Biodiversity Council

South Australia's biodiversity in a changing climate: the path to nature positive by 2030

Biodiversity Council, 2023

Image: Flinders Rangers, SA. Credit: Melody Ayres Griffiths /Unsplash

Further information

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Biodiversity Council

The Biodiversity Council brings together leading experts including Indigenous Knowledge holders to promote evidence-based solutions to Australia's biodiversity crisis. It was founded by 11 universities including its host the University of Melbourne, with support from The Ian Potter Foundation, The Ross Trust, Trawalla Foundation, The Rendere Trust, Isaacson Davis Foundation, Coniston Charitable Trust and Angela Whitbread.

Overview

Biodiversity is the diversity of life in all its forms and South Australia is an important region for biodiversity. According to most global assessments, Australia is one of the five most important countries in the world for biodiversity, especially if we focus on species only found in a single country (endemic species). If South Australia (about one million square km of land) was a country, it would be one of the 30 largest in terms of land area. It contains numerous endemic species and has a relatively sparse human population, which provides both opportunities and challenges.

South Australia's biodiversity is declining rapidly; it suffers from a legacy of past and current pressures, a few of which are largely outside of the control of the present people of South Australia (Bradshaw, 2018). The main pressures are: invasive species, land clearing and degradation, climate change, altered fire and water regimes, eutrophication and other forms of pollution and contaminants, over-abundant native species, and over-harvesting of natural resources (Legge et al. 2023).

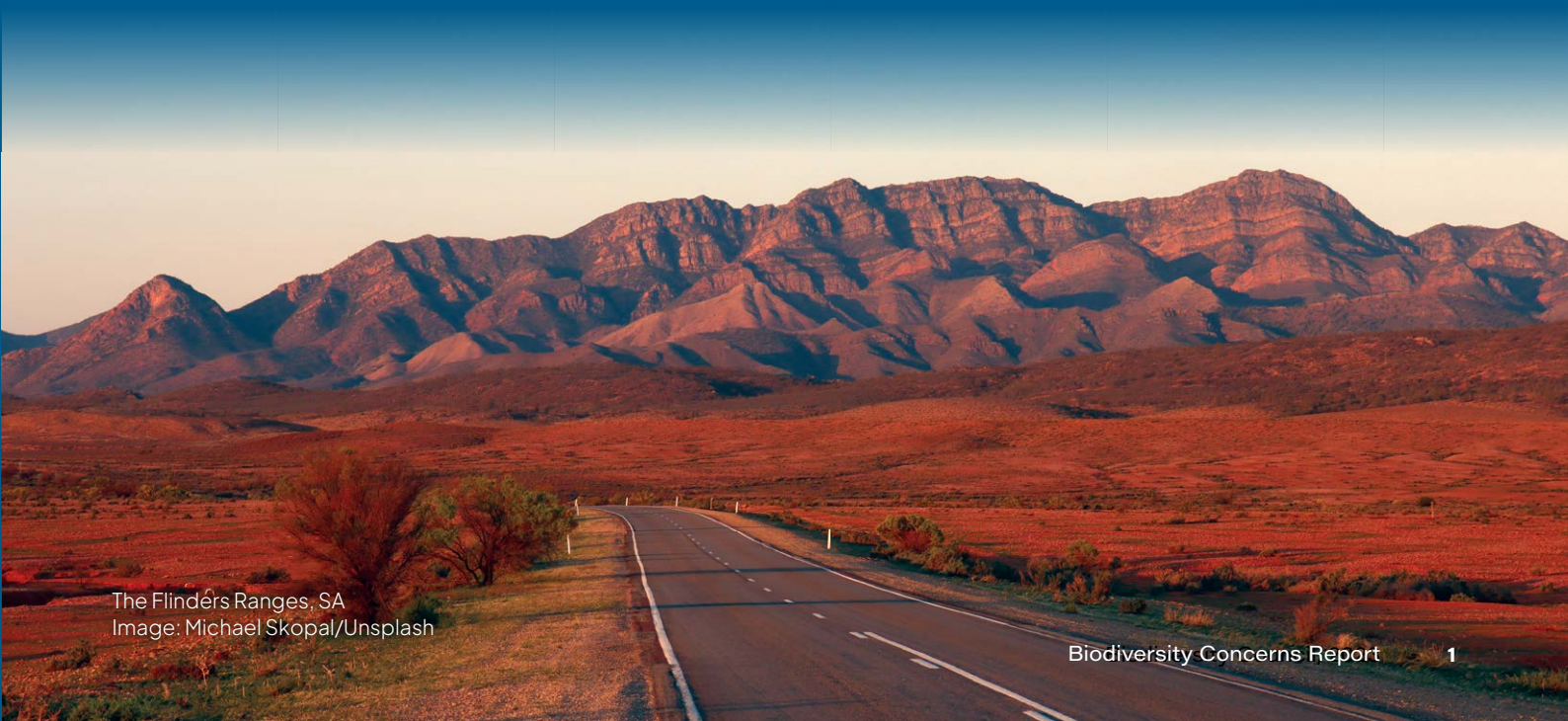
Monitoring and research needs to be more focussed, cost-effective, long-term, and integrated with partners nationally and globally. We recommend an independent standing committee to advise the state on future monitoring and research using a value-of-information lens – what do we need to know to attract investment, engage people, take action and continuously improve.

Australia has committed to meeting the 23 Targets and 4 Goals from the Kunming-Montreal Convention on Biological Diversity by 2030. If South Australian government are to meet their contributions to these targets, a substantial increase in investment is required, several hundreds of millions of dollars per year. Investments in on-ground actions should be prioritised in a new biodiversity strategy that uses a cost-utility approach so that the state achieves the biggest net return-on-investment for biodiversity, while accounting for leverage, equity and other co-benefits.

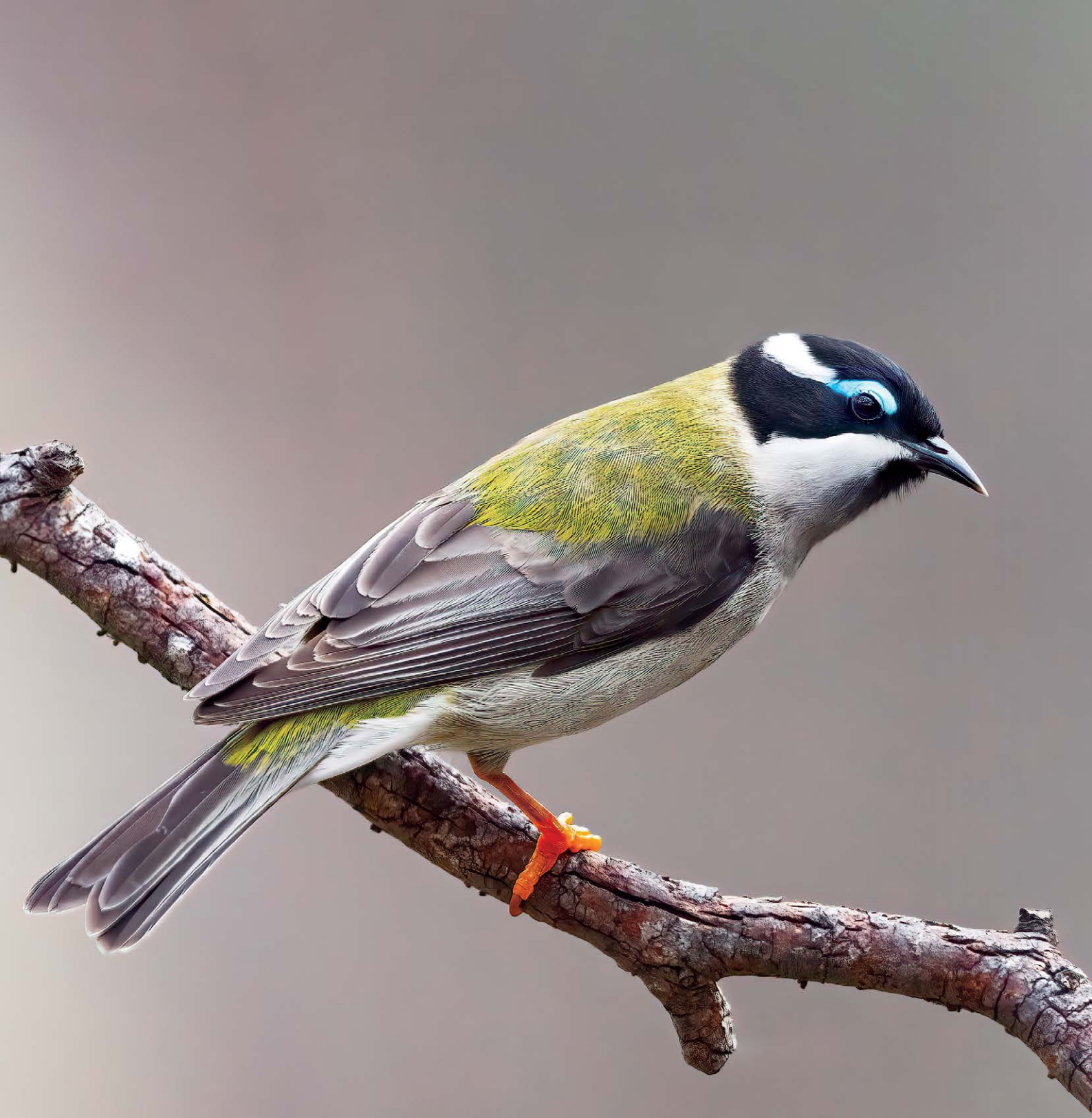
South Australia is in a good position to take advantage of novel conservation interventions and emerging biodiversity markets and needs to prepare for their rapid growth. That said, in the context of a rapidly changing climate[1], the state and community will need to take a far more radical approach to many conservation interventions, especially with respect to: rapid invasive species eradication, rewilding, restoration, and assisted migration.

