The Western Australian Biodiversity Science Institute

# Restoration standards for the Western Australian Wheatbelt

A practical guide for restoration managers

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## Acknowledgement of Country

We acknowledge the traditional custodians throughout Western Australia and their continuing connection to, and deep knowledge of, the land and waters. We pay our respects to Elders both past and present.



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A practical guide for restoration managers

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**Prepared by:**

The Western Australian Biodiversity Science Institute

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# Acronyms

| | |
|---|---|
| **ABARES** | Australian Bureau of Agricultural and Resource Economics and Sciences |
| **ACCU** | Australian Carbon Credit Units |
| **ALUM** | Australian Land Use Management |
| **BDR** | Biodiversity Data Repository |
| **CBH** | Cooperative Bulk Handling |
| **CCA** | Climate Change Authority |
| **CF-LRP** | Carbon Farming and Land Restoration Program |
| **CSIRO** | Commonwealth Scientific and Industrial Research Organisation |
| **DAFF** | Department of Agriculture, Fisheries and Forestry |
| **DAFWA** | Department of Agriculture and Food Western Australia |
| **DAP** | Data Access Portal |
| **DBCA** | Department of Biodiversity Conservation and Attractions |
| **DCCEEW** | Department of Climate Change, Energy, the Environment and Water |
| **DEC** | Department of Environment and Conservation |
| **DotE** | Department of the Environment |
| **DPaW** | Department of Parks and Wildlife |
| **DPIRD** | Department of Primary Industries and Regional Development |
| **DWER** | Department of Water and Environmental Regulation |
| **EC** | Electrical Conductivity |
| **EMSA** | Ecological Monitoring System Australia |
| **EP Act** | *Environmental Protection Act 1986* |
| **EPA** | Environmental Protection Authority |
| **EPBC Act** | *Environmental Protection and Biodiversity Conservation Act 1999* |
| **FLFT** | Farming Landscapes for the Future Tool |
| **FullCAM** | Full Carbon Accounting Model |
| **GBF** | Global Biodiversity Framework |
| **GIS** | Geographic information system |
| **IK** | Indigenous Knowledge |

| | |
|---|---|
| **ILUA** | Indigenous Land Use Agreement |
| **IUCN** | International Union for Conservation of Nature |
| **LEK** | Local Ecological Knowledge |
| **LOOC-C** | Landscape Options and Opportunities for Carbon Abatement Calculator |
| **MNES** | Matter of National Environmental Significance |
| **NESP** | National Environmental Science Program |
| **NLE** | Noongar Land Estate |
| **NRM** | Natural Resource Management |
| **NVIS** | National Vegetation Information System |
| **OCBIL** | Old Climatically-Buffered Infertile Landscape |
| **PEC** | Priority Ecological Communities |
| **PLANR** | Platform for Land and Nature Repair |
| **RAC** | Restoration Activity Class |
| **REM** | Restoration Environmental Management |
| **SEEA-EA** | System of Environmental Economic Accounting - Ecosystem Accounting |
| **SER** | Society for Ecological Restoration |
| **SERA** | Society for Ecological Restoration Australasia |
| **SMART** | Specific, Measurable, Achievable, Relevant, and Time-bound |
| **SoP** | Standards of Practice |
| **TAS** | Threat Abatement Strategy |
| **TEC** | Threatened Ecological Community |
| **TEK** | Traditional Ecological Knowledge |
| **TERN** | Terrestrial Ecosystems Research Network |
| **TGBS** | The Global Biodiversity Standard |
| **TSAP** | Threatened Species Action Plan |
| **UAV** | Unmanned Aerial Vehicles |
| **UN** | United Nations |
| **UNCEEA** | United Nations Committee of Experts on Environmental-Economic Accounting |
| **UWA** | University of Western Australia |
| **WA** | Western Australia |
| **WABSI** | The Western Australian Biodiversity Science Institute |
| **WRI** | World Resources Institute |
| **WRS** | Wheatbelt Restoration Standard |

**WWTEC**, Wheatbelt Woodland Threatened Ecological Community

# 1. Executive Summary

**The Wheatbelt region of the south-west of Western Australia is one of the most cleared and fragmented, ancient landscapes in Australia. The region is recognised as a globally significant biodiversity hotspot and for its exposure to a diverse range of threats including climate-induced drying.**

Inevitable decline in ecosystem condition from current and legacy degrading processes poses a significant threat to biodiversity, agricultural production, and the region’s cultural, social and economic aspirations. The impacts of climate change are unavoidable and disproportionately affect both rural and Noongar people as Traditional Custodians of the region. There is a clear imperative to reverse threats to ecosystem integrity and recover biodiversity with ecosystem restoration.

Multi-purpose restoration activities in pursuit of practical repair of degraded ecosystems, nature conservation, and nature positive goals are driving land use change across significant areas in the Wheatbelt. The developing restoration economy provides an investment framework supported by governments to protect and restore nature. Demand for restoration projects and services are anticipated to increase as:

1. Australia's environment ministers have agreed to national restoration targets to support the Global Biodiversity Framework.
2. Companies are considering their impact on climate and nature, driving  the demand for restoration as a mitigative tool.
3. Proponents following a mitigation hierarchy through legislated environmental approvals processes implement restoration projects to offset residual impacts.
4. Restoration methods are being recognised for their effectiveness in reversing degrading processes to soils, groundwater, and naturally occurring freshwater wetlands and for increasing natural capital in farming systems.

## Scope

Ecosystem restoration that aims to establish either endemic native ecosystems or novel communities may be subject to complex challenges throughout the life of a project. The Wheatbelt Restoration Standard (WRS) presents a linear framework, principles and tools to guide on-ground ecosystem restoration practice. A summary of the framework is shown below on the five key stages and nine supporting tools. This is based on the first seven years of a restoration project, assuming an assessment on ecosystem recovery is likely to be informative around seven years post commencement for ecosystems in the Wheatbelt. An assessment in this context can help to judge whether the trajectory of recovery toward a reference state is on track, noting a longer or shorter timeframe may be deemed more appropriate for the specific restoration project.

| YEAR 0 | | | YEAR 1–2 | YEAR 3–7 |
|---|---|---|---|---|
| **Stage 1** Scope | **Stage 2** Design | **Stage 3** Finance | **Stage 4** Implement | **Stage 5** Monitor |
| ✓ Polarity tool<br>✓ Restoration barriers checklist<br>✓ Example completion criteria | ✓ WWTEC tool<br>✓ Recovery Wheel<br>✓ Social Benefits Wheel | ✓ TAS cost model<br>✓ CF-LRP costings calculator | ✓ Recovery Wheel<br>✓ Social Benefits Wheel<br>✓ EMSA templates & App | ✓ Recovery Wheel<br>✓ Social Benefits Wheel<br>✓ EMSA templates & App |

The WRS applies to restoration of endemic native ecosystems and novel ecosystems such as those sometimes established through carbon farming restoration activities throughout the Wheatbelt. It supports restoration activities across a range of base states (e.g. cleared or highly degraded sites through to existing remnant vegetation where an improvement in condition is desired) and across a range of target levels of recovery (e.g. lower levels of recovery where there are specific ecological, economic or social conditions that limit recovery through to full recovery).

Given the extent of clearing and dynamic threats impacting the *Eucalypt Woodlands of the Western Australian Wheatbelt* Threatened Ecological Community (WWTEC), the WRS emphasises ecosystem restoration associated with these eucalypt woodland communities. A 'WWTEC tool' supporting the WRS presents key characteristics of eucalypt communities and subcommunities comprising the WWTEC. The WWTEC tool characterises each community by describing the dominant species forming the tree canopy and understorey, associated landforms, soil types and average species richness together with plant species associated with each community. The WWTEC tool is intended for use by restoration managers for a variety of purposes including selecting species that are suited to landforms and soil characteristics of a project site and developing planting designs analogous to the composition and structure of these ecological communities.

The WRS supports ecosystem restoration outcomes that are driven by local, state and Commonwealth level legislative processes, including but not limited to projects assessed under *Environmental Protection Act 1986* (EP Act) or the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) applying the mitigation hierarchy. The WWTEC tool may be used to inform key diagnostic characteristics of completion criteria developed in consultation with environment regulators and incorporated into either Restoration Environmental Management Plans (REM Plans) or Closure Plans that aim to achieve the highest level of recovery possible.

The Society for Ecological Restoration's (SER) Ecological Recovery Wheel (Recovery Wheel) provides a framework for the development of detailed monitoring, evaluation and reporting of projects. The WRS follows the SER approach, noting adjustments have been made to increase relevance, including the development of completion criteria for projects with legislative requirements. Examples of completion criteria against the six attributes of the Recovery Wheel is provided for values commonly associated with restoring eucalypt woodland communities endemic to the Wheatbelt. The Recovery Wheel is recommended for all restoration projects to measure and monitor performance against a project's scope, targets and environmental outcomes.

