



Submission on Australia's faunal extinction crisis

**– an inquiry by the Senate's Environment and
Communications References Committee**

**Centre for Ecosystem Science,
UNSW, Sydney**

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1. Executive Summary

Australia is facing an extinction crisis for biodiversity, including its fauna, but also flora and other organisms and processes. The country has one of the globe's worst extinction records with 449 bird, mammal, reptile, fish, frog and invertebrate species listed as Vulnerable, Endangered or Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*. There are also 30 mammal species, four frog and 22 bird species or subspecies that are extinct. The status of many other animal species remains poorly known with declining numbers. This extinction crisis is caused primarily by humans directly or indirectly destroying and degrading habitat loss and degradation, polluting, overharvesting, changing the climate, introducing invasive species and increasing incidents of disease. The Centre for Ecosystem Science welcomes the opportunity to provide a submission to the Senate's Committee for Environment and Communications on 11 terms of reference. Our researchers have decades of research background in identifying problems and solutions to mitigate this extinction crisis. Considerable successes can be achieved by improving legislation and policy which recognizes human impacts on biodiversity and the critical ecosystem services provided.

- Australia's extinction crisis continues, with increasing numbers of threatened species, declining numbers and distribution of native species. The full extent of this problem remains largely unknown.
- Australia is failing to mitigate rates of extinction, despite possessing much of the knowledge and legislative, policy and management capacity to slow extinction of fauna. There is an urgent need for improved protection, mitigation of key threats and restoration measures for the nation's ecosystems and their biodiversity.
- Increasing recognition of the value of biodiversity for ecosystem services providing for humanity needs to be realized in decision-making in relation to natural resource developments and other threats driving extinctions.
- Many of Australia's commitments to international agreements and conventions related to the extinction of fauna through goals and targets are poorly implemented, despite rapidly approaching deadlines (e.g. 2020 – Convention on Biological Diversity).
- Increased funding is essential for improved management and tracking of changes to biodiversity, including threatened species, ensuring that public and private conservation organizations are able to demonstrate the effectiveness of public investments. This should continue and expand resourcing of indigenous rangers.

programs.

- Australia should continue to grow its national reserve system, ensuring comprehensiveness, adequacy and representativeness of ecosystems.

We provide recommendations within this submission for changes in policy, legislation, management and funding which relate to the terms of reference.

2. Centre for Ecosystem Science, UNSW Sydney

The Centre for Ecosystem Science (CES), UNSW Sydney, supports instruments of government, including strategies that improve effectiveness of biodiversity conservation, founded on a strong evidence base, which assist in mitigating the extinction crisis in Australia. Current rates of biodiversity loss around the world and in Australia are unprecedented. Researchers in CES have established track records in the research and management of Australia's biodiversity, both within and outside protected areas. In particular, researchers focus on the three main realms of biodiversity (freshwater, terrestrial, marine) in the natural world (<https://www.ecosystem.unsw.edu.au/>) and welcomes the opportunity to provide a submission to into Australia's faunal extinction crisis.

3. Context

This Senate Inquiry is into

“Australia's faunal extinction crisis including the wider ecological impact of faunal extinction, the adequacy of Commonwealth environment laws, the adequacy of existing monitoring practices, assessment process and compliance mechanisms for enforcing Commonwealth environmental law, and a range of other matters.”

The world has entered the Anthropocene epoch, characterised by widespread loss of global biodiversity (nature) at unprecedented rates and scales, including species' extinctions, ecosystem collapses (Wilson, 2016), resulting in loss of ecosystem services (Newbold *et al.*, 2016) and straining planetary boundaries for human existence (Steffen *et al.*, 2015).

There is substantial scientific evidence to support this inquiry and the current extinction crisis, occurring in Australia. Australia has the worst mammal extinction record of any continent with more than 10% of 273 land mammal species becoming extinct in the last two centuries (Burbidge and McKenzie, 1989; McKenzie *et al.*, 2007b; Woinarski *et al.*, 2015), with 50% of the global mammal extinctions in the last 200 years from the continent (Short and Smith, 1994). The Bramble Cay melomys (*Melomys rubicola*) became extinct (Gynther *et al.*, 2016), likely due to sea level rise caused by climate change. Birds and frogs are also suffering extinctions and precipitous declines (Szabo *et al.*, 2012). The country has one of the globe's worst extinction records with 449 bird, mammal, reptile, fish, frog and invertebrate species listed as Vulnerable, Endangered or Critically Endangered under the

Environment Protection and Biodiversity Conservation Act 1999. There are also 30 mammal species, four frog and 22 bird species or subspecies that are extinct.

Climate change causing increasing severity of dry periods, increasing temperatures and sea level rise will continue to affect a range of biodiversity, including those occupying niches in mountains and rainforests (Williams *et al.*, 2003). While many mammal, frog, reptile and bird species have a high public profile, extinctions are occurring in other groups as well, including plants and invertebrates. Climate change will also interact with other threatening processes, exacerbating extinction risk (Kingsford *et al.*, 2009).

There are a range of different threatening processes driving this biodiversity loss in Australia including habitat destruction and degradation, invasive species, climate change, overharvesting, pollution and disease (Kingsford *et al.*, 2009). Habitat loss remains the overarching and most pressing of these threatening processes. Between 1972 and 2014, more than 7.2 million ha of primary forest was cleared across Australia, about 7% of the available forest (Evans, 2016). In 2015, Eastern Australia, including NSW, was identified as one of only 11 regions of the world undergoing high deforestation and the only one in a developed country (WWF, 2015). Deforestation includes vegetation clearing or land clearing and destroys habitats contributing to serious declines in woodland birds and reptiles (Garnett *et al.*, 2011; State of the Environment Committee, 2011; Bradshaw, 2012). For example, it was estimated that about 100 million native birds, reptiles and mammals were killed because of destruction of their habitat in NSW between 1998 and 2005 (Johnson *et al.*, 2007). The loss of such habitat threatens the continent's biodiversity, affecting 60% of Australia's nearly 1700 threatened species (Radford *et al.*, 2005; Natural Resource Management Ministerial Council, 2010; State of the Environment Committee, 2011).

Habitat loss and degradation is also the threat which can be most easily contained through focused legislation and policy but governments have generally failed to adequately address habitat loss and degradation occurring in terrestrial, marine and freshwater ecosystems around Australia. This is regularly the subject of state of environment reporting around Australia (e.g. (Australian State of Environment Committee, 2001; Australian State of Environment, 2006; State of the Environment Committee, 2011; Jackson *et al.*, 2017).

4. Terms of reference

In our submission, we structure our contribution by addressing each of the 11 terms of reference, providing recommendations for how the Governments and communities of Australia may address the ramifications.

i. The ongoing decline in the population and conservation status of Australia's nearly 500 threatened fauna species

Extinction rates in Australia are accelerating. There are currently nearly 449 species listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC

Act). Ten species, nine mammals and one frog species, are currently under consideration for listing as extinct under Commonwealth law, representing a 20% increase in number of extinct mammals (<https://www.theguardian.com/environment/2018/jul/11/threatened-species-nine-mammals-and-mountain-mistfrog-could-join-extinction-list>). Many more Australian animal and plant species have not been sighted for decades, warranting full scientific assessment for extinct listing. Lists of threatened species and ecological communities are burgeoning not only under Commonwealth legislation but also other relevant state legislation. Most threatened species assessments are highly biased towards better known organisms, particularly vertebrates, the focus of this inquiry. The failure of the terms of reference to address extinctions across all biodiversity reflects a continuing lack of awareness and neglect in government, industry and the public at large about the importance of plants, insects, fish, fungi and other organisms to ecosystem function, as well as the high risks of extinction faced by most other species not listed as threatened. While the Threatened Species Commissioner and other elements of government have found charismatic mammals and birds a useful mean of capturing public attention, a deeper commitment is needed to raise awareness about other species, their values and imperatives to save them from extinction. Prioritisation for resourcing also needs adjustment to correct this bias.

The protection of biodiversity which is not yet threatened is equally important, to avoid increasing lists of threatened species (Doherty *et al.*, 2015; Woinarski *et al.*, 2015; Niebuhr *et al.*, 2015). The removal of habitat provided by native vegetation destroys the dependent plants and animals, increases risks to wildlife from introduced predators, impacts surface and groundwater-dependent ecosystems, and fragments habitat so that individuals are unable to move through the landscape. It reduces the resilience of biodiversity to cope with a climate change (Reside *et al.*, 2012; Travis *et al.*, 2013) and has a long-term legacy of ongoing adverse impacts on biodiversity, including extinction debt (Tilman, 1999; Kuussaari *et al.*, 2009).

This comes on the back of high historic rates of extinction, related to the expansion of threats causing habitat loss and degradation (e.g. mining, farming, urbanization) across the continent, invasions of foreign predators, climate change, pollution, overharvesting and wildlife diseases. The most serious cause is loss and degradation of habitat due to land use intensification and infrastructure development.

