Australian Centre for Biodiversity
Monash University

Centre for Environmental Stress & Adaptation Research

Submission in response to Consultation Draft of Australia's Biodiversity Conservation Strategy 2010-2020

Our economy, environment and social wellbeing depend on natural resources and our sustainable management of them. It is also increasingly clear that climate change is resulting in unpredictable and changing weather patterns. These changes in climate pose an added threat to Australia's biodiversity that is already at risk from land degradation, habitat loss and overexploitation. Australia needs to develop an informed and integrated approach to dealing with the management and conservation of biodiversity in Australia. This approach must be multi-disciplinary and comprehensive, building on our understanding of the ecological and evolutionary biology of species, habitats and ecosystems. Above all else, the approach needs to be strategic and not piecemeal – our three tiers of government have contributed to incoherent policy and management. Australia needs much more effective linkages between the tiers of government and its intellectual capital in academia to respond to the biodiversity challenges of the near and medium future.

The **Australian Centre for Biodiversity (ACB)** is a Faculty of Science Research Centre at Monash University. We are a community of biologists that are committed to developing tools, understanding and the capacity to make sound decisions that will maintain and restore ecosystems now and into the future. Our research focuses on both aquatic and terrestrial habitats, in production/agricultural landscapes and conservation reserves. We work with community and government agencies to provide the understanding necessary to protect, restore and sustain our environment. The ACB contributed the Biodiversity chapter to the Garnaut Report.

The **Centre for Environmental Stress & Adaptation Research (CESAR)** was initiated through the ARC Special Research Centre funding program. It is a research centre spanning the School of Biological Sciences at Monash University and the Genetics and Zoology Departments at The University of Melbourne. Our research focus within the Climate Stress Program of CESAR is to understand the evolutionary processes underlying adaptation to environmental change, with a focus on climatic stress and climate change.

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Priority for change 1: Building ecosystem resilience

Objective 1.1. Biodiversity is actively managed for its own conservation value

1.1.1 Recognise the significance of maintaining and understanding ecological processes, and base the management of Australia's biodiversity on this principle.

There is increasing recognition of the fact that biodiversity is not static in space or time but generated and maintained by natural processes [1]. Biodiversity processes are sequences of changes in biological or physical characteristics, from molecular to global in scale. They include the birth, death and movement of individual organisms, local extinctions and decolonisation of populations, herbivory, predation, patch dynamics, seasonal migrations, adjustments of the distributions of species to changing climate and speciation. Unless such processes are explicitly planned for, many will be disrupted or cease altogether, with consequent loss of species [1].

The management of Australia's biodiversity must be based on conserving process (what generates and maintains biodiversity) rather than pattern (descriptions of biodiversity) however **evolutionary processes, as well as ecological processes, must also be explicitly included.** In conservation biology, evolution is recognised as important because it generates and maintains adaptive biological variation [2]. Maintaining and conserving the ability of organisms to adapt and evolve in response to new and changing circumstances must be central to biodiversity conservation in a future that includes climate change. Despite the general assumption that evolution proceeds slowly, there is increasing evidence that evolution can be quite rapid, particularly in response to anthropogenic environmental change [2]. There is already evidence for rapid evolution in response to climate change in several short-lived species, suggesting that many organisms have the capacity to respond to climate change within a timeframe of tens of years [3]. These responses depend on the presence of genetic variation (adaptive potential) in populations; in the absence of variation, there is now strong evidence for an increased risk of extinction in wild populations in nature [4].

Conserving genetic diversity for adaptive evolution has implications that go well beyond the long term persistence of species. For instance genetic diversity within different plant populations maintains an increased diversity of invertebrate communities, and thereby promotes the health of communities more generally as well as increasing ecosystem function [5] .

Examples of how ecological and evolutionary processes can be included in conservation planning do exist [1], and integrated frameworks have also been developed that outline how ecological, evolutionary as well as social and political factors might be considered in conservation and management decision making [6].

Within this context, it is crucial that clear goals for the conservation of Australia's biodiversity are set, and that conservation actions are clearly aligned to meet those goals.