SER has developed a complementary Social Benefits Wheel, highlighting the importance of stakeholder engagement particularly to restoration projects which are complex in terms of land use or level of degradation. The Social Benefits Wheel is a recommended tool for the WRS when developing performance indicators for social, environmental and economic values important to stakeholder and partners of a restoration project.

## Approach

In 2022, WABSI hosted a workshop that brought together stakeholders from government, industry and research, to identify gaps and barriers to advancing strategic restoration priorities within the Wheatbelt. Following further consultation with stakeholders, a program scope was developed to develop the Wheatbelt Restoration Standard (WRS), commissioned in 2023 and commenced in 2024.

Local, national, and international literature was reviewed, and interviews undertaken with Noongar kaartdijin (knowledge) holders, stakeholders in restoration ecology science, climate science, natural resource management, agriculture, government and industry to understand the needs and benefits of restoration activities, current barriers and priorities for the Wheatbelt. Following the WABSI program delivery model, the WRS was developed in an iterative approach with ongoing engagement between stakeholders and experts to refine the framework and tools.

# Conclusion and next steps

The WRS recognises all restoration efforts are intrinsically linked to long-term social-ecological outcomes for the region. A shared understanding of restoring resilient ecosystems is fundamental to achieving effective landscape-scale restoration outcomes for the Wheatbelt region. Adopting a consistent, repeatable and scalable approach to restoration enables synergistic interactions within environmental systems and land use. Standardised restoration-related information can contribute to improved environmental outcomes for the region through innovation, collaboration and research.

Stakeholders consulted in the development of the WRS have highlighted several key gaps in current knowledge to restoring ecological communities endemic to the Wheatbelt. Research priorities are proposed to optimise future funding streams and promote strategic outcomes for the region.

# 2. Introduction

**The Wheatbelt region is one of the most cleared and fragmented, ancient landscapes in Australia. Inevitable decline in ecological condition from current and legacy degrading processes poses a significant threat to agriculture production, biodiversity, and community cultural, social and economic aspirations.**

Indigenous culture and lore is deeply connected with terrestrial ecosystems endemic to the region, climate and their cycles and is largely unrecognised in western scientific research and standards. Recognising the wisdom and expertise to restore ecosystems, through the strength of Caring for Country, requires fairly valuing indigenous knowledge of natural processes and their complexities to ecosystem restoration is even more important as evidence of ecological crisis increases (Morrison 2024). It is important to acknowledge that the predominantly western-science perspective provided in this standard presents limitations as well as offering solutions. Integrating Indigenous and western ecological knowledge to inform ecosystem restoration will lead to more resilient outcomes to nature's climate and biodiversity crisis.

The south-west region of Western Australia is recognised as globally significant both for biodiversity value and for climate-induced drying (Myers et al. 2000, DWER 2023). Impacts of climate change are unavoidable across South-West Western Australia and disproportionately affect rural and Noongar people, the Traditional Custodians of the region (DWER 2023, Hughes et al. 2016). There is an increasing expectation from society and investors that restorative activities including carbon plantings, seek to restore local biodiversity values and improve soil health. There is a clear imperative to manage threats to ecosystem integrity on a regional or landscape scale and particularly reversing biodiversity loss (Wheatbelt Development Commission 2024, EPA 2024, DWER 2022a, Gann et al. 2019). Examples of causes and resulting effects of the threat of ecosystem decline or collapse are presented in Figure 1.

Restoration efforts have the potential to increase nature's resilience, facilitate recovery of threatened species and ecosystems and support ecologically sustainable development (Figure 2). Current approaches to restoration are ad-hoc, constrained, and may not deliver net positive impact (Samuel 2020). Adopting scientifically rigorous methods to restoration activities improves outcomes at a local scale and enables benefits to be leveraged at a regional scale (Figure 2). Further, determining how these restored ecosystems functionally 'connect' both at a local and landscape-scale will become increasingly important to demonstrating a project's value proposition to stakeholders (Standish and Parkhurst 2024).

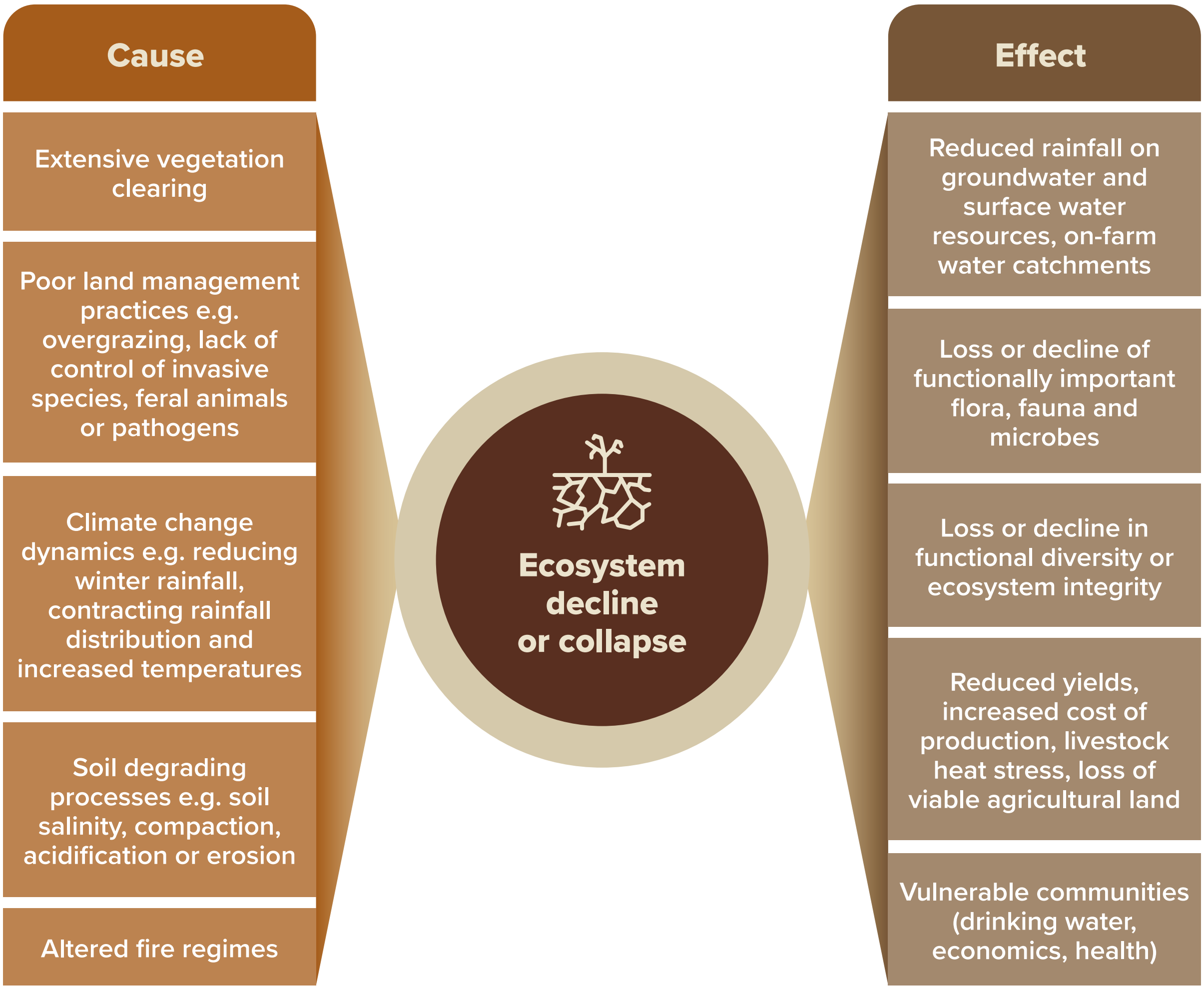



FIGURE 1: Example causes (Bergstrom et al. 2021, Wallace et al. 2003) and effects (Climate Change Authority 2024, Bergstrom et al. 2021, Hoffmann et al. 2019, Sudmeyer et al. 2016, Keith et al. 2013, Department of the Environment 2015) of Wheatbelt ecosystem decline or collapse

