PROJECT PHOENIX

SUCCESSFUL INTERNATIONAL RESTORATION SYSTEMS

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Project Phoenix
Greening Australia (National Office)
Level 3, 349 Collins Street
Melbourne VIC 3000
Tel: 1300 886 589
Email: phoenix@greeningaustralia.org.au
Website: www.greeningaustralia.org.au

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Author: Dr Lucy E. Commander, Project Manager, *Florabank Guidelines*, Australian Network for Plant Conservation

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Australian Government

Across all of our Project Phoenix activities and actions we pay respect to the Traditional Owners and Custodians of the lands and waters on which we work. We honour the resilience and continuing connection to country, culture and community of all Aboriginal and Torres Strait Islander people across Australia. We recognise the decisions we make today will impact the lives of generations to come.

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EXECUTIVE SUMMARY

Scope

A review of existing systems across other sovereign nations will be undertaken to identify if there are suitable models that may guide the development of a viable national restoration program.

Introduction

As Australia begins to recover from the catastrophic fires in 2019/2020, as well as drought and floods, we have much to learn about how to better restore our environment to ensure it is resilient to climatic events such as fire, floods and temperature extremes, and how to increase our capacity to plan, implement and sustain restoration.

The economic benefits of nature-based solutions to environmental problems are in the order of thousands to millions of dollars per year, hence we need to value and invest in our natural capital.

This review outlines international climate change and biodiversity agreements, the economics of restoration, and case studies of restoration programs across the globe. Recommendations for a future national restoration program in Australia are proposed.

Issues

Few issues were encountered in the development of this report. However, there are a couple of limitations to the report. Firstly, the short timeline precluded any collaboration with other authors. Secondly, while case studies are sourced from all continents except Antarctica, there was not an opportunity to investigate national restoration programs in all countries of the world.

Comment

Each of the countries in this report are at a different stage of their restoration journey. Some are still in the planning phase, while others have decades of experience. Some have experienced much success, whereas others have achieved comparatively little so far. There are also different socioeconomic conditions, different drivers and motivations for restoration (both at a government level and an individual level), different types of funding available and different levels of capacity. But one constant remains: nature is essential for human wellbeing, as well as having intrinsic value.

Outcomes

DRAFT OUTCOME STATEMENT*	TARGET/ MEASURABLES	MONITORING INDICATORS	ACTIVITIES/ METHODOLOGY ACTIVITIES/ METHODOLOGY
Targeted outputs should be major deliverables only	**Outcome and/or output targets**	**Outcome and/or output targets** **Quantifiable or milestone/time bound**	
Priority 2.15			
By 30 June 2021, identifying international policy models and Australia's international agreements that incentivise the seed and restoration sectors	Identifying successful international economic models to support restoration programs in Australia May lead to an economic stimulus package	Report produced	Review existing systems across other sovereign nations to guide development of a suitable national restoration program within Australia

* Note: Outcome statements may be targeted outputs where change cannot be realistically achieved during project period (e.g. target may inform future change).

Findings

Two key findings from this review are:

- Put a value on ecosystem products and services to help value restoration. This can be done through natural capital accounting.
- Invest in capacity to implement a National Restoration Program which complies with international agreements and increases the value of Australia's natural capital. This program should include:
  - establishment of leadership and coordination
  - assessment of current vegetation condition
  - spatial planning and prioritisation for restoration (a variety of economic tools and models are available)
  - identification of sources of funding
  - production of national guidelines for restoration of each biome including an outline of appropriate restoration approaches and
  - capacity building to enable restoration implementation.

Evidence

The data sources include:

- peer-reviewed literature from journals
- reports
  - e.g. *The Economics of Biodiversity: The Dasgupta Review* (Dasgupta 2021)
  - *Enabling Factors to Scale Up Forest Landscape Restoration: The Roles of Governance and Economics Full Report with Case Studies* (Mansourian 2020)
  - *The Economics of Ecosystems and Biodiversity for National and International Policy Makers — Summary: Responding to the Value of Nature* (TEEB 2009)
- online newspaper articles
- national guidelines
- books
- international agreements
- international strategy documents
  - e.g. *National Seed Strategy for Rehabilitation and Restoration (USA)* (Plant Conservation Alliance 2015b)
- websites

See the key websites, references, additional reading and endnotes.

Recommendations

Without sound economic models, restoration projects may not receive adequate funding. This lack of funding could lead to projects not being seen to completion (e.g. no follow up planting), cost-cutting measures leading to restoration failures (e.g. if fencing is not installed and grazing animals destroy planted seedlings, or lack of site preparation), lack of follow up care and maintenance (e.g. ongoing weeding), no long-term monitoring and reporting to determine success or otherwise.

Economic factors that will need to be included in, contribute to, or considered in future restoration programs include the following.

Direct and indirect costs of restoration

- Cost of establishing a restoration network or national body
- Cost of restoration and land use planning
- Cost of ecosystem assessments, both on ground and remote sensing
- Cost of seed collection and seedling production including research into propagation
- Cost of implementation, e.g. weeding, fencing, planting

- Cost of maintenance, monitoring and reporting
- Cost of infrastructure including nurseries and seed stores
- Cost of training programs and communication strategies
- Cost of establishing field trials and demonstration sites
- Opportunity costs — if land is restored, it can't be used for other purposes such as housing
- Payments for ecosystem services

Funding sources

- Federal, state and local government
- Private donors
- Carbon offset schemes
- Taxes, levies, tax exemptions, soft loans, micro-credit
- Matching schemes — matching government and private funding, or matching funding with in-kind support
- Public-private partnerships
- International funding
- International NGOs
- Nature-based tourism
- Combining funding from several government agencies or several private organisations
- Fiscal stimulus packages addressing the impact of COVID-19
- Aligning restoration with other government priorities

Natural capital accounting

For example, the United Nation's (UN) System of Environmental Economic Accounting[1] (SEEA)), which calculates stocks and flows of natural resources, can:

- Measure the condition of environmental assets (i.e. natural capital)
- Demonstrate improvements in condition and show trends over time
- Compare the relative condition of different assets
- Aggregate information at different scales (regional, state, national)
- Produce an asset table

[1] https://seea.un.org/ecosystem-accounting

- Prove sustainability claims to consumers and investors to open new markets and funding opportunities, e.g. access to premiums for products, or access to investors selecting sustainable investments
- Prove that investment or funding has had an environmental impact
- Lead to performance-based grant funding

Restoration benefits

- Creation of local jobs through restoration industry and tourism industry
- Creation of jobs for Indigenous Australians
- Increased availability of native plant species for the general public to purchase through native nurseries
- Improved ecosystem services
- Increased availability of ecosystem products (e.g. fisheries, forest products)
- Lower government and insurance payouts due to reduction in impact of extreme weather events
- Prevention of species extinctions
- Improved agricultural yields

Socioeconomic factors to take into account

- Population pressure
- Off-farm economy (e.g. secondary and tertiary industry)
- Rural economy (e.g. grain yield, area of arable land)
- Landowner aspirations
- Capital and resource flows
- Socioecological resilience
- End-user objectives
- Market volatility, risk and contract structure

ACRONYMS

ASBP	Australian Seed Bank Partnership
BGCI	Botanic Gardens Conservation International
BGCI	Botanic Gardens Conservation International
BIOFIN	Global Biodiversity Finance Initiative
BLM	Bureau of Land Management
CBD	Convention on Biological Diversity
CEN	Conservatoire d'Espaces Naturels de Nouvelle-Calédonie
COP	Conference of the Parties
E-NGP	Enhanced National Greening Program
EU	European Union
FAO	Food and Agriculture Organisation of the UN
FBER	Finnish Board on Ecological Restoration
FC	Forest Code
FLRA	Forest Landscape Restoration Act
FMNR	Farmer-managed natural regeneration
GIMMS	Global Inventory Modelling and Mapping Studies
GP	Gorongosa Project
INSR	International Network for Seed-based Restoration
InVest	Integrated Valuation of Ecosystem Services and Trade-offs
IUCN	International Union for Conservation of Nature
METSO	Forest Biodiversity Programme for Southern Finland
MODIS	Moderate Resolution Imaging and Spectroradiometer
MSBP	Millennium Seed Bank Partnership
MSBP	Millennium Seed Bank Project
NbS	Nature Based Solutions

NBSAPs	National Biodiversity Strategies and Action Plans
NDCs	Nationally Determined Contributions
NDVI	normalised difference vegetation index
NERP	National Emission Reduction Plan
NGP	National Greening Program
PATSPO	Provision of Adequate Tree Seed Portfolio
PLANAVEG	National Plan for Recovering Native Vegetation
RAMPS	Restoration Assessment and Monitoring Program for the Southwest
RBG Kew	Royal Botanic Gardens Kew
RNGR	National Reforestation, Nurseries, and Genetic Resources Program
ROOT	Restoration Opportunities Optimisation Tool
SEEA	System of Environmental and Economic Accounts
SER	Society for Ecological Restoration
SOS	Seeds of Success
STEP	Subtropical Thicket Ecosystem Planning
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
UNCC	United Nations Compensation Commission
UNCDD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Program
UNFCC	United Nations Framework Convention on Climate Change
WWF	World Wildlife Fund

INTRODUCTION

Land use change can result in altered fire regimes, reduced runoff and increased infiltration, reduced transpiration, heat islands, reduction in population size of wildlife, as well as species extinctions.

Therefore restoration is required to restore both biodiversity and ecosystem services.

As Australia begins to recover from the catastrophic fires in 2019–20, in addition to drought and floods, we have much to learn about how to better restore our environment to ensure it is resilient to climatic events such as fire, floods and temperature extremes, and how to increase our capacity to plan, implement and sustain restoration.

Valuing our natural capital and ensuring that it is able to provide ecosystem services will be essential to the recovery effort, as economic benefits of nature-based solutions to environmental problems are in the order of thousands to millions of dollars per year (Dasgupta 2021; TEEB 2009).

Increasing native seed and plant supply in preparation for the restoration of bushfire-affected areas and conservation of other valuable habitat is the purpose of Project Phoenix, for which this review was written.

This review outlines international agreements designed to protect and restore biodiversity and combat climate change. It provides a summary of the economics of restoration, explaining how economic models can be used in decision making and measurement of natural capital, as well as how transformation of institutions and systems is required. Case studies from several continents across the world are outlined, each with a summary of the key findings. These key findings are synthesised, as are the policy models, restoration drivers, funding sources and key areas of policy implementation. Finally, recommendations for economic investment to implement a future national restoration program in Australia are proposed.

METHODOLOGY

This report is a literature review. Information for this report was collated by assessing the international peer review literature using Google and Google Scholar, using the search terms 'national and restoration and program', 'restoration and seed', 'native seed industry', 'large-scale restoration', 'economics of restoration'. A search was performed within the author's personal EndNote Library.

Key findings, and how this information could be used within a 10-year restoration strategy is boxed throughout the review, and summarised in the final section.

INTERNATIONAL AGREEMENTS

International agreements are a driving force which can inform a country's strategy for restoration. International agreements involve multiple countries coming together to commit to change. Several of these agreements have influenced national policies and actions, as nations honour their contributions.

In 1992, at the UN Conference on Environment and Development in Rio de Janeiro, Brazil, three international agreements were opened for signature: the UN Convention on Biological Diversity; the UN Convention to Combat Desertification; and the UN Framework Convention on Climate Change.

UN Convention on Biological Diversity (CBD)

The Convention on Biological Diversity (CBD) is a multilateral environmental agreement. The objectives of the Convention are 'the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding'.[2]

The concept of the Convention was conceived by the UN Environment Program in 1998.[3] In 1992, the Conference for the Adoption of the Convention on Biological Diversity was held in Nairobi, Kenya, and the CBD opened for signatures.

[2] https://www.cbd.int/convention/articles/?a=cbd-01
[3] https://www.cbd.int/history/

The Convention is governed by the Conference of the Parties (COP), which includes all governments that have ratified the agreement, and has met annually between 1994 and 1996, then biennially thereafter. The CBD has developed a number of protocols and plans at these conferences. Some key conferences are listed below:

- 1994, COP1 in Nassau, Bahamas
  - First meeting of the parties to the convention
- 1999, EX-COP1, in Cartagena, Colombia
  - Resulted in 'Cartagena Protocol' on Biosafety in 2000. The Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology.
- 2002, COP6 in The Hague, Netherlands
  - 'Global Strategy for Plant Conservation' developed
- 2010, COP10 in Nagoya, Aichi Prefecture, Japan
  - 'Nagoya Protocol' (Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation to the Convention on Biological Diversity)
  - revised and updated Strategic Plan for Biodiversity, 2011–2020 including the 'Aichi Biodiversity Targets', comprising 20 targets addressing five strategic goals (Appendix 1).
  - 2011–2020 was declared as the UN Decade on Biodiversity
- 2014, COP12 in Pyeongchang, Republic of Korea
  - 'Pyeongchang Road Map'

One of the most relevant targets for restoration within the Aichi Biodiversity Targets is Target 15, which aims for 'restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification'.

Target 17 of the Aichi Biodiversity Targets (Appendix 1) requires parties to translate the revised and updated Strategic Plan for Biodiversity, into National Biodiversity Strategies and Action Plans (NBSAPs) within two years.[4] So far, 192 out of 196 parties have developed at least one NBSAP, which incorporate national targets for each party.[5]

COP15 is scheduled to be held in Kunming, China, in October 2021.[6] On the agenda is a new set of goals for the next decade through the Convention on Biological Diversity post 2020 framework process.[7]

[4] https://www.cbd.int/sp/
[5] https://www.cbd.int/nbsap/targets/
[6] https://www.unep.org/events/conference/un-biodiversity-conference-cop-15
[7] https://www.cbd.int/article/zero-draft-update-august-2020

UN Framework Convention on Climate Change (UNFCC)

The UN Framework Convention on Climate Change (UNFCC) is an international treaty addressing climate change. It was adopted in 1992, came into force in 1994, and has been ratified by 197 countries. As with the CBD, the parties meet at Conferences of the Parties. Key dates are as follows:

- 1997, COP3 in Kyoto, Japan
  - Kyoto Protocol[8] was adopted in 1997, entered into force in 2005, and outlines greenhouse gas emission reduction obligations
- 2012, COP18 in Doha, Qatar
  - Doha Amendment to the Kyoto protocol
- 2015, COP21 in Paris France
  - Paris Agreement

The Paris Agreement was adopted in 2015, with the goal to limit global warming, preferably to 1.5°C.[9] Countries each submit their plans for action, which are known as Nationally Determined Contributions (NDCs).[10] These NDCs can take the form of reductions in greenhouse gas emissions, renewable energy targets, sustainable transport and conservation and sustainable management of forests.