1.1.2 Prepare and implement plans for biodiversity conservation at all levels (local, regional, state and continental) that maintain ecosystem health and protect threatened and endangered species

While protecting threatened and endangered species is an important part of conservation planning, there are some limitations to a species focussed conservation strategy. In particular, we know that the most important mechanisms for maintaining and generating diversity are

likely to operate at local scales and involve interactions between species and the environment [2]. Yet species focussed conservation efforts limit their funding to individual species (as the name implies) not the interactions between them, nor their interactions with the biotic and abiotic environment [2]. In addition, threatened species are those that have not been able to adapt to the changing conditions imposed by human actions and/or climate change. They are species with little potential to adapt to stressful, large-scale environmental change. While we do not advocate the abandonment of actions focused on threatened species, we must also focus on species that are not yet threatened, and identify strategies to ensure that their adaptive potential is maximised. It is a reality that many species will not be able to survive climate change, but this acknowledgement must not be used to justify inaction on habitat loss, habitat protection, and controls on the future development of land. Government must also focus on species that are not yet threatened, and identify strategies to ensure that their adaptive potential is maximised, and reducing on-going threats to biodiversity (habitat fragmentation, habitat loss over-exploitation) is essential.

While it may difficult to predict which species will be most affected by climate change, we do know that those species with restricted distributions and specialist habitat requirements will be most at risk from climate change and on-going threatening processes like habitat fragmentation. Frameworks are being developed to assist with this [6] and the use of biophysical models, based understanding on species' physiological tolerance to climatic stress and adaptive potential will also help [7].

Pests and Pathogens – additional threats to biodiversity, agriculture and human health
More attention must be paid to the increased risk that not only pest species but also pathogens will present to agricultural landscapes, native ecosystems and human health. The distribution and abundance of many disease vectors are closely linked to temperature and rainfall patterns, and will therefore be sensitive to changes in regional climate as a consequence of climate change. The risk of disease vectors such as mosquitoes expanding their ranges into southern Australia as a consequence of climate change is highly likely to occur.

An area of priority in this regard must be research into pests and pathogens that incorporates information about their physiological tolerances to climate extremes and change, dispersal ability and evolutionary potential. This information will assist in the development of predictive models that will provide managers with some understanding of the extent to which a certain pest or pathogen will be a risk. The utility of such models has been recently highlighted in work modelling the spread of the dengue fever vector in Australia [7].

1.1.3 Establish conservation linkages that provide connectivity across bioregions, particularly at a continental scale

There is widespread recognition of the need for restoration of ecological connectivity to prepare for climate change. Habitat fragmentation and degradation present significant barriers to species that may need to move to new habitats and refugia in response to climate change. Successful migration requires viable source population and habitats, destination refugia and large-scale connectivity. Recent reports have addressed these issues for Australia [8, 9].

Biolinks
In eastern Australia, restoring ecological connectivity between major areas of native vegetation, reserves and climatic refugia has been seen as a critical for over 20 years. In the eastern intensive zone in Victoria the term "biolinks" was coined in the early 1990s in the

context of species migration and climate change (reviewed in [8]). Subsequently, large-scale landscape connectivity programs such as WildCountry, Gondwana link and The Great Eastern Ranges Initiative, and others across northern Australia have been initiated in part, as responses to future climate. These are all variants on the biolink theme. Biolinks are national ecological infrastructure that form part of an adaptive response to climate change and include all land tenures [8].

Biolinks differ from the traditional concept of "wildlife corridors" in many ways; their scale (tens to hundreds of km wide or long); their multi functional nature; boundaries that are not harsh but permeable; appropriate human settlement and use encouraged; and they more fully embrace the broad view of emergent ecosystem services and sustainable landscapes. Landscapes supporting diverse habitat matrices with high spatial cohesion are crucial as sources of recolonization. Ecological studies are illuminating key environments within the habitat, while landscape preferencing models allow efficient and effective design and catchment models effective investment in multiple outcomes (reviewed in [8]).

Large-scale landscape restoration – moving beyond local provenance

Large-scale revegetation will be central to restoring ecological connectivity. Current restoration guidelines place strong emphasis on using local seed sources to maximise local adaptation and to minimise outbreeding depression. However in highly degraded and fragmented landscapes this will restrict seed collection to small remnant populations where limited, poor quality seed is available [10]. This also means that these source populations will harbour limited amounts of genetic variation, which in turn will reduce the evolutionary potential of the populations planted and limit the long-term success of the revegetation project. Climatic matching should be used to ensure appropriate choice of genotypes of particular species and, importantly, inclusion of species with broader bioclimatic ranges chosen to match future climatic conditions.

1.1.4 Continue to support, expand and manage the National Research System as a foundation for biodiversity conservation

Protected reserves and areas play a central and vital role in the conservation and management of biodiversity. Increasing attention is being paid to the role that such reserves systems will have in enabling the conservation and management of biodiversity under climate change. Australia's national system of protected areas, the National Reserve System, is making a vital contribution to a national climate change adaptation strategy. There is however a need to expand the National Reserve System to meet agreed targets in areas such as freshwater protected areas, reducing threatening processes and enhancing natural (ecological and evolutionary) processes across landscapes by integrating off-reserve and on-reserve management through bioregional plans [8].