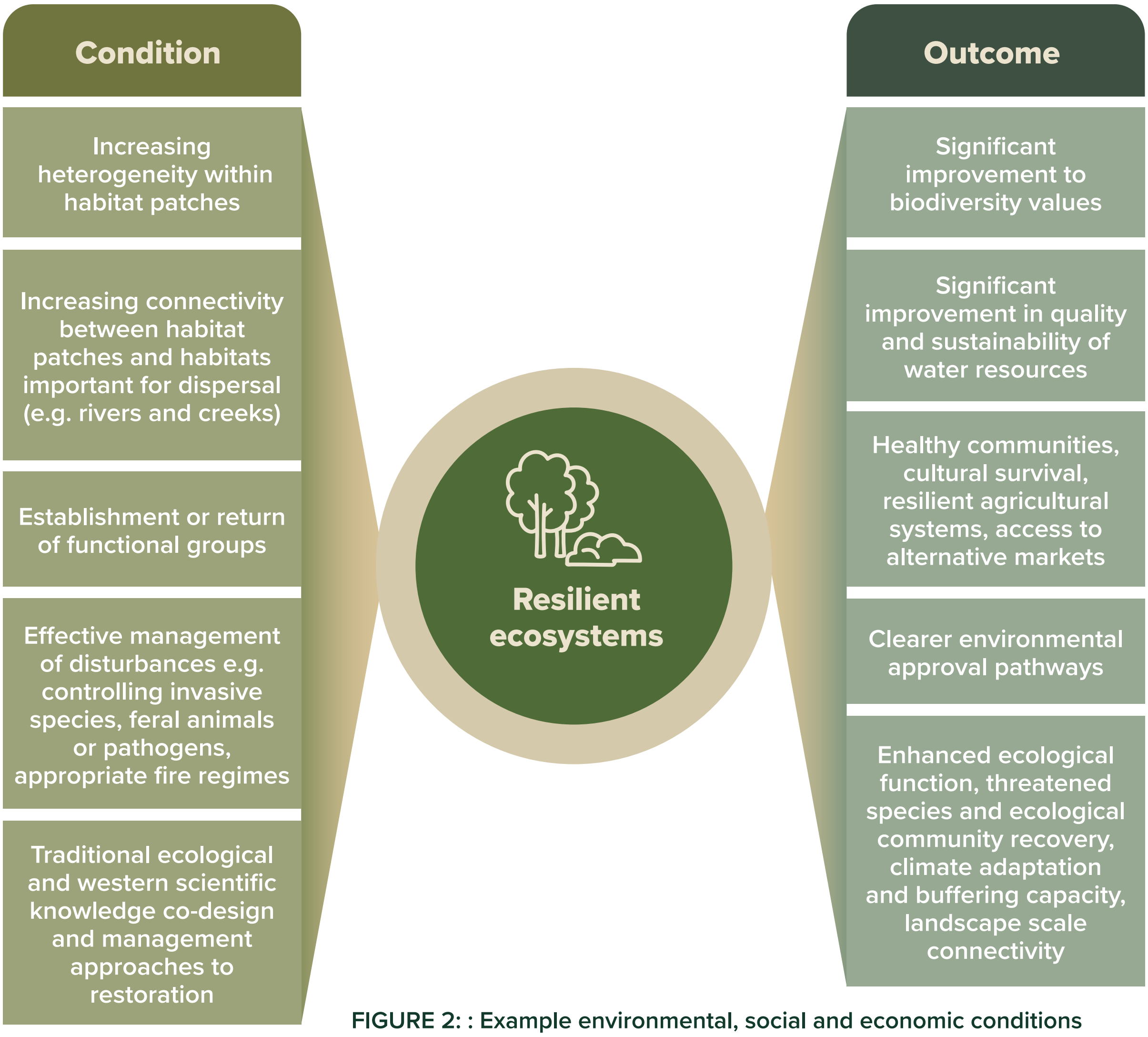



FIGURE 2: : Example environmental, social and economic conditions (Standish et al. 2014, Department of the Environment 2015) and outcomes of resilient ecosystems

Globally, governments have pledged to restore 350 million hectares by 2030. In Australia, the Commonwealth government enacted the Nature Repair Act 2023, forming part of its Nature Positive Plan and is establishing a new Nature Repair Market (Gibson 2023) with methods for qualifying a project for biodiversity certificates (DCCEEW 2024b). A new restoration economy is driven by a net zero target by 2050 and supported by multiple policy instruments and initiatives (Young et al. 2023). However, if not well considered, revegetation-based activities in the Wheatbelt risk locking in competing land use with limited environmental and other co-benefits (Young et al. 2023). Demand for restoration projects and services is anticipated to increase under global and national frameworks and as organisations look to reduce their climate and nature related financial risk and access growing sectors of the economy.

***The purpose of this Wheatbelt Restoration Standard (WRS) is to guide restoration managers through a practical framework informed by leading practice and principles, enabling a consistent approach to ecosystem restoration at a landscape scale.***

Restoration projects positioned along the restorative continuum (Figure 3) aim to achieve varying levels of recovery and require a practical method for measuring performance. The WRS adopts the Society for Ecological Restoration's (SER) 5-star system (Figure 3) approach to measuring recovery, discussed further in Stage 5.

All restoration efforts are intrinsically linked to long-term social-ecological outcomes for the region. A shared understanding of restoring resilient ecosystems is fundamental to manage the risks of poor restoration practice and to achieve exemplary landscape-scale restoration. Adopting a regional approach enables synergistic interactions within catchment scale environmental systems and land use. It promotes collaboration and innovation across industries and communities in the Wheatbelt, ensuring that research investment can address restoration challenges.

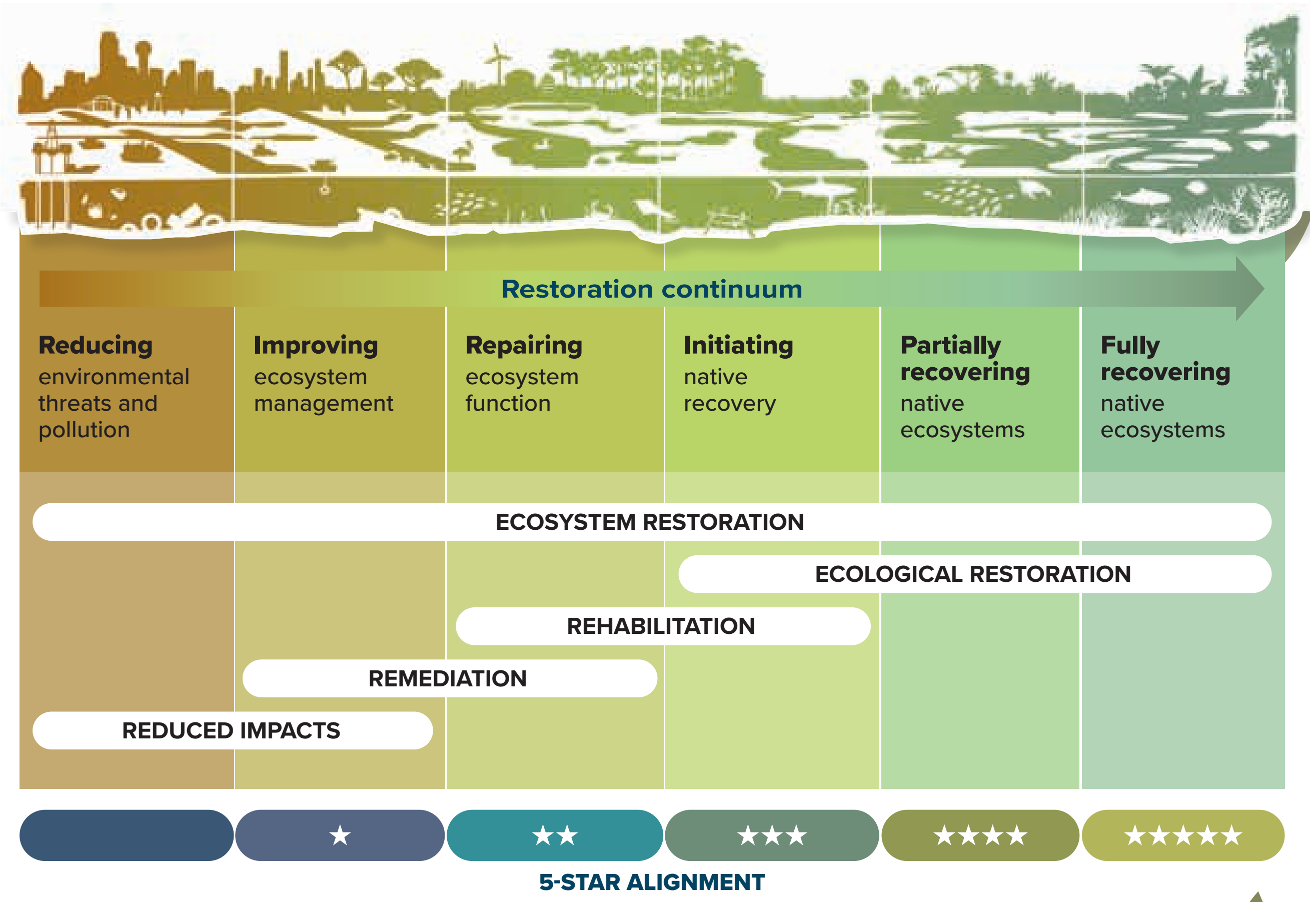



FIGURE 3: The restorative continuum and alignment with the 5-star recovery system (modified from FAO, SCBD & SER 2024)

# 3. Scope and limitations

**The WRS has been developed to enable restoration projects of variable spatial and temporal scales across the Wheatbelt region, including but not limited to projects aimed at ecosystem restoration, land rehabilitation and biodiverse carbon farming.**

The WRS provides restoration managers with technical assurance when planning, implementing and managing restoration projects. Standardised collection and development of information supports effective project governance and transparent stakeholder engagement. It enables best practice methods to be shared to better address ecosystem restoration challenges in the Wheatbelt.

