

Biodiversity

Preamble

Natural ecosystems support our health by filtering our air, providing fresh water and food, regulating our climate and protecting against the spread of disease and pests. They also foster our psychological and spiritual wellbeing and serve as places of recreation and sources of nature-based jobs in tourism and other vocations. Furthermore, with up to half of all medicines used by humans derived from nature, protected ecosystems are a form of innovative capital for future medical advances.

Ecosystems are the foundations of biodiversity, the infinite variation in life forms. Human resilience in the face of sudden and catastrophic shifts to the planet's life-support systems is strengthened by this variety of life.

Doctors for the Environment Australia is focussed on the complex interaction between human health and our natural environment and is therefore interested in environmental restoration and the protection of biodiversity to promote human health and social stability. A global environment that supports biodiversity is better able to support human health. This is a topic of utmost urgency, given the alarming decline in biodiversity in recent years.

Background

Biodiversity (or biological diversity) is defined as the variability of living organisms, the 'diversity of life on Earth', and the complex relationships that make up ecosystems (MEA, 2005). People are an integral part of ecosystems, and it is internationally recognised that biodiversity is intimately linked with human health. The United Nations Convention of Biological Diversity states the importance of biodiversity in maintaining life-sustaining systems as well as contributing to health, livelihoods and well-being (United Nations, 1992).

Ecosystem services

Biodiversity increases the resilience of ecosystems. The more biodiverse an ecosystem is, the more stability it has, and the more functions it provides. The services that ecosystems provide can be classified into four main categories: provisioning, regulating, supporting and cultural (Millennium Ecosystem Assessment, 2005). Provisioning services are the easiest to appreciate. They offer us the products of nature such as drinking water, food, timber and fuel and form the building blocks of primary industries like agriculture and forestry. Preservation of biodiversity strengthens these provisioning services, for example, greater diversity in fisheries is associated with greater stability of yields.

Regulating services offer us benefits from the control of natural processes. These include regulation of macro-systems like the climate, crop pollination, air and water purification, waste management, and pest and disease spread. Forests, for example, regulate air quality, flow of water, soil fertility, and the climate itself. The regulating services of ecosystems also protect us from natural disasters: vegetation helps buffer us from dust storms and landslides whilst coral reefs and mangrove swamps are natural barriers to coastal storms and tidal waves.

Supporting services of ecosystems facilitate the provision of all other ecosystem services.

Examples of these include nutrient dispersal and cycling, soil formation, seed dispersal and photosynthesis.

Cultural ecosystem services offer us non-material benefits and foster positive mental health and cohesive communities. These services include the provision of recreational opportunities, a sense of place and connection (especially for Indigenous peoples), a forum for aesthetic enjoyment, reflection and spiritual fulfilment.

Many ecosystems provide services in several or all four domains. For example, the benefits that oceans provide range from the supply of food and sustenance of coastal livelihoods to the provision of recreational opportunities and storage of carbon.

Beyond these services, the intrinsic value of nature's role in our daily lives is incalculable. Modifying ecosystems to meet the increasing demand for food, fresh water, energy, and fibre has enabled material wealth and economic growth for some societies. The commoditisation of nature, however, does not make us any less reliant on ecosystem services. The cost of such human 'progress' is the direct loss of key ecosystem services such as clean water and air, protection from climate change and increasingly frequent and severe extreme weather events, for ourselves and communities elsewhere.

The threats to biodiversity

Now more than ever, the diversity and sustainability of Earth's ecosystem services are at risk. Over the past century, human activities have contributed to species extinction rates tens to hundreds of times higher than the background rates that were typical over Earth's history. It is widely accepted by scientists that we are in the midst of the Earth's sixth mass extinction event. Human activities have caused the loss of 60% of all species of mammals, birds, fish and reptiles since 1970, with a further 1 million animal and plant species currently threatened with extinction, many within decades (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019). The main cause of terrestrial biodiversity loss is land use-change (mainly agricultural expansion but also urbanisation), while for marine environments, direct exploitation of organisms (mainly through fishing) has had the largest negative impact. Other major threats to biodiversity include climate change, pollution, over-harvesting, introduction of non-native species, and simplification of ecosystems (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019).

Less biodiverse ecosystems are less resilient and less able to adapt to ongoing and worsening threats like climate change, and this is contributing to the acceleration of species loss. Alarmingly, there has been a catastrophic decline in insect numbers globally with a recent worldwide review finding that over 40% of insect species may be threatened with extinction within the next few decades (Sanchez-Bayo and Wyckhuys, 2019). Insects are critical for pollinating crops and provide the foundation of the world's food chain, so this could have disastrous consequences for human health.