Extinction rates are accelerating because the underlying causes are not being addressed effectively by Australian governments, communities and industries, and laws and policies meant to protect against loss of species are not adequately implemented (regulation and compliance) or often subsidiary in decision-making to development legislation (e.g. mining, water resource management).

This problem is exacerbated because Australian culture publicly advocates for the importance and value of nature (e.g. Australia's draft strategy for nature 2018-2030:

Australia's biodiversity conservation strategy and action inventory), but decision-making inevitably treats nature as something that interrupts economic development or a resource to exploit unsustainably. Ecologically Sustainable Development (ESD), meant to protect natural resources, including biodiversity, for future generations, is seldom adequately considered, allowing exploitation of natural resources and driving the extinction crisis.

Stated intentions to protect threatened species and their habitats are rarely delivered as effective regulatory actions and outcomes. For example, rapid rates land clearing (high by global standards) continue in Australia into the 21st Century despite laws enacted to abate them; very few development applications under state and Commonwealth laws result in refusal or major redesign to avoid impacts on threatened species or ecological communities. There are increasing rates of land clearing in some jurisdictions (e.g. NSW, Northern Territory). Environmental Impact and Assessments (EIA) remain fundamentally flawed by not involving an independent provision processes, whereby governments commission independent consultants to provide objective information. For the current process, industry usually hires environmental consultants to do this work. Successive amendments to these laws (e.g. NSW *Biodiversity Act 2016*) have increased loopholes that exempt certain development types and stakeholders from full assessment or predetermine assessment outcomes. For example, 7,000 ha of native vegetation was cleared in NSW in 2015-2016, compared to 2,730 ha in 2014-2015 and 900 ha in 2013-2014 (<https://www.theguardian.com/australia-news/2018/aug/04/clearing-of-native-vegetation-in-nsw-jumps-800-in-three-years>).

Unfortunately, laws, policies, regulations, incentives and funding initiatives that halt the extinction crisis will remain ineffective and inefficient, despite their potential, until Australian governments, communities, industries and businesses show public leadership in changing the pervasive misperception that environmental values (including threatened species) are an obstruction to progress. Such leadership can only be effective when demonstrated by new action which proactively avoids and reduces the major causes of extinction, replacing an over-reliance on reactive responses to offset, repair or restore damaged habitats. Such a fundamental change would reap rewards, not only in reducing the extinction rate, but through enhanced quality of Australian life, cultural and social well-being, and economic opportunity.

Recommendations

1. Ensure that state and Australian Government laws, policies and regulations to protect biodiversity are adequately implemented and mitigate the extinction crisis.
2. Control key threatening processes, including those that cause habitat loss and degradation, invasive species, pollution, disease and overharvesting. In particular, land clearing laws need to protect biodiversity and environmental flows need protection.

3. Ensure transparency of reporting on threatened species and threats (e.g. land clearing).
4. Establish an independent Environmental Impact Assessment process whereby governments oversee independent assessment of development projects and their effects on the environment.
5. Invest significantly in understanding the extent of the crisis by providing resources for monitoring biodiversity, reporting on status and identifying solutions that mitigate the extinction crisis, particularly in relation to collecting data on species for which little is known.
6. Ensure that principles of Ecologically Sustainable Development are effectively implemented in all legislation related to development of natural resources, including:
 - (a) The precautionary principle—namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
 - (b) Inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
 - (c) Conservation of biological diversity and ecological integrity and
 - (d) Improved valuation and pricing of environmental resources.
7. Increase protected areas, ensuring that the National Reserve System is 'Comprehensive, Adequate and Representative (CAR), including increasing the number of Indigenous Protected Areas and Marine Protected Areas.
8. Commit to state, national and international action on climate change and adaptation.

ii. *The wider ecological impact of faunal extinction;*

Extinction is arguably the most recognisable end result of much broader erosion of Australian ecosystems and their biodiversity. The consequences of this decline are severe and pervasive as the fundamental character of Australian landscapes, rivers and wetlands and seascapes is transformed from one of complexity. As a result, diversity which is globally unique is simplified, depauperate, driving homogeneity in ecosystems. Some of Australia's modern agricultural landscapes are now more reminiscent of Kansas, Western Europe or northern China than their uniquely Australian predecessors, celebrated by Banjo Paterson, Tom Roberts and Dorothea Mackellar.

As well as expunging unique signatures of Australian nature and culture, prolonged over-exploitation of these landscapes has eroded their capacity to deliver economic prosperity and security. There are also strong non-use values and benefits, often linked to deep cultural values of society. The loss of species has global consequences because biodiversity promotes ecosystem functions and services that are essential for human well-being (Hooper *et al.*, 2005; Cardinale *et al.*, 2006).

Ecosystems deliver services such as clean water and air, soil stability and fertility, climate regulation, carbon storage, recreational and tourism opportunities, as well as production goods such as food, fibre and timber. Although many of these services are often regarded as economic externalities, they cannot be taken for granted and their maintenance costs cannot be ignored without eroding Australian incomes and business profitability. Nowhere is this more evident than the current drought, where hardship is at least partly a result of over-exploitation legacies of land and water resource developments that extend as far back as the late-nineteenth century. Overstocking removed vast areas of perennial vegetation cover, weakening landscape resilience when drought eventually came, and resulted in long-lasting soil erosion, land degradation, economic ruin and multiple extinctions that were the subject of a Royal Commission in NSW in 1901.

There are considerable impacts on agricultural productivity and costs resulting from removal of native vegetation. There is increased erosion and reductions in the fertility of Australia's ancient and fragile soils (Ludwig and Tongway, 2002 ; State of the Environment Committee, 2011), increasing salinity (Walker *et al.*, 1993; Lambers, 2003; Nulsen, 2012), increasing drought (McAlpine *et al.*, 2009; Martin and Watson, 2016), reductions in animals that pollinate and control agricultural pests (Whelan *et al.*, 2008; Isaacs *et al.*, 2009; Kunz *et al.*, 2011) and reducing condition of livestock (loss of shade and increased wind). Globally, there is a net imbalance between rates of erosion and replenishment of soil, resulting in a net soil loss (Montgomery, 2007). For example in NSW, rates of soil formation are generally less than loss (Edwards and Zierholz, 2001), raising concerns about the sustainability of soil resources (Montgomery 2007) and therefore the ability of the State to sustain productive agricultural enterprises.

Successive generations of farmers and their families since then confront "vicious circles" in which landscape resilience is increasingly eroded by a system that promotes intensification and large financial debts that can only be serviced by further over-exploitation. The risks are unsustainable, and the same processes that cause extinctions, inexorably linked to human well-being. While demonstrating a fundamental failure of the industry, economy and regulatory systems to deal with environmental variability (an inherent and enduring feature of Australian ecosystems), one among many consequences is a barrier to maintaining a continuous connection to the land. The severe personal, social and economic costs of families leaving the land are well documented.

The roots of the extinction crisis are not confined to rural landscapes, however. Urban

development pressures borne from unsustainable population growth in Australian cities drive a similar “vicious circle”, identified in Australia’s first State of Environment Report in the 1990s. Since then, the problem has exacerbated, driven by government incentives to increase populations. Again, the processes driving current congestion, declines in open space and quality of life are inexorably linked to those that drive extinctions in habitats affected by intensifying urban land use. The solution here lies in leading a public discussion to develop an Australian population policy, one that is socially and racially equitable and one that identifies and commits to more sustainable targets than the business-as-usual model.

Recommendations

1. Communicate and report on the value of biodiversity and ecosystem services to agricultural and fisheries production and urban quality of life.
2. Develop a population policy which specifically addresses issues of sustainability in supplying increasing populations with food, water and fibre from an environment where such processes drive extinction.

iii. The international and domestic obligations of the Commonwealth Government in conserving threatened fauna;

Australia is a leader in Conservation Science and Management, recognized around the world. This was often reflected in past in policy and resourcing of biodiversity conservation but, in recent years, such policies have lagged many other parts of the world. Worse, policies that further extinction, such as land clearing, water resource development, overharvesting of fish resources and poor action on climate change have come to the fore and exacerbated the loss of biodiversity. Australia has international and national obligations to conserving biodiversity, including threatened fauna. These include commitments to the Convention on Biodiversity (CBD), The World Heritage Convention, the Convention to Combat Desertification, the United Nations Framework Convention on Climate Change, the Ramsar Convention, the United Nations Sustainable Development Goals, International Conventions and agreements to protect migratory species and The convention on the international Trade in Endangered Species of Fauna and Flora (see Appendix 1). All of these international agreements and conventions have clear commitments to goals, targets and indicators relevant to the extinction crisis which Australia is not meeting.

There is also little tracking, transparent reporting or evidence of how these commitments are being met in documents produced by the Australian Governments. There is generally poor resourcing on effective on-ground action to stem extinction rates and little regard to these international obligations in policy development for natural resource management.