The WRS applies to restoration of endemic native ecosystems and novel ecosystems such as those sometimes established through carbon farming restoration activities throughout the Wheatbelt. It supports restoration activities across a range of base states (e.g. cleared or highly

degraded sites through to existing remnant vegetation where an improvement in condition is desired) and across a range of target levels of recovery (e.g. lower levels of recovery where there are specific ecological, economic or social conditions that limit recovery through to full recovery).

Given the extent of clearing and dynamic threats impacting the *Eucalypt Woodlands of the Western Australian Wheatbelt* Threatened Ecological Community (WWTEC), the WRS emphasises ecosystem restoration associated with eucalypt woodland communities described in the Commonwealth Government approved conservation advice (Department of the Environment 2015). The WRS also supports ecosystem restoration activities that are driven by local, state and Commonwealth level legislative processes, including but not limited to projects assessed under *Environmental Protection Act 1986* (EP Act) or the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) applying the mitigation hierarchy.

The WRS guides restoration managers as they develop an accumulation of experience, knowledge and understanding of key responsibilities, stakeholder and partnership development and operational requirements applicable to restoration activities in the Wheatbelt. The minimum requirements for undertaking ecosystem restoration presented are intended to support strategic regional policy, plans and guidance relevant to the Wheatbelt region and while every attempt to acknowledge key documents have been made, it is not intended as an exhaustive list.

The WABSI Conservation and Restoration Program provides a coherent framework to support the needs of  restoration managers (Figure 4). It addresses end user needs  identified by WABSI through stakeholder consultation in in  *Biodiversity Knowledge Priorities 2023–2028* (WABSI 2022) and complements The Western Australian Restoration Economy (Young et al. 2023) and *Restoration Economy Research Prioritisation* (Young in prep.).

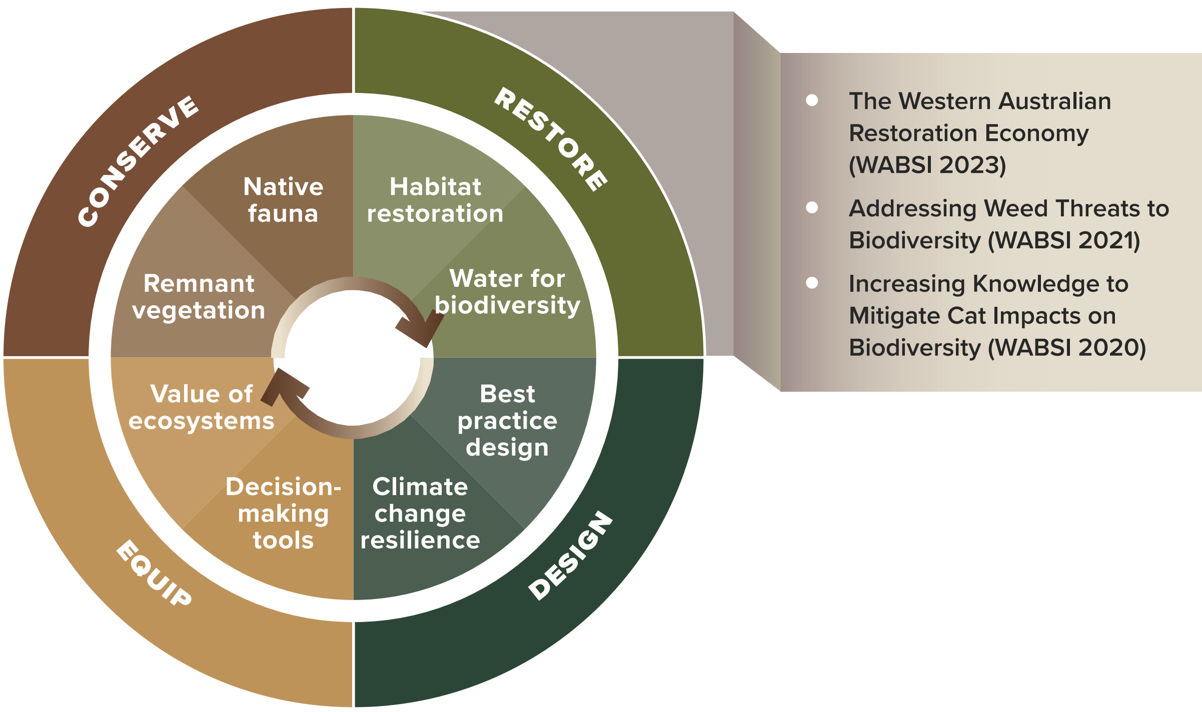



**FIGURE 4: A WABSI research program framework supporting environmental, social and economic benefits for the Wheatbelt through restoration actions**

## 3.1 Methods and terminology

The restoration process is often long, complex and contains uncertainty. A review on contemporary ecosystem restoration, social-ecological systems and related literature have produced an extensive body of research, best practice guidance and principles within Australia and internationally in recent years (Valderrábano 2021, Frietsch et al. 2023).

The development of the framework, tools and guidance provided in the Wheatbelt Restoration Standard (WRS) draws from diverse literature and considers important elements for restoration activities specific to the Wheatbelt region. Key resources informing the approach in this Standard are presented in Appendix 1, with additional nature-related policies, strategies and scientific publications cited throughout. For consistency and clarity, the WRS prioritises the information presented in the SER International Principles and Standards for the Practice of Ecological Restoration (Gann et al. 2019).

Interviews and workshops with Noongar kaartdijin (knowledge) holders, stakeholders in restoration ecology, ecological restoration science, climate science, natural resource management, agriculture, government and industry experts conducted in 2024 identified needs and benefits of restoration activities, knowledge gaps and research priorities for the Wheatbelt.

Terminology is primarily adopted from the Society for Ecological Restoration's (SER) International Principles and Standards for the Practice of Ecological Restoration (Gann et al. 2019), along with some adaptations to align with WA environmental policy including the Environmental Protection Authority (EPA) Guideline for the Restoration of Terrestrial and Aquatic Ecosystems (EPA, in prep.). Key terms and their definitions are presented in Appendix 2 and Section 4.3.1.

## 3.2 Defining the Western Australian Wheatbelt

The WRS adopts the Wheatbelt region spatially defined in the Generalised Land Use of Western Australia as 'broadacre farming' (Department of Agriculture and Food 2017, Figure 5). The Wheatbelt intersects four Interim Biogeographic Regionalisation of Australia (IBRA) bioregions; Geraldton Sandplains, Avon Wheatbelt, Mallee and Esperance Plains (Thackway and Cresswell 1995), comprising approximately 247,000 km$^2$ (Hobbs 2003).

The Wheatbelt region falls within the transitional rainfall zone (Hopper 1979), characterised by the 300–600 mm rainfall isohyets (Moore and Renton 2002). Decreasing rainfall trends over the past 30 years combined with water demand pressure poses threats to biodiversity and productive agriculture across large areas, particularly in the north and eastern Wheatbelt (Hoffmann et al. 2019, Sudmeyer et al. 2016).

## 3.3 Wheatbelt ecosystems and threatening processes

The Wheatbelt region of the south-west of Western Australia is a highly cleared and fragmented landscape, with more than 90% of parts of the Wheatbelt cleared (DBCA 2021). The region (part of the south-west region of Western Australia) is recognised as a globally significant biodiversity hotspot with a high level of species endemism and has undergone profound land use change for agriculture since European settlement (Monks et al. 2019). Characteristic terrestrial ecosystems include valley floors and lower slopes supporting eucalypt woodlands, mid slopes supporting mallee, granite complexes with rich assemblages, seasonally inundated valley floor drainage comprising woodlands and halophytic vegetation and kwongan heathlands on sandy soils in upland areas (McKenzie et al. 2004)

In addition to cumulative land clearing, the following threatening processes are likely to impact all endemic ecosystems in the Wheatbelt to varying degrees (Wallace et al. 2003, DBCA 2021):

- rising groundwater levels from legacy and contemporary land clearing have resulted in widespread water logging and dryland salinity affects (Caccetta et al. 2022, McKenzie et al. 2004)
- changes in soil organic chemistry to suit cropping or pasture systems, such as soil acidification and elevated phosphorous concentrations (Parkhurst et al. 2022)
- erosion, loss of topsoil
- altered soil biodiversity
- loss of habitat for native fauna
- feral animals (e.g. foxes, cats, pigs) and problem native animals (e.g. galahs)
- weed invasion and impact of plant pathogens
- spray drift from pesticide/herbicide application
- altered fire regimes, particularly the lack of fire or large intense bushfires.