A nature-positive future of improving the state of biodiversity, requires increased government partnerships with First Peoples, community, philanthropy, not-for-profits and business. This requires co-design and co-prioritisation of projects. Difficult discussions around rewilding and assisted migration need to start now.

1 The Department for Environment and Water (2022) predict >2 degrees warming and >10% declines in rainfall in most areas by 2070. This will put many terrestrial ecosystems under water stress, and many marine ecosystems under heat stress.



The Flinders Ranges, SA
Image: Michael Skopal/Unsplash



The black-chinned honeyeater (*Melithreptus gularis*). This species is Vulnerable in South Australia. Image: JJ Harrison CC-BY-SA 4.0/ Wikimedia Commons

Background

We acknowledge the previous report on "Better prospects for the future of South Australia's biodiversity" by Professor Corey Bradshaw. Bradshaw's (2018) comprehensive assessment of the state of South Australia's biodiversity is still entirely relevant today, and he makes a number of recommendations. We consider these, together with other biodiversity investment ideas from the literature, in the context of three key things: a rapidly changing climate, limited funding, and the global biodiversity targets. In short – what conservation interventions are likely to deliver the greatest long-term return-on-investment (benefit) for biodiversity in a changing climate with limited financial and human resources, with consideration to the 2022 Kunming-Montreal Convention on Biological Diversity Targets (Appendix 1).

We take as read, the guide to climate projections for risk assessment and planning (Department for Environment and Water, 2022).

The South Australian Department for Environment and Water has provided a summary of the state of the environment broken down to the level of the landscape region. This takes the form of a dozen one-page summaries, backed by c2000 pages of detailed analysis. Most aspects of the environment are in decline, which is consistent with national and international trends, and Bradshaw's (2018) assessment. Years where the environment appears to be improving are almost always because of temporary regional increases in rainfall.

As of September 2023, South Australia currently has no explicit goals and targets for biodiversity. There had been a zero-extinction target, but it lapsed. In the absence of state-based targets, we note that Australia has committed to the global Convention on Biological Diversity (CBD) targets and in the absence of any state-specific targets we will assume that these are South Australia's targets (Appendix 1).

The most relevant CBD targets are listed below (much abbreviated from Appendix 1). Ideally the state would agree with and restate these targets with more specificity, quantification and explicit timelines. Target 5, about sustainable use, is not a high priority, given most of the fisheries are sustainably managed, native forest logging stopped 50 years ago, and any wild harvest of terrestrial flora and fauna is heavily regulated. Target 8, accommodating climate change, pervades every strategy and should not be listed as a separate target.

Target 1: Credible and inclusive bioregional plans that ensure a net positive outcome for biodiversity.

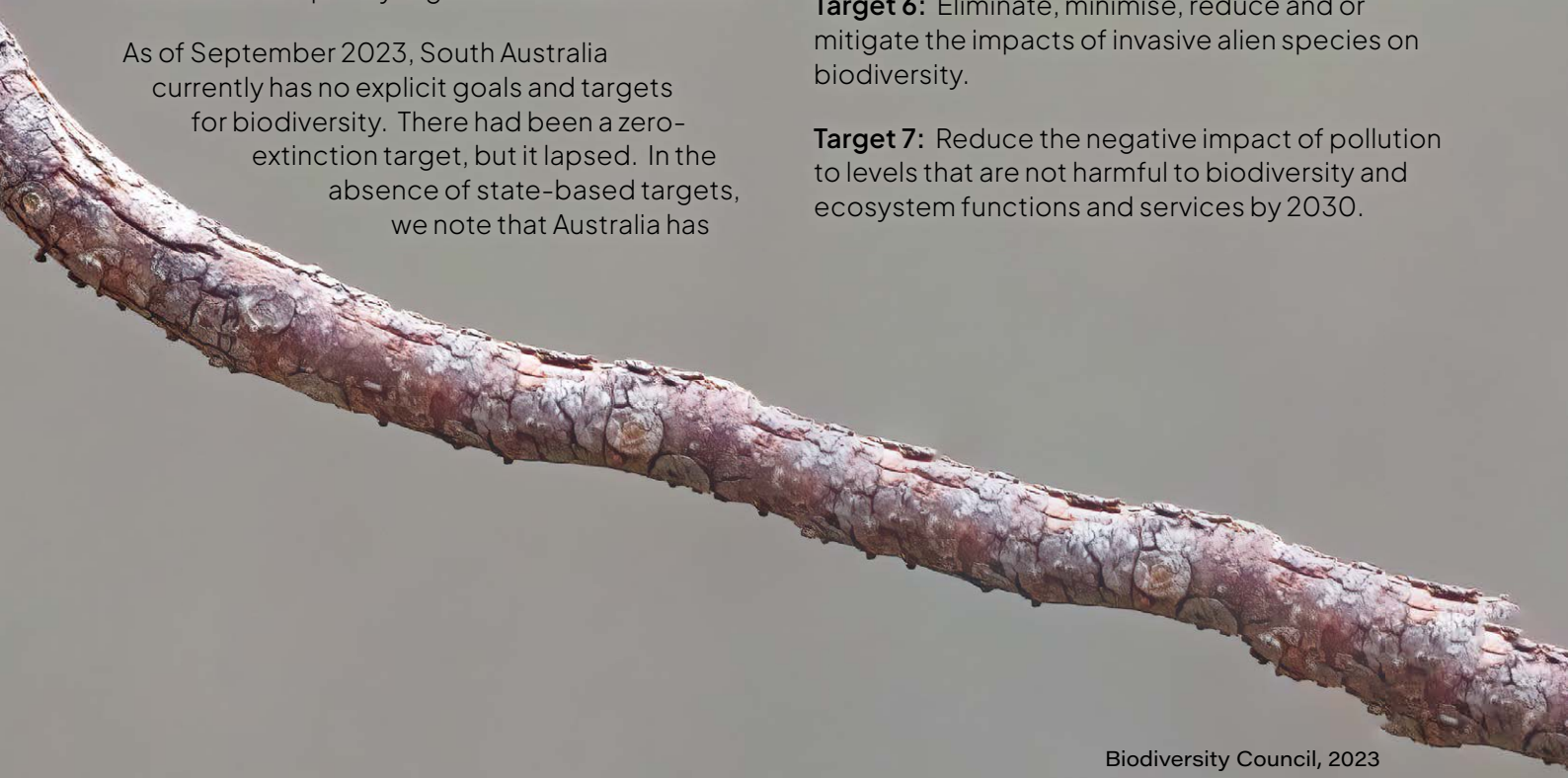
Target 2: At least 30 per cent of areas of degraded ecosystems are under effective restoration by 2030.

Target 3: Ensure at least 30 per cent of every ecosystem is effectively conserved by 2030.

Target 4: Halt human-induced extinction of known threatened species. This is equivalent to halting extinction of known species given a species has to be threatened before it goes extinct.

Target 6: Eliminate, minimise, reduce and or mitigate the impacts of invasive alien species on biodiversity.

Target 7: Reduce the negative impact of pollution to levels that are not harmful to biodiversity and ecosystem functions and services by 2030.