UN Convention to Combat Desertification (UNCDD)

The UN Convention to Combat Desertification (UNCDD) is an international agreement to link the environment and development to sustainable land management.[11] The drylands, i.e. arid and semi-arid areas of the world, are its focus. To implement the Convention, programs are developed at national, regional and sub-regional levels.[12] There are programs in Africa, Asia, Latin America & the Caribbean, Mediterranean and Central & Eastern Europe. To address desertification, the UNCCD uses both strategies to avoid or reduce land degradation, as well as activities to reverse past degradation. Ecological restoration is a mechanism to reverse degradation.

KEY FINDINGS

- Restoration is an action that can contribute to all three Rio Conventions, although there are no UNCDD programs in Australia, despite the large arid and semi-arid area.
- All three conventions can inform an Australian restoration strategy.

[8] https://unfccc.int/kyoto_protocol
[9] The Paris Agreement | UNFCCC
[10] https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs/nationally-determined-contributions-ndcs
[11] https://www.unccd.int/convention/about-convention
[12] https://www.unccd.int/convention/action-programmes

International organisations

International organisations that disseminate information and funds, assess environment conditions, set goals and provide standards include:

- United Nations Environment Program (UNEP)[13]
  - United Nations Decade on Ecosystem Restoration 2021–2030 (UN Environment Programme 2020) [14]
  - United Nations Environment Program (UNEP Sustainable Development Goals[15]
- United Nations Development Program (UNDP)[16]
- EU-LIFE, an alliance of European research institutes[17]
- Society for Ecological Restoration (SER)[18]
  - International principles and standards for the practice of ecological restoration. Second edition (Gann *et al.* 2019)
  - SER position statement[19]
  - International Network for Seed-based Restoration (INSR)[20]
- Botanic Gardens Conservation International (BGCI)[21]
  - Global Tree Assessment[22]
- International Union for Conservation of Nature (IUCN)[23]
  - Bonn Challenge: a global goal to bring 150 million ha of degraded and deforested landscapes into restoration by 2020, and 350 million ha by 2030[24]
- Global Landscapes Forum: dedicated to achieving the Sustainable Development Goals and Paris Climate Agreement[25]
- The Nature Conservancy, Plant a Billion Trees campaign[26]
- The Economics of Ecosystems and Biodiversity (TEEB)[27]
- The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)[28]

[13] https://www.unep.org/
[14] https://www.decadeonrestoration.org/
[15] https://www.un.org/en/desa
[16] https://www.undp.org/
[17] Home | EU-LIFE (eu-life.eu)
[18] https://www.ser.org/
[19] https://6zvjw1i9d632in9ii1izgap9-wpengine.netdna-ssl.com/europe/files/2020/12/Feedback-BS2030-112020-final-SERE_EFIB_CIREF_REVER_REAEET_SPECO.pdf
[20] https://ser-insr.org/
[21] https://www.bgci.org/
[22] https://www.globaltreeassessment.org/
[23] https://www.iucn.org/
[24] https://www.bonnchallenge.org/; http://www.forestlandscaperestoration.org/topic/bonn-challenge
[25] https://www.globallandscapesforum.org/
[26] www.plantabillion.org
[27] http://teebweb.org/
[28] https://ipbes.net/about

AUSTRALIA'S INTERNATIONAL COMMITMENTS

Australia submitted a National Biodiversity Strategies and Action Plan (NBSAP) for the Aichi Biodiversity Target, titled 'Australia's Biodiversity Conservation Strategy 2010–2030' in 2010.[29] Australia's targets are:

1. By 2015, achieve a 25% increase in the number of Australians and public and private organisations who participate in biodiversity conservation activities
2. By 2015, achieve a 25% increase in employment and participation of Indigenous peoples in biodiversity conservation
3. By 2015, achieve a doubling of the value of complementary markets for ecosystem services
4. By 2015, achieve a national increase of 600,000 km^2 of native habitat managed primarily for biodiversity conservation across terrestrial, aquatic and marine environments
5. By 2015, 1,000 km^2 of fragmented landscapes and aquatic systems are being restored to improve ecological connectivity
6. By 2015, four collaborative continental-scale linkages are established and managed to improve ecological connectivity
7. By 2015, reduce by at least 10% the impacts of invasive species on threatened species and ecological communities in terrestrial, aquatic and marine environments
8. By 2015, nationally agreed science and knowledge priorities for biodiversity conservation are guiding research activities
9. By 2015, all jurisdictions will review relevant legislation, policies and programs to maximise alignment with Australia's Biodiversity Conservation Strategy
10. By 2015, establish a national long-term biodiversity monitoring and reporting system.

[29] https://www.cbd.int/doc/world/au/au-nbsap-v2-en.pdf; http://www.environment.gov.au/biodiversity/strategy

THE ECONOMICS OF RESTORATION

Economics is the study of the production, distribution and consumption of goods and services. 'Economic value' means that goods or services have worth (Robbins and Daniels 2012). 'Natural capital' describes the world's natural assets, which include rock, soil, air, water and biota. Nature provides products (e.g. timber) and services (or 'ecosystem services', e.g. nutrient cycling) which are often seen as 'free'. Because ecosystem services are not bought and sold in existing markets, it is hard to quantify the value of these services. The end result of nature not being valued sufficiently, and not taken into account in economic decision making, is biodiversity loss (Ring *et al.* 2010). This loss and degradation of nature has led to the need for increased protection and restoration of what we have left.

Unfortunately, restoration practitioners do not always make use of economic tools which can inform decision making in restoration projects, because practitioners lack understanding of the tools, and the language of economics is largely unintelligible to ecologists (Robbins and Daniels 2012). Methods of estimating the costs and benefits of restoration include hedonic method, travel cost method, contingent valuation, experimental choice, benefit transfer and cost methods. Decision making and prioritisation frameworks include financial analysis benefit-cost analysis, cost-effectiveness analysis and multi-criteria analysis (Robbins and Daniels 2012).

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative to make nature's products and services visible.[30] Its approach has three principles: recognising, demonstrating, and capturing the value of nature.[31]

The task of quantifying multiple ecosystem services can be challenging. While some ecosystem services increase along with others (e.g. an increase in carbon storage may improve climate regulation), for others there is a trade-off (production of crops may negatively affect biodiversity) (Ring *et al.* 2010).

However, estimated values of ecosystem services can be substantial, such as in wetlands in Sri Lanka, the value of flood mitigation was US$1,907 ha^{-1} yr^{-1} and for wastewater treatment was US$654 ha^{-1} yr^{-1} (cited in TEEB 2009). Increased pollination in Costa Rica resulting from close proximity to forests is estimated to be US$395 ha^{-1} yr^{-1} (cited in TEEB 2009). TEEB has an economic model and a toolkit for decision making, as well as publications for policy makers.[32]

[30] http://teebweb.org/
[31] http://teebweb.org/about/approach/
[32] http://teebweb.org/publications/

TEEB recommends the following solutions for better stewardship of natural capital (TEEB 2009):

- Rewarding benefits through payments and markets (e.g. payments for ecosystem services, restoration, conservation, and certification, standards and labelling for reducing impacts on natural capital from supply chains)
- Reforming environmentally harmful subsidies
- Addressing losses through regulation and pricing
- Adding value through protected areas
- Investing in ecological infrastructure to maintain ecosystem function (such as water purification, waste water treatment, flood control, reducing storm impact) through maintenance and conservation as well as restoration

In a recent review on the economics of biodiversity[33] (Dasgupta 2021), the author makes three key recommendations:

1. Ensure demands on nature do not exceed supply, and increase nature's supply

The review recommends conservation and restoration of natural assets. Conservation is less costly than restoration, and hence more investment in Protected Areas is required. Restoration can address the imbalance between increasing demand and decreasing supply. Nature-based Solutions (NbS), or ecological solutions, are actions to 'protect, sustainably manage and restore natural or modified ecosystems while simultaneously providing benefits for human well-being and biodiversity'. Examples of NbS include coastal restoration to reduce flooding and storm surge risk, and riparian restoration to reduce the urban heat-island effect and provide recreation areas. NbS can often be more cost effective than engineering solutions. Economic benefits of NbS have found to be of €1,400 ± 600 ha^{-1} yr^{-1} in Europe and US$6.1–48.9 million in Fiji.

The author calls for fiscal stimulus packages addressing the impact of COVID-19 to invest in natural capital. He highlights that in addition to addressing biodiversity loss, this investment can help mitigate climate change and have economic benefits such as job creation. In fact, investing in NbS jobs can result in high employment returns than other sectors. Other investments could include agri-environment schemes and payments for ecosystem services, whereby farmers are provided with incentives to adopt farming practices that support biodiversity and ecosystem services.

Spatial planning, too, needs to take nature into account. Hence, planning frameworks should integrate economic, social and environmental considerations. Various models exist, such as the Integrated Valuation of Ecosystem Services and Trade-offs (InVest) and the Restoration Opportunities Optimisation Tool (ROOT) which quantify trade-offs between management decisions.

[33] The Economics of Biodiversity: The Dasgupta Review – GOV.UK (www.gov.uk)

2. Change our measures of economic success

A current measure of economic activity is Gross Domestic Product (GDP), but this does not incorporate depreciation of natural assets. Wealth should be the sum of produced capital, human capital and natural capital. Hence, wealth measurement should include a measure of natural capital. Natural capital accounting is an emerging concept and models need development. The UN's System of Environmental Economic Accounting[34] (SEEA) is a system through which a framework for natural capital accounting can be developed. In Australia, Accounting for Nature has developed framework compatible with SEEA.[35]

Governments can identify their expenditure on conservation and restoration, as well as expenditure which adversely affects natural capital. One approach to undertake this is the use of the United Nations Development Programme's (UNDP) Global Biodiversity Finance Initiative (BIOFIN).

3. Transform institutions and systems to enable these changes

The institutions that require changing are the protection of public goods, the financial system and education.

The author recommends institutions that pool knowledge across a global, regional, national and local level, and from organisations, communities and individuals, to allow for collaborative planning. This pooling of knowledge is enabled through institutions that are neither top down nor bottom up, they are 'polycentric' and 'layered'.

The author also calls for international payment arrangements to direct funding to biomes within and outside nations on which the world relies (e.g. tropical rainforests, river basins, oceans), termed 'global public goods'. Hence, if Australian ecosystems are relied upon internationally (e.g. as carbon sinks) then Australia could be eligible for international payments.

The review also encourages financial investment in economic activities that increase natural capital. Various tools available to governments to invest in nature include taxes, subsidies, regulations, prohibitions, offsets, debt forgiveness, grants and technical assistance. A set of global standards for business to integrate nature into decision making and nature-related financial risk assessment is also required.

[34] https://seea.un.org/ecosystem-accounting
[35] https://www.accountingfornature.org/

Finally, opportunities for people to understand and connect with nature are essential. Access to green space can increase contact and connectedness, as well as reducing health inequality due to socioeconomics. Environmental education programs are needed, and these should not cease at the end of primary school, but continue into high school and tertiary education. These opportunities will empower citizens to make change.

These three recommendations are summarised in Figure 1.

FIGURE 1. SUMMARY OF OPTIONS FOR CHANGE, TAKEN DIRECTLY FROM THE ECONOMICS OF BIODIVERSITY: THE DASGUPTA REVIEW (DASGUPTA 2021)

RESTORATION PROGRAMS ACROSS THE WORLD

Africa

The Great Green Wall — Senegal to Djibouti

The Great Green Wall is a project which aims to restore 100 million ha of land along 8,000 km across the African continent from Senegal in the west to Djibouti in the east.[36] The region has a semi-arid climate — to the north is the Sahara Desert and to the south are the humid savannas. Degradation has been caused by overgrazing, climate change and unsustainable farming practices. Initially, the project aimed for reforestation, but now the project has broader initiatives than simply planting trees; it aims to combat desertification, provide food, discourage migration, sequester carbon, create jobs and reduce conflict.

One of the first steps of the project was for each member country to develop a list of native tree species, based on ecological attributes and value to humans (Wade *et al.* 2018). In Ethiopia, the Provision of Adequate Tree Seed Portfolio (PATSPO) involves scientists and local communities identifying species which are locally adapted.

The project contributes to 15 of the 17 UN Sustainable Development Goals. Over 20 African countries are involved, the African Union, the Food and Agriculture Organisation of the UN (FAO), the UN Convention to Combat Desertification and several other international partners. Funding comes from a variety of sources including the World Bank,[37] Global Environment Facility, European Union, Food and Agriculture Organisation of the UN (FAO), International Union for Conservation of Nature (IUCN), and national budgets of participating countries.[38]

However, since the project's inception in 2007, it has only reached 16% of its goal.[39] Possible reasons for this slow progress include lack of local stakeholder engagement, poor species selection and no after-planting maintenance.

One challenge with species selection was that there is an absence of data on species performance to inform the restoration program (Wade *et al.* 2018). One study found that survival of planted trees after 24 months ranged from 0 to <40%, depending on the species, and highlighted the importance of field trials to provide data to inform species selection (Wade *et al.* 2018).

[36] https://www.greatgreenwall.org/
[37] https://www.greatgreenwall.org/news#resources
[38] https://catalogue.unccd.int/1551_GGW_Report_ENG_Final_040920.pdf
[39] https://www.sciencemag.org/news/2021/02/great-green-wall-could-save-africa-can-massive-forestry-effort-learn-past-mistakes

In Senegal, much of the land is grazed by livestock, so fencing to exclude livestock is not an appropriate restoration method in the project (Wade *et al.* 2018). However, a fenced field trial did have the benefit of enabling the study of natural recruitment potential, and show some recruitment of species with a soil seed bank, combined with adequate rainfall and, of course, an absence of grazing. This is the basis of the farmer-managed natural regeneration (FMNR) approach, in which farmers encourage recruitment from the soil seed bank, or resprouting plants, and has had some success in Niger.[39] In fact, trees can be of benefit to grazing lands (Wade *et al.* 2018).

KEY FINDINGS

- Landscape-scale and continent-wide restoration programs are highly ambitious, and have the potential to achieve great outcomes.
- However, while the plan may be big in scale, the individual actions still need to be tailored to the local context.
- Simply aiming to plant a lot of trees is not enough; the restoration plan needs to take into account appropriate species selection, financial considerations, landowner needs, climatic conditions and ongoing maintenance.
- While excluding grazing can facilitate natural regeneration, it may not be an option in locations where landowners derive their income from grazing animals. However, temporary fencing to initially exclude grazing animals while natural regeneration occurs and to protect planted seedings, then removing the fence when the ecosystem is resilient enough to cope with some level of grazing may be an option. Alternatively, exclusions could be implemented on a small scale for high-value species.
- Field trials should be undertaken to inform species selection and restoration approaches.