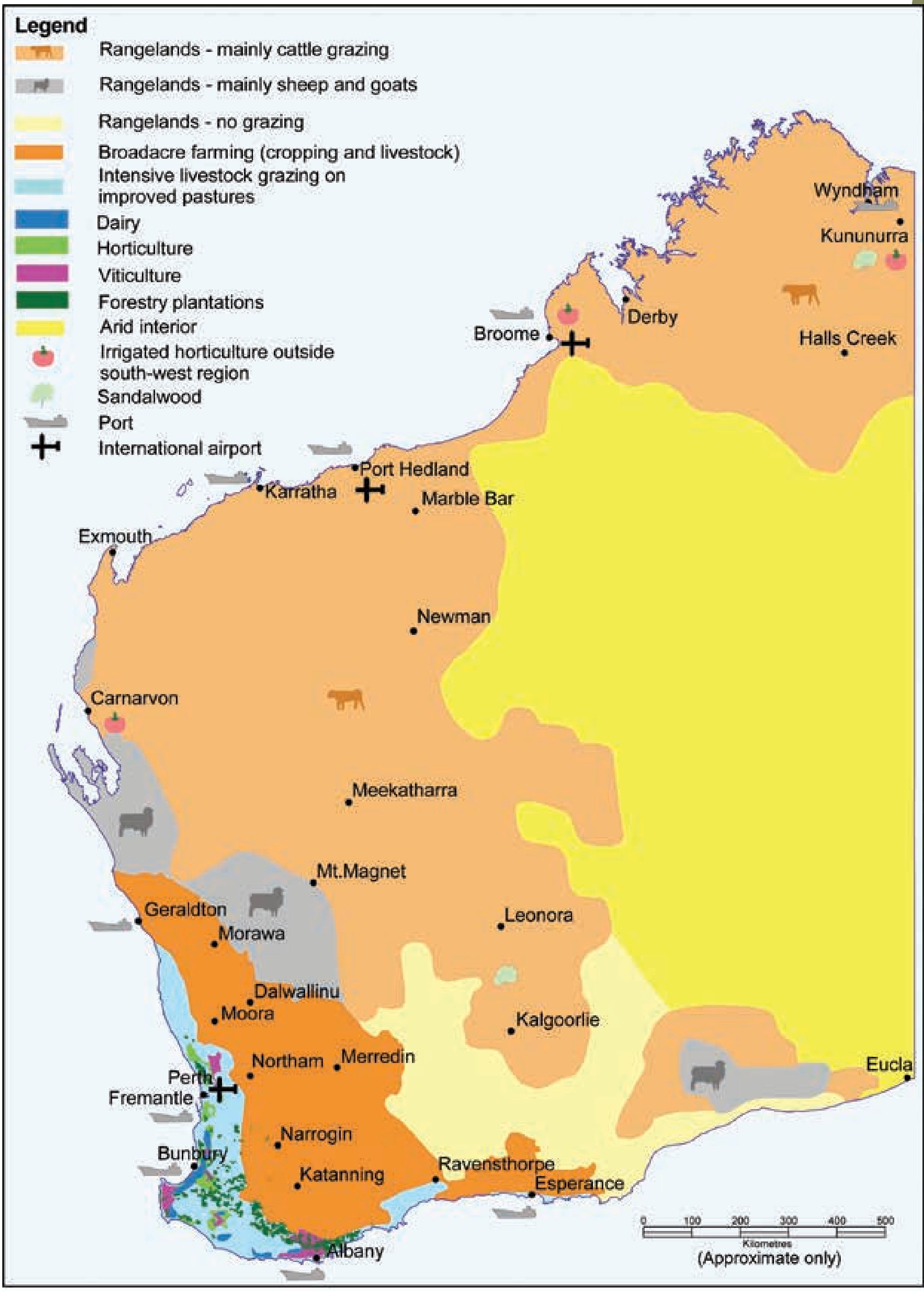



FIGURE 5: Wheatbelt region delineated by the ‘broadacre farming’ land use unit (Department of Agriculture and Food 2017)

*Plate 1:* Eucalyptus salmonophloia *(Salmon Gum) woodland (Photo: Suzanne Prober)*

*Plate 2:* Eucalyptus loxophleba *(York Gum) Woodland (Photo: Suzanne Prober)*

Although exposure to changing global climate dynamics is not fully understood or controllable, potential changes to species distribution and other ecological indicators have been modelled against plausible warming and drying climate scenarios (Ford and Cook 2015, Williams et al. 2014). The implications for ecosystem restoration under warming and drying climate scenarios in the Wheatbelt present significant regional planning and research opportunities. For example, research to identify suitable areas for restoring woodland connectivity for flora and fauna refugia may support range shifts, migration and adaptive processes of metapopulations.

Following the South West Native Title Settlement, the South West Conservation Estate (including areas of the Wheatbelt) will be jointly managed in recognition of the cultural responsibilities of the Noongar People (Government of Western Australia 2019). In addition, the future Noongar Land Estate (NLE) will be a 'significant asset' and will hold land associated as reserve or leasehold across the South West (Government of Western Australia 2019). Eligible land in the Wheatbelt for inclusion into the NLE through multiple Indigenous Land Use Agreements (ILUAs) is currently under consideration. Noongar history, language and cultural wisdom have created harmonious relationships with the environment and a highly nuanced 'knowledge of Country and everything in it' including a taxonomic system, their 'location, uses and needs' (e.g. Ballardong NRM Working Group n.d., Macintyre and Dobson 2019). It should be noted that while species and communities of biodiversity conservation significance are recognised through legislative and policy frameworks, species of cultural significance are not currently recognised in the same way (NESP 2024).

There is increasing recognition of the value of 'fair two-way knowledge sharing' with Indigenous corporations and western science restoration practitioners in land management practices (e.g. Badgebup Aboriginal Corporation 2024, Bradby and Cross 2023). Knowledge sharing has produced valuable outcomes for biodiversity including weed management (ABC Corporation 2014), seed dispersal (Bird et al. 2024) and the establishment of appropriate fire regimes to promote climate resilience in ecological restoration (Bradby and Cross 2023).

## Eucalypt Woodlands of the Western Australian Wheatbelt Threatened Ecological Community

Eucalypt Woodlands of the Western Australian Wheatbelt Threatened Ecological Community (WWTEC) are typically associated with valley floors and lower slopes and are most affected by legacy land clearing for agricultural production across the South West. Approximately 8% (76,000 ha) of approximately 939,470 ha WWTEC extent is protected as nature reserves, national parks or management areas managed by the Department of Biodiversity Conservation and Attractions (DBCA) (Department of the Environment 2015). Occurrences now occur mostly as small, isolated remnants on freehold land (Standish et al. 2007, Department of the Environment 2015).

*Plate 3:* Eucalyptus wandoo *(Wandoo) Woodland (Photo: Renee Young)*

*Plate 4:* Eucalyptus longicornis *(Red Morrel) Woodland (Photo: Helena Mills)*

In 2015, the WWTEC was added as a Matter of National Environmental Significance (MNES) under the Commonwealth *Environmental Protection and Biodiversity Conservation Act* (1999) (EPBC Act) and is currently listed as Critically Endangered (Department of the Environment 2015). Five Priority Ecological Communities (PECs) listed by the DBCA for woodland ecological communities in the Wheatbelt also recognise their conservation significance (DBCA 2023). The WA Environmental Protection Authority (EPA) Public Advice acknowledges restoration offsets as an instrument contributing to nature positive outcomes and their value in increasing resilience of high value remnant vegetation, such as WWTEC remnants (EPA 2024).

Ecological communities comprising the WWTEC listing are characterised by an open tree canopy dominated by eucalypts with a single trunk, and occur as a mosaic of multiple communities. The eucalypt woodlands communities and their subcommunities are classified from a benchmarking study conducted by Harvey and Keighery (2012). A total of 62 subcommunities comprising a diverse understory and variable conditions are described, with 31 eucalypt species forming the dominant canopy (see examples in Plates 1a–1d).

WWTEC are distinct from woodlands dominated by mallee eucalypts or non-eucalypt tree species and vegetation in which eucalypt trees may be present as scattered and emergent which do not comprise a distinct canopy (Department of the Environment 2015). Ground-truthing by a qualified person is required to verify if a particular patch meets the required diagnostic characteristics and minimum condition and size thresholds to be deemed to represent the WWTEC. Wheatbelt NRM have developed a survey assessment tool (available as an app) to assist with identifying sites that will require assessment against diagnostic criteria listed in the approved conservation advice (Department of the Environment 2015). Qualifying criteria for sites requiring assessment is summarised below (Wheatbelt NRM 2023):

- Trees typically spaced and the canopy is relatively open.
- The dominant tree is one of the 31 key Eucalypt species.
- Tree or mallet form (mallees may be present as an understorey species).
- There are mature trees present (mature defined as diameter >30cm).
- Sparse tree canopy cover up to 40%.

These highly diverse woodland systems support diverse mammals, birds, reptiles and invertebrates, many of which have specific habitat requirements requiring further research. Publicly available guides for identifying mammals, birds and wetland species, including threatened species in the Avon Region are available online through Wheatbelt NRM (Wheatbelt NRM Knowledge Hub 2024). Habitat degradation and fragmentation have significantly reduced populations, with many species under threat or considered locally extinct (e.g. Saunders 1988, Burbidge et al. 2004) and have provided favourable conditions for fauna-related threatening processes (e.g. fox and cat predation and increasing galah abundance ringbarking to legacy trees).