The current pressures on biodiversity and natural resources are collectively illustrated by Earth Overshoot Day, the calendar date on which humanity's resource consumption (defined as carbon, food, water, fibre, land and timber) for the year exceeds Earth's capacity to regenerate those resources that year (Earth Overshoot Day, 2019^a). Each year, the overshoot occurs earlier than in the previous year. In 2019, July 29 was Earth's Overshoot Day.) Australia is at the forefront of world biodiversity loss (see section on Biodiversity in Australia). It used its share of the world resources by March 21, 2019.

The driving forces behind biodiversity loss are the economic system and population growth, acting through climate change, land clearance for agriculture and urbanisation, pollution and chemical use.

For example, economic growth is linked to greenhouse gas emissions, which fall in recession and increase rapidly in economic boom (World Economic Forum, 2019). Population growth is a driver of economic growth. The scale of human population and the current pace at which is increasing

contribute substantially to the loss of biological diversity (Crist et al., 2017). Crist, Mora and Engelman (Crist et al., 2017) summarise the problem as follows: "Engineering the capacity to feed the world's population has proceeded at the cost of substantial disregard for ecological impacts. Given the conflicts surrounding the use of land and ocean for food production while also protecting biodiversity, some people question whether feeding the world and maintaining biodiversity are even compatible objectives. The deterioration of nature results from economic, technological, and demographic dynamics, yet unfortunately the scientific community generally remains reticent to discuss global population size and increase".

Case study: The Amazon Rainforest

The Amazon is the world's largest tropical rainforest, spanning 6.7 million square kilometres (WWF, 2019^a). It houses at least 10% of the world's known biodiversity, making it one of the most species rich places on earth. Its river system contains more than 3,000 species of freshwater fish, the largest number found in any one world region (WWF, 2019^b). Seventy five percent of all Amazonian plant species are found nowhere else.

Because its canopy cover emits water to the atmosphere, the Amazon has a major influence on local temperature, humidity and weather patterns (WWF, 2019^c). It is also the world's largest terrestrial carbon sink and therefore critical for global climate regulation.

Close to 20% of the Amazon's forest cover has been lost over the last half century, primarily to cattle ranching, oil drilling and soybean farming (Nobre et al., 2016; WWF, 2019^d). The underlying driver of this commoditisation is ever increasing international demand for raw materials creating opportunity for foreign trade and economic gain. Other lesser but still important causes of deforestation in the Amazon include logging, urban expansion, infrastructure development (e.g. road building) and population growth.

Comparison of biodiversity values in native, undisturbed Amazonian forests with those in areas of deforestation or secondary and plantation forests has demonstrated that biodiversity values are substantially lower in the latter. Plant and animal life in degraded areas is typically impoverished, with remaining species consisting of only limited subsets of the original flora and fauna (Ricardo et al., 2015).

Degraded Amazon forest areas are also less able to transfer water to the atmosphere which reduces their cooling capacity and causes local temperatures to rise (Baker and Spracklen, 2019). In addition, deforestation has the effect of worsening climate change because felled trees release carbon as they decompose.

Recently, wildfires have ravaged the Amazon rainforest with greater frequency (Mongabay, 2019; BBC, 2019). Wildfire burning is one of the main tools used for deforestation in the Amazon (Greenpeace, 2019). Trees are typically cut, left to dry then burnt.

While the cause of the current increase in fires is not known for certain, preceding government promises to open the rainforest to more farming, logging and mining are assumed to have encouraged more intentional burning. Other likely contributing factors include lax enforcement of laws in place to protect the rainforest, inadequate government environmental policies, climate change and previous deforestation.

For the people living in the Amazon, the fires are having serious public health, social and economic impacts. Small local producers and Indigenous peoples are particularly threatened due to the fires' effects on livelihoods, culture and spiritual connections (Metuktire, 2019). Apart from direct threats like injury and loss of life, air pollution from burning causes heart and lung diseases.

The immediate impact of fires on biodiversity is the death of thousands of species that call these forests home. The burning also causes loss of habitat that will threaten the survival of additional animals and plants for years to come.

In addition, the burning Amazon forests have this year already emitted 228 megatonnes of carbon (BBC, 2019). This not only contributes to global temperature rise, but also sets in motion a dangerous negative feedback loop whereby the warmer temperatures lead to further forest drying and increased risk of fires over time (WWF, 2019^e).

Biodiversity and health – how they are linked together

Biodiversity is a key foundation for human health and wellbeing. Protecting biodiversity and ecosystems preserves the essential services that they provide.

Food

Good nutrition depends on biodiversity. Fundamentally, the food and water we consume are produced by services of nature. Biodiversity in agriculture and fisheries is important for productivity and resilience to environmental threats like pests, diseases and climate change. Insects such as bees, wasps and beetles are essential for pollination, as are bats. It is well recognised that biodiversity in food production is key to food security. Balanced diets that are sourced from diverse food species promote human health and protect against a range of specific micronutrient deficiencies.