Recommendations

1. Explicitly and transparently link commitments (goals and targets) by the Australian Government to international agreements to on-ground actions.
2. Regularly report on Australia's progress in meeting each of its commitments to international agreements.
3. Provide funding support and government structural support to give effect to Australia's commitments to international agreements.
4. Australia should devote more resources to protect and research migratory species. Protection for migratory species additional to Australia's existing protected areas, needs to be improved with protection within strategic vulnerable sites to development and establishment of dynamic protected areas which can be moved with mobile fauna (Runge *et al.*, 2014).
5. There needs to be stronger negotiation with other countries for the management of migratory species which requires coordinated action involving many government, non-government and industry partners located around the world.
6. There needs to be improved understanding of migration dynamics of all of our migratory species with strong local protection during the migration season. There also needs to be improved understanding of development impacts, as well as cumulative ones, on migratory species, and increasing resourcing for environmental impact assessment procedures.

iv. *The adequacy of Commonwealth environment laws, including but not limited to the Environment Protection and Biodiversity Conservation Act 1999, in providing sufficient protections for threatened fauna and against key threatening processes;*

National laws are currently not strong enough to halt the extinction crisis. They inadequately deal with widespread threats; they are often subordinate to development legislation and policy; they inadequately show national leadership in terms of regulating deleterious developments at the state level; they inadequately deal with small scale cumulative developments and they do not assess planning frameworks which support developments known to accelerate the extinction crisis. They also clearly require review and reform as detailed in the Hawke review (Hawke, 2009).

The most fundamental deficiency in Commonwealth environment laws is lack of provisions to deal with the most serious threat to biodiversity which is habitat loss, through land clearing of terrestrial environments, water resource developments affecting rivers and climate change effects on marine environments. Most responsibilities currently lie with state and territory jurisdictions. Although some potentially effective laws have been enacted in some jurisdictions, experience has shown these arrangements are fundamentally

inconsistent and unstable, as jurisdictional regulations are repeatedly undermined by successive amendments.

Land clearing rates remain high and poorly reported, fueling an accelerating extinction debt and undermining the capacity of Australian landscapes to support sustainable production and ecosystem services into the future. A national approach to land clearing is required that is constitutionally robust, publicly supported by government and industry, and sufficiently resourced to ensure sustainable outcomes into the future.

Water resource developments are planned for northern Australia and underway in many other parts of Australia. Even where there have been significant efforts to restore freshwater habitats in the Murray-Darling Basin, there are significant challenges to water resource management acknowledged by different reviews of water management inadequacies (Matthews, 2017) which have repeatedly identified impacts to the environment, increasing extinction risk.

Resourcing of extinction risk assessment for species of fauna and other biodiversity, key threatening process listing, recovery planning and threat abatement planning has languished. This is particularly true for key threatening processes, with no listing since 2011, despite good knowledge of the effects of threats on biodiversity. Similarly, few ecological communities have been listed.

Recommendations

1. Strengthen national legislation to address key weakness, as detailed in the Hawke review (Hawke, 2009). Ensure that the following are adequately included: incorporation of international commitments (goals and targets), national oversight over state legislation and policies, address small-scale cumulative developments.
2. Ensure that the EPBC Act adequately assesses small scale developments that cumulatively amount to large scale developments and natural resource decisions that drive extinction, including planning decisions.
3. Ensure that the EPBC Act maintains oversight on assessment of national and international matters of significance and does not defray these decisions to state based processes which may not have sufficient cognizance of matters of national and international importance and may be affected by political opportunism.
4. Ensure the EPBC Act includes vulnerable ecological communities as a Matter of National Environmental Significance.
5. Increase resourcing for adequate management of threatened species, including for assessment of listing of species and ecological communities and development of recovery plans. In particular, this resourcing should focus on many species for which there is little information.

6. Improve the implementation of the Key Threatening Processes and their management through threat abatement planning (TAP).

v. *The adequacy and effectiveness of protections for critical habitat for threatened fauna under the Environment Protection and Biodiversity Conservation Act 1999;*

Management of the environment is clearly a joint state, territory and Australian government responsibility. Provisions for declaring critical habitat, under the *Environment Protection and Biodiversity Conservation Act 1999*, are rarely invoked, giving an impression of active avoidance by Commonwealth authorities. Government documents use terminology such as “habitat critical to the species” to avoid expectations for substantive measures that invoke statutory provisions for declaring critical habitat. This is a potentially strong initiative which could be used to fundamentally mitigate against the extinction crisis. There are clearly many critical habitats which could be declared and then protected under this provision. In addition, critical habitat identified under EPBC Act 1999 is only protected if on Commonwealth land and sea, which includes a relatively small part of areas requiring national protection.

Recommendations

1. Establish a clear, transparent process for identifying and nominating critical habitat for threatened fauna which is objectively assessed, including nominating critical habitat for all threatened species.
2. Ensure there are strong mechanisms for implementing protection of critical habitat which is sufficient to ensure its protection not only from on-site impacts (e.g. overharvesting, invasive species) but also from off-site impacts (e.g. water resource developments, pollution).
3. Ensure protection for nationally listed critical habitat for threatened fauna, applies to all land and water where that habitat occurs

vi. *The adequacy of the management and extent of the National Reserve System, stewardship arrangements, covenants and connectivity through wildlife corridors in conserving threatened fauna;*

Protected areas are linchpins in preventing extinctions, explicitly stated in Australia’s first national biodiversity strategy in 1996 (Australian Government, 1996). Establishment of protected areas and appropriate management can reduce threatening processes and extinction risk of fauna (Karanth *et al.*, 2010). The Convention on Biological Diversity (including Australia) adopted the Strategic Plan for Biodiversity 2011–20, with 20 Aichi Targets (CBD, 2011). Many depend on the successful implementation of protected area network. However, Australia continues to fail in meeting its biodiversity targets as detailed in the 2011 national report on the state and trends of biodiversity. An independent review

commissioned found that of the ten specified interim goals made in the Australian Biodiversity Conservation Strategy 2010-2030, only one had largely been achieved (HSI, 2015).

The National Reserve System is underpinned by a scientific framework (Margules and Pressey, 2000) with a clear objective: “to develop a comprehensive, adequate and representative system of protected areas”. This framework was endorsed by all Australian governments as signatories to the National Strategy for Conservation of Australia's Biological Diversity (2010), and the National Forest Policy statement (1992). This approach aimed to improve the past opportunistic process of designating protected areas towards a more quantitative and systematic process, attempting to capture the full patterns of biodiversity (Brooks *et al.*, 2006; Wilson *et al.*, 2006). Although recent protection of areas has improved towards threatened species, the increase in protected areas in poorly protected regions has occurred more slowly than expected if protected area selections were fully guided by systematic conservation planning principles (Barr *et al.*, 2016). Assessment of recent changes in the protected area network identified over 1,500 events of downgrading, downsizing, and degazettal of protected areas, affecting over one-third of the network, largely the result of widespread downgrading of protection (Cook *et al.*, 2017).

The National Reserve System covers 16.5% of Australia's land area but highly protected areas, such as national parks, only cover 8.3% (Taylor *et al.*, 2014). Shortfalls remain in the marine environment, although the National Reserve System extends over one-third of Australian waters, only 13.5% of the area is highly protected areas such as national parks and no-take green zones (Taylor *et al.*, 2014). The level of protection offered to marine biodiversity is generally low, with insufficient coverage of no-take Marine Protected Areas across many bioregions (Roberts *et al.*, 2018). Representation of freshwater systems is varied with overall representation of mapped wetlands good for lacustrine (40.6%) and estuarine (34.4%), fair for riverine (16.8%), but inadequate for palustrine (10.8%) wetlands (Bino *et al.*, 2016).

Establishing protected areas as the sole strategy for preventing extinction of species is insufficient (Burbidge and McKenzie, 1989). This is especially relevant when protected areas remain “islands” surrounded by areas undergoing unsustainable use of land and water resources. Susceptibility of fauna to extinction and threatening processes vary across the landscape (Fritz *et al.*, 2009), requiring explicit spatial prioritisation for conservation within Australia (McKenzie *et al.*, 2007a). Evidence of continuing declines and extinctions of populations within protected areas around the world (Geldmann *et al.*, 2013) suggest many protected areas fail to support viable populations (Newmark, 2008). For populations of fauna to persist, protected area network must be sufficiently large and connected to support natural fluctuations in demographic, environmental and genetics and support sufficiently large populations and areas to withstand disturbance (e.g., fire) and climate change (Caughley, 1994). The protected area network and the mosaic in which they exist

must allow movement between protected areas. This is critical for important seasonal movements of species between habitats. In testament, a recent study found that the protected area network is incapable of supporting enough habitat requirements and thus viable populations for several Australian mammals (Clements *et al.*). Fencing as a strategy to minimise extinction should also be incorporating with recent assessments suggesting 67% of predator-sensitive species were unrepresented in the fence network (Ringma *et al.*, 2017).