Mozambique

The Parque Nacional da Gorongosa in Mozambique[40] is a national park created in 1960 (Pringle 2017). The 3,700 km^2 area consists of savannas and woodlands that provide habitat to wildlife. The civil war (1977–1992) resulted in large scale losses of mammals in the park, as well as human fatalities and poverty.

[40] https://gorongosa.org/

In 2004, the Gorongosa Restoration Project was formed, and restoration of the park commenced. Then, in 2007, the project and the Government of Mozambique agreed to jointly manage the park, resulting in the Gorongosa Project (GP), and a science-based management approach was mandated.

Not only does the project aim to return wildlife and help post-war recovery, but also to assist economic development and give back to the local community. Park employees are recruited from local communities, and the project funds health professionals to vaccinate children and treat malaria. The project provides assistance to agricultural and agroforestry smallholders, and university scholarships. The park's budget is provided by donors, but in the future, it plans to work towards funding through nature-based tourism. This project shows that despite becoming a degraded area, the national park was restored, expanded, and integrated into the local communities.

Pringle (2017), through analysing GP as well as a protected area in Costa Rica, developed 'eight pillars of upgrading protected areas':

- Protect remaining natural areas and use natural regeneration.
- Upsize and connect restored areas.
- Projects need to be long-term (multi-decadal) and local.
- Pay the opportunity costs, for instance through increasing tourism, sharing revenue, sourcing locally.
- Develop creative financial strategies, e.g. through public-private partnerships, philanthropic donations or tourism.
- Develop an inventory of biodiversity.
- Be adaptable.
- Involve young people through education programs, which results in a bio-literate community.

KEY FINDINGS

Criteria for selecting areas for restoration include those that are:

- degraded, but retain enough potential to regenerate;
- in landscapes that have room for expansion through land acquisition;
- poorly financed or managed, but managed by owners with the incentive to invest in restoration.

South Africa

The Subtropical Thicket Biome surrounds Port Elizabeth, on the southern coast of South Africa (Pierce *et al.* 2005; Rouget *et al.* 2006). The biome is threatened by agriculture, urbanisation, afforestation and invasive plants. The aim of the four-year Subtropical Thicket Ecosystem Planning (STEP) project was to identify priority areas to ensure long-term conservation of this biome. Also, it aimed to ensure that the outcome of the conservation assessment was implemented by the policies and practices of the land managers (both public and private).

The project designed large-scale conservation corridors comprising of multiple landowners, conservation status categories for biodiversity features (i.e. areas that are critically endangered, to areas currently not vulnerable), and a conservation priority map integrating the corridors and categories (Pierce *et al.* 2005).

Land use guidelines were produced for each conservation category, as well as a handbook to increase awareness of biodiversity benefits which included environmental legislation. Stakeholders' input was sought for the whole project period.

The large-scale corridors were designed based on both the principles of systematic conservation planning, as well as taking into account issues of implementation (Rouget *et al.* 2006). The conservation assessment took into account habitat types, habitat suitability for mammals, and conservation targets. Seven conservation corridors were identified. In addition to conservation assessments, it is essential to involve stakeholders and develop an implementation strategy.

A model of sustainable land management termed the Megaconservancy Network concept was developed for each corridor. The network, consisting of landowners within each corridor, is an approach to enable cooperative management of natural or financial capital for common goals such as agricultural production, nature conservation or water use. However, formation of these networks requires understanding issues such as landowner aspirations, capital and resource flows and socioecological resilience.

Following the project, there was evidence that the outcomes were implemented (Pierce *et al.* 2005). However, improvements to the project could have be made. For instance, the project proponents identified that they aimed to increase awareness of ecosystem services, their assessment highlighted existence of biodiversity features, rather than their usefulness. They suggested that stakeholders should be involved in the identification of natural capital, as well as communicating to government and the general public of its importance. Putting a dollar value on ecosystem services may be useful, the project proponents propose that 'impassioned narratives, fierce lobbying and effective social marketing' are likely to be more effective.

KEY FINDINGS

- Integrating systematic conservation planning into land use planning policy and practice could have positive benefits for biodiversity and help with restoration planning
- Conservation assessments at a regional scale may be useful to identify priority areas for conservation and restoration, and can quantify trade-offs between criteria.
- The needs of the organisations implementing the conservation plans must be considered.
- The conservation planning products need to be easily understood by end users
- Megaconservancy Network is a concept that could be useful in Australia as a way of encouraging landowners to work together for a common goal.
- Stakeholders should be involved in identifying natural capital and ecosystem services to increase awareness of the importance of biodiversity, and to encourage them to champion it.

Asia

China

China has six national restoration projects (Cao *et al.* 2011):

- The Grain to Green program is the largest, and covers the whole of China except for the south east, with a project goal of soil and water conservation. It covers 32 million ha.
- The Three Norths Shelter Forest System Project operates in the northern and western provenances, with the aim to plant 27.5 million ha to control desertification.
- The Natural Forest Conservation Program of northern and central China is for soil and water conservation and covers an area of 4.4 million ha.
- The Sand Control Program across northern China is also for desertification control and covers 5.2 ha.
- The Forest Industrial Base Development program is aimed at wood production, planting an area of 13.3 million ha.
- The Wildlife Conservation and Nature Reserves Development Program covers the whole of China.

These projects are mainly afforestation projects, through tree-planting and aerial seeding, particularly in semi-arid and arid regions, as well as prohibition of grazing in some areas.

However, while vegetated areas have increased, there is conflicting evidence as to whether or not these projects have achieved their aims. In a review by Cao *et al.* (2011), issues such as low tree survival, soil erosion, increasing desertification rate, and little evidence that afforestation decreases the frequency and intensity of dust storms and sandstorms were highlighted. They postulate that fast-growing but short-lived species were used, rather than using both pioneer and later successional species.

Converting grasslands into shrublands and forests lowers the water table due to higher evapotranspiration of trees and shrubs compared with grasses, negatively impacting survival of the grasses. A lack of ground layer vegetation such as grasses and non-woody vegetation can then lead to areas of bare soil, concentration of air flow below tree branches, and subsequently increased water flow due to reduced interception. Hence, the main failing of these projects is that they did not restore appropriate vegetation communities and did not select local species, adapted to the local conditions.

Not all studies agree with these claims, with Zhang *et al*. (2016) pointing out that some of the studies that question the projects' effectiveness only studied a small region, single dataset, or short period of time. They instead found that the 'Three North' region showed increased greening, as it had a satellite-derived, positive normalised difference vegetation index (NDVI) from Global Inventory Modelling and Mapping Studies (GIMMS), Moderate Resolution Imaging and Spectroradiometer (MODIS) datasets.

Conflicting evidence of success from these programs is likely due to different methods and scales of monitoring, and also, the lack of a comprehensive monitoring program against the aims of the project.

Li *et al*. (2017) set out to assess the effectiveness of ecological restoration programs in China, because there are few practical tools available to do so, especially in large-scale restoration. They highlight the importance of socioeconomic factors in influencing restoration effectiveness. Developing a composite index and using a structural equation modelling approach, they investigated the impact of population pressure, off-farm economy (e.g. secondary and tertiary industry) as well as rural economy (e.g. grain yield, area of arable land). They found that population pressure and secondary industry had a negative impact on restoration effectiveness in this region, however, improving the rural economy improves restoration effectiveness.

Another factor that may have improved effectiveness is that the Chinese government undertook adaptive management. Initially in one of the earlier programs, they paid workers a low wage, and workers were not responsible for plant survival. Then, in the Grain to Green program they changed their actions, and subsidies to workers were only given when trees survived (Zhang *et al.* 2016).

KEY FINDINGS

- Tree planting alone is not an adequate method. Ecological restoration should use local plants, adapted to the climate and soils.
- Monitoring programs need to be designed prior to implementation to measure success against the goals of the program. Simply measuring the area planted is not sufficient to determine whether or not functional goals (e.g. soil and water conservation) are achieved. Also, having goals of planting a specific number of trees, or planting trees in a specific area may be counterproductive in ecosystems which are naturally devoid of trees, such as grasslands.
- Socioeconomic factors play a role in restoration effectiveness, and need to be taken into account in restoration planning, monitoring and adaptive management.

The Philippines

The Department of Environment and Natural Resources in the Republic of the Philippines has a National Greening Program (NGP) which aims to restore large areas of public land. Initially, in 2011, the NGP aimed to plant 1.5 billion trees across 1.5 million ha. Then, in 2015, this program was expanded to aim to rehabilitate 'all the remaining unproductive, denuded and degraded forestlands estimated at 7.1 million ha from 2016 to 2028'.[41] The Enhanced National Greening Program (E-NGP) has six main aims:

1. reduce poverty
2. sustainable management of natural resources
3. provide foods, goods and services, such as timber, aesthetic values and climate change mitigation
4. promote awareness and environmental consciousness on the value of forests
5. enhance positive values through shared management responsibilities
6. consolidate greening efforts by government, civilians and private sector.

The NGP/E-NGP is mostly implemented by planting seedlings — for instance, in 2011 there was a target to produce or procure 50 million seedlings for the program. The guidelines and procedures for implementing the NGP provide regulations governing forest tree seed and seedling production. These regulations dictate how to collect and handle germplasm, and distribution to regional nurseries. They also mandate that only seedlings from accredited nurseries can be used in government plantations. The NGP has exceeded the target area for planting, and reported the number of seedlings planted, however, there is conflicting data on seedling survival (Gregorio *et al.* 2017).

[41] https://www.denr.gov.ph/index.php/priority-programs/national-greening-program

Low survival rate has been attributed to low quality seedings, hence a study was undertaken to investigate seedling production systems for the NGP (Gregorio *et al.* 2017). Despite a protocol for accrediting the germplasm sources, there is no mechanism to monitor the collection and use of germplasm from these sources (Gregorio *et al.* 2017). There is a set of assessment criteria for seedling quality, but no guidelines on seedling production. Hence, lack of information and knowledge on how to produce high quality seedlings has led to the production of seedlings of poor quality, which may lead to low seedling survival.

To overcome the issue of poor-quality seedlings, incentives such as capacity building may help. These could include training for nursery operators to improve their skills and information about nursery accreditation. In addition, planning that takes into account seedling production schedules will help ensure that plants are the right size at planting (Gregorio *et al.* 2017).

Gregorio *et al.* (2017) lists the following set of recommendations:

- 'Quality standards for seedlings need to be developed as an integral part of the design and implementation of reforestation programs.
- If nursery accreditation is in place, an effective process to monitor the operation of accredited nurseries is required.
- In promoting the planting of indigenous species, efforts need to be made to identify sources of high quality germplasm of broad species base for nursery operators to access.
- Capacity-building support is needed for nursery operators.
- Adequate planning of forest restoration activities including appropriate seedling production schedules is necessary to allow ample production time for seedlings to develop desirable morphological qualities before out-planting.
- Seedling production by people's organisation is an important reforestation based livelihood activity and helps provide tangible economic benefits to communities implementing reforestation programs.
- Seedling damage during transport is a problem and is ideal for seedling production to be on-site rather than for seedlings to be purchased at distant locations. Local production of seedlings also provides social and economic benefits to communities engaged in forest restoration programs.
- While seedling price is a factor to consider in forest restoration programs, it should not undermine the use of high-quality seedlings.'

KEY FINDINGS

- The quality of seedlings used for restoration needs to be regulated. It is important to have a set of clear and specific quality standards for seedlings, which includes all important attributes for survival, including root systems.
- Comprehensive training for nursery producers is needed. This will ensure that seedlings are of high quality, which will likely result in better survival and growth. Increased survival lowers costs, as fewer seedlings need to be planted to achieve the target density.
- Accredited nurseries should be audited to ensure seedling quality is up to standard.
- Producing seedlings close to the area to be restored creates local jobs, thereby providing social and economic benefits, and minimises seedling damage during transport.

Europe

European Union

To adopt the European Union (EU) commitments within the CBD in 2010, the EU developed the 'EU Biodiversity Strategy to 2020'.[42] The overall aim was to stop biodiversity and ecosystem services losses. The strategy outlines a bold 2050 vision: 'by 2050, European Union biodiversity and the ecosystem services it provides — its natural capital — are protected, valued and appropriately restored for biodiversity's intrinsic value and for their essential contribution to human wellbeing and economic prosperity, and so that catastrophic changes caused by the loss of biodiversity are avoided'.[43]

There are six targets and 20 actions within the strategy. These targets are:

1. Protect species and habitats — better conservation or a secure status for 100% more habitats and 50% more species.
2. Maintain and restore ecosystems — restore at least 15% of degraded ecosystems.
3. Achieve more sustainable agriculture and forestry — improve conservation of species and habitats depending on or affected by agriculture and forestry and the provision of their ecosystem services.
4. Make fishing more sustainable and seas healthier.
5. Combat invasive alien species.
6. Help stop the loss of global biodiversity.

[42] https://ec.europa.eu/environment/nature/biodiversity/strategy_2020/index_en.htm
[43] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0244

To help meet the EU Biodiversity Strategy to 2020, the EU developed a network of protected areas called Natura 2000.[44] These areas are both nature reserves and privately-owned land. The network includes a knowledge exchange and communication platform.

Subsequently in December 2019, the 'European Green Deal'[45] was presented, a core part of which is the 'Biodiversity Strategy for 2030',[46] released in May 2020. This latest strategy is developing nature restoration targets. The European Green Deal aims to make the EU's economy sustainable by transforming climate and environmental challenges into opportunities. The Green Deal outlines the economic benefits of biodiversity,[47] such as:

- Conserving marine stocks would increase profits in the seafood industry by €49 billion
- By reducing flood damages, save the insurance industry €50 billion yr^{-1}
- Job creation, e.g. an estimated 104,000 jobs have been supported through the Natura 2000 network
- Increased crop yields.

Overall, the Green Deal estimates that over half of global GDP (€40 trillion) depends on nature.

Finland

Landscape context

In Finland, forest covers 75% of the land area, of which approximately 90% is managed for timber production.[48] Almost one third of the land area is peatlands, and some of this land also supports forests. These large areas of forest and/or peatland are significant in Europe, as they represent 10% of European forests and one third of European peatlands. However, these native forests and peatlands are under threat. Over 50% of the peatlands in Finland have been drained for forestry.

Although forestry has provided economic benefits, there have been some detrimental effects. Forest management for timber production has resulted in the loss of biodiversity, old trees and decomposing wood and drainage of peatlands has led to eutrophication (nutrient enrichment) of waterways.

Only about 13% of forests is protected, which is insufficient for biodiversity conservation. There are benefits in addition to biodiversity conservation, as peatlands are long-term carbon stores. So, to address these issues, Finland has implemented a variety of restoration programs.