Many modern agricultural practices have major negative effects on biodiversity, with flow on effects for future food security, nutrition and human health (World Health Organization, 2015). For example, the widespread use of pesticides negatively affects soil biota leading to lower organic matter content and reduced water retention (Lotter et al., 2003). This in turn can reduce crop yields in times of drought. It has been estimated that pesticides applied to fields in the US eliminate about one fifth of honey bee colonies annually, costing US farmers about USD \$200 million per year from reduced crop pollination (Tyler-Miller, 2004). The overuse of synthetic fertilisers impacts soil biota and soil acidification, while monoculture and low diversity cropping systems make crops more vulnerable to wide sweeping pest and disease outbreaks.

Exposure to particular pesticides through occupation, diet or the environment (water, air, soil) has also been shown to directly cause human illness. For instance, organochlorines have the potential to disrupt the human endocrine system resulting in impaired reproductive and sexual development and linked to impaired neurologic and intellectual function in infants and young children (Wisse et al., 2011).

Water

Healthy intact forests surrounding catchment areas improve water quality and thus drastically reduce the cost of water treatment. Sydney's Catchment Authority recognises the importance of preserving forest quality and manages a buffer zone of forest around the storage area in order to protect water quality and reduce pollutants. Forests also increase the amount of water entering the soil, thereby regulating the water table. In Melbourne, there is good evidence that the forested catchment area regulates water flow, maintaining a more constant supply in times of drought (Stolton and Dudley, 2007). In contrast, it has been shown that continued logging in Melbourne's water catchments could reduce the city's water supply by the equivalent of 600,000 people's annual water use every year by 2050 (Taylor et al., 2018).

Land degradation, pollution, nutrient run-off and loss of biodiversity around waterways can have direct health consequences, for example causing outbreaks of blue-green algae. The toxins produced by some species of blue-green algae have the potential to cause liver damage, gastroenteritis and skin irritation and have been linked to an increased incidence of fatal neurodegenerative disease such as the motor neuron disease amyotrophic lateral sclerosis (Victorian Department of Health and Human Services, 2016; Jonasson et al., 2008).

Medications and research

The wealth of diversity in nature is behind much advancement in medical research, particularly in enhancing the understanding of diseases and development of medications. Over 50% of commercially available medications are sourced from nature: examples include aspirin, digoxin, warfarin and morphine. Between 1981 and 2010, 75% of antibacterial agents newly approved by the US FDA had their origins in natural products, while percentages of antivirals and antiparasitics derived from natural products approved during that same period were similar or

higher (World Health Organization, 2015). Traditional medicines from plants and animals are used as primary healthcare throughout the world.

The study of cone snails, a genus of predatory sea snails living on or near coral reefs, has led to breakthroughs in neuroscience and drug development (Aguirre et al., 2012). Ziconitide, a pain medication 1000 times more potent than morphine, was developed from cone snail venom and is used to treat chronic severe pain (Carey M, 2011).

Beyond pharmacological applications, the study of animals and plants contributes to further understanding of our anatomy, physiology, and biochemistry. Biodiversity remains an important resource for future medical research and development. With most of the medicinal potential of nature yet to be tapped, we may be losing potential new cures with biodiversity loss. This makes conservation of biodiversity a public health imperative.

Biodiversity and infectious diseases

Preserving biodiverse ecosystems can reduce the incidence of some infectious diseases. Around half of the new diseases spreading from animals to humans since the 1940s have resulted from changes in land use, particularly clearing forests for agriculture and from wildlife hunting (Keesing et al., 2010). In the case of malaria transmission, deforestation reduces forest mosquito diversity, and the species that survive and become dominant often transmit disease better than the species formally abundant in the intact forest. This same effect of deforestation increasing transmission of disease has been noted with Lyme disease which is spread by ticks (Keesing et al., 2010; Chivian and Bernstein, 2010; Young et al., 2014).

Outbreaks of Hendra virus in Queensland, a virus transmitted from flying foxes to horses to humans, were partly attributed to loss of flying fox habitat. This drove the flying foxes closer to human settlement and also stressed them, increasing virus excretion (Carey M, 2011).

Climate change, with changes in rainfall and temperature, is expected to expand the range of mosquito-borne diseases such as Dengue and Ross River Virus further south into NSW (Steffen and Hughes, 2013). However, keeping ecosystems intact and preserving biodiversity may reduce the incidence of these infectious diseases.