State resourcing of protected area management is inadequate and declining

<https://theconversation.com/australia-relies-on-volunteers-to-monitor-its-endangered-species-97532> . Ongoing diminution of the workforce is pervasive, as is a ‘brain-drain’ of

scientific expertise in conservation agencies to support strategic management of protected areas and their biodiversity. Conservation in protected areas has also been undermined by decisions that permit livestock grazing and prevent cost-effective control of feral animals.

For example, the NSW Government has legislated for the protection of feral horses in Kosciuszko National Park, which cause considerable ecological impacts. Grazing by livestock affects a range of processes and organisms, including native plants and dependent biodiversity as well as becoming a vector for invasive plants. The Queensland Government has allowed the grazing in National Parks, effected by a change in legislation

(https://www.npsr.qld.gov.au/managing/commercial-activities/grazing_on_qpws_estate.html , <http://www.abc.net.au/news/2016-05-11/cattle-grazing-leases-national-parks-laws-pass-qld-parliament/7404184>)

There is a clear need for protected areas to be primarily for the conservation of ecosystems but also supporting indirect benefits such as tourism. There is a need for protected areas to also have sufficient funding to ensure that there is targeted management of threatening processes to maximize biodiversity outcomes.

Recommendations

1. Pursue and report on Australia’s national commitment and progress to achieve Aichi Target No. 11: “by 2020, at least 17% of terrestrial lands and inland water, and 15% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are considered through effectively and equitably managed ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape”.
2. Complete establishment of comprehensive, adequate and representative system of assessment of landscapes for potential inclusion in the National Reserve System.
3. Resource and establish new Indigenous Protected Areas and areas for private land conservation.
4. Resource protected area management sufficiently to ensure that threatening processes

are adequately managed. This includes management of threats affected protected areas from outside the boundaries (e.g. development of water resources upstream affecting wetland flooding regimes).

5. Do not allow threatening processes (e.g. livestock grazing) to occur in protected areas as these impact on biodiversity outcomes.

vii. *The use of traditional knowledge and management for threatened species recovery and other outcomes as well as opportunities to expand the use of traditional knowledge and management for conservation;*

Full understanding of biodiversity and ways in which Australia can mitigate the extinction crisis demand multiple lines of evidence and support from Indigenous and non-Indigenous groups. Traditional knowledge and management practices provide a significant body of environmental information, accumulated over 65,000 years of experience, with scientific information, can assist effective conservation. At a global scale, the inclusion of traditional knowledge in conservation decision making and practice is a goal of the Aichi Targets (Target 18, Convention of Biological Diversity 2011). Nationally, the EPBC Act 1999 promotes 'a partnership approach to environmental protection and biodiversity conservation' between Indigenous and non-Indigenous land managers (Ens *et al.*, 2012).

In addition to traditional knowledge, engagement and employment of Indigenous Rangers in land management situations have proven highly successful (Social Ventures Australia, 2016). Indigenous Ranger Programs deliver a substantial return on investment, and increasing investment in these activities will accelerate rates of social return (Social Ventures Australia, 2016). Positive returns from Indigenous Ranger Programs are not limited to environmental outcomes, with improved societal, health, and economic conditions reported (Social Ventures Australia, 2016). The Australian Government has made progress in this area with the Caring for our Country and Working on Country programs, which currently provides short-term (< 5 year) funding to 118 different ranger groups. In Australia, Indigenous Rangers work largely on matters of National Environmental Significance, including recovery of threatened species and management of invasive pests. Indigenous Ranger Programs are of critical importance to conservation. These programs should be secured with long-term funding and significantly expanded to provide increased support to programs throughout the states and territories.

Recommendations

1. Continue to resource Indigenous Ranger Programs. Commit to long-term funding and expand the Caring for our Country and Working on Country programs to increase the number of employed Indigenous Rangers.
2. Increase opportunities for traditional knowledge to be included in effective conservation of biodiversity and mitigation of the extinction crisis. Ensure the inclusion

of traditional knowledge at all stages of the threatened species management planning process.

3. Create opportunities for non-Indigenous groups to receive cross-cultural training to increase awareness and understanding of Indigenous land management and conservation practices.

viii. *The adequacy of existing funding streams for implementing threatened species recovery plans and preventing threatened fauna loss in general;*

Australia performs poorly in its resourcing of biodiversity conservation, essential for mitigating the extinction crisis. It remains one of only four developed countries in the top 40 underfunded countries in terms of conservation expenditure (Waldron *et al.*, 2013; Waldron *et al.*, 2017). In the last decade, funding for biodiversity conservation has only amounted to less than five cents for every \$100 of Australia Commonwealth spending (ACF, 2018). This was further underlined by the National Audit Office (Australian National Audit Office, 2017) identifying three key themes affecting Australia's delivery of programs and regulation:

- *'weaknesses in the arrangements for the provision of Australian Government funding for environmental purposes;*
- *variability in the maturity of risk-based frameworks for the delivery of regulatory functions; and*
- *weaknesses in performance measurement frameworks that are to be used to determine the impact and effectiveness of the Government's environmental programs and regulatory functions.'*

Under the Environment Protection and Biodiversity Conservation Act 1999, recovery plans are required for threatened species to guide recovery, allowing measurement of progress. Although the Commonwealth supports drafting of recovery plans, there is an enormous and growing backlog of new listings and outdated plans for existing listings. Only 736 (42%) of 1765 threatened taxa (listed as Critically Endangered, Endangered, Vulnerable) have had a recovery plan prepared (including out-of-date plans), and 24 (30%) of 81 listed ecological communities (Department of the Environment, 2018). The Commonwealth no longer funds implementation of recovery plans, which has been a contributing factor to the extinction crisis. Many recovery plans have lapsed and are being replaced by Conservation Advices, which have limited statutory effect and for which no resources are allocated to support implementation. Lack of monitoring data makes it hard to assess whether recovery planning processes aid population recovery or not (Bottrill *et al.*, 2011). A major funding package is needed to redress this deficiency. This poor national record inadequately meets Australia's commitment to Aichi Target 12 of the Convention on Biological Diversity (see above).

If Australia is to establish leadership in management of threatened species and ecosystems, it will need to adequately ensure there is good information on the status of Australian

ecosystems. Funding to support recovery of threatened ecological communities is waning as current programs come to an end and need to be boosted with new investments to ensure dual outcomes for food production and biodiversity. It is essential that the information base for biodiversity be provided investment and so decisions on the environment can be supported by a good evidence base. Funding for biodiversity conservation to offset the extinction crisis has declined significantly over the last decade, with less than five cents in every \$100 of Commonwealth government spending in 2018 (ACF, 2018). We perform poorly at an international, ranking in the top four of 40 countries in terms of poor funding for conservation (Waldron *et al.*, 2013).

Recommendations

1. There should be a significant long-term investment in resourcing for threatened species management, including listing of species and their recovery plans and subsequent management, listing of threatened ecological communities and key threatening processes.
2. There also needs to be significant funding increases in biodiversity conservation more broadly.
3. Biodiversity Conservation needs to be integrated throughout all natural resource management resourcing and implementation.
4. Tracking of effectiveness of natural resource management and biodiversity conservation expenditure is essential, linked to biodiversity outcomes that mitigate the extinction crisis.
5. There needs to be a substantial focus in attention and funding on the ecosystem or ecological communities aspect of the biodiversity agenda as this is most likely to have the most significant benefits for conservation and mitigating the extinction crisis.

ix. *The adequacy of existing monitoring practices in relation to the threatened fauna assessment and adaptive management responses;*

Monitoring is fundamental to good management and decision-making, ensuring that resourcing is well spent on achieving outcomes. Australia's lacks a clear commitment to the monitoring of biodiversity programs, critical for slowing the rate of extinction.

A recent review of monitoring by the TSC NESP Hub showed monitoring of threatened species and ecological communities to be wholly inadequate (Legge *et al.*, 2018). Of Australia's 548 threatened species (506 listed under the EPBC Act 1999), a third do not have a formal monitoring program, with the remainder relying on poor monitoring. With increasing numbers of species added to threatened species lists, it means that this fraction is increasing. Adding to the problem, Commonwealth funding for the Long Term Ecological Research Network under TERN/NCRIS was terminated, removing the largest source of

monitoring of threatened fauna and their ecosystems in Australia (Lindenmayer, 2017).

Further, few recovery plans are effective because of inadequate resourcing. Most threatened species continue to decline, mainly because of habitat loss and degradation.

Recommendations

1. A comprehensive monitoring program needs to be established for threatened species and their ecosystems.
 2. Australia should implement national monitoring of biodiversity, identifying groups of key organisms where data are available that allow for tracking of trends in rates of biodiversity loss (abundance, range, diversity) in the three main realms: freshwater, marine and terrestrial environments.
 3. Data reporting should be routine for all survey work and reported regularly by all bodies involved in biodiversity management, collection and assessment, including environmental assessments for impacts.
 4. Substantial resourcing should be provided for monitoring biodiversity at the national and state scales; this may include surveillance monitoring.
 5. Management of natural resources (Environmental impact assessment, vegetation management plans and water resource planning) should incorporate and fund monitoring programs focused on key indicators that inform management decisions.
 6. Invest in Citizen Science but not to the detriment of other survey programs, allowing for collection of large amounts of data.
 7. Regularly report trends in State of Environment Reporting at National and State and Territory levels.
- x. *The adequacy of existing assessment processes for identifying threatened fauna conservation status;***

Australia has a highly respected commitment to assess and monitor the status of its biodiversity to high international standards. The Threatened Species Scientific Committee was established under the EPBC Act to advise the minister on listings and management of threatened species, ecological communities and key threatening processes. Listing and delisting should continue to be oversighted by an independent Scientific Committee which can rigorously assess the evidence of risk to extinction of species or collapse of ecosystems. The Committee is composed of high-calibre independent scientists with expertise across the full range of Australian biodiversity.