The way in which new protected areas might be designed to take climate change into account in Australia has been outlined in recent publications covering the complexities surrounding this issue (see [8, 9]). A crucial objective for the selection and spatial design of conservation must be to promote the adaptation of species and natural processes (ecological and evolutionary) to changing climates. Key considerations must include:

- Recognising and planning for new patterns (e.g. projected rises in sea level, spatial changes in agricultural suitability) and combinations (e.g. altered fire regimes combined with the spread of invasive species) of threats.

- Adjusting conservation targets to account for climate-related issues such as altered vulnerability of species to new threats, population sizes required for genetic adaptation to climate and associated changes.
- Identification of populations within the ranges of species that might be pre-adapted to make the required changes for genetic adaptation and shifts in distributions.
- Identification, protection and/or restoration of climatic gradients to promote migration by species in response to changing environmental conditions. This involves ensuring that reserves/landscapes can sustain large populations and that they encompass a range of habitats where specific genotypes can be selected, in particular steep ecological gradients and areas with recent geological or climatic change.

Examples of where such considerations are being emphasised in conservation planning do exists. They include the Cape Floristic Region of South Africa, a global biodiversity hotspot and the Thicket Biome of South Africa [1]. Here, the planning exercises targeted regions that included riverine corridors crossing mountain ranges, allowing for dispersal and providing climatic refugia, and they include environmental/climatic gradients. This type of design and planning not only allows for the movement of species' distributions with climate change, but also maximises the opportunity for *in situ* adaptation and evolution in response to climate change.

Such approaches reflect a shift in how biodiversity is valued and assessed from static descriptions of 'value' based on habitat attributes like extent of vegetation cover, to include the processes that actually generate and maintain biodiversity. They include assessments of how well these processes will maintain those biodiversity values into the future, which is critical at a time of climate change.

1.1.5 Establish a national program for off-reserve conservation

New ways of thinking about conservation of biodiversity that move beyond the reserve system are also required. Protected areas occur on public land, yet they also represent patches (both large and small in scale) within highly modified landscapes that in large part are privately owned.

1.1.6 Maintain and enhance ex situ conservation measures as a last resort for biodiversity conservation

This area of conservation is perhaps the most obvious point at which evolutionary processes can and should be prioritised. Ex situ conservation (captive breeding) programs typically seek to preserve the option of release into the wild. However adverse genetic changes in captivity jeopardise the ability of captive populations to reproduce and survive when returned to the wild [11].

Four types of harmful genetic changes can occur during captivity, namely:
1) Loss of genetic diversity,
2) Inbreeding depression,
3) Accumulation of deleterious mutations and
4) Genetic adaptation to captivity.

The first three are associated with small population size, and they can be addressed by implementing management regimes that aim to maintain population size and minimise inbreeding through the development of appropriate breeding pedigrees. However, the degree

to which this is in reality achieved is questionable. Many captive breeding programs still do not assess levels of genetic diversity as a matter of course, and information on the extent to which captive populations are inbred is still largely lacking. Yet with the development of molecular genetic tools, levels of genetic diversity within captive bred populations can easily and cheaply be assessed. The lack of genetic assessment is a serious failing of current captive breeding programs, and must be addressed if ex situ conservation measures are to be a successful part of Australia's Biodiversity Conservation Strategy.

Further limiting ex situ approaches to conservation is that fact that adaptation to captivity is rarely considered in captive breeding programs, despite the fact that genetic adaptations to captivity have been documented in mammals, fish, insects and plants [11]. Considerable difficulty has been encountered in the reintroduction of endangered species into their natural habitats, and genetic adaptations to captivity that reduce fitness in the wild are one of the possible reasons for this low success rate. The impact of genetic adaptation to captivity is likely to be an increasing problem in the future, particularly if captive breeding and reintroductions are being seen as an "insurance against extinction" in responses to biodiversity conservation under climate change. Genetic adaptation to captivity is currently not addressed as an issue in captive breeding and reintroduction programs, even though the evidence indicates that it is, and will continue to be, a serious problem.

Minimising genetic adaptation to captivity might be achieved by minimising generations in captivity, or by equalising the number of individuals from any one family contributing to future generations. It might also be reduced by occasional crossing between different breeding populations across institutions [11].

Ex situ conservation measures are problematic, even as a last resort for biodiversity conservation and careful thought, planning and resourcing must go into the development of such measures.

Priority for change 2: Mainstreaming biodiversity

Objective 2.1.3 Develop a series of national biodiversity indexes (based on a comprehensive dataset that measures the status of, and trends in, Australia's biodiversity) that is frequently and publicly reported to influence decision making and public opinion.