Biodiversity and Allergies

Research is increasingly exploring contributory links between the rapid loss of global biodiversity and increasingly common immunological conditions in urban populations where green space and contact with nature is declining swiftly. The 'biodiversity hypothesis' proposes that people who have less contact with the natural environment may be more likely to develop allergies or 'atopy'. Testing this hypothesis on adolescents in 2012, Hanski et al (Hanski et al., 2012) found environmental biodiversity in the surrounding of adolescents' homes influenced the composition of types of normal bacteria on their skin. Specifically, individuals with an allergic disposition had lower biodiversity in their surroundings and lower skin bacteria diversity compared with healthy individuals. In vitro studies found that the abundance of certain types of skin bacteria positively correlated with the blood levels of Interleukin-10, an anti-inflammatory cytokine which regulates immune tolerance or allergic disposition.

More recently in Australia, surrogate measures of landscape biodiversity were found to correlate with respiratory health. The higher the environmental biodiversity in the areas in which children lived, the lower the rate of admissions to hospital for respiratory disease (Liddicoat C et al., 2018). The magnitude of the effect was similar to that of other known predictors, with the authors suggesting this may be due to a protective immunomodulatory influence from microbial diversity and other bioactive agents associated with biodiverse environments.

Biodiversity and climate change

Ocean acidification, extreme weather events like drought, cyclones, bushfires and flooding and shifts in the distribution of plants, animals and pathogens affect ecosystem health and

productivity. Climate change limits the availability of ecosystems' goods and services and affects the viability and health of human-ecosystem interactions. For instance, climate change is expected to reduce both agricultural productivity and nutritional content of foods, particularly with respect to production of grains and legumes which provide a large portion of the global population with their primary source of iron and zinc (World Health Organization, 2015). This will have flow on effects for global nutrition. Climate change will also alter the distribution of climate sensitive disease vectors such as mosquitoes, thereby increasing mosquito-borne disease risk.

On the other hand, biodiversity provides natural buffers to increasingly frequent and severe extreme weather events occurring due to climate change. Improved biodiversity helps to improve resilience of ecosystems, contributing to adaptation to climate change and moderating the impacts of disasters.

Evidence exists to show the importance of urgent mitigation of climate change in reducing biodiversity loss. A publication in the journal *Nature* suggested that without mitigation, over half of plants and over one third of animals would be likely to lose over half their climatic range by the 2080s (Warren et al., 2013). This biodiversity loss could be reduced by 60% with peak of emissions by 2016, or by 40% with peak of emissions in 2030.

The spiritual and cultural values of biodiversity

Cultural services of biodiversity, recognised in the Millennium Ecosystem Assessment report, include recreational uses, spiritual fulfillment, and aesthetic enjoyment (Millennium Ecosystem Assessment, 2005). For Aboriginal Australians and Torres Strait Islanders, it is well recognised that the connection to land and Country is integral to well-being and physical health (Sangha et al., 2011; Butler et al., 2019). Aboriginal Australians and Torres Strait Islander people's relationships to Country may be profoundly spiritual, connecting them to their ancestors and providing identity, validation and meaning in life. Country can provide Aboriginal Australians and Torres Strait Islander people with ceremonial objects and meaning, sacred names, kinship and languages (Sangha et al 2015).

Time spent in natural places can support optimal wellbeing and development

There is also a growing body of evidence that spending time in nature has tangible health benefits, for example reducing social dysfunction, alleviating anxiety and depression and improving physical health by promoting physical activity which improves blood glucose control in diabetics (World Health Organization, 2015). Studies from Japan found spending time in a forest lowers blood pressure and feelings of stress whilst also increasing the activity of natural killer cells, white cells which fight inflammation in the body (Hansen et al., 2017).

In Japan, the practice of 'Shinrin Yoku' or 'forest bathing' is widely practised as a preventative health measure. It involves people at high risk of stress related illnesses, including cardiovascular and mental health problems, spending specified periods of time in accredited forests under the guidance of health professionals. Participants are given a prescription from their medical doctor outlining the frequency and duration of visits. This innovative approach addresses human health problems whilst simultaneously protecting the biodiversity, carbon storing and water purifying values of forests.

In the United Kingdom, the National Health Service supports many nature-based health programs, for patients with early dementia, mental health problems and cardiac rehabilitation amongst others (O'Brien, L. 2018). There are currently very few such programs in Australia, and this is an area ripe for excellent health outcomes and job creation.