There is a need to liaise with other jurisdictions to ensure that the species and communities most at risk of extinction or collapse are adequately assessed. Importantly, the listing and

delisting processes should remain independent of any referral process or mitigation or management processes. Measures to reduce regulatory burden should not compromise the internationally regarded scientific integrity of the listing process. For Australia to meet its international reporting obligations on biodiversity, listings must be assessed transparently on scientific grounds without conflating various other socio-economic factors and stakeholder issues. The latter need to be considered through separate mechanisms so that decisions about action are clearly separated from questions about current status of biodiversity. It should remain immaterial what type of development is considered whether agriculturally based or some other development (e.g. industry, urban). The Common Assessment Method (CAM) provides considerable promise for improving efficiencies in the way different processes to manage threatened species at national and jurisdictional scale interrelate and integrate.

There is also a need for a concerted focus in terms of funding and resources at the ecosystem scale of risk assessment. This is the most likely productive way to address the extinction crisis because it focuses on the broad scale. There are also well established and rigorous objective process in place for assessment, in which Australia is leading the world (Keith *et al.*, 2013; Nicholson *et al.*, 2015).

Recommendations

1. The current process of listing species and ecological communities should be continued but with one major change. It should be an independent scientific process, divorced from management and policy implications. The Minister for the Environment should not be the determining authority for listing as currently under the EPBC Act. Note that a similar committee is independent in NSW, resulting in a more objective process.
2. Current list of Australia's threatened species needs updating and resourcing on species which are not currently well covered (e.g. plants and invertebrates).
3. There needs to be a stronger emphasis (listing, funding) on listing of threatened ecological communities, following IUCN developed protocols of Red-listing of Ecosystems (<https://iucnrle.org/>).
4. Australia should invest in a national assessment of the continent's freshwater, terrestrial and marine ecosystems.

xi. The adequacy of existing compliance mechanisms for enforcing Commonwealth environment law;

Legislative arrangements provide the essential structure for ensuring ecological sustainability. However there is a need for resources provided for compliance. In particular, unsustainable practices may continue without government oversight. This was most recently identified during alleged water resource development, with poor compliance

identified along Murray-Darling Basin Rivers (Besser, 2017) and independent assessment (Matthews, 2017). There is a clear need to resource compliance to ensure that legislation and policies are respected by both government and communities. Increasingly sophisticated tools in remote sensing are providing Governments with opportunities to more effectively regulate agricultural activities which are unsustainable.

Recommendations

1. There is currently insufficient oversight of Australia's poor record in conservation of biodiversity or tracking effectiveness of mitigation and restoration efforts. We recommend establishment of an independent Environmental Commissioner, charged with State of Environment Reporting and providing independent advice to governments.
2. Rigorous Commonwealth referral and assessment processes should not defer to State process that may not adequately assess priority State projects
3. Referrals and assessment should consider the impacts of cumulative developments to ensure ecological sustainability.
4. The integrity of the independent Threatened Species Committee under the EPBC Act needs to be maintained and strengthened, with increased independence and resourcing. Listing and delisting of species and communities needs to be independent and dependent on the evidence base and not conflated with policy and management interpretations.
5. In 2016, State, Territory and Commonwealth Government signed an intergovernmental agreement on a Common Assessment Method (CAM) to harmonise listing of species and ecological communities. Only two state/ territory have governments are implementing the agreement. The Australian Government should consider implementing this agreement, demonstrating leadership to remaining states/ territories. This would significantly harmonise listing processes and reduce duplication.

Appendix 1 – International obligations relevant to mitigating the extinction crisis for fauna

Convention on Biodiversity

Australia gives effect to its commitments to the Convention on Biodiversity (<https://www.cbd.int/>) through the *Environment Protection and Biodiversity Act 1999* and associated state legislation, as well as provisions in other laws concerning fisheries, forestry, agriculture and biosecurity. There should commitment to implementing the five Aichi strategic goals and 20 targets under the Convention on Biological Diversity (<https://www.cbd.int/sp/targets/>). They provide a sound basis for national commitments to nature or biodiversity. Commitments establish a strong framework for protected areas and environmental regulation and incentive programmes. However, the framework has never been implemented to its full potential. For all five Strategic Goals (A-E) and their associated 20 targets (see below), Australian governments and communities are generally failing, even though these are meant to be achieved in under two years. Even where there are initiatives, many of these are not adequately progressed.

Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society

Target 1. By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.

Target 2. By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.

Target 3. By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.

Target 4. By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.

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

Target 5. By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.

Target 6. By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.

Target 7. By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.

Target 8. By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.

Target 9. By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.

Target 10. By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.

Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity

Target 11. By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Target 12. By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

Target 13. By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

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

Target 14. By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.

Target 15. By 2020, ecosystem resilience and the contribution of biodiversity to carbon

stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.

Target 16. By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.

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

Target 17. By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.

Target 18. By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.

Target 19. By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.

Target 20. By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.

Convention Concerning the Protection of the World Cultural and Natural Heritage

This Convention aims to identify and protect the world's natural and cultural heritage of outstanding universal value. Australia currently has 12 natural heritage sites listed <https://whc.unesco.org/en/statesparties/au>. None are currently listed in danger but significant impacts to the Great Barrier Reef from coral bleaching, ports, run-off and invasive species continues to drive degradation in this ecosystem and increase extinction risk.

Convention to Combat Desertification

Australia is a signatory to this Convention <https://www.unccd.int/>. Australia's economy is

heavily reliant on sustainable agriculture production (<https://theconversation.com/australias-five-strong-pillar-economy-agriculture-40388>). However, the cumulative effects of overgrazing, poor irrigation practices, climate change, and deforestation are increasing the rate of desertification, globally, with important implications for Australia's farming future. This recently developed initiative will be critical for Australia's future, charting a course of world-leadership in sustainable agricultural practices, preserving the land.

United Nations Framework Convention on Climate Change

Human induced climate change is managed internationally through this Convention <https://unfccc.int/resource/docs/convkp/conveng.pdf>, underpinned by the most recent Paris Agreement <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>. The Paris agreement is an international initiative to keep global temperature rise this century below 2° C, and Australia has commitments on emissions to be met by 2030 <http://www.environment.gov.au/climate-change/publications/factsheet-australias-2030-climate-change-target>, through a nationally determined contribution (<https://unfccc.int/process/the-paris-agreement/nationally-determined-contributions/ndc-registry>). Every five years demands countries provide transparent assessment of progress towards meeting their commitments. Continued and increasing removal of forests, woodlands and grasslands with land clearing increases the cost of restoring landscapes and reduces the chance of success in reaching emissions targets. For example, the Australian Government has committed to plant 20 million trees by 2020 (<http://www.nrm.gov.au/national/20-million-trees>).

Ramsar Convention

Australia is also a signatory to Ramsar Convention (<https://www.ramsar.org/>), the main policy instrument for protection wetlands around the world. Biodiversity loss is worst across the world's freshwater realm, predominantly the wetlands (Dudgeon *et al.*, 2006). This crisis is reflected in 'fresh water', ranking among the top five global risks to human well-being (World Economic Forum, 2018), threatening critical ecosystem functions and services. The Ramsar Convention addresses the global freshwater crisis (Gell *et al.*, 2016; Finlayson *et al.*, 2017) by identifying internationally important wetlands (Ramsar sites), assessing, and reporting on risks to their ecological character (ecosystem components, processes and services). Australia does not adequately protect many of these wetlands with three wetlands (Macquarie Marshes; Lower Lakes, Corong and Murray Mouth; Gwydir wetlands) currently formally listed under the Ramsar Convention, as likely affected by human-induced changes.

All scientific evidence currently available indicates that Australia is failing to meet its international obligations for the management of internationally important wetlands: Ramsar listed wetlands. This was one of the major reasons the Australian Government,

under its international responsibilities was able to establish new water legislation, the *Water Act 2007*, to try and avoid the mismanagement of the Murray-Darling Basin by the States. Australia's three internationally listed wetlands under the Ramsar Convention in the Northern Basin (Gwydir wetlands, Macquarie Marshes, Narran Lakes) will fail to change their ecological character, mainly as a result of reductions in flow. Current water recovery is not sufficiently providing for the ecological character of the three internationally listed wetlands which are in ecological decline. For example, considerable rigorous research has been done in the Ramsar-listed Macquarie Marshes to support decision-making (Ren *et al.*, 2010; Ren and Kingsford, 2011; Thomas *et al.*, 2011; Steinfeld and Kingsford, 2013; Bino *et al.*, 2014; Ocock *et al.*, 2014; Bino *et al.*, 2015; Catelotti *et al.*, 2015; Steinfeld *et al.*, 2015; Thomas *et al.*, 2015). Most of this research was not mentioned in the Northern Basin Review, despite its rigor and relevance.