Such a series of indexes will rely on on-going, supported monitoring. See our points under Objective 6.1.1. Will the use of such indexes really be about influencing decision making and public opinion or enabling communication and engagement with the broader community to ensure that informed debate occurs around the issues? The latter will be essential to the success of any long term Biodiversity Conservation Strategy. The use of the word influence hints at manipulation, pressure and persuasion, rather than an informed dialogue between equally respected actors. Is this the intention?

Priority for change 3: Knowledge for all

Objective 3.1 Knowledge about biodiversity and its scientific, economic, social and cultural importance is improved and made more accessible.

Communication between the research (e.g. Universities) and the applied management/policy and business sectors needs to be strengthened. There have been successes, and there are some modest programs, but it is still difficult for researchers to get their information into the hands of the policy-makers, and equally for the policy-makers to have access to much of the relevant information.

Differences in institutional cultures and priorities between the sectors are part of the issue, but even so there are rather few conduits for this sort of flow of information. A simple example: university researchers are under intense pressure to publish at a high rate and in high-impact journals, even including 'easy-to-read' high-profile, review journals such as Trends in Ecology & Evolution. In the main, the more applied management agencies do not have a strong culture of publishing, nor strong consumption of the peer-reviewed literature. There is strong potential for functions that bridge these gaps in information flow. This will ensure that the strengths of all groups are recognised and brought together to achieve the same goal.

The main issues with institutional arrangements are that the full magnitude of the issue of biodiversity loss and ecosystem function degradation is yet to be recognized and adequately resourced as the top priority.

The solutions will lie overwhelmingly in equipping landscapes and their biodiversity for an uncertain future. Resilience will be best promoted by maximizing amount of habitat, and having it functionally connected for the highest possible proportion of organisms.

Education and information will be critically important in explaining why very large amounts of resources are needed and why major changes in lifestyles and activities are essential.

Priority for change 6: Measuring success

Objective 6.1.1 Build baseline datasets, including key indicators, to measure biodiversity condition and trends over time

On-going monitoring is crucial to biodiversity management and conservation programs, particularly under climate change. How this is performed will determine the success of such programs. In particular, great care is required in the choice and use of headline indicators to maintain and enhance natural capital. In particular,

- We must include consideration of measures of adaptive potential in our monitoring programs.
- We must not base monitoring and research programs solely on the conservation status of native species, but rather extend attention to species and ecosystems that are not yet threatened, but are at risk of becoming so under climate change.
- Headline indicators must be chosen carefully, based on scientific merit. That is, will headline indicators be sensitive enough to track/detect changes over the time scales required of management programs? Climate change is already occurring, and headline indicators must be sensitive enough to detect the effects of those changes on our biodiversity over very short (several years/few decades) time scales.

- The proposed headline indicators must be able to provide insight into the resilience (the ability to withstand/recover from impacts) of ecosystems.

Objective 6.1.3 Implement and maintain a nationally representative set of long-term monitoring protocols and sites

Long-term monitoring protocols and sites will be essential to any successful biodiversity conservation strategy essential. However, their implementation and maintenance will depend on on-going financial support and commitment from Government. The tradition in Australia of funding such programs over the very short term (1-3 years, rarely longer) if at all will be a major impediment to this objective being met, and will not be adequate in a future that includes climate change.

Objective 6.2 Biodiversity and ecosystem services are integrated into national accounts and markets

While we do not know enough about the link between biodiversity and ecosystem services, it is clear that fundamental provisioning of the world with air, water, food and shelter is dependent on biodiversity and the functions it performs. Technological solutions to environmental challenges can only make a minor contribution to the major problem of maintaining healthy land and biodiversity. Biodiversity has operated to provide essential life services since the first emergence of life, and is honed to perform the relevant functions. Thus protection of biodiversity is very likely to be the most cost-effective approach to provisioning ecosystem services – the infrastructure already exists, and we know it works.

Two kinds of research should be of high priority here:

(1) FULL economic and risk assessment of the cost of providing essential and desirable ecosystem services by protection of biodiversity versus provision of the same services via technology. It should be recognised that it is already known that biodiversity is effective in this regard – most technologies will be new ones, and uncertainty and risk will be associated with whether such new technologies will be found and the extent to which they will be effective.

(2) Ecological research into the relationship between biodiversity and ecosystem services, considering sustainability into the future. There has been little of this kind of research in the world, and even so, generalities from elsewhere often are not convincingly relevant to the Australian situation. The unique biodiversity and diverse geographic regions of the Australian landscape must be recognised and taken into account.

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