[44] https://ec.europa.eu/environment/nature/natura2000/index_en.htm
[45] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[46] https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en
[47] https://ec.europa.eu/commission/presscorner/detail/en/fs_20_907
[48] https://www.ser.org/news/551775/Open-Access-SER-Europe-Webinar-State-of-Ecological-Restoration-in-Finland.htm

Policies and targets

Restoration has in part been driven by government policies and international targets, as well as government and EU funding, and more recently, carbon compensation schemes and small but increasing private funding. National restoration targets were set in 2003, then the EU Biodiversity Strategy targets were set in 2010.[49] Two years later in 2012, taking into account the EU objectives and to implement the decisions made at COP10 (Nagoya Protocol), the Finnish government produced a national strategy and action plan for the conservation and sustainable use of biodiversity, entitled 'Saving Nature for People' for 2013–2020.[50]

The action plan incorporated communication, public awareness, education and training, financial instruments, legislation, land use planning, biodiversity conservation, climate change, invasive species, nature-based tourism and recreation, and monitoring and research, as well as outlining specific habitat challenges and restoration. The latest EU target, set in 2020,[51] is to establish protected areas for at least 30% of land in Europe, following which the Government established the Helmi Habitats programme.

Programs

Restoration trials began in Finland in the 1970s, and from 1995, the number of restoration projects increased dramatically, with the EU funded restoration projects in protected areas. Then, the Forest Biodiversity Programme for Southern Finland (METSO) commenced in 2008 and will run until 2025.[52] This program aims to stop biodiversity loss by paying for voluntary conservation by private forest owners. It is implemented by three methods:

1. permanent protection (private nature reserves or selling the land to the state for conservation purposes)
2. temporary conservation (environmental forestry subsidy agreement (10 years) or temporary nature reserve (20 years))
3. nature management projects.[53]

This collaboration between forest owners and environmental authorities has been considered successful, although the temporary protection of only 10 years is not considered effective.[54]

[49] https://ec.europa.eu/environment/nature/biodiversity/strategy_2020/index_en.htm
[50] https://ym.fi/en/national-biodiversity-policy; https://ym.fi/documents/1410903/38439968/National_action_plan2013_SavingNatureforPeople-EA60AA4E_861F_414D_9EFE_E8B967313381-96885.pdf/3fd101e9-6a12-91f8-211c-a2ab1d32794b/National_action_plan2013_SavingNatureforPeople-EA60AA4E_861F_414D_9EFE_E8B967313381-96885.pdf?t=1603260663505
[51] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/eu-biodiversity-strategy-2030_en#the-business-case-for-biodiversity
[52] http://www.metsonpolku.fi/en-US
[53] http://metsonpolku.fi/en-US/METSO_Programme
[54] https://www.ser.org/news/551775/Open-Access-SER-Europe-Webinar-State-of-Ecological-Restoration-in-Finland.htm

Following the launch of the 2013–2020 national strategy 'Saving Nature for People', the Finnish Government established a program on the sustainable use of peatlands. Then, in 2020, the government announced an investment of €100 million for nature conservation, and established the Helmi Habitats programme, which will receive €42 million[55] from that investment. Targets for the Helmi Habitats programme by the end of 2023 include:

- Protection of 20,000 ha of peatlands (also known as mires). Landowners will receive government compensation.
- Restoration of 12,000 ha of drained (ditched) peatlands within protected areas and restoration of drained peatlands surrounding protected areas.
- Rehabilitate 15,000 ha of semi-natural grasslands.

Governance

These programs have been supported by information generated through research. Handbooks have been published by the Finnish Board on Ecological Restoration (FBER) on forest and peatland restoration as well as monitoring.[56] Synthesis papers and policy briefs based on research have also been written. FBER was established in 2004 by Parks and Wildlife Finland, and brings together experts, researchers and practitioners from government, universities, private companies, environmental centres and institutes.[57]

A Steering Group oversees three expert groups: Forest Group, Peatland Group and Grassland Group. Their task is to 'evaluate, develop and promote the quality of the ecological restoration and management of natural and semi-natural habitats, and their impact on society'. As well as publishing guidelines, they also organise training and seminars and they collaborate with SER Europe.

Prioritisation

One aspect of research has focused on prioritising areas for restoration. The single variable optimisation tool has been used to determine which variables benefit from restoration — biodiversity, eutrophication, climate or income (Juutinen *et al.* 2020).

Both ecological and economic information was used to develop a decision support tool to quantify ecosystem services and thus support decision making surrounding land use planning, i.e. deciding which areas to restore.[58] Unproductive areas of drained peatlands are considered high priority for restoration, as they are not currently generating income, but they are contributing to eutrophication.

[55] https://ym.fi/en/helmi-habitats-programme; https://www.metsa.fi/en/nature-and-heritage/habitats/semi-natural-grasslands/
[56] https://www.metsa.fi/en/nature-and-heritage/habitats/finnish-board-on-ecological-restoration-fber/#:~:text=The%20working%20group%20for%20ecological%20restoration%20and%20management,brochure:%20FBER%20brings%20together%20nature%20management%20experts%20(julkaisut.metsa.fi)
[57] https://julkaisut.metsa.fi/assets/pdf/lp/Esitteet/FBER-brings-together-nature-management-experts.pdf
[58] https://www.luke.fi/en/projektit/lifepeatlanduse-eu-150/

Species distributions for 48 threatened species were predicted to quantify the percentage of species that would benefit from restoration, and also the increase in suitable habitat area (Tolvanen *et al.* 2020). However, as useful as these planning tools are, practical considerations such as land tenure need to be taken into account.

KEY FINDINGS

- Develop a board on Ecological Restoration.
- Develop a national strategy and action plan for the conservation and sustainable use of biodiversity, linked to international agreements to show how these agreements will be implemented.
- Develop tools to prioritise areas for restoration, based on both biodiversity conservation and economic outputs to know where to restore to have the most impact.
- Quantify the benefits of restoration.
- Consider identifying economically unproductive land for restoration such as abandoned farmland, and land subject to overgrazing, salinisation and erosion, as these lands have low economic output.

Hungary

Hungary has recently taken an approach to planning to determine how the country may fulfill its obligations under the EU Biodiversity Strategy[59] (Cevallos *et al.* 2020; Somodi *et al.* 2017; Török *et al.* 2018; Török *et al.* 2019). The natural environments in the country are highly modified, as over half of the country has been converted to farmland, 20% is grazed or mown and 10% is urban areas or waterways. Twenty per cent of the land is protected, either as national parks, under the European Natura 2000 network, or protected by some other mechanism.

The planning approach initially consisted of an estimate of restoration achievement. To do this, four databases were used. One of these databases was the META program, which was a whole-country, grid-based ecological mapping program. The country was divided into hexagonal grids, and from 2003 to 2006, 200 experts spent 700 field days mapping the semi-natural vegetation. The vegetation was classified according to vegetation types (forest, grassland, wetland) ecological condition status (from 1–5, 1 being poor condition to 5 being good condition), and the main threats (e.g. mismanagement, invasion). Once the information from the four databases was combined, the baseline restorable area was determined for each vegetation type and condition status.

[59] https://www.ser.org/news/555737/Open-Access-SER-E-Webinar-State-of-Ecological-Restoration-in-Hungary.htm

A database of all the ecological projects from 2002 to 2006 was developed, which included 634 projects. The projects were classified according to vegetation type. The analysis found that more restoration projects were needed in forests.

An analysis also determined the types of degradation and the restoration interventions. One of the limitations was that there was no data on restoration success. So, the restored area was estimated, but with the lack of data, as a proxy they estimated that for each intervention, the ecological condition status moved up one point.

The subsequent project involved five steps:

- Evaluation of the state of Green Infrastructure
  - incorporating ecological conditions' state, connectivity (to what extent can land support movement of terrestrial organisms) and ecosystem services (e.g. pollination)
  - mapping the information
- Prioritisation of potential interventions
  - 'good' areas were candidates for protected areas, those in a 'medium' state were candidates for improvement, and those in a 'poor' state were potential for ecosystem change (these were mostly plantation forests and arable land)
- What to restore
- Where to restore
  - target areas for restoration included potential ecological corridors, arable areas that would help with flood protection and erosion control
- How to restore
  - organisations with knowledge of restoration were consulted.

Given that this Hungarian strategy has recently been released, it has not yet been integrated into policy or legislation.

KEY FINDINGS

- Hungary has taken a strategic approach to restoration planning which involved mapping all areas of vegetation, classifying vegetation condition, listing all restoration projects.
- This comprehensive approach was possible in Hungary partly due to the small land area, and already large proportion converted to agriculture. In Australia, this approach may not be practical at a national scale, but could be used at a regional scale.
- Data on restoration success is critical for planning.

United Kingdom

UK Government

In 2011, the government of the United Kingdom developed a biodiversity strategy[60] for England, which outlines how the government is implementing both international and EU commitments (DEFRA 2011). It follows on from the UK National Ecosystem Assessment, which found that ecosystem services are in decline, as are over 40% of priority habitats and 30% of priority species. The national plan is informed by both the Nagoya Protocol (2010) and the EU Biodiversity Strategy (2011).

The strategy goal is:

> *'to halt overall biodiversity loss, support healthy well-functioning ecosystems and establish coherent ecological networks, with more and better places for nature for the benefit of wildlife and people.'*

The goal will be delivered through four main areas, and each have a number of key actions. Actions relevant to restoration include:

- **Action 1.1:** Establish more coherent and resilient ecological networks on land that safeguards ecosystem services for the benefit of wildlife and people
- **Action 1.3:** Take targeted action for the recovery of priority species, whose conservation is not delivered through wider habitat-based and ecosystem measures
- **Action 2.2:** Promote taking better account of the values of biodiversity in public and private sector decision-making, including by providing tools to help consider a wider range of ecosystem services
- **Action 2.3:** Develop new and innovative financing mechanisms to direct more funding towards the achievement of biodiversity outcomes

[60] https://www.gov.uk/government/publications/biodiversity-2020-a-strategy-for-england-s-wildlife-and-ecosystem-services

- **Action 3.4:** Through reforms of the planning system, take a strategic approach to planning for nature within and across local areas; guide development to the best locations, encourage greener design and enable development to enhance natural networks; retain the protection and improvement of the natural environment as core objectives of the planning system
- **Action 4.1:** Work collaboratively to direct research investment to areas of highest priority to deliver the outcomes set out in this strategy, and in partnership with the Research Councils and other organisations to build the evidence base
- **Action 4.2:** Implement coordinated arrangements to monitor changes in the state of biodiversity and flow of benefits and services it provides, to assess the outcomes of this strategy.

Subsequently, the 25-year plan,[61] 'A Green Future: Our 25 Year Plan to Improve the Environment', published in 2018 outlined six key actions, which incorporate sustainable land management, restoration, connecting people to nature to improve health, reducing waste and pollution, healthy oceans and improving the global environment.

The policy summary for aim 3, 'Protecting and recovering nature', along with its specific actions is:

- Publishing a strategy for nature
  - build on the current strategy, Biodiversity 2020
  - coordinate action between academic partners, farmers and land managers
  - demonstrate global best-practice
- Developing a Nature Recovery Network
  - provide 500,000 ha of additional wildlife habitat
  - link existing protected sites and landscapes, and urban infrastructure
  - recovering wildlife will require more habitat; in better condition; in bigger patches that are more closely connected
  - provide additional benefits e.g. greater public enjoyment; pollination; carbon capture; water quality improvements and flood management
  - use data and mapping tools to maximise wildlife, economic and social gain
  - include input from a range of stakeholders
- Providing opportunities for the reintroduction of native species
  - develop best practice guidance for assessing benefits and risks of species reintroduction projects
  - develop a code based on the IUCN guidelines (IUCN/SSC 2013)
  - publish the guidance to sit alongside existing international guidelines

[61] https://www.gov.uk/government/publications/25-year-environment-plan

- Exploring how to give individuals the chance to deliver lasting conservation
  - assess the potential role of conservation covenants
- Improving biosecurity to protect and conserve nature
  - develop plans to reduce the risk for invasive non-native species introduction
  - raise awareness of invasive non-native species
  - maintain a system to detect and eradicate invasive non-native species
  - place biosecurity at the centre of buying practices.

Some areas of the plan apply to the entire UK, whereas others apply just to England, as some environmental responsibility is devolved, and sits with the Scottish Government, Welsh Government and Northern Ireland Executive.

The UK has had success with projects such as the Nature Improvement Area, the farmer cluster concept, and Back from the Brink — a species recovery program.

Royal Botanic Gardens, Kew

Royal Botanic Gardens, Kew has a team of scientists who undertake research on plants. Along with Botanic Gardens Conservation International (BGCI), they have recently released 10 golden rules for reforestation[62] (Di Sacco *et al.* 2021):

1. Protect existing forest first.
2. Work together with local stakeholders.
3. Aim to maximise biodiversity recovery to meet multiple goals, such as ecosystem services, carbon emissions reduction and threatened species conservation.
4. Select appropriate areas, i.e. plant trees in areas where trees were previously, not current/former grasslands or wetlands. Ensure that reforesting agricultural areas doesn't result in deforestation elsewhere.
5. Use natural regeneration where possible.
6. Select species to maximise biodiversity.
7. Use plant material with appropriate genetic variability to enable adaptation to a changing climate.
8. Plan ahead — use locally available seed supply chain and infrastructure or incorporate it into the project, provide training.
9. Learn by doing — use existing sources of information, including Traditional Knowledge, perform trials, monitor success indicator, undertake adaptive management.
10. Make it pay — ensure that projects are economically sustainable and generate diverse income streams such as sustainably harvested timber, honey, carbon credits and ecotourism.

[62] https://www.kew.org/read-and-watch/10-golden-rules-for-reforestation

RBG Kew also recently a manifesto for change 2021–2030, which is a 10-year strategy to end extinction crisis and protect nature (RBG Kew 2021). The strategy has five priorities: deliver science-based knowledge; inspire people to protect the natural world; train the next generation; extend our reach; and influence national and international policy. Several action items are listed under each priority.

RBG Kew includes the Millennium Seed Bank (MSB) at Wakehurst, which is the largest seed bank for wild seeds.[63] It houses over 2.3 billion seeds from over 39,000 species. Research facilities are part of the infrastructure, which houses underground chambers to store seeds at –20°C.

The seed bank has a global partnership — the Millennium Seed Bank Partnership (MSBP) — and the Australian partner is now called the Australian Seed Bank Partnership.[64] The MSB is a conservation seed bank, and while able to hold small volumes of threatened species, does not have the capacity to store large volumes of seed for large-scale restoration. However, it is an excellent model of global partnership and cooperation in the seed community, and shows that investment needs to be made into infrastructure for seeds. Building on Australia's current seed bank partnership, and existing infrastructure and knowledge centres, investment could be used to scale up the resources.