For example, there are now a series of applied analyses that can link river flows to flooding regimes in the Macquarie Marshes (Thomas *et al.*, 2011; Thomas *et al.*, 2015), condition of vegetation (Bino *et al.*, 2015) and breeding of waterbirds (Bino *et al.*, 2014) in the Macquarie Marshes, supplied by the Macquarie River. These peer reviewed papers show ecosystem assets in decline. There is also a peer reviewed paper showing the current inadequacy of the current modelling framework, underestimating impacts of water resource developments (Ren and Kingsford, 2011). Little of this scientific information was used in the Murray-Darling Basin Authority's assessment of changes to flow and effects on environmental assets in the Macquarie Marshes and Macquarie River.

For the Narran Lakes Ramsar site, the Murray-Darling Basin Authority commissioned research into the requirements for breeding (Brandis and Bino, 2016b; Brandis and Bino, 2016a; Merritt *et al.*, 2016), given the value of this site for breeding of waterbirds. These studies identified a threshold when breeding occurred. Researchers from the Centre for Ecosystem Science used historical ibis breeding data over five decades (1970-2016) to determine the flow requirements for colonial waterbird breeding and modelled the impacts of water resource management options (current and restoration) on breeding. These identified thresholds (>154,000ML in 90 days with a secondary threshold of >20,000ML in the first 10 days) of river flow volume, necessary to stimulate breeding. Water resource development reduced the frequency of large flows resulting in ibis breeding by 170%, from 1 in 4.2 years to 1 in 11.4 years. Restoration efforts by government to recover water for the environment was predicted to improve colonial waterbird breeding frequency associated with large flow events to 1 in 6.71 years, representing a 59% reduction from pre-development periods. This fails to meet obligations of the Australian Government or New South Wales Government in the management of this Ramsar-listed site. It is likely that there will be a future requirement for an Article 3.2 notification of the Ramsar Convention for this site. Further, Narran Lakes will join the other two wetlands in the future when the Australian Government will need to similarly admit to the international community that the ecological character of the Narran Lakes Ramsar site has changed, as a result of human

impacts (water resource development predominantly) upstream (Brandis *et al.*, 2018).

Despite this scientific evidence, the Australian Government approved a recommendation to remove 70GL of environmental flow from the Northern Basin (Murray-Darling Basin Authority, 2016), the Murray-Darling Basin Authority assessed Macquarie Marshes and Gwydir wetland systems with too much environmental water, based on hydrological modelling (see commentary on hydrological modelling). For the Gwydir, the assessment concluded that there should be a reduction of environmental flows of 14,000 ML a year and for the Macquarie, it was 12,000 ML a year, based on shared and local recovery (Murray-Darling Basin Authority, 2016a). This decision exposes the Australian and State Governments to criticism about not meeting their international obligations for these wetlands, given their current state of decline.

United Nations Sustainable Development Goals

Australia is also a signatory to the United Nations Sustainable Development Goals. On the 17th September 2015, 193 United Nations Countries, including Australia, signed up to the 17 Sustainable Development Goals (<http://www.un.org/sustainabledevelopment/sustainable-development-goals/>). Six of these goals and their associated targets are critical to arresting the extinction crisis.

Goal 1 commits nations to “make cities inclusive, safe, resilient and sustainable”.

Relevant targets of Sustainable Development Goal 1 to extinction of biodiversity

- Strengthen efforts to protect and safeguard the world’s cultural and natural heritage
- By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
- By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

Goal 6 commits nations to “ensure access to water and sanitation to all”.

Relevant targets of Sustainable Development Goal 6 to extinction of biodiversity

- By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
- By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
- By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
- By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

Goal 12 commits nations to “ensure sustainable consumption and production patterns”.

Relevant targets of Sustainable Development Goal 12 to extinction of biodiversity

- Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries
- By 2030, achieve the sustainable management and efficient use of natural resources
- By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
- By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
- Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle
- By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature
- Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production
- Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products
- Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities

Goal 13 commits nations to “take urgent action to combat climate change and its impacts”.

Relevant targets of Sustainable Development Goal 13 to extinction of biodiversity

- Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
- Integrate climate change measures into national policies, strategies and planning
- Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
- Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and

transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible

- Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities

Goal 14 commits nations to “conserve and sustainably use the oceans, seas and marine resources”.

Relevant targets of Sustainable Development Goal 14 to extinction of biodiversity

- By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution
- By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
- Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels
- By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics
- By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information
- By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation
- By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism
- Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries
- Provide access for small-scale artisanal fishers to marine resources and markets

- Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want

Goal 15 commits nations to “sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss”.

Relevant targets of Sustainable Development Goal 15

- “By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements”;
- “By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally;”
- By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
- By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development
- Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
- Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed
- Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products
- By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species
- By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts
- Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems
- Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation
- Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities

Protection of migratory species – International Conventions and agreements

Australia is party to seven bilateral and multilateral conservation agreements and conventions, related to migratory species

<http://www.environment.gov.au/biodiversity/migratory-species>. These include bilateral migratory bird agreements (JAMBA (Japan-Australia), CAMBA (China-Australia) and ROKAMBA (Republic of Korea-Australia), the Convention on the Conservation of Migratory Species of Wild Animals – (Bonn Convention) <https://www.cms.int/>, the Ramsar Convention and Agreement on the Conservation of Albatrosses and Petrels (ACAP). In addition, migratory species are a matter of national environmental significance under the Environment Protection and Biodiversity Conservation Act 1999.

Despite these policy and legislation instruments, migratory species in Australia and around the world continue to decline (Bauer and Hoyer, 2014; Clemens *et al.*, 2016; Murray *et al.*, 2017; Studds *et al.*, 2017). The causes for the declines are broad, ranging from climate change (van Gils *et al.*, 2016), habitat loss (Murray *et al.*, 2017; Studds *et al.*, 2017), interruption of migratory pathways (Iwamura *et al.*, 2013) and hunting while on migration (Murray and Fuller, 2015). Further, Australia culled threatened Great White Sharks (Vulnerable under IUCN Red List) in Western Australia, with limited supportive scientific evidence (Trouwborst, 2014). Reversing the declines of migratory species is a difficult issue requiring a new suite of conservation actions. Because migratory species leave our shores to breed or forage in other parts of the world, migratory species are difficult to protect with traditional conservation actions such as the gazettal of protected areas. Australia can only physically protect migratory species within its jurisdiction and needs to rely on other countries for protection elsewhere.

Convention on the International Trade in Endangered Species of Wild Fauna and Flora

Australia is a signatory to this Convention <https://www.cites.org/>. Among the many human-pressures on native fauna, both in and outside of Australia, wildlife trafficking is increasingly a significant threat. For example, Australian reptiles can fetch tens of thousands of dollars on the black market

(<https://www.news.com.au/technology/science/animals/cashedup-buyers-demand-aussie-reptiles-in-cruel-illegal-trade/news-story/4df72faaf37f7e09fd86d19691ec8559>).

CITES is an international initiative aimed at ensuring wildlife trade does not threaten the organisms' survival. CITES is funded through a fund, replenished by the United Nations, as well as independent countries contributing to the funding, but Australia is absent from this list (<https://www.cites.org/eng/disc/fund.php>). Australia is committed to protecting and conserving native Australian wildlife

(<http://www.environment.gov.au/biodiversity/wildlife-trade/cites>). There is a need to increase resourcing to ensure that Australia develops new techniques for identifying

trafficked wildlife and improves funding to wildlife authorities to ensure that illegal wildlife trade is halted from Australia.