Monitoring and research

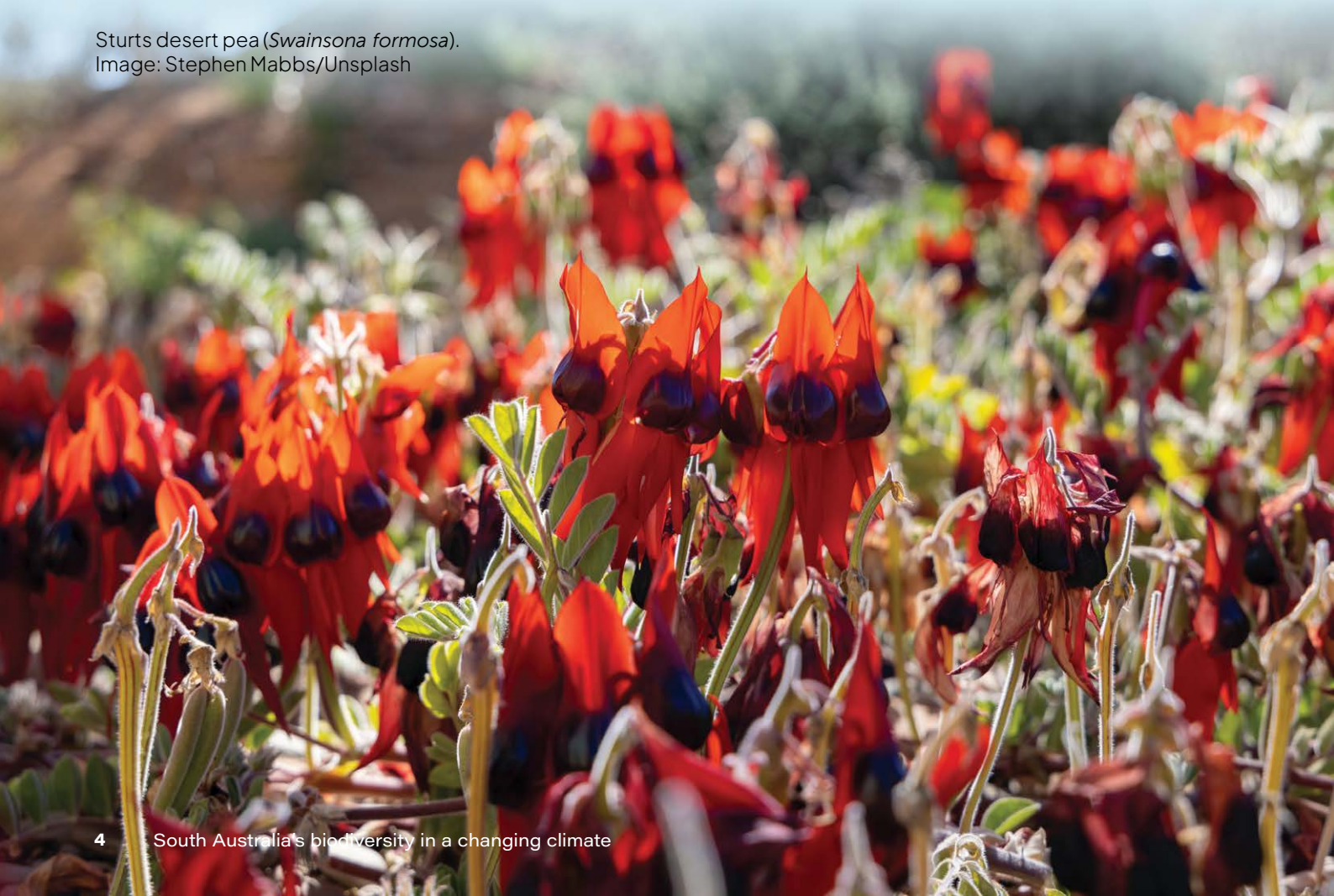
We reviewed the state of environment report cards and found them sound and useful, but in most cases, heavily constrained by lack of data. Notable is a lack of certainty about trends in much of South Australia's biodiversity because there are very few well-structured long-term monitoring programs, which is also true for the rest of Australia.

While the state embarked on a very successful whole-of-state biological survey, which provided invaluable distribution data, especially for poorly known and difficult to identify groups like mammals and reptiles, that survey proved to be a once-off and took about 25 years.

Monitoring all trends in biodiversity and ecosystem processes across the huge state of South Australia is impossible. The department has very few staff and funds to collect primary data. Hence, there are three elements to success – building on existing endeavours, engaging people, and investing in the monitoring that is most likely to deliver cost-effective benefits by changing policy, management and external investment. That final idea underpins "Value of Information" theory which argues that monitoring for monitoring's sake is imprudent in a resource-constrained world. Or in lay terms – what is interesting is not always important, and what is important is not always interesting.

Some successful examples of long-term biodiversity monitoring exist that can be built on:

1. There is excellent **monitoring in the Coorong and Lower Lakes**, including the "Lower Lakes aquatic and littoral vegetation condition monitoring", waterbird monitoring, and fish monitoring. These long-term programs provide annual data and trends with a high level of reliability. Presumably these are facilitated by Murray-Darling Basin federal and state funds. They should be continued and ideally integrated into a whole of system model akin to the Receiving Water Quality model used to understand interactions between the physical and biological elements of Moreton Bay. A whole system model could be used to explore the cost-effectiveness of different policy and management options for this important part of the state.



Sturts desert pea (*Swainsona formosa*).
Image: Stephen Mabbs/Unsplash

2. Satellite data is being used to monitor the **extent and condition of key marine and coastal habitat types**. This is smart emerging work that will deliver credible trend data in these ecosystems and, in the future, the extent and condition of terrestrial ecosystems. For example, Queensland is on the verge of being able to map extent and condition for most terrestrial vegetation. South Australia should watch developments in this area and adopt these approaches when appropriate to create a time series of vegetation extent and condition across the state, including back-casting. Vegetation condition has been assessed using onsite surveys at over 2500 sites across South Australia and this data could be used with the satellite data to create statistical models of vegetation condition statewide (Bond et al. 2019, Prowse et al. 2019). Such models would provide a powerful platform for facilitating emerging nature positive markets.

3. **Protected area extent monitoring**, both terrestrial and marine, is relatively accurate and credible. That said we need to remember the extent of the protected area is not a "state" of the environment, it is an account of an action intended to improve the state of the environment by reducing known pressures and, finances permitting, improving management. Notably, there are scientific publications (e.g. Ferraro and Pattanayak, 2006) that shed some doubt over the effectiveness of protected area management in Australia. Two improvements could be made. First, to align this work with the 2022 CBD the state should assemble the polygons for OECMs (Other Area-based Ecosystem Conservation Measures) such as Bush Heritage Trust reserves, Heritage Agreement Areas etc.. Second, the success of the system should be aligned to the 2030 CBD targets, and a simple metric of how many of the 382 terrestrial landforms and mappable marine habitats meet the 30% target should be the time-series indicator of progress (see Jenke et al. 2018) – this can be back-cast 50 years.

4. The Nature Conservation Society of South Australia's **Mount Lofty Ranges woodland bird monitoring** (1999 to present) is the longest well-structured annual multi-species regional monitoring in South Australia. It was used as a rallying cry for the recent Labor Party environment platform but is not reported in the state-wide analysis. It shows a general decline in terrestrial bird abundance, not surprising in a highly fragmented region. Similar programs could be deployed for the rest of South Australia at very low cost in partnership with BirdLife Australia, Birds SA and the Landscape Boards. When coupled with spatial management data, this monitoring allows us to test the effectiveness of conservation interventions, something that is sorely lacking and is important for investments and markets.

5. The national Threatened Species Index is growing, providing an easy to explain national metric for Australia's threatened species, that can be broken down by state, region and species group. To its credit, South Australia has contributed substantially to this program (69 species). It is now Federal Treasury's only biodiversity indicator in their national "Measuring What Matters" report. This, and other Terrestrial Environmental Research Network programs provide a national framework for data collection and integration reducing the need for South Australia to reinvent the wheel. Bespoke new databases have little place in a fully integrated continent of environmental data and modelling – integration with national collection, handling and analysis protocols is essential.

All based on partnerships, these excellent examples of long-term monitoring have already had impact. New opportunities will arrive with regional and national groups: Trees For Life, Bush Heritage Australia, Australian Wildlife Conservancy, the Nature Conservation Society of South Australia, BirdLife Australia, the Terrestrial Ecosystem Research Network (TERN), etc. – especially where technology (e.g. satellites, acoustic monitoring) is rapidly developing and where there are emerging national standards (for example the new TERN field survey protocols; the Australian Acoustic Observatory and BirdLife Australia's standard 2 ha 20 min counts). The key is to not re-invent the wheel and use approaches that are the same as, or are convertible to, national standards.

Active adaptive management monitoring, "learning while doing", is the gold standard of biodiversity monitoring (Walsh et al. 2012). There remain large scientific uncertainties about the benefits of different types of conservation investment: habitat restoration (especially in the ocean), fire regime management, invasives and water management etc., that need targeted active adaptive management.

Further recommendations

1. **Long-term monitoring programs** with partners are essential

   While attempts to mine unstructured survey data to determine trends in biodiversity are laudable, they are fraught with dangers. Further, it is unlikely that the state government will ever afford the staff to collect, organise, analyse, curate and disseminate structured monitoring data. New opportunities for long-term monitoring of biodiversity will emerge through partnerships with regional and national groups. An independent expert body would ideally advise on the return on investment for new partnerships.

2. We need more **adaptive management monitoring** with research partners and land trusts

   As emphasised by Bradshaw (2018), there remain large scientific uncertainties about the benefits of different types of conservation investment: habitat restoration (especially in marine and coastal areas, Bayraktarov et al 2016), fire regime management, invasives and water management etc., that need targeted active adaptive management (learning while doing). Further, it is unlikely that the state government will ever be able to afford all the resources necessary to collect, organise, analyse, curate and disseminate monitoring data. Consequently, they need to embrace new opportunities to deliver long-term monitoring of biodiversity through partnerships. This sort of research is best done with university partners, is best-delivered through Australian Research Council (ARC) Linkage grants or Collaborative Research Centres, and is often easier to carry out with land trusts, First Nations partners and the landscape boards. Setting aside an annual fund ($200,000) to support one new ARC linkage grant each year ($50,000 per annum per grant for an average of four years each) to understand the impact of management on biodiversity makes sense. Some smart projects include: whole-of-ecosystem accounting for marine restoration (fisheries, carbon, nutrient removal), socio-ecological benefits of paddock trees on long-term biodiversity persistence, cost-benefit analysis of ecosystem services (and disservices) provided by invertebrates in natural and agricultural systems, costs and benefits of restoration and revegetation on biodiversity, testing the impact of introduced mammal exclusion zones, invasive species control, rapid regional eradication approaches, mental and physical health benefits of nature, and regional plans for restoration and revegetation to sequester carbon, secure biodiversity and maximise ecosystem services (like flood protection, Villarreal-Rosas et al 2022).

Hibbertia tenuis, Image: South Australian Seed Conservation Centre

Thelymitra sp., Limestone Coast, SA. Image: Hugh Possingham

Overall, we believe that the best approaches to improving monitoring and certainty about the state of biodiversity in South Australia will be: harnessing citizen scientists, being part of nationally-funded programs, and exploiting advances in technology (e.g. acoustics, wildlife cameras, eDNA and remote sensing).