[63] https://www.kew.org/science/collections-and-resources/research-facilities/millennium-seed-bank
[64] https://www.seedpartnership.org.au/

KEY FINDINGS

- International agreements can be a driving force in informing national strategies.
- Develop best practice guidelines for reintroductions – Australia already has these in place for threatened species reintroductions (Commander *et al.* 2018).
- Restoration is integrated into a holistic environmental strategy, which includes connecting people with nature to improve human health.
- The UK is focusing on ecological networks and priority species, as well as empowering landowners to deliver conservation.
- Protection and improvement of the natural environment is a core objective of the planning system. Planning is aimed to guide development and enhance natural networks.
- The UK strategy aims to work collaboratively to direct research to where it's needed.
- RBG Kew's Manifesto for Change and the 10 golden rules for reforestation could be adapted to the Australian context for ecological restoration.
- Seed banking at a global scale requires specialist infrastructure and expertise. Australia already has a long-standing partnership with the Millennium Seed Bank, which is the world's largest seed bank of wild species. The MSB provides a good example of investment into infrastructure for seed storage and research, and a model for collaboration.

North America

Canada

Parks Canada manages the 33 national parks, national historic sites and national marine conservation areas in the country.[65] They have a variety of Conservation and Restoration (CoRe) projects ranging from forest restoration to saving endangered plants (Parks Canada Agency 2018). The projects all:

- identify problems
- collaborate
- invest in solutions and
- realise achievements.

Ecosystems that are in poor or fair condition, and species that are at risk are both prioritised for restoration actions. To plan and implement these actions, Parks Canada uses the 'Open Standards for the Practice of Conservation'.[66] In 2008, they published 'Principles and Guidelines for Ecological Restoration in Canada's Protected Natural Areas',[67] in collaboration with Canadian and international restoration experts.

KEY FINDINGS

- Having a national set of restoration guidelines helps policy makers and practitioners make consistent and informed decisions. It also serves as a mechanism to engage and collaborate with key stakeholders.

United States of America

National and Regional Restoration Programs

In 2009, the Forest Landscape Restoration Act (FLRA) was passed in the United States of America (US) (Monroe and Butler 2016). This Act established the Collaborative Forest Landscape Restoration Program, which, over a 10-year period, funded ecological restoration on National Forest System land. The program was administered by the US Department of Agricultural Forest Service. It provided funds for implementation and monitoring of landscape-scale forest restoration projects, and called for proposals that were long-term (a 10-year period) and large scale (at least 50,000 acres (~20,000 ha)).

[65] https://www.pc.gc.ca/en/agence-agency/bib-lib/rapports-reports/core-2018/apercu-overview
[66] https://conservationstandards.org/about/
[67] https://www.pc.gc.ca/en/nature/science/conservation/ie-ei/re-er/pag-pel

The Secretary of Agriculture selected the successful projects with up to 10 projects being funded per year, and no more than two projects per region. The projects needed to be collaborative. Projects were selected based on several criteria:

- *'the strength of the proposal and strategy;*
- *the strength of the ecological case of the proposal and the proposed ecological restoration strategies;*
- *the strength of the collaborative process and the likelihood of successful collaboration throughout implementation;*
- *and, whether the proposal is likely to achieve reductions in long-term wildfire management costs.'*

(Forest Landscape Restoration Act of 2009)

One of the important criteria in this program was the mandate for collaboration. Reflection on the program has found that vague mandates for collaboration allow flexibility, but can lead to confusion. The projects needed to identify the requirements of the mandate and also determine if there was a history of prior collaboration (Monroe and Butler 2016). In some cases, participants were used to doing collaborative planning but not collaborative implementation (Butler *et al.* 2015). This collaborative implementation has potential benefits in that it can incorporate a wider range of stakeholders. This, in turn, incorporates more values and perspectives, strengthens accountability, continuous monitoring, feedback and adaptive management, as well as opportunities for social learning.

The National Reforestation, Nurseries, and Genetic Resources (RNGR) Program is provided by USDA Forest Services and Southern Regional Extension Forestry.[68] It incorporates the Native Plant Network, and provides information on growing North American native plants for restoration and other uses.[69]

The network produces a journal[70] and has an online propagation protocol database.[71] Users can contribute to the database to share their knowledge. There is also a database of technical articles and instructional videos.

In the US, there are also several large-scale regional programs. The Great Basin Native Plant Project,[72] for example, was established in 2001. Founded by the BLM and the US Forest Service, it aims to meet the increasing demand for native seed for restoration of burned land (Plant Conservation Alliance 2015b). It also aims to develop knowledge and technology for restoration.

[68] https://www.rngr.net/
[69] About the Native Plant Network — Reforestation, Nurseries and Genetics Resources (rngr.net)
[70] Native Plants Journal (uwpress.org)
[71] https://npn.rngr.net/propagation
[72] https://www.greatbasinnpp.org/

Over 20 organisations across several states are collaborating in the project. Other ecoregions have similar programs, however, there is not complete coverage across all regions in the US.

National Seed Strategy

The 'National Seed Strategy for Rehabilitation and Restoration 2015–2020' was established by the Plant Conservation Alliance, a public-private partnership involving twelve federal agencies and non-federal partners chaired by the Department of Interior's Bureau of Land Management (BLM) (National Academies of Sciences Engineering and Medicine 2020; Plant Conservation Alliance 2015b).

Two main driving factors for the development of the strategy were Hurricane Sandy (2012), which damaged coastal wetlands and forests from Florida to Maine, and the increasing wildfires in Western US, particularly in 1999 and 2000. Fire dynamics have changed in the sagebrush steppe of the west, due to an invasive grass, *Bromus tectorum* (cheatgrass), which has increased fuel loads making fires more frequent, with a detrimental effect on native plants. The BLM manages a large area of sagebrush steppe, hence has a vested interest in the strategy.

The strategy's vision is: 'The right seed in the right place at the right time'. The mission is: 'To ensure the availability of genetically appropriate seed to restore viability and productive plant communities and sustainable ecosystems' (Plant Conservation Alliance 2015b). There are four goals of the strategy:

1. Identify **seed needs** and ensure the reliable **availability** of genetically appropriate seed.
2. Identify **research needs** and conduct research to provide genetically appropriate seed and to **improve technology** for native seed production and ecosystem restoration.
3. Develop **tools** that enable managers to make timely informed seeding **decisions** for ecological restoration.
4. Develop strategies for internal and external **communication**.

Within each goal there are a series of objectives, which are then broken down into actions (Appendix 2). These series of goals, objectives and actions provides a very clear structure for the strategy. For each action, the coordinating agencies and other participants are listed. The method by which the strategy aims to achieve success is through coordinated establishment of nationwide networks of seed collectors, growers, seed stores, nurseries and restoration ecologists. In this way, they are coordinating the seed supply chain from collection, production and storage, to propagation and establishment.

By coordinating both public and private efforts in restoration, people and organisations can work together to restore healthy native plant communities.

The Seed Strategy's business plan outlines the expected costs of implementing the strategy, so agencies can develop an interagency budget and non-federal partners can determine how they can raise funds to support the strategy (Plant Conservation Alliance 2015a). The costings are based on an assumption that each action is implemented across the entire country over a five-year period, and are itemised by action and year to enable estimation if they are scaled up or down. The total estimated cost was almost US$360 million. This amount would be divided across five years and shared across multiple agencies. Facilitated workshops were planned to coordinate implementation and agency contributions.

The business plan also suggested some options for raising funds, including creating a national seed strategy fund (matching federal funding with private sector donations) and aligning the seed strategy with other national priorities (e.g. habitat creation, fire prevention).

In 2018, a report outlining progress towards the goals was released (Plant Conservation Alliance 2018). To address goal one, a National Assessment of Seed Needs and Capacities was commissioned (National Academies of Sciences Engineering and Medicine 2020). As part of goal two, a manual will be developed to communicate cultivation practices of forb species.

The Restoration Assessment and Monitoring Program for the Southwest (RAMPS) was launched in 2016 to provide monitoring protocols, tools for land managers, guidance for selecting plant materials, networks of field trials and data synthesis. It has created a community to exchange knowledge. The Training Tools task force was formed to address goal three, and identified the gaps between training courses available, and training that is needed. The Communications Task Force, under goal four, produced a presentation and fact sheets, and the USFS produced an annual report which shared success stores and lessons learned.

National seed collection program

The BLM leads a national seed collection program called 'Seeds of Success' (SOS).[73] This program aims to 'establish a national, high quality, accurately identified and well documented native plant species seed collection'. This collection is both for ex situ conservation and to provide material for research and use in the Native Plant Materials Development Program.[74]

Initially (2000–2010), the program was a partnership with Kew's Millennium Seed Bank Project (MSBP), which aimed to collect single collections of 10% of the world's wild plant species, but then the SOS collection strategy shifted to multiple collections of species required for restoration.

[73] https://www.blm.gov/programs/natural-resources/native-plant-communities/native-plant-and-seed-material-development/collection
[74] https://www.blm.gov/programs/natural-resources/native-plant-communities/native-seed-and-plant-material-development

There are now more than 65 collection teams, which include Botanic Gardens, Wildflower Societies and Parks and Recreation Departments (Seeds of Success 2018). SOS has developed a training course named 'Seed Collection for Restoration and Conservation' and a technical protocol so that all collectors follow the same procedures.

Seed supply chain

The largest purchasers of native seed are government agencies, who manage more than 640 million acres (~ 260 million ha) of land (National Academies of Sciences Engineering and Medicine 2020). In particular, in the western US, seed demand for post-wildfire restoration is driving the market. Seed collected from natural populations may either be used directly for restoration or as material for seed production. Hence, seed passes from collectors to growers and end users, in some cases directly and in other cases via seed warehouses where seeds are cleaned, packed, labelled, stored and shipped.

Other participants in the supply chain are permitting officers who issue collection permits, government and commercial laboratories that test seed, seed certification inspectors, those in charge of seed contracts and seed storage managers. Interestingly, federal and state laws require that seed that is sold to an end user must be tested and labelled (National Academies of Sciences Engineering and Medicine 2020).

One issue with the supply chain is that there is a lack of established testing procedures, which can lead to delays and increased costs. Results may differ between testing laboratories (National Academies of Sciences Engineering and Medicine 2020).

Seeds for short-term use are stored under ambient conditions in warehouses. These warehouses can store large volumes — the BLM can store 2.6 million pounds (1.2 million kg) of seed and the Utah Division of Wildlife resources can store 1 million pounds (0.45 million kg). Seed longevity is increased with reductions in temperature and relative humidity, hence certain states (e.g. Utah, Nevada, eastern Oregon) are more suited to ambient storage conditions than others. Small volumes of seeds are kept in seed banks (National Academies of Sciences Engineering and Medicine 2020).

Contracts differ between agencies, and also depending on whether seeds are wild collected or produced, and either place all the risk on the supplier or share the risk between the supplier and purchaser (National Academies of Sciences Engineering and Medicine 2020).

Seed use is also influenced by various mechanisms including policies, funding, guidance on species selection, research and decision-making tools. These ancillary influencers may be government agencies, land planners, landscape architects, university researchers or seed associations (National Academies of Sciences Engineering and Medicine 2020).

The assessment on seed demand and supply (National Academies of Sciences Engineering and Medicine 2020) identified some factors affecting the performance of the seed supply chain.

These are:

- End users have varied objectives (e.g. restoration vs production value) which influence their seed needs.
- Decision making by land management agencies in the western US strongly influences the seed market.
- Seed that is desired may not be available due to time frame, quantity and quality issues.
- Seed choices do not always lead to successful restoration, and restoration outcomes do not always inform seed choices, possibly due to selection of seeds not matched to the local climate, and an imbalance between quantities of grasses, shrubs and forbs.
- Budgets and specifications of users varies greatly, as do seed costs.
- Market volatility, risk and contract structure may adversely affect seed procurement.
- Limited capacity for seed storage may affect the market.
- Issues are regionally specific.

Any national seed strategy therefore needs to address these factors, taking into account local conditions.

KEY FINDINGS

- Long-term and landscape scale projects with multiple, collaborating stakeholders have value and should be considered as part of a national restoration program.
- Collaborative implementation has the potential to benefit restoration programs, although it is likely that some effort may need to be made to provide scaffolding to ensure that it is effective.
- An online propagation database would enable practitioners to find information about how to grow native species, and enable them to share their information with others.
- Eco-regional programs that focus on increasing seed availability and developing knowledge about species in a specific region are an opportunity to collaborate at a regional level.
- The seed strategy covers supply and demand, research and technology, decision making tools, and communication.
- Having a structured strategy with a vision, mission, goals, objectives and actions clearly outlines what they want to do and how they will get there.
- Establishment of nationwide networks through the seed supply chain will enable large-scale restoration.
- A formalised public-private partnership would assist all the organisations to work together towards a common goal.
- Develop a national seed collection program. A similar program already exists through the ASBP (also initially an MSBP partner), but there are 12 partners and they collect for conservation seed banks.
- Consider developing laws mandating basic seed testing and labelling for seed that is sold.

Oceania

New Zealand

The New Zealand government plans to plant one billion trees by 2028[75] through the One Billion Trees Programme. The aim of the programme is to improve the environment, social outcomes and economic performance[76] by reducing erosion and improving water quality, creating jobs and supporting Māori aspirations for their land and forests. Overall, the programme supports the New Zealand Government's goal of a low emissions economy.[77]

Rather than just focusing on the number of trees planted, they want to ensure that the right tree is planted in the right place for the right purpose. The trees that they are using are both native and non-native species, however, native species are encouraged, to improve diversity. Trees are to be planted across the landscape, rather than solely in forestry. The purpose of the trees needs to be considered prior to planting, and takes into account maintenance and end use.

The government is implementing this project by offering funding to landowners, organisations and community groups to plant trees through grants. NZD $240 million (approx AUD $223 million) is available through two funding streams,[78] Direct Grants[79] (tree planting and restoration of land to native forest) and Partnership Funding[80] (for projects that improve tree-planting success, through research, information or catchment restoration — in these cases each party contributes 50% of the project costs).

The One Billion Trees Programme is underpinned by science, with short, medium and long-term research priorities (Table 1) and projects in each priority area.[81] Research proposals to address these priorities are assessed by the One Billion Trees Strategic Science Advisory Group, which consists of members from government, forestry, Māori and scientific organisations.