Biophilia is the term used to describe the innate connection humans have for the natural world. It describes the way in which we experience optimal wellbeing when we live with thriving nature in our everyday lives. Biophilic design uses this understanding to incorporate natural elements into buildings, communities and cities. Its principles include the incorporation of natural light and

ventilation, organic shapes and natural sensory experiences (sights, sensations and smells) into the design of man-made structures. Psychologically, we find views of nature restful and restorative and this is borne out by patients with these views recovering more rapidly from surgical procedures and generally finding their hospital stay more pleasant. The Khoo Teck Puat hospital in Singapore is an exemplary example of biophilic design with extensive plantings to support butterflies, green roof tops and walls and vertical gardens. This rich natural environment exists within and around a modern hospital (de Wet, N, 2018). In Melbourne, the Royal Children's Hospital was designed so that almost all patients' rooms had views over the surrounding Royal Park and there is a central garden for patients, staff and families to enjoy. Utilising biophilic design within public health buildings not only enhances human health, it also promotes biodiversity as a rich variety of plants and animals are incorporated.

Time in nature has been shown to alleviate symptoms in children with Attention Hyperactivity Disorder (ADHD) and enhance the restoration of attention and focus (Bagot, KL, 2004; Martin, K, 2011). In a large longitudinal study from New Zealand involving almost 50,000 children, increased 'greenness exposure' was independently and significantly associated with a reduced incidence of ADHD (Donovan et al., 2019). Time spent in a natural setting also offers opportunities for spontaneous exercise through play and exposure to fresh air and healthy amounts of sunlight, essential for the formation of vitamin D.

Nature play is widely recognised for providing the best opportunities for child development and learning. As children's lives have become more highly scheduled and technology has intruded, screen spaces have replaced green places and they are spending much less time outside than previous generations. This is associated with a rise in behavioural and mental health issues in younger children and simple opportunities for play in nature, or 'nature play', is a valuable lifestyle intervention (McCurdy et al. 2010).

Biodiversity and global health

The health burden of biodiversity loss disproportionately affects poor individuals and nations, who are more directly reliant on ecosystem services, less able to adapt to their destruction and have less access to social protection mechanisms such as healthcare. Biodiversity loss thus threatens the achievements made towards reaching the Millennium Development Goals of eradicating extreme poverty and hunger (Millennium Ecosystem Assessment, 2005).

The Millennium Ecosystem Assessment identified credible threats to human wellbeing: depleted global fish stocks, worsening pollution, climate change, and precipitous rates of species extinction. Investment to conserve nature is far cheaper and more effective than the cost of measures engineered as alternatives to the declining services of nature. The loss of such services in poorer regions of the world will increase financial and geopolitical strain on the international community, with greater need for aid and emergency relief.

Biodiversity in Australia

Australia is one of the 17 'megadiverse' countries in the world which together are home to more than 70% of the planet's species. Most of Australia's species are found nowhere else on Earth - 85% of our terrestrial mammals, 90% of our reptiles and frogs and 91% of our flowering plants. Therefore, Australia is in a unique position to gain from conserving its rich inheritance of biodiversity whilst at the same time particularly vulnerable to a devastating loss of endemic species if threats to this natural heritage are not addressed. The most vulnerable species in Australia are those with limited distribution, such as in iconic heritage sites including the Great Barrier Reef, the Queensland Wet tropics, the Australian Alps, the Kakadu wetlands and south-western Western Australia (Steffen W et al., 2009).

Unfortunately, Australia's rich biodiversity is being depleted at an alarming rate. Indeed, Australia has experienced the largest documented decline in biodiversity of any continent in the world over the past 200 years (Australian Bureau of Statistics, 2010). Under Australia's Environmental Protection and Biodiversity Conservation (EPBC) Act, 37 species of Australian plants and 54 species of Australian animals have been listed as extinct, with the latter including

27 mammals, 22 birds, 4 frogs and an earthworm (the Lake Pedder Earthworm) (Australian Government^b, 2019; Australian Government^c, 2019). The list of nationally threatened species is also long and growing, with more than 1,800 species and ecological communities currently listed as critically endangered, endangered, vulnerable or conservation dependant (Australian Government^d, 2019). Many more Australian animal and plant species have not been sighted for decades, warranting full scientific assessment for extinct listing.

In states like Victoria, some original vegetation types have been reduced by more than 99% since the time of European colonisation. Australia also has the dubious honour of being home to the world's most recent known mammalian extinction – the Bramble Cay Melomys in 2016.

Habitat modification is the key driver of biodiversity loss in Australia. Deforestation and land clearing are particular problems, with over half of all the native species listed as threatened under the EPBC Act at risk of habitat loss from these processes (The Wilderness Society, 2017). Similarly, of the 74 ecological communities listed on the Federal threatened list, most lie within areas of high current or historic land clearing and deforestation.

This is well illustrated in the Tarkine region of Tasmania which contains the largest tract of temperate rainforest in the southern hemisphere. The Tarkine is home to a numerous rare and threatened species including one of the last disease-free populations of Tasmanian Devils. The fatal Devil Facial Tumour Disease is estimated to have killed 64% of the Tasmanian Devil population over the last two decades (Tasmanian Parks and Wildlife Services, 2018), making the Tarkine an increasingly vital refuge. The Tarkine region is threatened by destructive logging practices and open-cut mining, which, by destroying habitat and increasing road traffic and associated roadkill, pose a direct threat to the Devil's existence.