All too often, decisions about research are driven by the passions of well-intentioned local individuals. To avoid this bias, the state needs a completely independent research and monitoring expert advisory group that guides investment in research and monitoring projects so that they deliver the greatest return on investment for biodiversity conservation using a Value of Information framework.

Further notes on research investment

There is little time for basic ecology work, but there are some emerging frameworks for prioritising research programs for threatened and poorly known species. In many cases our knowledge is so poor we have no idea if any action can secure a species, let alone having a choice of actions. There is promising emerging science: Watson et al. (in prep) have devised a scheme for identifying the most pressing needs for species recovery, cost-effective threat abatement for multiple species is possible (Carwardine et al. 2012), and there are approaches for identifying hotspots and climate/fire refugia for poorly known taxa such as invertebrates and fungi (Guerin et al 2019).

One of the greatest challenges in environmental reporting is disentangling the impacts of management and climate change, from various forms of "natural variation". Long-term rainfall cycles, often with periods of several years, invariably overwhelm the impact of local and regional management actions meaning that apparent improvements or declines, in environmental state, can be falsely attributed to successful reductions in pressures or management interventions. This conundrum of causality can only be resolved with the clever use of control sites (it is essential to monitor sites where there is business-as-usual management, although in many cases, like the Coorong, there is no "control site"), very long time-series, first-class statistical analysis, and wise counter-factual modelling – that is, backwards and forwards projections of what has, and will, happen in the absence of interventions.

Value of information theory can be a guide to choosing research investment that delivers benefits to biodiversity, but it is expensive. Here is a very simple "back of the envelope approach" to prioritising research. Research that does not deliver direct benefits to policy and management should be done by agencies other than the state government.

Vittadinia triloba, Limestone Coast, SA. Image: Hugh Possingham

Stackhousia monogyna, Limestone Coast, SA. Image: Hugh

Opportunities to be nature positive through policy and management

Reversing the decline in the diversity and abundance of flora and fauna will take at least a decade of state-wide investment. Estimates of the cost of reversing biodiversity decline and restoring over-cleared landscapes to ecologically functional levels (30%) consistent with the national commitment to the Kunming-Montreal Convention on Biological Diversity, are at least $4 billion per annum for Australia (Wintle et al. 2019, Mappin et al. 2022); 10% of that amount is what South Australia would need at $400 million per annum. Until industry, society and philanthropy can find that sort of funding, $100 million per annum is a realistic increase in annual government investment, or about $11 million per Landscape Board, entirely focussed on biodiversity. We can but hope that partnerships, philanthropy and emerging nature positive markets underpinned by advanced policy, will fill the funding gap beyond this increased investment.

Climate adaptation

Disentangling the past, present and likely future impacts of climate change on biodiversity, from the known threats, such as invasive species, is extremely difficult. That said, there is a broad consensus that climate change could be the greatest threat to biodiversity by 2050. Consequently, we need to identify strategies to enhance the resilience of biodiversity in a rapidly changing climate, and against a backdrop of past and existing human pressures. Much has been written about climate adaptation for biodiversity, but very few strategies are being deployed because conservation organisations are often too conservative.

On the positive side, most positive actions for biodiversity reduce greenhouse gas emissions. At a global and national scale, nature-based solutions (for example habitat restoration, blue carbon and climate-friendly agriculture) are expected to be 30% of the climate change solution from now to 2050 (Griscom et al. 2017). Nature-based solutions

Over several weeks 211,474 hectares of Kangaroo Island burnt in early 2020 - almost half of the island. Image: Nicolas Rakotopare

Yellow-footed rock-wallaby (*Petrogale xanthopus*) in the Flinders Ranges, SA. Image: Rolf Lawrenz CC-BY/iNaturaliast

deliver win-win outcomes and if the full benefits can be sensibly accounted for, they are often profitable financially.

Typically, species are already moving poleward about 12km per decade, and upwards at about 9m per decade, with little downwards movement in the ocean. Changes in rainfall patterns, in amount, seasonality and intensity, are uncertain, as is the impact of climate change on associated catastrophic events such as fires, floods and disease. More predictable is that the sea level is rising, on average, about 5cm per decade, and the ocean is rapidly becoming more acidic. Overall, because of the impacts of stochastic events and complex interactions (including changes in human behaviour) predicting exactly how species will redistribute themselves in response to climate change is highly uncertain. Whole ecosystems are unlikely to move in an orderly fashion; the responses of some species will be highly unpredictable. Identifying credible climate refugia is urgent (Guerin et al. 2019),

Most importantly, catastrophes have been at the heart of about half of all extinctions (Mangel and Tier 1994) and there are empirical and theoretical lines of evidence that suggest that catastrophic events will be more frequent. Consequently, we believe that risk spreading is the most important climate adaptation action. This means that species and/or ecosystems that exist in less than a few places need to exist in more places, where "places" are relatively independent from the same catastrophic event. Estimates of the number of viable populations to secure a species range from 3 to 10 (Burgman et al. 2002; Joseph et al. 2007; McCarthy et al. 2012).

The state has never formally adopted a climate adaption approach to underpin its conservation investments. The parts of South Australia that are most resilient to climate change impacts will be: southern coastal areas, areas with a lot of topographic variability, islands, places with surface and ground-water, and places in the ocean near or close to sources of cooler water, for example upwelling areas. Further analysis of climate refugia is warranted (Guerin et al 2019). Fortunately, investments in areas like "Operation Bounceback", Marna Banggara, and islands including Kangaroos Island, is worthwhile from a climate perspective. The state should continue to work with key partners like Australian Conservation Foundation, Bush Heritage Australia, Nature Glenelg Trust and Nature Foundation to come up with a climate resilient strategy for intensively managed protected areas.

Regulation and planning

South Australia has a variety of laws, for example the Native Vegetation Act, that are intended to protect biodiversity. That legislation is the strongest and most effective native vegetation protection legislation in Australia, and has been in place for a long time, but has been unable to stop the decline in biodiversity in South Australia. There are other laws, rules and regulations around pollution, harvesting natural resources, construction etc. that also help to reduce threats to biodiversity.

From a regulatory perspective, improvements would include better use of the mitigation hierarchy in the Native Vegetation Act (too many developers are happy to pay into the offset fund for their clearing), biodiversity offsetting that delivers nature positive outcomes quickly, more use of advanced offsets, and removing excessive legal impediments to more interventionist pro-active conservation (such as marine restoration, rapid eradication of invasives with novel technology, rewilding and assisted migration).

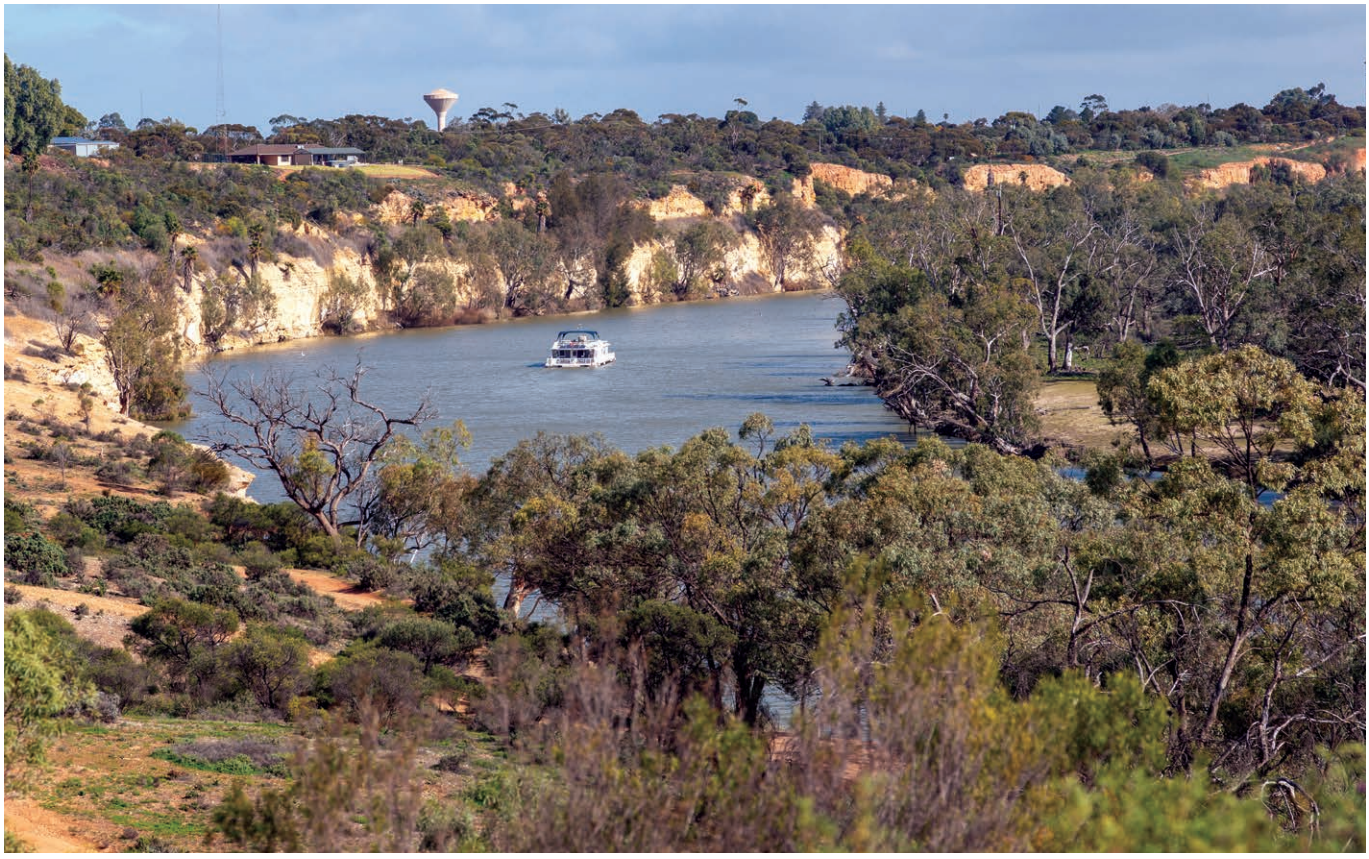
From a planning perspective the state needs to urgently develop regional biodiversity plans that identify green zones where renewable energy infrastructure and urbanisation can occur with negligible impacts on biodiversity; while at the same time identifying red zones where biodiversity and ecosystem service values should not be compromised and cannot be offset.