# 4.

# The Wheatbelt Restoration Standard

## 4.1 How to use this standard

**The WRS presents a linear framework and sets out guidance for key stages and sub-steps applicable for any restoration project in the Wheatbelt.**

Supporting tools assist restoration managers to develop strategies and actions, navigate complexity and target resources toward the greatest benefit. The framework is underpinned by complementary principles that should be considered altogether to improve restoration outcomes.

While the framework is presented in sequential order, the restoration process is often not linear, and steps may occur earlier than presented in the framework, or simultaneously. restoration managers should become familiar with the framework and content in the WRS as part of planning any restoration project.

The degree of intervention needed from natural regeneration to reconstruction is proportional to a project's position along the restorative continuum (Chazdon et al. 2021, SERA 2021). For example, an achievable target may be to restore to a lower level of ecosystem function and biodiversity (partial recovery) quantified by the cost of intensive site preparation, rather than trying to achieve as close to full recovery as practical with scientific uncertainty and unrealistic expectations increasing likelihood of wasted resources (Hobbs 2007). Restoration goals and their related degree of intervention is characterised in the Wheatbelt as three interrelating Restoration Activity Classes (RACs) (Figure 6).

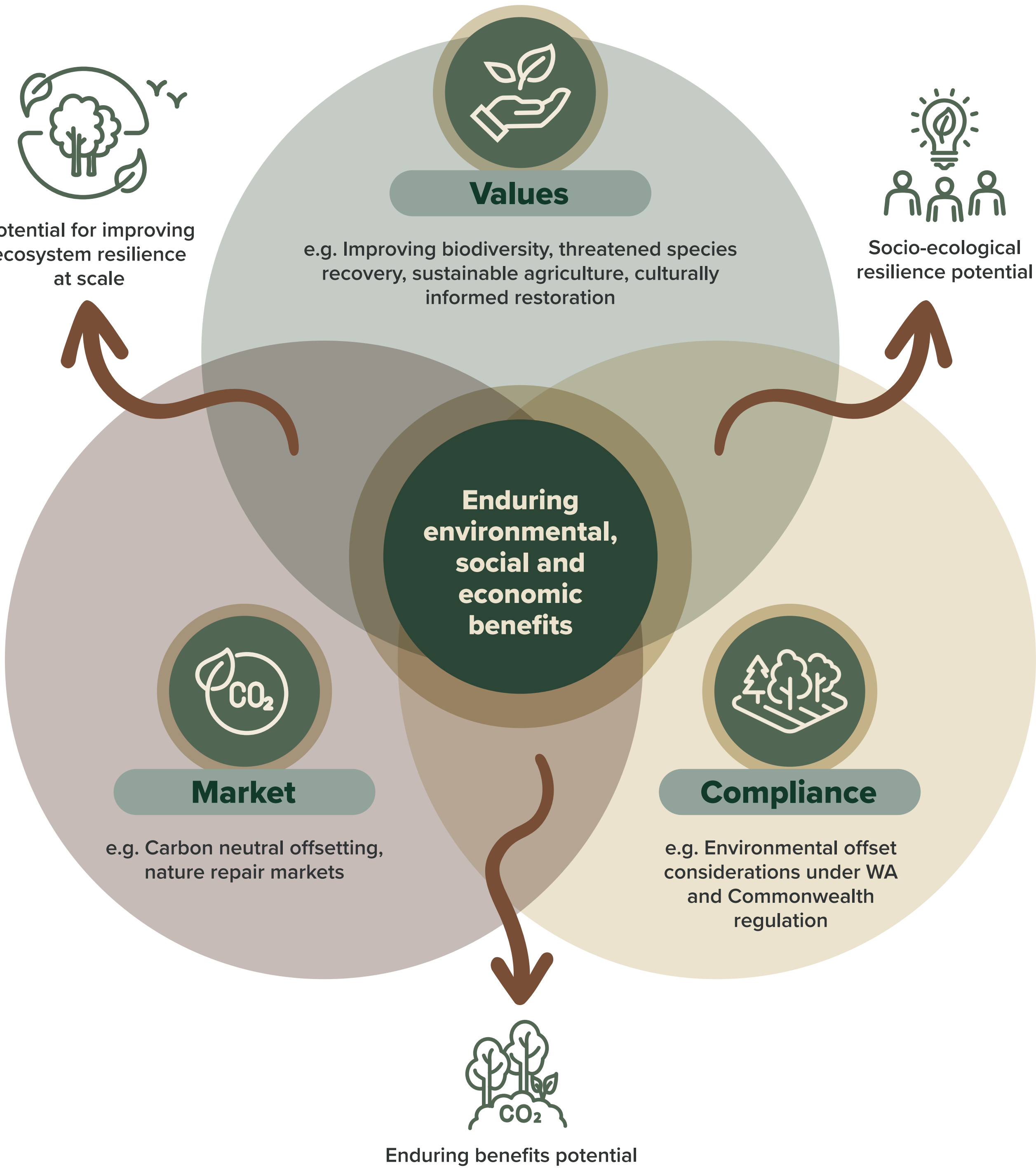
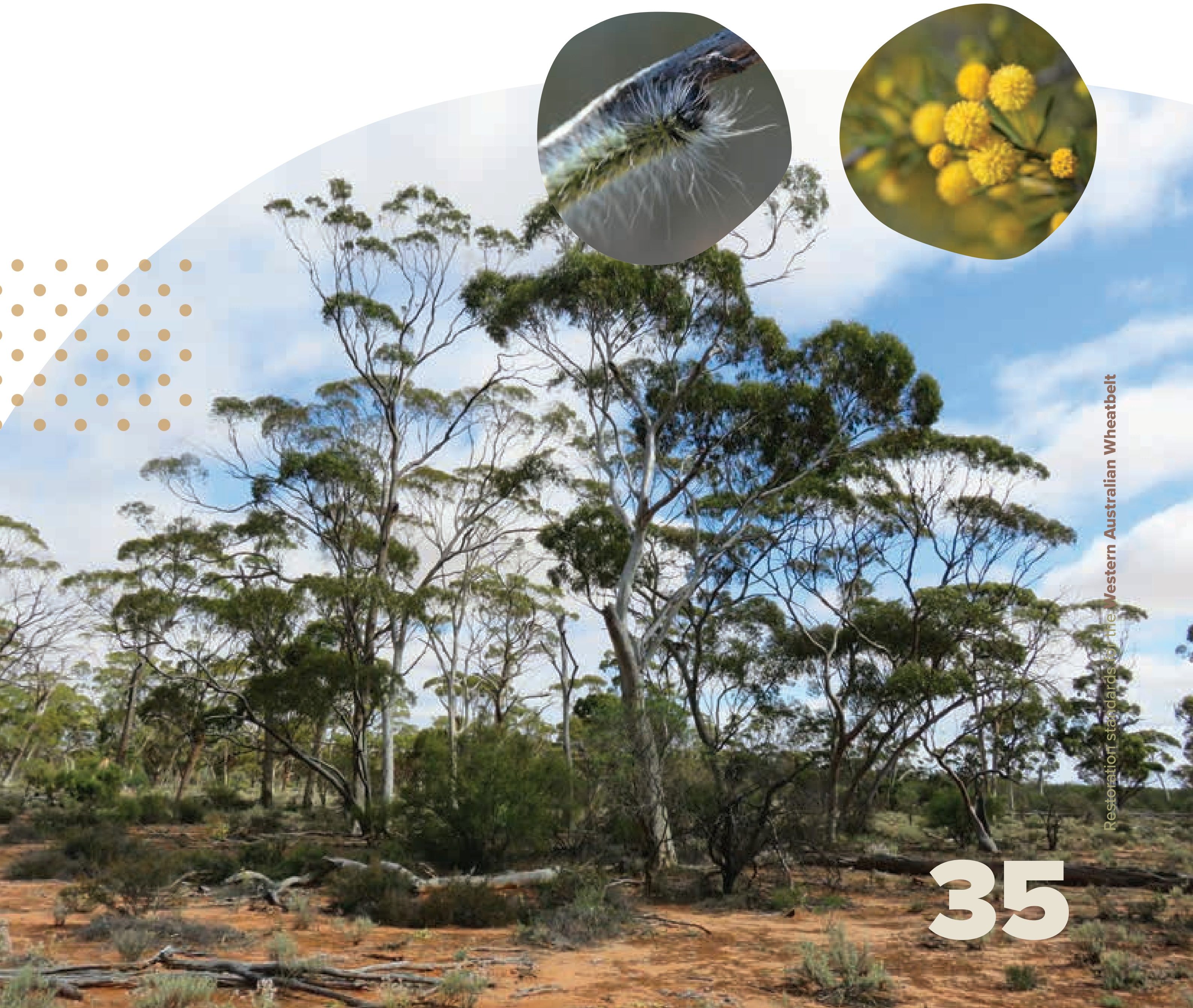



FIGURE 6: Restoration Activity Classes and their intersection within the Western Australian Wheatbelt

To help restoration managers navigate the framework and tools, fact sheets specific to each of the three restoration activity classes have been developed (Figure 6, Appendix 3). These present key information for each stage in the framework and can also be used as a checklist when operationalising the WRS.