[75] https://www.mpi.govt.nz/forestry/funding-tree-planting-research/one-billion-trees-programme/
[76] https://www.mpi.govt.nz/forestry/funding-tree-planting-research/one-billion-trees-programme/about-the-one-billion-trees-programme/
[77] https://www.mpi.govt.nz/forestry/funding-tree-planting-research/one-billion-trees-programme/science-and-the-one-billion-trees-programme/science-priorities-to-support-one-billion-trees/
[78] https://www.mpi.govt.nz/forestry/funding-tree-planting-research/one-billion-trees-programme/one-billion-tree-fund/
[79] https://www.mpi.govt.nz/forestry/funding-tree-planting-research/one-billion-trees-programme/direct-landowner-grants-from-the-one-billion-trees-fund/
[80] https://www.mpi.govt.nz/forestry/funding-tree-planting-research/one-billion-trees-programme/partnership-grants-from-the-one-billion-trees-fund/
[81] https://www.mpi.govt.nz/forestry/funding-tree-planting-research/one-billion-trees-programme/science-and-the-one-billion-trees-programme/

TABLE 1. SHORT, MEDIUM AND LONG-TERM RESEARCH PRIORITIES FOR THE NEW ZEALAND ONE BILLION TREES PROGRAMME[82]

TIME FRAME	AREA	RESEARCH
Short	Scale up planting	Improve methods to produce native seedlings
	Tools to support decision making around land use change	
	Researching social licence to operate	Research barriers to planting trees
	Diversification of forest systems	Trials on indigenous and mixed species forests
Medium	Forestry benefits	Managing harvesting models
	Innovating through Kaupapa Māori	Weaving Māori aspirations into forest system design and management
	Environmental benefits	Quantify and enhance ecosystem services
Long	Climate change	Research climate sink enhancement and impacts of climate change

Norton *et al.* (2018) have developed eight recommendations to support scaling up of restoration in New Zealand:

1. Retain what is left and manage it properly.
2. Before starting restoration, address the factors that limit natural regeneration and hence will also limit any planting.
3. Consider how large-scale plantings can increase strategic linkages and habitat area, and enhance all-year round food supplies for local fauna.
4. Eco-source an ecologically appropriate range of plant species and mycorrhizae.
5. Establish certification for seed and seedling supply.
6. Invest in new technologies for revegetation.
7. Adopt best-practice planting and early management, including appropriate monitoring, to ensure the long-term success of restoration.
8. Integrate all for an optimum result.

KEY FINDINGS

- Ensure that the right tree is planted in the right place for the right purpose.

[82] https://www.mpi.govt.nz/dmsdocument/41920-One-Billion-Trees-Science-Plan

New Caledonia

Dry tropical forest used to cover half of New Caledonia, a collection of islands in the Pacific Ocean (Mansourian *et al.* 2018). The forest is biodiverse, and around 60% of species are endemic to New Caledonia, meaning they are found nowhere else. Today, the forests cover just 2% of their original extent and are highly fragmented. To address this loss, in 2001 public and private partners established the 'dry forest program', and in 2011, the partnership was formalised 'Conservatoire d'Espaces Naturels de Nouvelle-Calédonie' (CEN) (Conservation of Natural Spaces in New Caledonia). The CEN is part of a network across France. Funding for the program has come from WWF, the French Government, the New Caledonian government and the main island's two provinces (Mansourian *et al.* 2018).

Threats and causes of degradation include urban development, overgrazing, invasive species and fire. Given the small area of forest that remained, the program protected the existing forest, and also undertook restoration.

Restoration activities in the dry forest have included invasive exotic species management, fencing to protect from grazing, and planting. The knowledge gained through the program has resulted in nurseries being able to grow native species to sell to the public.

The program has been through a number of phases, each lasting approximately five years. In the first phase, the program concentrated on protecting the remaining forest, increasing biological and ecological knowledge, restoring degraded forest, raising awareness and building local capacity. Mapping forest fragments and overlaying with land ownership helped stakeholder engagement and threat identification. Restoration techniques were developed based on the identified threats (e.g. fencing to exclude grazing). Public lands were used to showcase pilot examples of good restoration. Planting days were held to engage the public.

The second phase focused on reconnecting forest fragments, restoring degraded sites, developing the program at a local, national and international level and sustainable forest management. Plants were propagated in nurseries, and the program worked with nurseries to increase the availability of native species diversity.

In the third phase, the CEN was created, becoming the 29th CEN in the French territory. The CEN is a not-for-profit, multi-stakeholder platform. This phase concentrated on increasing the protected area, increasing the restored area, communication and crosscutting actions.

As a result of the program, there was an increase in:

- the area of forest fenced to exclude non-native grazing animals
- the area protected to allow natural regeneration and
- the area legally protected.

Over 100,000 saplings were planted, extinction of one species was prevented, propagation techniques of 18 rare and threatened species were developed, and over 10,000 people participated in educational activities. The program has built local capacity by increasing scientific knowledge about the ecosystem, its threats, and restoration techniques, as well as delivering training. Workshops have been organised and the program has been showcased at conferences.

Communication has focused on raising awareness about the dry forest, and the program has produced fact sheets, flyers and posters. Volunteer days have been organised, which are family events involving both fun and education. Signage for nature trails, a documentary, illustrated guidebooks and a twice-yearly magazine have all been part of the communication outputs.

The CEN is governed by a board, consisting of seven public sector and five civil sector organisations. The president is elected for a two-year period. A scientific committee advises the CEN, and there are technical committees for each of the three themes. This legal structure has increased political visibility of the program.

A number of lessons were learned through the project:

- Firstly, identify the causes of degradation and the values of the forest
- Ground implementation in scientific knowledge
- A hierarchical strategy for intervention is needed — in this case, firstly, remaining forest fragments and highly endangered species were saved, then fencing, planting and passive restoration were undertaken
- Link science and practice
- Make a long-term commitment
- Consider scale and the mosaic of land use across a landscape
- Use a partnership approach engaging all stakeholders
- Citizen involvement leads to stronger ownership
- High restoration costs call for alternative approaches
- Landscape-level thinking requires a shift in mindset
- Design an exit strategy — the leading organising should be willing to commit for at least 10–15 years, and needs an exit strategy to be prepared to hand the project over.

KEY FINDINGS

- Working in partnership with local nurseries can increase knowledge of propagation, increase plants available for restoration and increase the diversity of species available to be sold to the general public.
- Mapping the remaining vegetation and determining the landowners can identify key stakeholders and prioritise restoration techniques.
- Have pilot examples of restoration on public lands to inspire, educate and garner the support of private landowners.
- National restoration programs could benefit from being run by a well-structured organisation with clear governance, representatives from both the public and private sector, scientific input and technical committees.

South America

Brazil

Brazil has a long history of ecological restoration (Rodrigues *et al.* 2009). From 1862 to 1982, planting was undertaken to protect water and soil resources. Government institutions mainly planted exotic and native trees, however, diversity was generally low. From 1982 to 1985, native species were planted, but they were not necessarily local, diversity was low and plantings were not self-perpetuating. Then, between 1950 to 2000, local remnants were used as targets, species diversity increased although there was still low species availability. Following this (2000–2003) restoration focused on restoring ecological processes, in particular natural succession.

Since 2003, seeds have been collected locally, including managing natural regeneration (i.e. recruitment from the soil seed bank). Both political and legal changes have driven restoration, with social pressure on governments to enforce environmental laws, and international market mechanisms (Rodrigues *et al.* 2009).

Now, Brazil has two separate, but overlapping targets for restoration (Nunes *et al.* 2017). Brazil's Nationally Determined Contribution (NDC), a strategy to reduce greenhouse gas emissions from land use change, has a target to restore 12 million ha by 2030. As part of Brazil's NDC policies, the National Plan for Recovering Native Vegetation (PLANAVEG) incorporates the Forest Code (FC), under which 24 million ha of private lands must be restored or offset.

However, there are challenges associated with implementing such high targets, including costs, planning restoration actions and socio-political issues (Rodrigues *et al.* 2009). Because information on restoration costs is lacking, and restoration methods may not have been identified for each area, Nunes *et al.* (2017) developed a spatially-explicit model to estimate costs and benefits based on different restoration methods. Given that natural regeneration (recruitment from the soil seed bank, dispersal or colonisation) is less expensive than planting, policies are needed to incorporate natural regeneration into these restoration strategies. In addition, areas to be intensively planted need to be prioritised, with places which are critical to ecosystem services considered a high priority for planting.

Nurseries that supply native plants for restoration have some challenges (Nunes *et al.* 2017). Despite the fact that the nurseries propagate a large number of species (38–44% of the regional flora), and this area has the highest diversity of native tree production in the world, several functional groups are absent or under-represented in nursery production.

One reason why a large number of species is available is due to the distribution of nurseries — they are scattered across the region, and collect seeds from their local area to grow. However, nurseries aren't evenly distributed across the region.

Under-representation of functional groups and uneven distribution of seed collection has meant that not all species required for restoration are available. In addition, nurseries are growing non-native species due to mis-identification. To address these two issues, the authors recommend training and capacity building for nursery staff in terms of plant identification and propagation knowledge, and ensure that local nurseries are growing plants where they are needed.

Governments play an important role in encouraging and facilitating restoration. For instance, in Sao Palo, there is a state decree with minimum standards for restoration (listing minimum number of species, proportions and monitoring indices, techniques and species lists for each region), which is a very useful restoration tool. In addition, the federal government has a restoration fund in the Atlantic Forest region. But, more can be done in Brazil, with Rodrigues *et al.* (Rodrigues *et al.* 2009) recommending that public policies should be used more to encourage restoration, for instance using financial and tax incentives.

Socioeconomic factors need to be considered, as restoration needs to be economically viable, and the benefits clearly communicated to local stakeholders. Also, better information on how to monitor restoration should be included in policies, as well as the provision of standardised designs which would provide comparable data.

Rodrigues *et al.* (2009) list a number of key learnings from restoration in the Atlantic Forest region of Brazil, many of which could be applied to other ecosystems. These are:

- select a restoration strategy based on site conditions
- consider socioeconomic and political issues

- increase species diversity
- ensure monitoring parameters provide sufficient information with which to do adaptive management
- share information on species such as phenology, seed storage and seedling production
- reduce costs of restoration
- combine economic activities with restoration
- train local people and form community cooperatives to do restoration activities (e.g. seed collection and nursery production of seedlings as well as implementation)
- political, financial and legal instruments are required to encourage restoration
- provide stakeholders with financial incentives to restore their land.

Subsequently Crouzeilles *et al.* (2019) attributed the success of the Atlantic Forest Restoration Pact in Brazil, which pledged 1m ha to the Bonn Challenge, to three key activities:

- 'development of restoration governance, communication and articulation;
- promotion of strategies to influence public policies; and
- establishment of restoration monitoring systems.'

KEY FINDINGS

- Identify restoration methods based on the degree of degradation of the ecosystem. Natural regeneration harnesses the capacity of the system, such as the existing soil seed bank, or potential for propagules to be dispersed into the system. Natural regeneration is likely to be the least expensive form of restoration, as seeds and plants are not required to be purchased. However, some level of threat management to halt and reverse the causes of degradation may be required, such as fencing to exclude herbivores.
- Determine the costs of restoration in each area, keeping in mind that different methods of restoration are required for different areas, and these different methods have different associated costs.
- Provide training and capacity building for nursery staff, including plant identification and propagation knowledge. Ensure that nurseries are growing a diversity of species, and a cross-section of the functional groups required for restoration.
- Social concern can pressure governments into acting to protect the environment.

The Middle East

Kuwait

Kuwait is situated in the Persian Gulf between Iraq and Saudi Arabia. In 1990, Kuwait was invaded and occupied by Iraq. A military intervention led by the US in 1991 then forced the Iraqi troops to withdraw, and during their retreat, the Iraqi troops set Kuwaiti oil wells on fire. As a result of the disturbance, Kuwait's natural environment, including flora, fauna and groundwater, was negatively impacted (Omar-Asem 2011). The UN Compensation Commission (UNCC) awarded Kuwait around US$2.95 billion for environmental restoration.

The Kuwait Environmental Remediation Program includes large-scale restoration of areas damaged by the military due to vehicle movement and trenches (Omar-Asem 2011). Around 80km^2 needs to be re-vegetated. Soil and groundwater contaminated by oil deposited from the explosion of oil wells needs to be treated. Contaminated soil still remains even after 29 remediations (Al-Qallaf *et al.* 2020). The program also aims to establish five protected areas. The management and supervision of the program is the responsibility of the Kuwait Institute for Scientific Research,[83] and the project implementation is supervised by the Kuwait National Focal Point (formed in 2006) and undertaken by the stakeholders (government organisations).

Large-scale restoration in Kuwait faces many challenges, especially due to the arid environment (Omar-Asem 2011). There are additional and ongoing factors which have led to degradation, including overgrazing by sheep, camels and goats, quarrying, camping, off-road vehicles, and gravel quarries (Omar and Bhat 2008).

Capacity building is required to develop propagation protocols for native plants. Fresh water needs to be supplied in the early stages of plant establishment, so water needs to be sourced and irrigation systems developed. Another complication is the existence of unexploded mines. There has been a loss of topsoil, as well as soil compaction and a reduction in water infiltration (Omar *et al.* 2005).

Recovery of the natural environment has been slow, and it appears that natural regeneration is ineffective. Suggestions to improve recovery include shelter belts, water conservation practices and native plant reintroduction, as well as protection from grazing and human activity (Omar and Bhat 2008). However, one area that was fenced in 1997 has shown an increase in vegetation cover. This enclosure has proven useful for studying vegetation succession, and has shown the potential for recovery, and hence is essential for long-term research and to provide a species inventory.

[83] UN Compensation for 1990 Iraqi Aggression (kisr.edu.kw)

KEY FINDINGS

- Natural recovery can be slow, particularly in areas with continuing threats and low rainfall.
- Areas protected from grazing and other threats can become good long-term study sites.

SYNTHESIS

FIGURE 2. WORD CLOUD OF THE TEXT IN THIS DOCUMENT

Key findings

Key findings within this review are combined and grouped according to international agreements, technical, socioeconomic and planning categories.

1. International agreements

- Restoration is an action that can contribute to all three Rio Conventions, although there are no UNCDD programs in Australia despite the large arid and semi-arid areas.
- International agreements can be a driving force in informing national strategies, hence all three conventions can inform an Australian restoration strategy.
- Develop a national strategy and action plan for the conservation and sustainable use of biodiversity, linked to international agreements to show how these agreements will be implemented.

2. Technical

Species selection

- Simply aiming to plant a lot of trees is not enough. The restoration plan needs to take into account appropriate species selection, financial considerations, landowner needs, climatic conditions and ongoing maintenance.
- Tree planting alone is not an adequate method. Ecological restoration should use local plants, adapted to the climate and soils.
- Having goals of planting a specific number of trees, or planting trees in a specific area may be counterproductive in ecosystems which are naturally devoid of trees, such as grasslands.
- Ensure that the right tree is planted in the right place for the right purpose.