Opportunities for investment

There are long lists of conservation opportunities, hundreds of strategies and plans, but little action. We will not repeat the long lists, but instead focus on what we consider to be the "low-hanging fruit" of conservation interventions, plus the investments in knowledge or policy reform that may enable more dramatic interventions in the future, such as assisted migration and marine habitat restoration.

We have tried to frame all the opportunities in the context of cost-effectiveness and climate change. "The two most urgent and interlinked environmental challenges humanity faces are climate change and biodiversity loss" notes Shin et al. (2022). "A climate-driven global redistribution of species is currently underway" writes Scheffers and Pecl (2019). These ideas are now well known, but exactly how this information influences our decisions about policy, management and monitoring is more challenging.

Ideally, all management and policy interventions are assessed not just in the context of abating climate change and reversing biodiversity loss, but also in their direct and indirect benefits to people



Murray River, Waikerie, SA. Image: Stephen Mabbs/Unsplash

– for example reduction in flooding. Government investments in nature that provide tangible ecosystem services are more likely to be embraced by the public. And finally, we need to consider the all-pervasive issues of equity, engagement of traditional custodians, local communities' preferences, and a raft of socio-political issues such as unemployment rates and the viability of rural communities.

1. **Reducing all human-induced pressures [Targets 1, 2, 6 and 7]** helps biodiversity respond to climate change. The low hanging fruit here is stopping land clearing and minimising the number of new and potentially harmful invasives (e.g, deer, ants, marine pests). Maintaining areas of long-unburnt habitat in the landscape, particularly habitats which are naturally resistant to fire and burn at a lower frequency can act as natural fire breaks or refugia (for e.g, mesic areas, or wet gullies) (Collins et al. 2019), is an important step in maintaining ecological integrity and preserving biodiversity. This is especially true when faced with an increasingly hot and drying climate, which will likely erode the protective capacity of these habitats. These natural refugia are often centres of invertebrate endemism, containing multiple species with highly restricted ranges and likely of conservation significance. In a broader context, once such centres of endemism are identified, conservation actions focussed on protecting them can maximise biodiversity wins, protecting a large number of vulnerable species per dollar, and safeguarding the ecosystem services they provide.

Reducing habitat loss on the land or sea has direct benefits for climate change and biodiversity. In South Australia habitat destruction is tightly regulated by the Native Vegetation Act. Whilst this legislation has proved to be one of the most effective in Australia, it is not delivering no net loss with respect to the quality and quantity of native vegetation across the state, and there are some future challenges.

One challenge is that the Native Vegetation Act does rely heavily on biodiversity offsetting with the offsetting entity paying into a fund. Biodiversity offsetting has repeatedly been shown to not deliver the net gain in habitat condition and extent that we expected where vegetation is concerned, and even less so with offsetting impacts on threatened species (reviews in NSW, QLD and around the world). There are many reviews and reports on these failures and we suggest two here. First, enabling the proponent to pay the offset in cash means the state bears the burden of finding the biodiversity offsets. History has now shown that the payments are inadequate and governments are not the best organisations for doing property deals. We would urge consideration of the payment formula to be revised up based on scientific analysis of outcomes, payment-based offsetting to be half or less of the total offset amount, and an independent not-for-profit be in charge of delivering the offsets. Second, the pressure of renewable energy infrastructure on native vegetation will rise rapidly. Providing solar and wind renewable energy companies with clear upfront spatially explicit guidelines on where they can develop and how those developments need to be mitigated, is urgent. If offsetting is essential for these expected interventions, the relevant organisations (agencies, companies and developers) should be delivering advanced offsets now; offsets that are established well ahead of the habitat destruction. Improvement in offsetting, plus a thorough evaluation of how well offsetting has been delivered in the past, lies at the heart of delivering nature positive by 2030.

Invasive species, especially ones that have not established, represent huge costs to all parts of society. A rapid response approach to new species is essential as eradication is almost impossible when species are well established – for example deer may now be beyond eradication and will cost tens of millions of dollars a year to South Australia. That said, regional eradications are possible, take for example the decisive action taken on feral pigs on Kangaroo Island. In the case of deer, ending the deer industry may be essential for successful eradication, and that requires a decade of consultation and compensation. Prioritising prevention and eradication, plus acting decisively on opportunities, will save the state money.

In some parts of South Australia, overabundant native animals are a significant threat to biodiversity, for example macropods in agricultural districts and koalas in local areas. While restoring dingo populations can lead to less damaging macropod populations, this is only likely to be possible in cattle rangelands. The first step to these broadscale re-engineering of ecosystems is building the social license for managing at scale. These discussions would ideally be driven bottom-up, by First Nations people, other land managers and regional bodies – and they need to start now.

Eutrophication has an under-estimated impact on terrestrial and marine ecosystems. Nutrient offsetting, markets and regulations on development are the most likely mechanisms to deliver outcomes (Target 7).

2 **Any sort of habitat restoration, revegetation or rehabilitation** is beneficial for both climate change and biodiversity **[Targets 1, 2 and 3].** There are two major ecological challenges in this area. First, should we be accepting and utilising novel ecosystems for biodiversity conservation? For example, many valuable wetlands are un-natural. Hence, in some cases, poorly rehabilitated mine sites, rather than being turned back to their former state, could become biodiverse (albeit un-natural) wetlands. Second, given substantial increases in temperature and reductions in annual rainfall, especially spring rainfall, many South Australian species might move up to 200km by the end of the century. Should we be restoring ecosystems for species 200km away, especially species that are more drought and heat-adapted. We urge trials of restoring species, say of semi-arid acacias and mallee, well into southern agricultural districts to provide resilience to biodiversity and carbon investments.

In theory carbon offsetting should be driving a large amount of habitat restoration. However, the benefits of the carbon restoration market to biodiversity are unknown. In Queensland the state Land Restoration Fund provides a premium for biodiverse carbon. Furthermore, a successful bid for a Nature Positive CRC might be able to carry out the necessary research to identify the highest win-win restoration and revegetation projects for biodiversity and carbon sequestration on the land and the sea. Advances in methods and mechanisms for equitable nature positive interventions can be commercialised globally. South Australia urgently needs an action map for biodiverse carbon opportunities. This sort of work presents global business opportunities.

3 **Expanding and managing the protected area network,** including OECMs in all their forms **[mainly Target 3].** OECMs are a new concept that will play a large role in conservation, especially in a state with inadequate finances to manage traditional protected areas. Aside from properly accounting for our OECMs, they are usually a cost-effective way for the state to improve the quality of native vegetation and conserve species. They need to be defined and accounted for in the Target 2 accounting. Protected area and heritage area management in South Australia (indeed much of Australia) has fallen by the wayside. Traditional custodians, friends of parks groups, industry, and private landowners all need more resources, encouragement and autonomy to engage. Reverse auctions for management actions, such as invasive species control, are a cost-effective way of engaging landowners with valuable native vegetation.

4 **Establish a dedicated Threatened Species and Ecological Community Recovery program** that mirrors the NSW Save Our Species program, with a particular focus on plants and community involvement **[Target 4]**. Fully funding the recovery of all threatened species in South Australia seems unlikely in the short term. Until that full funding happens, the Save Our Species program offers a way of targeting actions and monitoring to deliver the greatest impact per dollar. For threatened invertebrates there is an urgent need to identify and protect centres of endemism.

About half of South Australia's EPBC listed species are plants, representing an opportunity to leverage the community by investing in community-based regional threatened plant action groups. The community has the resources and capacity to deliver most threatened plant recovery, given the authority, resources and scientific guidance from the state and other bodies. These groups need to be encouraged, authorised and empowered to create insurance populations for all species (at least five for every species), often well outside their natural range, in natural or semi-natural settings that ensure the plants don't become "domesticated".

For invertebrates, where formal listing of most species is unlikely in the short term, there is an urgent need to identify, manage and protect (especially from fire and other catastrophes) hotspots of diversity and centres of endemism. Simply identifying small sites that have been long unburnt, or could develop into sites that are long unburnt, and presenting that information to fire managers, would be extremely valuable.

5 **Blue carbon and marine (subtidal and tidal) habitat restoration [Targets 1 and 2]** has the multiple benefits of very high potential carbon sequestration, high biodiversity, benefits for protecting humans from sea level rise and storm surges, reduced eutrophication of coastal areas, and other ecosystem services. That said, some coastal ecosystems are expensive and hard to restore, and we need to be sure the pressures that caused their degradation have been removed. Coastal ecosystems suffer under multiple pressures: sea level rise, ocean warming, acidification, eutrophication, encroachment, over-fishing, etc. Further regulations, such as maritime transport laws, can make coastal restoration challenging.