Similarly, vast areas of native bushland and forest have been cleared in NSW over the last decade, predominantly for livestock but also for timber harvesting (WWF, 2018). Indeed, tree-clearing increased 800% from 2013/14 to 2015/16, and that was before the laws were further weakened in 2017. This is putting Australia's iconic koalas at risk of local extinction, potentially as early as 2050.

Currently, most of the powers relating to land clearing and deforestation lie with Australian states and territories, with little Federal oversight. This results in inconsistent approaches to regulation, utilisation of loopholes particularly for large agricultural, mining and urban development projects and poor or non-existent monitoring (The Wilderness Society, 2017).

Climate change is another increasingly important and pervasive pressure, with some state and territory reports acknowledging that this could surpass habitat modification as the greatest threat to biodiversity in Australia in the next few decades (Cresswell and Murphy^a, 2016). The Bramble Cay Melomys' extinction is the world's first known due to climate change, with sea level rise and damaging storm surges thought to be responsible for dramatic loss of the small mammal's habitat (a cay on the Great Barrier Reef) and possibly direct mortality (Gynther et al., 2016). Importantly, climate change not only directly drives biodiversity loss but also exacerbates the impact of other drivers (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019).

The impacts of invasive species have also increased in importance as key threatening processes to biodiversity in Australia generally, and to threatened species specifically (Cresswell and Murphy^b, 2016). Invasive species exert their effects through preying on native species, competing for resources and space and causing habitat degradation and loss. The impact of invasive species is currently the most frequently cited threat to EPBC Act-listed species (Cresswell and Murphy, 2016^b). Successful management of invasive species in Australia is hindered by a lack of knowledge of their distribution and abundance and a lack of resourcing.

Other key threats to Australia's biodiversity include urban development, livestock production and grazing, extractive industries, coastal activities, changed fire regimes and changed hydrology (Cresswell and Murphy, 2016^c). These interact in cumulative and often synergistic ways, although understanding of their full impact is low because of the inadequacy of long-term biodiversity data and monitoring (Cresswell and Murphy, 2016^c).

The impacts of economic and population growth discussed above (see section on Threats to Biodiversity) are also highly relevant in Australia. Economic management in Australia centres on the ideology of “Jobs and Growth”, and in turn, immigration is regarded as vital for economic growth. Indeed, population growth has underpinned more than half of real GDP growth in Australia over the last decade (the Australian Population Research Centre, 2019).

Case study: Bogong moth

The plight of Australia’s Bogong Moth highlights the extent of our biodiversity crisis.

Once an abundant food source for Aboriginal people, the moth is the only insect known to use the Earth’s magnetic field for navigation. After breeding in lowland areas of northern New South Wales and southern Queensland, some two billion moths have typically journeyed up to 1,000 kilometres each year to hibernate in caves in south eastern Australia’s alpine region. Over 30 years of study, certain caves have been observed to contain many millions of moths at a time. This year, however, fewer than ten moths were found.

The Bogong Moth is a key food source for the endangered Mountain Pygmy Possum. The consequence of diminished moth numbers is the scientific discovery of the widespread death of baby possums in female possums’ pouches in 2019. The outlook for this possum is dire.

Climate change, habitat destruction and the use of agricultural chemicals are thought to be responsible for the Moth’s decline. As the moth is a major pollinator it is likely that its diminished numbers will affect crop agriculture in south-eastern Australia, a significant food bowl, and subsequently human food supply.

Protecting Australia’s biodiversity

Efforts to address the biodiversity crisis in Australia are woefully inadequate. An underlying and fundamental issue relevant to all aspects of biodiversity protection in Australia is that it is unclear who is ultimately responsible for ensuring our environment is managed well. The current system distributes responsibility across the federation, with many powers and responsibilities lying with state and territory governments (The Australian Panel of Experts on Environmental Law, 2017). No one jurisdiction is charged with coordinating efforts to protect our environment and existing legislative arrangements are out-of-date, lack cohesion and consistency, and are fractured across at least 20 pieces of legislation.

For threatened species specifically, the decision to develop a recovery plan relies on ministerial discretion rather than this being mandatory. The result is that less than 40% of threatened species have recovery plans in place to ensure their long-term survival (Convention on Biological Diversity, 2019). An added problem is that some existing plans are years or decades out of date, while a further 10% of species have been identified as needing plans but the documents are either unfinished or have never been developed. Implementation of recovery plans is also inadequate, hindered by lack of funding and weak co-ordination between Commonwealth, state/territory and local authorities (Convention on Biological Diversity, 2019).