Restoration approaches

- While excluding grazing can facilitate natural regeneration, it may not be an option in locations where landowners derive their income from grazing animals. However, temporary fencing may be used to initially exclude grazing animals while natural regeneration occurs and to protect planted seedings, then removed when the ecosystem is resilient enough to cope with some level of grazing. Alternatively, exclusions could be implemented on a small scale for high-value species.
- Field trials should be undertaken to inform species selection and restoration approaches.
- Identify restoration methods based on the degree of degradation of the ecosystem. Natural regeneration harnesses the capacity of the system, such as the existing soil seed bank, or potential for propagules to be dispersed into the system. Natural regeneration is likely to be the least expensive form of restoration, as seeds and plants are not required to be purchased.

However, some level of threat management to halt and reverse the causes of degradation may be required, such as fencing to exclude herbivores.

- Natural recovery can be slow, particularly in areas with continuing threats and low rainfall.
- Areas protected from grazing and other threats can become good long-term study sites.

Seed-based restoration

- Develop best practice guidelines for reintroductions. Australia already has these in place for threatened species reintroductions (Commander *et al.* 2018).
- Seed banking at a global scale requires specialist infrastructure and expertise. Australia already has a long-standing partnership with the Millennium Seed Bank, which is the world's largest seed bank of wild species. The MSB provides a good example of investment into infrastructure for seed storage and research, and a model for collaboration.
- Eco-regional programs that focus on increasing seed availability and developing knowledge about species in a specific region are an opportunity to collaborate at a regional level.
- Develop seed testing techniques/rules for the most commonly used species in restoration.
- Large warehouses are required to store large volumes of seeds for restoration.
- Large-scale, short-term seed storage may be under ambient conditions, however, seeds will live longer under low temperatures and humidity. Hence, in the tropics, ambient conditions may not be suitable for storage.

Nursery production of seedlings

- The quality of seedlings used for restoration needs to be regulated. It is important to have a set of clear and specific quality standards for seedlings, which include all important attributes for survival, including root systems.
- Comprehensive training for nursery producers is needed. This will ensure that seedlings are of high quality, which will likely result in better survival and growth. Increased survival lowers costs, as fewer seedlings need to be planted to achieve the target density.
- Accredited nurseries should be audited to ensure seedling quality is up to standard.
- Producing seedlings close to the area to be restored creates local jobs, thereby providing social and economic benefits, and minimises seedling damage during transport.
- An online propagation database would enable practitioners to find information about how to grow native species, and enable them to share their information with others.

- Working in partnership with local nurseries can increase knowledge of propagation, increase plants available for restoration, and increase the diversity of species available to be sold to the general public.
- Provide training and capacity building for nursery staff, including plant identification and propagation knowledge. Ensure that nurseries are growing a diversity of species, and a cross-section of the functional groups required for restoration.

Monitoring

- Monitoring programs need to be designed prior to implementation to measure success against the goals of the program. Simply measuring the area planted is not sufficient to determine whether or not functional goals (e.g. soil and water conservation) are achieved.

3. Socioeconomic factors

- Socioeconomic factors play a role in restoration effectiveness, and need to be taken into account in restoration planning, monitoring and adaptive management.
- Stakeholders should be involved in identifying natural capital and ecosystem services to increase awareness of the importance of biodiversity, and to encourage them to champion it.
- Consider sharing risk between supplier and purchaser through contract arrangements e.g. a fixed fee irrespective of final yield of seed production.
- Consider developing laws mandating basic seed testing and labelling for seed that is sold.
- Develop tools to prioritise areas for restoration, based on both biodiversity conservation and economic outputs to know where to restore to have the most impact.
- Quantify the benefits of restoration.
- Consider identifying economically unproductive land for restoration such as abandoned farmland, and land subject to overgrazing, salinisation and erosion, as these lands have low economic output.
- There are numerous individuals and organisations involved directly and indirectly in the seed supply chain. Factors affecting the performance of the seed supply chain in the US may apply to other regions, and should be addressed in any national seed strategies.
- Have pilot examples of restoration on public lands to inspire, educate and garner the support of private landowners.
- Determine the costs of restoration in each area, keeping in mind that different methods of restoration are required for different areas, and these different methods have different associated costs.
- Social concern can pressure governments into acting to protect the environment.
- The needs of the organisations implementing the conservation plans must be considered.

4. Planning

Coordination and governance

- Develop a board on ecological restoration.
- Megaconservancy Network is a concept that could be useful in Australia as a way of encouraging landowners to work together for a common goal.
- The UK strategy aims to work collaboratively to direct research to where it's needed.
- Long-term and landscape scale projects with multiple, collaborating stakeholders have value and should be considered as part of a national restoration program.
- Collaborative implementation has the potential to benefit restoration programs, although it is likely that some effort may be needed to provide scaffolding to ensure that it is effective.
- Establishment of nationwide networks through the seed supply chain will enable large-scale restoration.
- A formalised public-private partnership would assist all the organisations to work together towards a common goal.
- Develop a national seed collection program. A similar program already exists through the ASBP (also initially an MSBP partner), but there are 12 partners and they collect for conservation seed banks.
- National restoration programs could benefit from being run by a well-structured organisation with clear governance, representatives from both the public and private sector, scientific input and technical committees.

Land use planning and prioritisation

- Mapping the remaining vegetation and determining the landowners can identify key stakeholders and prioritise restoration techniques.
- Criteria for selecting areas for restoration include those that are: degraded, but retain enough potential to regenerate; in landscapes that have room for expansion through land acquisition; poorly financed or managed, but managed by owners with the incentive to invest in restoration.
- Integrating systematic conservation planning into land use planning policy and practice could have positive benefits for biodiversity and help with restoration planning.
- Conservation assessments at a regional scale may be useful to identify priority areas for conservation and restoration, and can quantify trade-offs between criteria.
- The conservation planning products need to be easily understood by end users.

- Hungary has taken a strategic approach to restoration planning which involved mapping all areas of vegetation, classifying vegetation condition, listing all restoration projects. This comprehensive approach was possible in Hungary partly due to the small land area, and already large proportion converted to agriculture. In Australia, this approach may not be practical at a national scale, but could be used at a regional scale.
- Data on restoration success is critical for planning.
- Restoration is integrated into a wholistic environmental strategy, which includes connecting people with nature to improve human health.
- The UK is focusing on ecological networks and priority species, as well as empowering landowners to deliver conservation.
- Protection and improvement of the natural environment is a core objective of the planning system. Planning is aimed to guide development and enhance natural networks.
- RBG Kew's Manifesto for Change and the 10 golden rules for reforestation could be adapted to the Australian context for ecological restoration.

Guidelines and strategies

- Having a national set of restoration guidelines helps policy makers and practitioners make consistent and informed decisions. It also serves as a mechanism to engage and collaborate with key stakeholders.
- The US seed strategy covers supply and demand, research and technology, decision making tools and communication. Having a structured strategy with a vision, mission, goals, objectives and actions clearly outlines what they want to do and how they will get there.
- Landscape-scale and continent-wide restoration programs are highly ambitious, and have the potential to achieve great outcomes. However, while the plan may be big in scale, the individual actions still need to be tailored to the local context.

International policy models

National and regional policies, Acts, strategies and programs include:

- Brazil: National Plan for Recovering Native Vegetation (PLANAVEG)
- China: Wildlife Conservation and Nature Reserves Development Program; Grains to Green; Three Norths Shelter Forest System Project; Natural Forest Conservation Program; Sand Control Program; Forest Industrial Base Development
- EU: EU Biodiversity Strategy to 2020[84]
- Finland: Saving Nature for People, for 2013–2020[85]

[84] https://ec.europa.eu/environment/nature/biodiversity/strategy_2020/index_en.htm
[85] https://ym.fi/en/national-biodiversity-policy;
https://ym.fi/documents/1410903/38439968/National_action_plan2013_SavingNatureforPeople-

- Kuwait: Kuwait Environmental Remediation Program
- NZ: One Billion Trees Programme[86]
- The Philippines: National Greening Program
- UK: A Green Future: Our 25 Year Plan to Improve the Environment[87]
- US: the Forest Landscape Restoration Act (FLRA); National Seed Strategy for Rehabilitation and Restoration 2015–2020 (National Academies of Sciences Engineering and Medicine 2020; Plant Conservation Alliance 2015b).

International economic models

Restoration drivers, including contributions to International Agreements

There are a variety of restoration drivers. These include:

- Biodiversity conservation, including threatened species protection (South Africa, Finland, Hungary, UK, Canada, US, New Caledonia)
- Climate change mitigation, sequester carbon (Great Green Wall, the Philippines)
- Combat desertification (Great Green Wall, China)
- Conservation and restoration of ecosystem function and services (e.g. soil conservation, reducing eutrophication, flood protection, erosion control, water quality) (South Africa, China, Finland, Hungary, UK, NZ)
- Consolidate greening efforts by government, civilians and private sector (the Philippines)
- Create (local) jobs (Great Green Wall, Mozambique, NZ)
- Discourage migration (Great Green Wall)
- Economic development/performance (Mozambique, NZ)
- Enhance positive values through shared management responsibilities (the Philippines)
- Implement international and regional commitments, e.g. Nationally Determined Contributions (Brazil), Nagoya Protocol (UK, Finland), EU Biodiversity Strategy (UK, Hungary)
- Increase number and quality of places for nature to benefit people, other social outcomes (UK, NZ)
- Invasive species management (US, New Caledonia)

EA60AA4E_861F_414D_9EFE_E8B967313381-96885.pdf/3fd101e9-6a12-91f8-211c-a2ab1d32794b/National_action_plan2013_SavingNatureforPeople-EA60AA4E_861F_414D_9EFE_E8B967313381-96885.pdf?t=1603260663505

[86] https://www.mpi.govt.nz/forestry/funding-tree-planting-research/one-billion-trees-programme/about-the-one-billion-trees-programme/

[87] https://www.gov.uk/government/publications/25-year-environment-plan

- Promote awareness and environmental consciousness on the value of forests (the Philippines)
- Provide benefits for wildlife (UK, Mozambique)
- Provide food (Great Green Wall)
- Provide foods, goods and services, such as timber, aesthetic values (Great Green Wall, the Philippines)
- Recover from conflict, political instability, war (Kuwait, Mozambique)
- Recover from hurricane (US)
- Recover from wildfire (US)
- Reduce conflict (Great Green Wall)
- Reduce poverty (the Philippines)
- Support a low emissions economy (NZ)
- Support Indigenous Peoples' aspirations (NZ)
- Sustainable management of natural resources (the Philippines, Finland).

Funding sources

Across the globe, restoration programs receive funding, or are working towards receiving funding, from the following:

- Donors (philanthropy) (Mozambique)
- European Union (Finland, Great Green Wall)
- Federal government funding and federal government environment/national parks agencies (US, NZ, Brazil, China, Philippines, Canada, Finland, New Caledonia, Great Green Wall)
- Local government (New Caledonia)
- Matching federal funding with contributions from the implementing organisation (NZ)
- Matching federal funding with private sector donations (US)
- Nature-based tourism (Mozambique)
- Other international organisations, e.g. IUCN, FAO, Global Environment Facility (Great Green Wall)
- Private funding (Finland)
- UN (Kuwait)
- WWF (New Caledonia).

Government financial incentives can include tax exemptions (e.g. making the cost of restoration tax-deductible), disincentives (e.g. penalties for logging), tax levies on specific industries, payments for ecosystem services through restoration and provision of free seedlings (Mansourian 2020). In fact, tax levies on industries such as the energy sector or fees on electricity bills, can be used to fund payments for ecosystem services. Other options include schemes which match donors with restoration implementers, private companies and investors, soft loans, micro-credit systems and carbon funding.

Market conditions (e.g. an increase in ecotourism, decrease in agricultural products) can influence restoration. Long-term financing from federal governments is essential (Mansourian 2020). Financial payments such as grants or subsidies could be based on tree survival, rather than number of trees planted to incentivise restoration success (Zhang *et al.* 2016).

Economic benefits

- Forest products (timber, honey)
- Ecotourism
- Employment of local people to implement restoration
- Improved agriculture through improved pollination, water availability
- Reduced insurance costs and recovery costs through reduced damage from weather events (fire, floods).

Policy implementation

Financial support is required to implement policies in several key areas.

Leadership and coordination

While restoration and/or conservation programs in some countries are run through a single government department (e.g. Parks Canada), several countries have multi-organisation partnerships to run restoration programs, like the CEN in New Caledonia, the Plant Conservation Alliance in the US, One Billion Trees Strategic Science Advisory Group in New Zealand, and Finnish Board on Ecological Restoration (FBER) in Finland. In the Philippines, the National Greening Program aimed to consolidate greening efforts by government, civilians and the private sector, and the National Seed Strategy in the US also aims to coordinate public and private restoration efforts. While coordinated governance is useful for planning, having local authorities and officers to guide implementation is critical (Mansourian 2020).

A multi-organisation, polycentric partnership to lead and coordinate restoration in Australia, and provision of resources and capacity building at a local level, would provide benefits and require funding for establishment and maintenance.

Assessment

One of the first steps in understanding what needs to be restored is to understand the current condition of ecosystems in the country. This provides a starting point for prioritisation and a baseline with which to compare interventions. Ecosystem assessments have been undertaken in several countries — the UK and Hungary have performed national assessments, South Africa has performed a regional one. In Australia, ecosystem assessments at national, state and regional levels are required. Assessments may already be complete in some areas. However, the methodologies may not be standardised, and hence results not comparable. Such an assessment would require funding.

Prioritisation/spatial planning

National and regional restoration projects have used different methods to prioritise areas for conservation/restoration (e.g. South Africa, Hungary, Finland). An investigation into conservation planning, restoration prioritisation, land use planning and spatial planning should be undertaken to investigate how restoration is prioritised currently in Australia.

- For instance, is restoration done mostly where there are people who are keen to do it, who apply for grants, and who give up part of their farmland to convert back to an ecological community, or who restore existing vegetation on their land, or who care about their local bushland or national park?
- Is there a connection or synergy between prioritisation being undertaken by state and territory governments on the land that they manage, and restoration being undertaken on private land?
- Are some ecosystems receiving more funding and attention than others, and is this due to higher needs of some ecosystems, or higher public profile? Which ecosystems are in danger of 'death by a thousand cuts', whereby small areas are destroyed, each adding up to a large impact?

Opportunity cost

Several countries have recognised that restoration has an opportunity cost (e.g. Mozambique, Finland), that is, restored land cannot be sold for housing, used for cropping, or other land uses. So, in these cases, landholders need to be compensated for the lack of direct income, or a viable business opportunity needs to be presented, e.g. whether the land be used for seed collection for which they receive payment, ecotourism opportunities such as camping, wildflower tours, hiking trails, sustainable wildflower harvesting, or carbon credits.

