enhanced if those decisions can be informed by science. Our writers also believe that the extent of the continuing challenges in biodiversity will motivate contributions from future generations of Australian scientists. Science will increasingly provide options for the diverse values held across society so as to enhance a reasoned debate and, in time, enable progress towards a healthy future for our unique Australian landscape.

FURTHER READING

Lindenmayer D, Dovers S, Harriss Olson M, Morton S (2008) *Ten Commitments: Reshaping the Lucky Country's Environment*. CSIRO Publishing, Melbourne.

Steffen W, Burbidge AA, Hughes L, Kitching R, Lindenmayer D *et al.* (2009) *Australia's Biodiversity and Climate Change*. Australian Government Department of Climate Change, Canberra.