South Australia has been fortunate to be at the leading edge of marine habitat restoration

Red-capped robin (*Petroica goodenovii*) at Talapar Conservation Park. Image: Graham Possingham

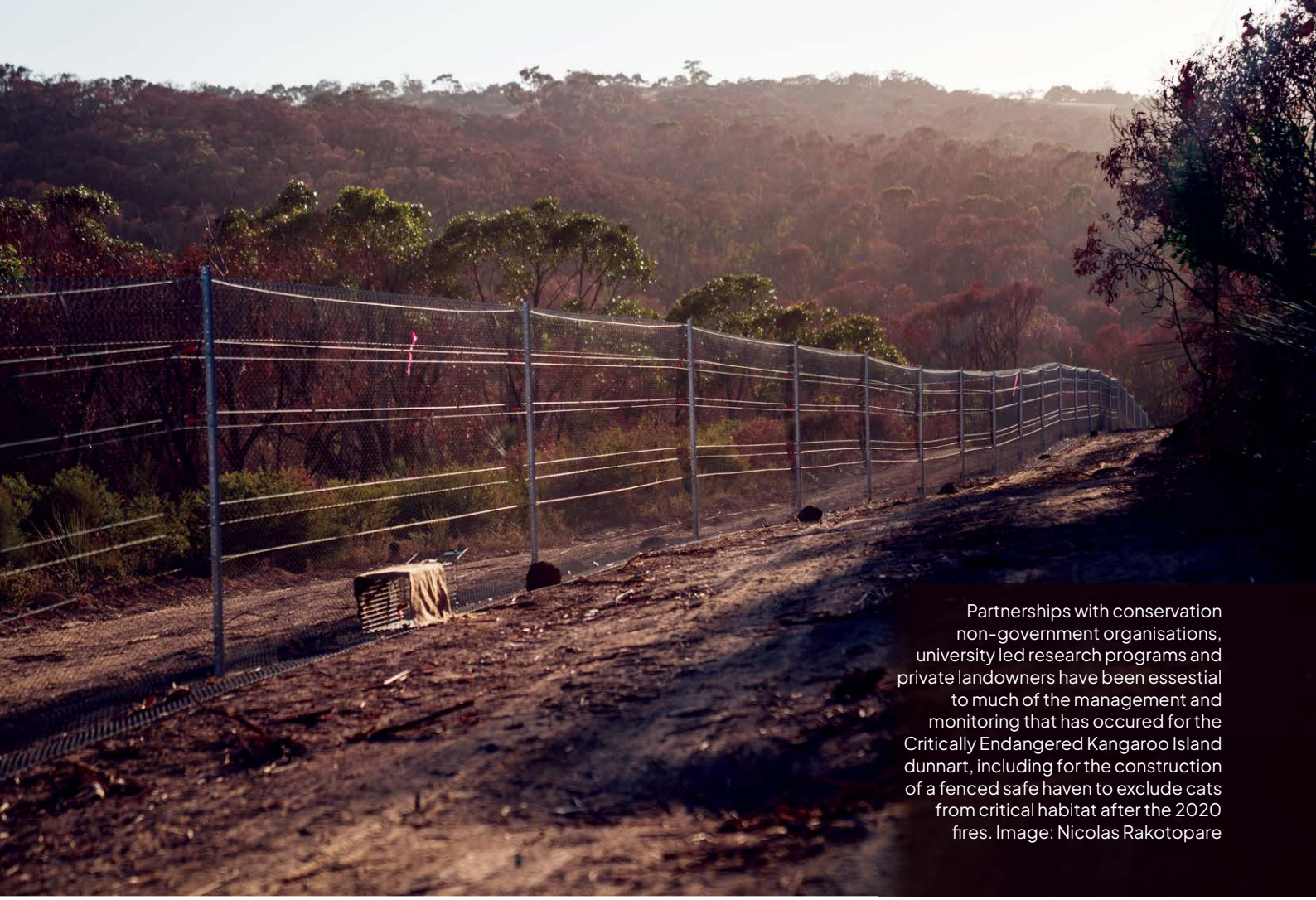
experiments. Continuing to create an attractive location for investment and reducing the regulatory burden for marine restoration, is critical to the future of this industry in South Australia. Regional plans where marine restoration of seagrass, mangroves, shellfish and saltmarsh habitats are front and centre of the planning, with all approvals for interventions baked into the zoning would be ideal.

Saltmarsh/coastal samphire is a particular coastal ecosystem that contains a number of endemic threatened species and is likely to suffer most from sea level rise. Now is the time for the state government to embark on some ambitious experiments on saltmarsh creation in marginal agricultural land for carbon and biodiversity.

One thing that South Australia has not taken full advantage of is reminding people that our great southern reefs are more significant from a biodiversity perspective that our northern tropical reefs. This is because they contain a very large fraction of species found nowhere else in the world while our tropical coastal ecosystems share many species with northern neighbours. This represents a major opportunity for biodiversity credits and certificates in emerging nature repair markets, but the case needs to be prosecuted and proselytised.

6 Fast and implemented bioregional biodiversity plans [Target 1]. Ideally, Opportunities 1–5 above are delivered simultaneously through credible regional biodiversity plans. Regional biodiversity plans are a major part of the EPBC Act and the new federal government is keen to deploy them. Better integration delivers cost-efficiencies. That said, regional biodiversity planning invariably fails because they are too slow to develop and implement. Plans need to be made now with NO NEW DATA. They are especially important with respect to managing biodiversity offsets, habitat restoration and large-scale corridor restoration with an eye on climate change and ecosystem representation. Examples already exist for South Australia (Tulloch et al. 2019) and they are urgently required in likely hotspots of renewable energy infrastructure deployment. These plans would not just identify "no-go" (red) zones but also "go" (green) zones where renewable energy infrastructure can be deployed now with limited regulatory burden.

7 Reduced degradation in semi-arid ecosystems [Target 1, 2 and 6] (especially grazing of feral, domestic and native animals). This has been found to be disproportionately beneficial for climate change per unit loss of agricultural productivity – but the carbon and biodiversity



Partnerships with conservation non-government organisations, university led research programs and private landowners have been essestial to much of the management and monitoring that has occured for the Critically Endangered Kangaroo Island dunnart, including for the construction of a fenced safe haven to exclude cats from critical habitat after the 2020 fires. Image: Nicolas Rakotopare

benefits of reduced stocking and reducing feral herbivores in the arid and semi-arid are under much dispute. South Australia, with its long-term rangeland vegetation and kangaroo (large herbivore) monitoring schemes, is in the ideal position to quantify the benefits of changed rangeland management on carbon and biodiversity. At certain scales the potential benefits for carbon and biodiversity of re-instating dingo populations could be explored.

8 **Restoring inland wetlands and environmental flows [Target 1, 2 and 6]**. Declining flows and water tables have caused dramatic declines in the extent and health of South Australia's wetlands. For example, the water table in the Limestone Coast has gone down several metres in the past few decades. This has a secondary consequence of reducing the state's ability to manage wildfire – riparian areas and wetlands slow or stop wildfire. Wetlands and riparian areas have disproportionate amounts of biodiversity per unit area. Dedicated adaptive management is urgently required in these ecosystems. The existing water regulations are not delivering increases and improvements in wetlands across the state.

9 **Ex situ conservation [Target 4]** of various kinds is going to be more and more important under a changing climate and increases in catastrophes. The herbarium's state seed bank is an excellent example of this sort of work, but also living seed bank gardens of threatened species close to their natural habitat, but protected from catastrophes, are going to be increasingly important. The Threatened Flora Seed Production Garden on Kangaroo Island is precisely the kind of activity that needs to be replicated and funded across the state in key areas, including islands. While such interventions would have once been seen as too expensive and radical, they should now be a major part of the state conservation strategy (see interventions 12 and 13).

10 **New biodiversity markets [Target 19]** are emerging, driven by business trying to offset their impacts under the framework of the Taskforce on Nature-related Financial Disclosures (in prep 2023). In theory this will drive companies to reduce their impacts and risks via the mitigation hierarchy and ultimately restore past losses. The first Australian state that makes the development of such markets easy and of exemplary quality, has a lot to gain.

11 Biodiversity in productive landscapes [Target 10] is going to become more important as the extinction debt kicks in (Bradshaw, 2018). Education, extension and low-cost incentive and reward schemes to help landowners to create vegetation corridors (more than a single tree wide, with shrubs) and to protect and restore scattered paddock trees is important for reducing local extinctions in the isolated areas of natural vegetation that characterise the agricultural districts of South Australia. This can be expensive work, so the state and landscape boards and eNGOs need to focus on how to increase cost-effectiveness and reward innovative landowner behaviour. Private land offers many opportunities to create novel ecosystems and spread risk.

12 Creating novel ecosystems for specific biodiversity outcomes [Target 2 and 4]. Conservation is typically an extremely conservative endeavour, especially in Australia. In Europe and North America many organisations create ecosystems to deliver biodiversity gains, often for specific threatened species, rather than restoring habitat to their "pre-European" state. Modifying rice field management for Australasian Bitterns is an example in Australia. Many degraded lands, especially where fundamental ecosystem processes such as ground-water and fire regimes cannot be restored, need to be considered from a less conservative perspective.