Biodiversity protection is also inadequately funded in Australia. Biodiversity expenditure has remained between AUD \$400 million and 500 million per year (less than 0.05% of GDP) since 2010 (Convention on Biological Diversity, 2019), equating to less than five cents for every \$100 of Australia Commonwealth spending (Australian Conservation Foundation, 2018). National Landcare Program funding is also dropping, the Green Army programme has not been renewed, there is no longer funding for new state-led National Reserves and there have been cuts to funding of biodiversity research. Australia 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 a recent study of 109 countries, all signatories to the Convention on Biological Diversity and Sustainable Development Goals, 60% of total global biodiversity decline over the period 1996-

2008 was ascribable to only seven countries, one of which was Australia (Waldron et al., 2017). A clear relationship was demonstrated between increases in conservation investment in signatory countries and major, quantifiable reductions in biodiversity decline.

Recently, a panel of fourteen experts in environmental law, including academics, practicing lawyers and a former Federal Court judge, developed and released a blueprint for a new generation of Australian environmental laws (the Australian Panel of Experts on Environmental Law, 2017). This proposes the establishment of (1) an independent National Sustainability Commission to set national environmental standards, undertake strategic regional planning and report on national environmental performance; and (2) an independent National Environmental Protection Authority that operates at arm's-length from Government to conduct transparent environmental assessments and inquiries and undertake monitoring, compliance and enforcement actions. The blueprint reflects international best practice and, if implemented, has the potential to ensure effective and efficient protection and management of Australia's environment. A truly national approach to environmental protection would build on the Federal Government's capacity to bring authority and resources to environmental governance and better enable Australia to meet its international responsibilities.

Aboriginal and Torres Strait Islander Land and Sea Management

The Aboriginal and Torres Strait Islander estate held under various land rights and native title regimes covers an estimated 1.7 million square kilometres or 23% of Australia (Altman and Yarbakhsh, 2012). It includes some of the most biodiverse lands in Australia, many of which remain relatively ecologically intact (Altman and Yarbakhsh, 2012).

There is increasing recognition of the critically important role of Aboriginal and Torres Strait Islander land and sea management in maintaining biodiversity in Australia (Cresswell and Murphy, 2016^a). This is in part because of the extraordinary environmental significance of Aboriginal and Torres Strait Islander lands but also because of growing evidence showing positive environmental outcomes (including biodiversity preservation) from Aboriginal and Torres Strait Islander-led environmental programs and initiatives (Metcalf and Bui, 2016; Altman and Yarbakhsh, 2012). Additional benefits of these programs include protection of cultural heritage, employment, education and training opportunities for Aboriginal and Torres Strait Islander people in remote areas (Australian Government^a, 2019).

However, simultaneously, there is growing evidence of inadequate public funding for work on Indigenous lands. For instance, in the Northern Territory, Indigenous Protected Areas have historically received three times less funding per square kilometre than other National Reserve System properties (Altman and Yarbakhsh, 2012). Investment in Indigenous land and sea management decreased from \$106 million in 2011–12 to \$81 million in 2015–16 (Metcalf and Bui, 2016). In addition, confusing and bureaucratic processes still limit engagement of Indigenous people in land and sea management, while short-term funding cycles reduce both job security and long-term management planning (Metcalf and Bui, 2016).

DEA Policy

Due to the complex interplay between biodiversity and other threats to natural ecosystems, policy on biodiversity involves other areas of DEA's work. Our policies on climate change, unconventional gas, the coal industry and forests all support the protection of ecosystems because the preservation of biodiversity is essential for human health.

DEA calls for:

Overarching legislative framework and biodiversity funding

1. The introduction of a new national framework of environmental laws as proposed by the Australian Panel of Experts on Environmental Law (APEEL).
2. Substantial and immediate increases in government funding to address the current biodiversity crisis in Australia.

Population and economic issues

3. The development of a population policy which includes considering projections on climate change and water resources.
4. Expertise to be developed within Treasury on circular economies and full cost accounting with links to organisations for new economic thinking.

Biodiversity hotspots and threatened species

5. Legislative change to make threatened species protection non-discretionary.
6. Greater co-ordination of recovery efforts between Commonwealth, state/territory and local authorities.
7. A comprehensive monitoring system to ensure that recovery plans are implemented and successful.
8. The establishment of an independent watchdog to oversee environmental policy and force parliaments to act to protect species if this is not occurring.
9. Adequate funding of species recovery plans.
10. Control of key threatening processes, including those that cause habitat loss and degradation, invasive species, pollution, disease and overharvesting.