Alternatively, nature-based solutions using restoration could be fully costed, and landowners paid for restoring ecosystem services. In Finland, for instance, private forest owners are paid for voluntary conservation to stop biodiversity loss, either by permanent or temporary protection or nature management projects.

National guidelines

National restoration guidelines have been developed in both Finland and Canada. International (Gann *et al.* 2019) and Australian (Standards Reference Group SERA 2017) restoration standards have also been published. These standards could be used to develop national restoration guidelines, to complement the existing national guidelines on threatened plant translocation (Commander *et al.* 2018), ex situ plant conservation (Offord and Meagher 2009) and seed collection and use (Commander in prep).

Given the large land area of Australia, and the diversity of ecosystems, it is likely that overarching guidelines for each biome in each climatic zone (temperate and tropical, grasslands, woodlands, forests, coastal, riparian, alpine), will be required, along with specific guidelines for each ecological community.

Restoration approaches

Several countries have used or highlighted the effectiveness of natural regeneration, such as in Niger (Great Green Wall), New Caledonia and Brazil. Natural regeneration has also been recommended in reports by Di Sacco *et al.* (2021) and Pringle (2017). Natural regeneration is often less expensive than planting seedlings, however, it may not always be an effective approach.

Restoration approaches should match the level of degradation of the ecosystem and its potential for recovery (Gann *et al.* 2019) — if no propagules remain, and are unable to colonise, then plants will need to be reintroduced. It is also possible to have a range of approaches for different species — while some species may naturally regenerate, others may need reintroduction.

How natural regeneration is funded may be problematic, given that many restoration programs fund tree planting (e.g. NZ's One Billion Trees Programme), and reporting statistics are based on the number of trees planted.

Technical capacity

Reports from restoration projects in both the Philippines and Brazil recognised that issues with seedling production hampered restoration efforts. Nunes *et al.* (2017) recommended training and capacity building in Brazil so that nursery staff could improve plant identification and propagation knowledge. Gregorio *et al.* (2017) recommended nursery accreditation, capacity building for nursery operators, and developing quality standards for seedlings.

Restoration programs in New Caledonia resulted in an increase in local capacity by increasing scientific knowledge and restoration techniques (Mansourian *et al.* 2018). In New Caledonia, there were additional flow-on benefits, such as an increased diversity of plant species becoming available to the general public through nurseries.

In the US, a comprehensive strategy has outlined the need for an increase in technical capacity, including increasing seed availability, improved technology for seed production and restoration and decision-making tools (Plant Conservation Alliance 2015b).

Australia could invest in increasing technical capacity to increase seed production, seedling production and restoration implementation.

RECOMMENDATIONS

Recommendations for a future national restoration program in Australia, including policy implementation and opportunities for economic stimulus.

Investment

A national restoration plan could help Australia fulfil its international commitments, e.g. meeting Aichi biodiversity targets (UN Convention on Biological Diversity) and the Nationally Determined Contributions (NDCs) under the Paris agreement (UN Framework Convention on Climate Change).

Several aspects of a national restoration program require funding. To achieve landscape scale restoration, Australia could invest in the following areas.

National coordination

- A national board of restoration with public and private representatives.
- Creating coordination and governance among those implementing restoration to consolidate restoration efforts by government, organisations and individuals.
- National alliance of Australian research institutions (similar to EU LIFE).
- Networks to enable cooperative management of natural capital for common goals (e.g. the Megaconservancy Network concept).

Increase in technical capacity and infrastructure

- The how-to of restoration — improving practice to make restoration cheaper and more cost effective. For instance, developing technical knowledge on how to restore ecosystems and how to propagate plants. This is likely to require an inter-disciplinary research program with networked field trials.
- Building local infrastructure such as seed processing facilities, seed storage facilities and nursery facilities.
- Training for seed collectors, nursery propagators, practitioners, landowners and volunteers.
- Training for those planning and implementing restoration: local government, landholders, volunteers and restoration practitioners.
- Training for Indigenous rangers and Indigenous seed collectors.
- Quality standards for seedlings and standardised seed labelling.

Business development to invest in nature-based solutions, restoration and natural capital

- Business development for Indigenous restoration practitioners.
- Ecotourism opportunities — setting aside areas for recreation to make restoration pay — integrating campsites into ecological restoration, walking/hiking trails, mountain bike trails, wildlife tours, 'glamping', network of long-distance hikes through restored areas with supporting infrastructure (e.g. the Bibbulmun Track in Western Australia, El Camino de Santiago in Spain).
- Develop business plans for the sustainable use of 'forest products' including timber, wildflowers, honey, bushfoods.
- Research to quantify carbon storage of native plants, and also soil carbon storage of restored ecosystems.
- Increase the number and capacity of carbon offset providers, which are currently experiencing increasing demand, and develop standards for these providers to ensure that they are planting the right species in the right place, and that they have correctly calculated the carbon sequestration.

Ensure that these carbon offset plantings are sustainable and are subject to ongoing monitoring and management — currently those seeking to offset their carbon purchase a tree to be planted, but whether or not that tree survives may not be recorded.

Also, determine whether purchasing a tree is the best method of carbon offsets. Perhaps providing money for an area of land to undergo ecological restoration may be a more sustainable option, particularly to encourage biodiverse ecological restoration, and enable funding of restoration in areas with few trees (e.g. shrublands and grasslands) and non-seedling based restoration approaches (e.g. natural regeneration), and recognising the contribution of soil carbon.

Land use and restoration planning

- Increasing site knowledge (at various scales) of existing vegetation, the degree of degradation, the potential for recovery, which determines which restoration approaches to choose.
- Developing a prioritisation tool to determine which areas to restore first, and which should receive higher levels of intervention.
- Increasing remote sensing capacity to assess Australia's existing vegetation, and document a baseline by which to determine restoration success.
- Developing clear goals and a monitoring and evaluation program to assess when/if the goals are achieved.

Communication

- Developing a communication strategy to build social consciousness, including mainstream media such as TV documentaries — the general public need to know why restoration is needed, and need to pressure governments to act.
- Developing a communication strategy to educate those involved in restoration. This depends on the target audience and scale (regional, state, national) and may include websites, fact sheets, volunteer days, training programs, workshops, conferences, and educational signage.

Socioeconomics

- Investigating how socioeconomic issues drive or restrict restoration.
- Developing legal and political mechanisms to encourage, fund and mandate.

Benefits

Benefits of investment would flow to:

- Tourism sector, especially in the regions, e.g. accommodation and camping, regional food and drink vendors (i.e. cafes and restaurants), wildflower, wildlife and Indigenous tour operators, ecotourism.
- Nursery industry — increased availability of native plants for sale.
- Industries using native plants for food/drink (bushfoods, 'native botanicals' used in gin and other alcoholic drinks, macadamia).
- Cosmetics and fragrance industries that use native products.
- Agricultural sector (improved water quality, dust suppression, increased infiltration for flood prevention).

Funding

The Restoration Plan could potentially access funding for:

- fire recovery
- flood prevention and recovery
- drought recovery
- threatened species recovery
- carbon credits
- complying with Paris Agreement and Aichi Targets
- fiscal stimulus packages addressing the impact of COVID-19
- other government priorities aligned with restoration.

Funding could also be sourced from:

- federal, state and local government
- philanthropy
- partnerships with industry/private sector
- funding matching arrangements.

CONCLUSION

Australia has an opportunity to learn from restoration programs across the world, as well as international and regional (e.g. EU) agreements and policies.

Investing in our natural capital through restoration will conserve biodiversity and improve ecosystem services, create jobs, and increase our landscape's resilience to fire and weather events.

KEY WEBSITES

- The Society for Ecological Restoration
  https://www.ser.org/

  https://www.ser-rrc.org/project-database/

  https://ser-insr.org/https://chapter.ser.org/europe/

  https://www.seraustralasia.org/
- The UN Decade on Restoration
  https://www.decadeonrestoration.org/
- United Nations Environment Program
  https://www.unep.org/
- Reforestation, Nurseries & Genetic Resources
  https://rngr.net/
- The Economics of Ecosystems and Biodiversity
  http://teebweb.org/
- The Economics of Biodiversity: The Dasgupta Review
  https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review
- UN System of Environmental Economic Accounting (SEEA)
  https://seea.un.org/ecosystem-accounting

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APPENDIX 1

Aichi Biodiversity Targets, taken from https://www.cbd.int/sp/targets/

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Target 13
By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.

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

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

Target 15
By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.

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

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

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

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

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

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

APPENDIX 2

Goals, objectives and actions of the US National Seed Strategy (Plant Conservation Alliance 2015b).

1. Identify Seed Needs, and Ensure the Reliable Availability of Genetically Appropriate Seed

1.1. Assess the Seed Needs of Federal Agencies and the Capacity of Private and Federal Producers

1.1.1. Conduct an assessment of seed needs for all Federal agencies and their offices that provide or use seed.

1.1.2. Identify and inventory agency and private sector seed collections, nurseries, and storage capacity.

1.1.3. Identify existing federal seed and restoration policies and guidance.

1.1.4. Analyze results of needs and capacity assessment to determine if agencies' needs are met.

1.1.5. Analyze results of policy and guidance assessment and develop restoration program.

1.2. Assess Capacity and Needs of Tribes, States, Private Sector Seed Producers, Nurseries, and Other Partners

1.2.1. Conduct a needs and capacity assessment of tribal, state, local, private sector, and nonprofit seed storage and distribution facilities.

1.2.2. Work with partners to leverage strengths and address deficiencies in distribution and availability of genetically appropriate seed.

1.2.3. Analyze results of needs and capacity assessment.

1.3. Increase the Supply and Reliable Availability of Genetically Appropriate Seed

1.3.1. Expand and improve facilities and plant production capacity.

1.3.2. Improve capability to plan for seed needs by seed zone.

1.3.3. Assess and implement alternative seed production methods for 'workhorse' shrub species.

1.3.4. Expand collection, conservation, and assessment of native plant genetic resources through programs such as SOS.

1.3.5. Engage Federal procurement specialists to assess contracting regulations and practices; correct deficiencies.

2. Identify Research Needs and Conduct Research to Provide Genetically Appropriate Seed and to Improve Technology for Native Seed Production and Ecosystem Restoration

2.1. Characterise Genetic Variation of Restoration Species to Delineate Seed Zones, and Provide Seed Transfer Guidelines for Current and Projected Future Environmental Conditions

2.1.1. Conduct genetic research to develop seed zones for key restoration species.

2.1.2. Develop predictive models of climate change effects.

2.2. Conduct Species-Specific Research to Provide Seed Technology, Storage, and Production Protocols for Restoration Species

2.2.1. Conduct seed germination studies and develop seed testing protocols for key restoration species.

2.2.2. Develop storage guidelines for key restoration species to improve maintenance of seed viability.

2.2.3. Develop species-specific protocols for seed and seedling production practices to maintain genetic diversity.

2.3. Conduct Research on Plant Establishment, Species Interactions, and Ecological Restoration

2.3.1. Develop site preparation and seeding and transplanting strategies that improve plant establishment and diversity.

2.3.2. Within seed zones, examine capacity of native plants to establish and persist.

2.3.3. Advance investigations to diversify depleted native communities.

2.3.4. Assess soil degradation, and develop treatments, soil amendments, and other site preparation techniques.

2.4. Develop or Modify Monitoring Techniques, and Investigate Long-Term Restoration Impacts and Outcomes

2.4.1. Analyze new and existing monitoring methodologies to evaluate restoration outcomes.

2.4.2. Quantify ecological and economic costs/benefits of planting native and non-native plants on public lands.

2.4.3. Study selected native plant restoration projects to evaluate short- and long-term responses.

3. Develop Tools that Enable Managers to Make Timely, Informed Seeding Decisions for Ecological Restoration

3.1. Develop Training Programs for Practitioners, Producers, and Stakeholders on the Use of Genetically Appropriate Seed for Restoration

3.1.1. Develop a cadre of experts, and work with partners to establish a restoration certification program.

3.1.2. Use and, where appropriate, expand the network of restoration field sites and demonstration areas.

3.1.3. Develop resources for managers to highlight successful/unsuccessful projects, including site visits.

3.2. Develop Native Seed Source Availability Data and Tools for Accessing the Data

3.2.1. Support regional/nongovernmental native seed networks that provide seed with seed zone origin.

3.2.2. Maintain a website with seed zone maps and publications, and develop a web-based seed selection tool to match seed source/planting site.

3.2.3. Create a multiagency and non-Federal partner seed inventory system.

3.2.4. Develop/enhance Federal agreement/procurement tools for multiagency seed acquisition.

3.3. Integrate and Develop Science Delivery Tools to Support Restoration Project Development and Implementation

3.3.1. Identify available restoration guides and protocols by ecoregion.

3.3.2. Write and distribute ecoregional native plant project reports.

3.3.3. Support field implementation of restoration tools.

3.4. Build on Ecological Assessments and Disturbance Data, and Provide Training that will Allow Managers to Anticipate Needs and Establish Spatially-Explicit Contingency Strategies

3.4.1. Identify/inventory climate-based geospatial tools to inform decisions on restoration site priority/methods.

3.4.2. Develop crosswalk of agency habitat restoration priorities/tools by provisional seed zone and plant community.

3.4.3. Assess climate modelling and soil/water remote sensing to forecast seedling establishment and persistence.

3.4.4. Develop GIS-based tools with disturbance data for prioritizing seed needs/projects.

3.4.5. Use risk-based assessment tools to prioritise treatment locations and refine strategies based on wildfire.

3.4.6. Develop a decision tool of belowground assessment and treatment.

3.4.7. Develop informational tools and guidelines on the appropriate use of cultivars, hybrids, and non-invasive non-native species.

4. Develop Strategies for Internal and External Communication

4.1. External Communications: Conduct Education and Outreach through the Plant Conservation Alliance Network

4.1.1. Develop a communications plan.

4.1.2. Involve the Plant Conservation Alliance in communications.

4.2. Internal Communications: Distribute and Implement the Strategy Across Agencies, and Provide Feedback Mechanisms

4.2.1. Develop internal communications plans.

4.2.2. Identify and use communication mechanisms for implementing the Strategy.

4.2.3. Make existing agency native plant policies available to the public.

4.2.4. Incorporate Strategy goals and key messages into landscape-scale restoration initiatives.

4.3. Report Progress, Recognise Achievements, and Revise Strategy

4.3.1. Establish mechanism to report progress, including successful native plant projects and lessons learned.

4.3.2. Recognise/promote achievements/needed improvements across all agencies and partners.

4.3.3. Review and revise the Strategy every 5 years or as needed.