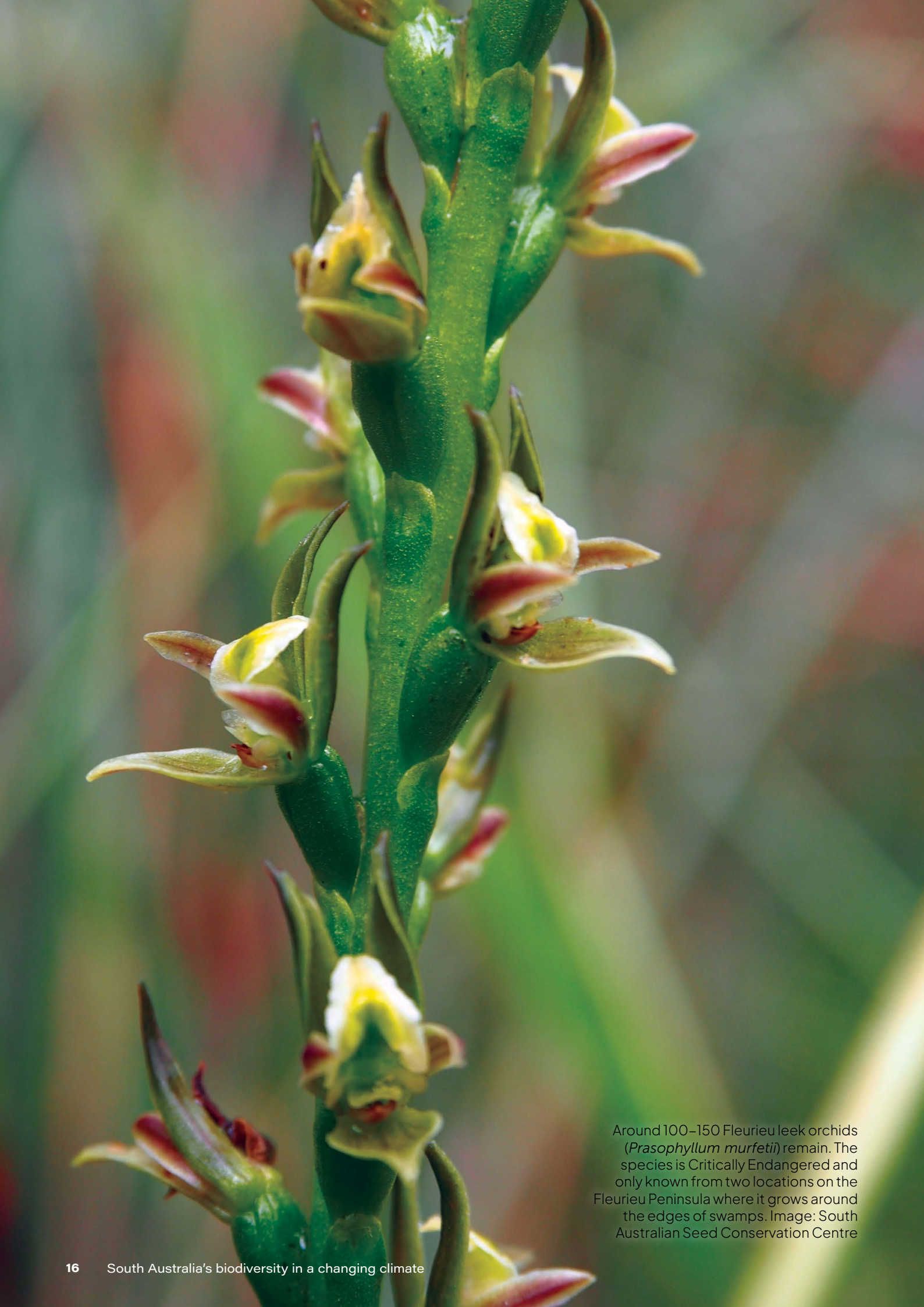
13 Assisted migration and rewilding involves the re-introduction and/or introduction of species, often mammals, to restore ecosystem function. These actions, such as the introduction of mammals to Wilpena Pound and the tip of York Peninsula, are important interventions. Ideally, they are done in climate resilient landscapes and in private public partnerships. Climate change downscaling models will assist with area selection, but the southern coastline, islands, and areas of high topographic variability are logical starting points. There can be perverse impacts of rewilding and assisted migration with vertebrates, especially mammals, where they can threaten invertebrates or plants such as terrestrial orchids. Hence, long-term monitoring tied to action triggers is essential (e.g. if a threatened terrestrial orchid declines precipitously there needs to be a rapid response).

14 Creating heat (climate) resistant species is a controversial climate adaptation action (and even more controversial option is developing heat and drought resistance through genetic modification). This sort of intervention is expensive and unproven in natural ecosystems (although successful in agriculture). It is being explored and tested in locations around the world, but we rule it out for now given the very low expected return-on-investment. If local universities that are world-leaders in the science wish to embark on such work, they should be supported with permits but not finances.

15 Direct climate intervention, such as cloud brightening, is a local or regional scale intervention. It is expensive and has not been tested at scale. As with opportunity 13 and 14, South Australia's response should be to watch and learn from the Reef Restoration and Adaptation program being delivered by the Great Barrier Reef Marine Park Authority and the Australian Institute of Marine Science. I ignore global geo-engineering solutions to climate change as they will occur at a national and/or international scale.

Critically Endangered Iron-grass Natural Temperate Grassland of South Australia, Karinya Reserve, SA. Image: Alan Dandie CC BY-NC/iNaturalist

The Endangered Adelaide pygmy blue-tongue skink (*Tiliqua adelaidensis*). Image: Antoni Camozzato CC BY-NC/iNaturalist



Around 100–150 Fleurieu leek orchids (*Prasophyllum murfetii*) remain. The species is Critically Endangered and only known from two locations on the Fleurieu Peninsula where it grows around the edges of swamps. Image: South Australian Seed Conservation Centre

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Appendix 1. Convention on Biological Diversity Targets

1. Reducing threats to biodiversity

TARGET 1

Ensure that all areas are under participatory, integrated and biodiversity-inclusive spatial planning and/or effective management processes addressing land- and sea use change, to bring the loss of areas of high biodiversity importance, including ecosystems of high ecological integrity, close to zero by 2030, while respecting the rights of indigenous peoples and local communities.

TARGET 2

Ensure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and marine and coastal ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity.

TARGET 3

Ensure and enable that by 2030 at least 30 per cent of terrestrial and inland water areas, and of marine and coastal areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures, recognising indigenous and traditional territories, where applicable, and integrated into wider landscapes, seascapes and the ocean, while ensuring that any sustainable use, where appropriate in such areas, is fully consistent with conservation outcomes, recognising and respecting the rights of indigenous peoples and local communities, including over their traditional territories.

TARGET 4

Ensure urgent management actions to halt human-induced extinction of known threatened species and for the recovery and conservation of species, in particular threatened species, to significantly reduce extinction risk, as well as to maintain and restore the genetic diversity within and between populations of native, wild and domesticated species to maintain their adaptive potential, including through in situ and ex situ conservation and sustainable management practices, and effectively manage human-wildlife interactions to minimise human-wildlife conflict for co-existence.

TARGET 5

Ensure that the use, harvesting and trade of wild species is sustainable, safe and legal, preventing overexploitation, minimising impacts on non-target species and ecosystems, and reducing the risk of pathogen spillover, applying the ecosystem approach, while respecting and protecting customary sustainable use by indigenous peoples and local communities.

TARGET 6

Eliminate, minimise, reduce and/or mitigate the impacts of invasive alien species on biodiversity and ecosystem services by identifying and managing pathways of the introduction of alien species, preventing the introduction and establishment of priority invasive alien species, reducing the rates of introduction and establishment of other known or potential invasive alien species by at least 50 per cent by 2030, and eradicating or controlling invasive alien species, especially in priority sites, such as islands.

TARGET 7

Reduce pollution risks and the negative impact of pollution from all sources by 2030, to levels that are not harmful to biodiversity and ecosystem functions and services, considering cumulative effects, including: (a) by reducing excess nutrients lost to the environment by at least half, including through more efficient nutrient cycling and use; (b) by reducing the overall risk from pesticides and highly hazardous chemicals by at least half, including through integrated pest management, based on science, taking into account food security and livelihoods; and (c) by preventing, reducing, and working towards eliminating plastic pollution.

TARGET 8

Minimise the impact of climate change and ocean acidification on biodiversity and increase its

resilience through mitigation, adaptation, and disaster risk reduction actions, including through nature-based solutions and/or ecosystem-based approaches, while minimising negative and fostering positive impacts of climate action on biodiversity.

2. Meeting people's needs through sustainable use and benefit-sharing

TARGET 9

Ensure that the management and use of wild species are sustainable, thereby providing social, economic and environmental benefits for people, especially those in vulnerable situations and those most dependent on biodiversity, including through sustainable biodiversity-based activities, products and services that enhance biodiversity, and protecting and encouraging customary sustainable use by indigenous peoples and local communities.

TARGET 10

Ensure that areas under agriculture, aquaculture, fisheries and forestry are managed sustainably, in particular through the sustainable use of biodiversity, including through a substantial increase of the application of biodiversity friendly practices, such as sustainable intensification, agroecological and other innovative approaches, contributing to the resilience and long-term efficiency and productivity of these production systems, and to food security, conserving and restoring biodiversity and maintaining nature's contributions to people, including ecosystem functions and services.

TARGET 11

Restore, maintain and enhance nature's contributions to people, including ecosystem functions and services, such as the regulation of air, water and climate, soil health, pollination and reduction of disease risk, as well as protection from natural hazards and disasters, through nature-based solutions and/or ecosystem-based approaches for the benefit of all people and nature.