Forests and land clearing

11. The permanent protection of all intact ecosystems including old growth, remnant and high conservation value forests as well as the sustainable management of plantation forests. Some highly biodiverse regions will need great protection, as will water catchments, whereas other areas will be amenable to access for recreational activities.
12. Cessation of ongoing broad-scale land clearing.
13. The extinction of Regional Forest Agreements which have facilitated overharvesting of native and old growth forests nationally contributing to a loss of biodiversity.
14. A national approach to and regulation of deforestation and land clearing, with the Federal Government having sufficient constitutional power to override states and territories where they are not complying with and/or meeting national environmental plans and targets.

Climate change mitigation and response to extreme weather and other disasters

15. Urgent mitigation of climate change to limit global warming to less than 1.5°C (see DEA policy: [Action on Climate Change and Health; Governance and Strategy](#)).
16. Sustainable management of existing biodiversity in disaster-prone regions to bolster resilience to climate change and aid in relief and recovery efforts post-disaster.

Invasive species

17. Expanded efforts to control invasive species, including support for research, funding for key invasive species management activities and improved reporting of management outcomes.
18. Expansion and strengthening of the national reserve system, with adequate funding for threat management within the existing protected area network.
19. Adequate funding of efforts to protect species outside reserves, recognising that investing in the continued expansion of Australia's protected area network without addressing threats beyond the existing protected area network will benefit few threatened species.
20. Expansion of Indigenous ranger and farm stewardship programs, recognising the vital role these can play in managing habitat and threats to biodiversity outside of protected areas.

Mining

21. Thorough and independent health and environmental impact assessments prior to the approval of any new mine; these must look at the cumulative impact of multiple mines within a region, their impact on water flows through the region, air quality and the

impact of transport both to and from the mine, including shipping's impact on the marine environment.

Marine parks, fisheries and coastal regions

22. Full reinstatement of Australia's national network of marine parks as initially established in 2012.
23. Greater transparency in the labelling of fish for consumption with respect to its threatened status and mode of catch.
24. Greater research into the wellbeing of marine and other aquatic environments in the face of expanding commercial development and other threats.
25. Enhanced coastal protection, including improved management of farms, mines and ports to prevent downstream coastal impacts.
26. Protection and restoration of mangroves, salt marshes, coral reefs and seagrass beds to reverse the adverse impacts of human activity.
27. Thorough and independent health and environmental impact assessments prior to development in and adjacent to coastal areas; these must examine not just individual projects but also the cumulative impacts of multiple projects.

Agriculture and food production

28. Changes to agriculture with a move away from environmentally destructive farming methods and a move towards methods to increase soil integrity, decrease erosion and salinity; these changes also include protecting bees and other pollinators essential to food production by moving away from pesticides that have harmful effects on them.
29. Ensuring continuing diversity in food species by preserving and utilising heirloom varieties.

Aboriginal and Torres Strait Islander partnerships

30. Recognition of Aboriginal and Torres Strait Islander knowledge and skills in biodiversity and conservation.
31. Expansion of movements towards recognition and promotion of Aboriginal and Torres Strait Islanders' cultural connection to Country and the substantial contribution that Aboriginal and Torres Strait Islander knowledge is making in tackling Australia's biodiversity and other environmental problems.
32. Expanded and fair resourcing of programs involving work on Indigenous lands.

Research and Education

33. Greater research and education on the importance and interconnectedness between biodiversity, natural systems and human health, with the prioritising of funding to research and conservation efforts through creation of a biodiversity fund.
34. Medical schools to incorporate this interconnectedness between biodiversity and health into medical student teaching and to highlight biodiversity loss as an important threat to public health.
35. Inclusion of ecocentric perspectives in national school curricula to provide Australians with broader awareness of the relationship between nature and human health and a deeper understanding of living natural systems.

Nature based health interventions

36. Incorporation of nature-based health interventions and biophilic design into our health system including gardens within and around hospitals and community health centres, guided nature walks other outdoor exercise programs to promote physical activity and address psychosocial problems.
37. Promote the value of and endorse the provision of biodiverse natural areas in school grounds, early learning centres and other places where children congregate to improve air quality, provide natural shade and enhance mental restoration.

38. Support community and government initiatives which promote the value of nature play for child development and wellbeing.

Summary

Doctors for the Environment Australia seeks to raise awareness of both the general public and policy makers of the risks to local and global health, both present and future, from environmentally damaging and disruptive technologies and choices, and related short-term economic priorities. Biodiversity loss, through the destruction of ecosystems and accelerating climate change, has profound impacts on human health and wellbeing.

DEA calls for the importance of biodiversity to be reflected in all policy areas and associated budgetary commitments of our governments. The absolute dependence of our health and wellbeing on natural systems, as outlined above, is clear, as is the dependence of our future survival on the restoration of balance within and between these systems.

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