The information and guidance in the following sections provide a minimum performance standard for utilising the framework, while understanding and addressing challenges to current and future restoration efforts in the Wheatbelt. Each stage in the WRS framework generates a set of resources which can be shared as part of collaboration or engagement with stakeholders to demonstrate effective governance, including compliance-related activities.

The framework is presented as a 7-year indicative timeframe. An assessment on the information collected and developed during the first seven years can help to judge whether the trajectory of recovery toward a reference or goal state is on track. Alternative timeframes may be more appropriate to assess against specific goals, such as assessing evident diagnostic characteristics of the approved conservation advice for the WWTEC based on the specific environmental conditions of a site. For example, Parkhurst et al. 2024 observed 'modest signs of woodland recovery' 10-years following planting York gum (*Eucalyptus loxophleba*) in old field restoration in the northern Wheatbelt with a long-term mean annual rainfall average of 340 mm.



# 4.2 The WRS Framework, Principles and Tools

## 4.2.1 Framework

The WRS framework steps restoration managers through a set of key stages and recommended sub-steps to meet restoration scope, targets, goals (completion criteria) and objectives (milestones) for a particular project (Figure 7).

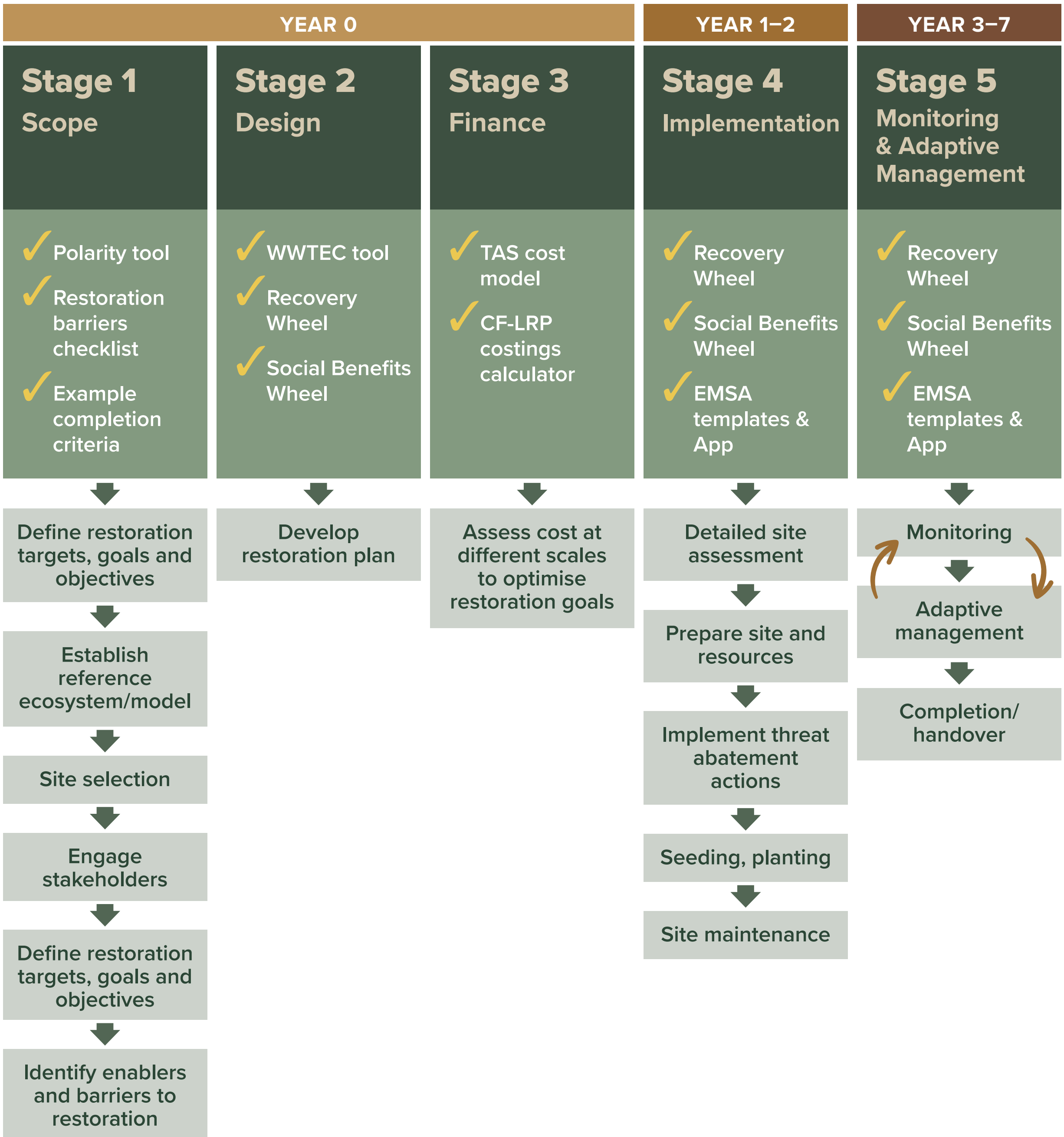



FIGURE 7: The WRS framework. Key stages are presented as dark green boxes, sub-steps as green/grey boxes and supporting tools as checklists in the relevant key stages

## 4.2.2 Principles

The framework is underpinned by ten principles to define, guide and measure the activities and outcomes of ecosystem restoration practice (Figure 8). The principles are adopted from the *Principles for Ecosystem Restoration to Guide the United Nations Decade on Ecosystem Restoration (2021-2030)* and 'should be read and considered altogether' (FAO, IUCN CEM & SER, 2021). These principles have been adopted over the principles outlined in the Society for Ecological Restoration Australasia's (SERA) *National Restoration Standards* (Standards Reference Group SERA 2021) as they include a principle that recognises the context of the UN Decade and the remaining principles and content covered in the WRS are complementary to the SERA principles.

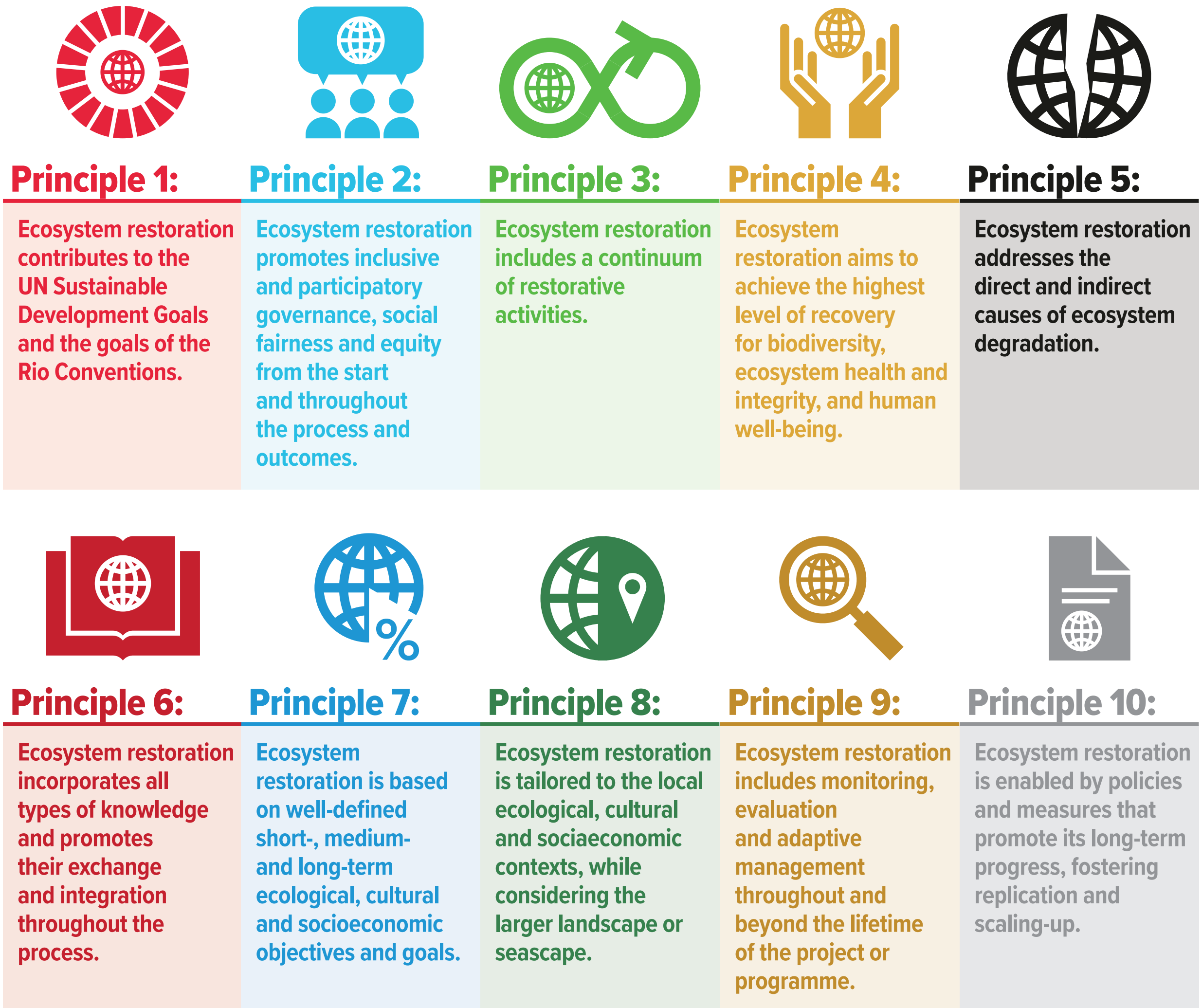



FIGURE 8: Principles for ecosystem restoration to guide the United Nations Decade 2021–2030. FAO, IUCN, CEM & SER 2021