TARGET 12

Significantly increase the area and quality, and connectivity of, access to, and benefits from green and blue spaces in urban and densely populated areas sustainably, by mainstreaming the conservation and sustainable use of biodiversity, and ensure biodiversity-inclusive urban planning, enhancing native biodiversity, ecological connectivity and integrity, and improving human health and well-being and connection to nature, and contributing to inclusive and sustainable urbanization and to the provision of ecosystem functions and services.

TARGET 13

Take effective legal, policy, administrative and capacity-building measures at all levels, as appropriate, to ensure the fair and equitable sharing of benefits that arise from the utilization of genetic resources and from digital sequence information on genetic resources, as well as traditional knowledge associated with genetic resources, and facilitating appropriate access to genetic resources, and by 2030, facilitating a significant increase of the benefits shared, in accordance with applicable international access and benefit-sharing instruments.

3. Tools and solutions for implementation and mainstreaming

TARGET 14

Ensure the full integration of biodiversity and its multiple values into policies, regulations, planning and development processes, poverty eradication strategies, strategic environmental assessments, environmental impact assessments and, as appropriate, national accounting, within and across all levels of government and across all sectors, in particular those with significant impacts on biodiversity, progressively aligning all relevant public and private activities, and fiscal and financial flows with the goals and targets of this framework.

TARGET 15

Take legal, administrative or policy measures to encourage and enable business, and in particular to ensure that large and transnational companies and financial institutions:

(a) Regularly monitor, assess, and transparently disclose their risks, dependencies and impacts on biodiversity, including with requirements for all large as well as transnational companies and financial institutions along their operations, supply and value chains, and portfolios;

(b) Provide information needed to consumers to promote sustainable consumption patterns;

(c) Report on compliance with access and benefit-sharing regulations and measures, as applicable;

in order to progressively reduce negative impacts on biodiversity, increase positive impacts, reduce biodiversity-related risks to business and financial institutions, and promote actions to ensure sustainable patterns of production.

TARGET 16

Ensure that people are encouraged and enabled to make sustainable consumption choices, including by establishing supportive policy, legislative or regulatory frameworks, improving education and access to relevant and accurate information and alternatives, and by 2030, reduce the global footprint of consumption in an equitable manner, including through halving global food waste, significantly reducing overconsumption and substantially reducing waste generation, in order for all people to live well in harmony with Mother Earth.

TARGET 17

Establish, strengthen capacity for, and implement in all countries, biosafety measures as set out in Article 8(g) of the Convention on Biological Diversity and measures for the handling of biotechnology and distribution of its benefits as set out in Article 19 of the Convention.

TARGET 18

Identify by 2025, and eliminate, phase out or reform incentives, including subsidies, harmful for biodiversity, in a proportionate, just, fair, effective and equitable way, while substantially and progressively reducing them by at least $500 billion per year by 2030, starting with the most harmful incentives, and scale up positive incentives for the conservation and sustainable use of biodiversity.

TARGET 19

Substantially and progressively increase the level of financial resources from all sources, in an effective, timely and easily accessible manner, including domestic, international, public and private resources, in accordance with Article 20 of the Convention, to implement national biodiversity strategies and action plans, mobilising at least $200 billion per year by 2030, including by:

(a) Increasing total biodiversity related international financial resources from developed countries, including official development assistance, and from countries that voluntarily assume obligations of developed country Parties, to developing countries, in particular the least developed countries and small island developing States, as well as countries with economies in transition, to at least $20 billion per year by 2025, and to at least $30 billion per year by 2030;

(b) Significantly increasing domestic resource mobilisation, facilitated by the preparation and implementation of national biodiversity finance plans or similar instruments according to national needs, priorities and circumstances;

(c) Leveraging private finance, promoting blended finance, implementing strategies for raising new and additional resources, and encouraging the private sector to invest in biodiversity, including through impact funds and other instruments;

(d) Stimulating innovative schemes such as payment for ecosystem services, green bonds, biodiversity offsets and credits, and benefit-sharing mechanisms, with environmental and social safeguards;

(e) Optimising co-benefits and synergies of finance targeting the biodiversity and climate crises;

(f) Enhancing the role of collective actions, including by indigenous peoples and local communities, Mother Earth centric actions [1] and non-market-based approaches including community based natural resource management and civil society cooperation and solidarity aimed at the conservation of biodiversity;

(g) Enhancing the effectiveness, efficiency and transparency of resource provision and use;

TARGET 20

Strengthen capacity-building and development, access to and transfer of technology, and promote development of and access to innovation and technical and scientific cooperation, including through South South, North-South and triangular cooperation, to meet the needs for effective implementation, particularly in developing countries, fostering joint technology development and joint scientific research programmes for the

1 Mother Earth Centric Actions: Ecocentric and rights-based approach enabling the implementation of actions towards harmonic and complementary relationships between peoples and nature, promoting the continuity of all living beings and their communities and ensuring the non-commodification of environmental functions of Mother Earth.

conservation and sustainable use of biodiversity and strengthening scientific research and monitoring capacities, commensurate with the ambition of the goals and targets of the Framework.

TARGET 21

Ensure that the best available data, information and knowledge are accessible to decision makers, practitioners and the public to guide effective and equitable governance, integrated and participatory management of biodiversity, and to strengthen communication, awareness-raising, education, monitoring, research and knowledge management and, also in this context, traditional knowledge, innovations, practices and technologies of indigenous peoples and local communities should only be accessed with their free, prior and informed consent, [2] in accordance with national legislation.

TARGET 22

Ensure the full, equitable, inclusive, effective and gender-responsive representation and participation in decision-making, and access to justice and information related to biodiversity by indigenous peoples and local communities, respecting their cultures and their rights over lands, territories, resources, and traditional knowledge, as well as by women and girls, children and youth, and persons with disabilities and ensure the full protection of environmental human rights defenders.

TARGET 23

Ensure gender equality in the implementation of the Framework through a gender-responsive approach, where all women and girls have equal opportunity and capacity to contribute to the three objectives of the Convention, including by recognising their equal rights and access to land and natural resources and their full, equitable, meaningful and informed participation and leadership at all levels of action, engagement, policy and decision-making related to biodiversity.

2 Free, prior and informed consent refers to the tripartite terminology of "prior and informed consent" or "free, prior and informed consent" or "approval and involvement.

Appendix 2. Possingham conflicts of interest

Conflict of Interest Data: Hugh Possingham (September 2023)		
Paid jobs	**Role**	**Hours per week**
University of QLD	VC research fellow	15
Accounting for Nature	Chief Scientist	4
Biodiversity Council	co-chair	5
IRRG - AIMS Reef	Member	3
SA Native Veg Council	Member	1.8
Unpaid Committees and roles		
Australian Research Council	Reviewer	0.2
Archerfield Wetlands	Committee	0.05
Australian Academy of Science	Committees	0.2
BCEC	Advocate	0.2
BirdLife board – VP	Vice-President	2
BirdLife Community subcommittee	Chair	0.2
BirdLife Finance subcommittee	Member	0.2
BirdLife RACC subcommittee	Member	0.4
Cons Lettters Editorial board	Member	0.5
Conference - AOC	Chair	3
Conference - ICCB	Chair	1
Conservation International	Member	1
eBird	Committee	0.05
EDIC	Member	0.3
Environment Institute Board - University of Adelaide	Chair	1
Eureka Prize selection	Member	0.1
Fishpath (TNC)	Committee	0.1
FOOCC	President	1
FOSA - Patron	Patron	0.5
Healthy Land and Water	Committee	0
Hidden Vale	Member	1
Marxan	Chair	0.1
MLR bird survey	Member	0.5

Unpaid Committees and roles continued		Hours per week
Nature positive CRC	Advisory Committee	0.4
Nature Prize (Netherlands)	Committee	0.2
Offset committee	Chair	0
Paper reviewer, many journals	Reviewer	2
PNAS Editorial board	Member	0.5
QLD Trust for Nature	Committee, Advisor	0.2
TERN board	Chair	1
Nature Festival birder in residence	Birder	2
Nature Positive CRC	Advisory Committee	1
Oxford Universty	Senior Research Associate	0.1
TSX advisory committee	Chair	0.2
Untamed Planet	Advisor	1
Random talks (arguably UQ woek)	1 a fortnight	2
Community Bird Walks	1–2 a month	2
Regular donor to ($1000 (small) to $100,000 (large) per annum)		
The University of Adelaide	Large	
BirdLife Australia	Medium	
Nature Glenelg Trust	Medium	
Trees for Life, SA	Small	
Nature Conservation Society, SA	Small	
The Nature Foundation	Small	
Past donor and advisor to many more eNGOs		
Investments		
Own house in Brisbane		
UniSuper		
Investment house in Canberra		
Investment house in Adelaide (spouse)		
NAB savings account		
Electric Car, Kona		

Biodiversity Council

The Biodiversity Council brings together leading experts including Indigenous Knowledge holders to promote evidence-based solutions to Australia's biodiversity crisis. It was founded by 11 universities: The University of Melbourne, The University of Western Australia, The Australian National University, The University of Adelaide, The University of Sydney, The University of Queensland, Deakin University, The University of Canberra, Monash University, Macquarie University, and The University of New South Wales. It is host by The University of Melbourne. It receives support from The Ian Potter Foundation, The Ross Trust, Trawalla Foundation, The Rendere Trust, Isaacson Davis Foundation, Coniston Charitable Trust and Angela Whitbread.

Image: Flinders Rangers by Stephen Mabbs/Unsplash