References

- Acf (2018) *Background brief: Environment spending in Australia* [Online]. Australian Conservation Foundation. Available: https://www.acf.org.au/background_briefs [Accessed].
- Australian Government (1996) National Strategy for the Conservation of Australia's Biological Diversity, Government A, Canberra.
- Australian National Audit Office (2017) Environmental Audit: a Commonwealth Perspective, Auditors-General Conference in New Delhi, India, and presented a keynote speech on 22 March 2017 titled Environmental Audit: A Commonwealth Perspective.
- Australian State of Environment (2006) Australian State of Environment Report 2006. Department of Environment and Heritage, Canberra [Accessed Access 2006].
- Australian State of Environment Committee (2001) Independent Report to the Commonwealth Minister for the Environment and Heritage, CSIRO. *Publishing on behalf of the Department of the Environment and Heritage, Canberra.*
- Barr LM, Watson JE, Possingham HP, Iwamura T, Fuller RA (2016) Progress in improving the protection of species and habitats in Australia. *Biological Conservation* **200**, 184-191.
- Bauer S, Hoyer BJ (2014) Migratory Animals Couple Biodiversity and Ecosystem Functioning Worldwide. *Science* **344**, 1242552.
- Besser L (2017) Pumped: who's benefitting from the billions spent on the Murray-Darling? Available: <http://www.abc.net.au/4corners/pumped/8727826>.
- Bino G, Kingsford R, Brandis K (2016) Australia's wetlands—learning from the past to manage for the future. *Pacific Conservation Biology* **22**, 116-129.
- Bino G, Sisson SA, Kingsford RT, Thomas RF, Bowen S (2015) Developing state and transition models of floodplain vegetation dynamics as a tool for conservation decision-making: a case study of the Macquarie Marshes Ramsar wetland. *Journal of Applied Ecology* **52**, 654-664.
- Bino G, Steinfeld C, Kingsford RT (2014) Maximizing colonial waterbirds' breeding events using identified ecological thresholds. and environmental flow management. *Ecological Applications* **24**, 142-157.
- Bottrill MC, Walsh JC, Watson JE, Joseph LN, Ortega-Argueta A, Possingham HP (2011) Does recovery planning improve the status of threatened species? *Biological Conservation* **144**, 1595-1601.
- Bradshaw CJA (2012) Little left to lose: deforestation and forest degradation in Australia since European colonization. *Journal of Plant Ecology* **5**, 109-120.
- Brandis K, Bino G (2016a) Habitat use by waterbirds in and adjacent to the Murray-Darling Basin. Final report to the Murray-Darling Basin Authority. Canberra.
- Brandis K, Bino G (2016b) A review of the relationships between flow and waterbird ecology in the Condamine-Balonne and Barwon-Darling River Systems. Final report to Murray-Darling Basin Authority, Canberra.
- Brandis K, Bino G, Spencer J, Ramp D, Kingsford R (2018) Decline in colonial waterbird breeding highlights loss of Ramsar wetland function. *Biological Conservation* **225**, 22-30.

- Brooks TM, Mittermeier RA, Da Fonseca GA, Gerlach J, Hoffmann M, Lamoreux JF, Mittermeier CG, Pilgrim JD, Rodrigues AS (2006) Global biodiversity conservation priorities. *science* **313**, 58-61.
- Burbidge AA, Mckenzie N (1989) Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. *Biological conservation* **50**, 143-198.
- Cardinale BJ, Srivastava DS, Duffy JE, Wright JP, Downing AL, Sankaran M, Jouseau C (2006) Effects of biodiversity on the functioning of trophic groups and ecosystems. *Nature* **443**, 989-992.
- Catelotti K, Kingsford RT, Bino G, Bacon P (2015) Inundation requirements for persistence and recovery of river red gums (*Eucalyptus camaldulensis*) in semi-arid Australia. *Biological Conservation* **184**, 346-356.
- Caughley G (1994) Directions in conservation biology. *Journal of Animal Ecology* **63**, 215-244.
- Convention on Biodiversity (2011) Published Strategic plan for biodiversity 2011–2020 and the Aichi targets. In *Report of the Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity*.
- Clemens RS, Rogers DI, Hansen BD, Gosbell K, Minton CDT, Straw P, Bamford M, Woehler EJ, Milton DA, Weston MA, Venables B, Weller D, Hassell C, Rutherford B, Onton K, Herrod A, Studds CE, Choi C-Y, Dhanjal-Adams KL, Murray NJ, Skilleter GA, Fuller RA (2016) Continental-scale decreases in shorebird populations in Australia. *Emu* **116**, 119-135.
- Clements HS, Kearney SG, Cook CN Moving from representation to persistence: The capacity of Australia's National Reserve System to support viable populations of mammals. *Diversity and Distributions* **0**.
- Cook CN, Valkan RS, Mascia MB, Mcgeoch MA (2017) Quantifying the extent of protected-area downgrading, downsizing, and degazettement in Australia. *Conservation Biology* **31**, 1039-1052.
- Department of the Environment (2018) *Recovery Plans made or adopted under the EPBC Act in Species Profile and Threats Database* [Online]. Department of the Environment, Canberra. Available: <http://www.environment.gov.au/sprat>. [Accessed 2018-08-02T15:42:20].
- Doherty TS, Davis R, Van Etten E, Algar D, Collier N, Dickman C, Edwards G, Masters P, Palmer R, Robinson S (2015) A continental-scale analysis of feral cat diet in Australia. *Journal of Biogeography* **42**, 964-975.
- Dudgeon D, Arthington AH, Gessner MO, Kawabata ZI, Knowler DJ, Leveque C, Naiman RJ, Prieur-Richard AH, Soto D, Stiassny MLJ, Sullivan CA (2006) Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews* **81**, 163-182.
- Edwards K, Zierholz C (2001) Soil formation and erosion rates. *Soils: Their Properties and Management*. (Eds. PEV Charman and BW Murphy) pp, 39-58.
- Ens EJ, Finlayson M, Preuss K, Jackson S, Holcombe S (2012) Australian approaches for managing 'country' using Indigenous and non-Indigenous knowledge. *Ecological Management & Restoration* **13**, 100-107.
- Evans M (2016) Deforestation in Australia: drivers, trends and policy responses. *Pacific Conservation Biology* **22**, 1-22.
- Finlayson C, Capon S, Rissik D, Pittock J, Fisk G, Davidson N, Bodmin K, Papas P, Robertson H,

- Burgman MA, Comer P, Comin FA, Essl F, Faber-Langendoen D, Fairweather PG, Holdaway RJ, Jennings M, Kingsford RT, Lester RE, Mac Nally R, McCarthy MA, Moat J, Oliveira-Miranda MA, Pisanu P, Poulin B, Regan TJ, Riecken U, Spalding MD, Zambrano-Martinez S (2013) Scientific Foundations for an IUCN Red List of Ecosystems. *Plos One* **8**.
- Kingsford RT, Watson JEM, Lundquist CJ, Venter O, Hughes L, Johnston EL, Atherton J, Gawel M, Keith DA, Mackey BG, Morley C, Possingham HP, Raynor B, Recher HF, Wilson KA (2009) Major conservation policy issues in Oceania. *Conservation Biology* **23**, 834-840.
- Kunz TH, Braun De Torrez E, Bauer D, Lobo T, Fleming TH (2011) Ecosystem services provided by bats. *Annals of the New York Academy of Sciences* **1223**, 1–38. doi: 10.1111/j.1749-6632.2011.06004.x.
- Kuussaari M, Bommarco R, Heikkinen RK, Helm A, Krauss J, Lindborg R, Öckinger E, Pärtel M, Pino J, Roda F (2009) Extinction debt: a challenge for biodiversity conservation. *Trends in ecology & evolution* **24**, 564-571.
- Lambers H (2003) Introduction, Dryland Salinity: A Key Environmental Issue in Southern Australia. *Plant and Soil* **257**, 5-7.
- Legge S, Robinson N, Lindenmayer D, Scheele B, Southwell D, Wintle B (2018) *Monitoring Threatened Species and Ecological Communities*. CSIRO PUBLISHING.
- Lindenmayer D (2017) Save Australia's ecological research. *Science* **357**, 557-557.
- Ludwig J, Tongway D (2002) Clearing savannas for use as rangelands in Queensland: altered landscapes and water-erosion processes. *The Rangeland Journal* **24**, 83-95.
- Margules CR, Pressey RL (2000) Systematic conservation planning. *Nature* **405**, 243.
- Martin TG, Watson JE (2016) Intact ecosystems provide best defence against climate change. *Nature Climate Change* **6**, 122-124.
- Matthews K (2017) Independent investigation into NSW water management and compliance, Government N, Sydney.
- Mcalpine C, Syktus J, Ryan J, Deo R, Mckeon G, Mgowan H, Phinn S (2009) A continent under stress: interactions, feedbacks and risks associated with impact of modified land cover on Australia's climate. *Global Change Biology* **15**, 2206-2223.
- Mckenzie N, Burbidge A, Baynes A, Brereton R, Dickman C, Gordon G, Gibson L, Menkhorst P, Robinson A, Williams M (2007a) Analysis of factors implicated in the recent decline of Australia's mammal fauna. *Journal of Biogeography* **34**, 597-611.
- Mckenzie NL, Burbidge AA, Baynes A, Brereton RN, Dickman CR, Gordon G, Gibson LA, Menkhorst PW, Robinson AC, Williams MR, Woinarski JCZ (2007b) Analysis of factors implicated in the recent decline of Australia's mammal fauna. *Journal of Biogeography* **34**, 597-611.
- Merritt W, Spencer J, Brandis K, Bino G, Harding P, Thomas R (2016) Review of the science behind the waterbird breeding indicator for the Narran Lakes. . Final report to the Murray-Darling Basin Authority, Canberra [Accessed Access 2016].
- Montgomery DR (2007) Soil erosion and agricultural sustainability. *Proceedings of the National Academy of Sciences* **104**, 13268-13272.
- Murray-Darling Basin Authority (2016) Basin Plan amendments. Northern Basin Review. Murray-Darling Basin Authority, Canberra [Accessed Access 2016].
- Murray NJ, Fuller RA (2015) Protecting stopover habitat for migratory shorebirds in East Asia. *Journal of Ornithology* **156**, 217-225.
- Murray NJ, Marra PP, Fuller RA, Clemens RS, Dhanjal-Adams K, Gosbell KB, Hassell CJ,

- Iwamura T, Melville D, Minton CDT, Riegen AC, Rogers DI, Woehler EJ, Studds CE (2017) The large-scale drivers of population declines in a long-distance migratory shorebird *Ecography*.
- Natural Resource Management Ministerial Council (2010) Australia's Biodiversity Conservation Strategy 2010–2030, Australian Government DOS, Environment, Water, Population and Communities, Canberra.
- Newbold T, Hudson LN, Arnell AP, Contu S, De Palma A, Ferrier S, Hill SL, Hoskins AJ, Lysenko I, Phillips HR (2016) Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. *Science* **353**, 288-291.
- Newmark WD (2008) Isolation of African protected areas. *Frontiers in Ecology and the Environment* **6**, 321-328.
- Nicholson E, Regan TJ, Auld TD, Burns EL, Chisholm LA, English V, Harris S, Harrison P, Kingsford RT, Leishman MR (2015) Towards consistency, rigour and compatibility of risk assessments for ecosystems and ecological communities. *Austral Ecology* **40**, 347-363.
- Niebuhr BBS, Wosniack ME, Santos MC, Raposo EP, Viswanathan GM, Da Luz MGE, Pie MR (2015) Survival in patchy landscapes: the interplay between dispersal, habitat loss and fragmentation. . *Scientific Reports* **5** Article number: 11898
doi:10.1038/srep11898.
- Nulsen RA (2012) Changes in soil properties. In *Reintegrating fragmented landscapes: towards sustainable production and nature conservation*. (Eds Hobbs RJ & Saunders DA) 107-145. Springer-Verlag, New York.
- Ocock JF, Kingsford RT, Penman TD, Rowley JLL (2014) Frogs during the flood: Differential behaviours of two amphibian species in a dryland floodplain wetland. *Austral Ecology* **39**, 929-940.
- Radford JQ, Bennett AF, Cheers GJ (2005) Landscape-level thresholds of habitat cover for woodland-dependent birds. . *Biological Conservation* **124**, 317-337.
- Ren S, Kingsford R (2011) Statistically Integrated Flow and Flood Modelling Compared to Hydrologically Integrated Quantity and Quality Model for Annual Flows in the Regulated Macquarie River in Arid Australia. *Environmental Management* **48**, 177-188.
- Ren SQ, Kingsford RT, Thomas RF (2010) Modelling flow to and inundation of the Macquarie Marshes in arid Australia. *Environmetrics* **21**, 549-561.
- Reside AE, Vanderwal J, Kutt AS (2012) Projected changes in distributions of Australian tropical savanna birds under climate change using three dispersal scenarios. . *Ecology and Evolution* **2**, 705-718.
- Ringma JL, Wintle B, Fuller RA, Fisher D, Bode M (2017) Minimizing species extinctions through strategic planning for conservation fencing. *Conservation Biology* **31**, 1029-1038.
- Roberts KE, Valkan RS, Cook CN (2018) Measuring progress in marine protection: A new set of metrics to evaluate the strength of marine protected area networks. *Biological Conservation* **219**, 20-27.
- Runge CA, Martin TG, Possingham HP, Willis SG, Fuller RA (2014) Conserving mobile species. *Frontiers in Ecology and the Environment*.
- Short J, Smith A (1994) Mammal decline and recovery in Australia. *Journal of Mammalogy* **75**, 288-297.
- Social Ventures Australia (2016) Consolidated report on Indigenous Protected Areas

- following social return on investment analyses, Social Ventures Australia and Department of Prime Minister and Cabinet C, Australia, Canberra.
- State of the Environment Committee (2011) Australia state of the environment 2011 Independent report to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities., Department of Sustainability E, Water, Population and Communities, Canberra.
- Steffen W, Richardson K, Rockström J, Cornell SE, Fetzer I, Bennett EM, Biggs R, Carpenter SR, De Vries W, De Wit CA (2015) Planetary boundaries: Guiding human development on a changing planet. *Science* **347**, 1259855.
- Steinfeld CMM, Kingsford RT (2013) Disconnecting the floodplain: earthworks and their ecological effect on a dryland floodplain in the Murray-Darling Basin, Australia. *River Research and Applications* **29**, 206-218.
- Steinfeld CMM, Kingsford RT, Webster EC, Sharma A (2015) A simulation tool for managing environmental flows in regulated rivers. *Environmental Modelling and Software* **73**, 117-132.
- Studds CE, Kendall BE, Murray NJ, Wilson HB, Rogers DI, Clemens RS, Gosbell K, Hassell CJ, Jessop R, Melville DS, Milton DA, Minton CDT, Possingham HP, Riegen AC, Straw P, Woehler EJ, Fuller RA (2017) Rapid population decline in migratory shorebirds relying on Yellow Sea tidal mudflats as stopover sites. *Nature Communications* **8**, 14895.
- Szabo JK, Butchart SH, Possingham HP, Garnett ST (2012) Adapting global biodiversity indicators to the national scale: A Red List Index for Australian birds. *Biological Conservation* **148**, 61-68.
- Taylor M, Fitzsimons J, Sattler P (2014) *Building Nature's Safety Net 2014: A decade of protected area achievements in Australia*. WWF-Australia.
- Thomas RF, Kingsford RT, Lu Y, Cox SJ, Sims NC, Hunter S (2015) Mapping inundation in the heterogeneous floodplain wetlands of the Macquarie Marshes, using Landsat Thematic Mapper. *Journal of Hydrology* **524**, 194-213.
- Thomas RF, Kingsford RT, Lu Y, Hunter SJ (2011) Landsat mapping of annual inundation (1979–2006) of the Macquarie Marshes in semi-arid Australia. *International Journal of Remote Sensing* **32**, 4545-4569.
- Tilman D (1999) The ecological consequences of changes in biodiversity: A search for general principles. *Ecology* **80**, 1455-1474.
- Travis JMJ, Delgado M, Bocedi G, Baguette M, Bartoń K, Bonte D, Boulangeat I, Hodgson JA, Kubisch A, Penteriani V, Saastamoinen M, Stevens VM, Bullock JM (2013) Dispersal and species' responses to climate change. *Oikos* **122**, 1532-1540.
- Trouwborst A (2014) Aussie jaws and international laws: The Australian shark cull and the convention on migratory species. *Cornell International Law Journal Online*, 41-46.
- Van Gils JA, Lisovski S, Lok T, Meissner W, Ożarowska A, De Fouw J, Rakhimberdiev E, Soloviev MY, Piersma T, Klaassen M (2016) Body shrinkage due to Arctic warming reduces red knot fitness in tropical wintering range. *Science* **352**, 819-821.
- Waldron A, Miller DC, Redding D, Mooers A, Kuhn TS, Nibbelink N, Roberts JT, Tobias JA, Gittleman JL (2017) Reductions in global biodiversity loss predicted from conservation spending. *Nature* **551**, 364.
- Waldron A, Mooers AO, Miller DC, Nibbelink N, Redding D, Kuhn TS, Roberts JT, Gittleman JL (2013) Targeting global conservation funding to limit immediate biodiversity declines. *Proceedings of the National Academy of Sciences* **110**, 12144-12148.
- Walker J, Bullen F, Williams BG (1993) Ecohydrological Changes in the Murray-Darling Basin

- .1. The Number of Trees Cleared over 2 Centuries. *Journal of Applied Ecology* **30**, 265-273.
- Whelan CJ, Wenny DG, Marquis RJ (2008) Ecosystem Services Provided by Birds. . *Annals of the New York Academy of Sciences* **1134**, 25-60. doi: 10.1196/annals.1439.003.
- Williams SE, Bolitho EE, Fox S (2003) Climate change in Australian tropical rainforests: an impending environmental catastrophe. *Proceedings of the Royal Society of London Series B-Biological Sciences* **270**, 1887-1892.
- Wilson EO (2016) *Half-earth: our planet's fight for life*. WW Norton & Company.
- Wilson KA, McBride MF, Bode M, Possingham HP (2006) Prioritizing global conservation efforts. *Nature* **440**, 337.
- Woinarski JCZ, Burbidge AA, Harrison PL (2015) Ongoing unraveling of a continental fauna: Decline and extinction of Australian mammals since European settlement. *Proceedings of the National Academy of Sciences* **112**, 4531-4540
doi:10.1073/pnas.1417301112.
- World Economic Forum (2018) The global risks report 2018 - 13th edition, Forum WE, Geneva.
- WWF (2015) WWF Living Forests Report, Nature WWFF, Gland, Switzerland.