## 4.2.3 Tools

### 1. SER Ecological Recovery and Social Benefits Wheels

**The SER Ecological Recovery Wheel tool (herein Recovery Wheel, Figure 9) evaluates baseline ecological conditions against the 5-star recovery system (Figure 3) and is recommended for all restoration projects.**

The Social Benefits Wheel is also recommended for developing performance indicators for social, environmental and economic values (Figure 9).

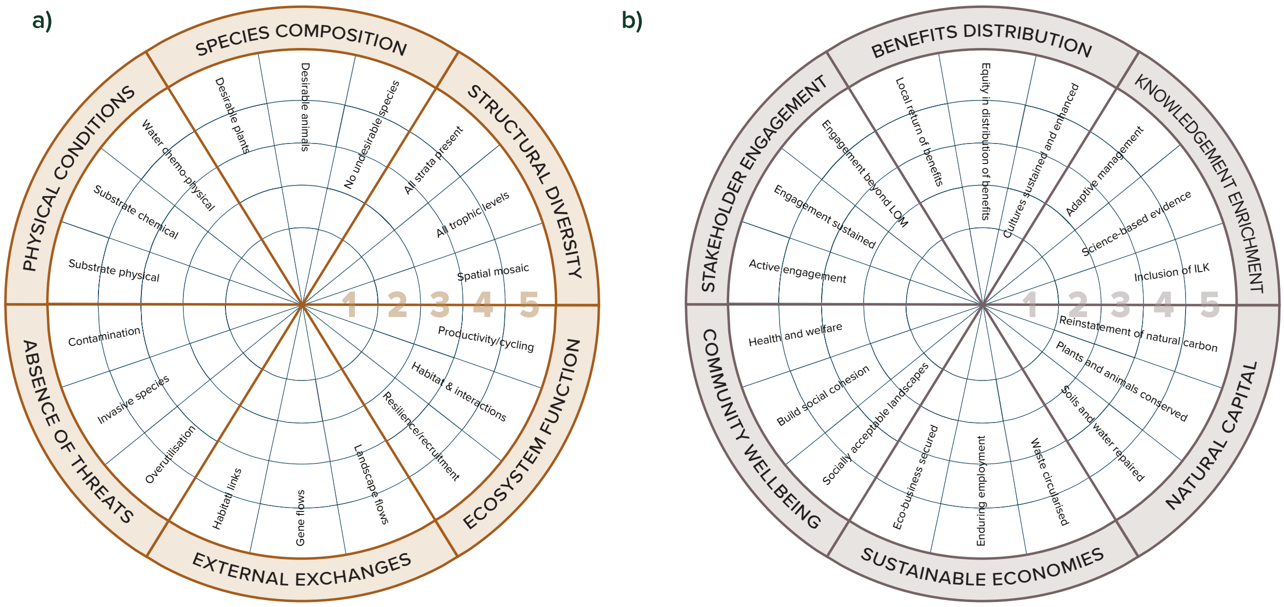



**FIGURE 9: Example of a) Ecological Recovery and b) Social Benefits Wheels to assist in measuring progress towards goals and targets (Gann et al. 2019)**

## 2. WWTEC tool: An online workbook

**A new WWTEC tool (available as an online workbook on the project page of the WABSI website) has been developed from information compiled in the DBCA factsheets classifying eucalypt woodlands of the Wheatbelt (Harvey and Keighery 2012). It is recommended for all RACs as it provides key diagnostic characteristics of the communities and sub-communities comprising the WWTEC. These include the dominant canopy and understorey species, associated landforms, soil types, average species richness and associated species recorded from the sub-community reference site. The WWTEC tool is intended to be used for a variety of purposes including selecting species that are suited to landforms and soil characteristics of a project site and developing planting designs analogous to the composition and structure of these ecological communities.**

Percentage cover values may also be derived from the tool from users with a degree of technical expertise by cross referencing the ‘sub-community reference site vegetation description’ attribute with the relevant vegetation cover class (NVIS Technical Working Group 2017). For example, the ‘Red Morrel and Wandoo’ subcommunity describes the overstorey as Eucalyptus longicornis and E. wandoo open woodland. In the vegetation cover class index (available in the tool) an ‘open woodland’ is equal to <10% cover. Cover values may be used to measure composition values for monitoring sites, to determine similarity with an appropriate reference site or model.

Re-introducing endemic species improves biodiversity values and adds potential benefit as a future seed resource reducing pressure on wild seed stocks. Improving access to endemic species derived from the WWTEC tool within nursery and seed supply chains may also provide a critical enabler to landscape scale recovery of functional and resilient ecosystems.

Further, the WWTEC Tool may be used to inform key diagnostic characteristics of completion criteria developed in consultation with environment regulators and incorporated into either Restoration Environmental Management Plans (REM Plans) or Closure Plans that aim to achieve the highest level of recovery possible.

## 3. Example completion criteria

**Example completion criteria developed for a hypothetical WWTEC site is presented in Box 2 and in full in Appendix 13. These examples are a guide for the development of specific completion criteria required under regulatory environmental approval process. They are intended to support the development of detailed monitoring, evaluation and reporting following the WRS framework.**

Example criteria are provided for all six attributes and their sub-attributes in the Recovery Wheel for values typically associated with restoring endemic eucalypt woodland communities. These examples are not exhaustive and are expected to evolve as further research, assessments and decision-making processes make environmental data available.

## 4. Polarity tool

**The questions posed in the polarity tool are intended to guide decision-making against target values when planning and implementing a restoration project.**

Specifically, the tool can help restoration managers decide:

- where to locate the project in the landscape
- what benefits could be achieved
- what conditions will inform species selection
- what is the next land-use
- why restoration is being undertaken
- what knowledge sources to draw upon and
- what timeframes should be adopted for monitoring.

Box 3 presents a case study example of using the tool to shape questions related to an existing restoration project.

## 5. Restoration barriers and enablers checklist

A checklist tool of elements that may be barriers or enablers of a restoration project is provided as a starting point to consider factors that may be relevant to a project.

This will help develop management actions and prioritise available resources to maximise likelihood of success (Appendix 8).

## 6. TAS cost model and CF-LRP costings calculator

The habitat restoration threat abatement strategy (TAS) cost model and the WA Government Carbon Farming and Land Restoration Project (CF-LRP) costing calculators are recommended as starting points for restoration managers.

These will assist with developing budget inputs, assumptions, resource requirements and the availability of expertise.

## 7. EMSA field data templates

Terrestrial Ecosystems Monitoring Network (TERN) ecological field monitoring protocols (EMSA 2024) provide standardised data collection templates and methods, together with a field data collection app digitising data templates.

**These resources can be used when implementing a restoration plan, including capturing site assessment and monitoring information.**

# Box 1.

## A note on terminology

The WRS adopts the terminology of the Society for Ecological Restoration's International Principles and Standards for the practice of ecological restoration, unless that terminology presented inconsistencies with Western Australian regulation and policy. As such, and for clarity, we provide the following hierarchy of terms with equivalencies when deviations from SER have been made.

These terms are used interchangeably in the WRS, generally applying the SER terminology, unless the RAC is specifically aligning with regulatory, or compliance led restoration activities.

### *Hierarchy of terms commonly used in project planning*:*

| SER & WA regulation – indicators |
|---|
| Scope |
| Targets |

| SER | WA regulation + policy |
|---|---|
| | Environmental outcomes |
| Goals | Completion criteria |
| Objectives | Milestones |

* Terms used here, with some adaptations, are based on those of the Open Standards for the Practice of Conservation (Conservation Measures Partnership 2013), SERA 2021 and Gann et al. 2019.

- The **scope** is the broad geographic or thematic focus of a project.
- The **targets** identify the native ecosystems to be restored at a site as informed by the reference model, along with any social outcomes or constraints expected of the project.
- **Environmental outcomes** are used in WA regulation and policy and are the state of the environment at a specific point in time during implementation, or after a proposal has been implemented.
- **Goals (completion criteria)** are formal statements of the medium to long-term desired ecological or social condition, including the level of recovery sought. Goals must be clearly linked to targets, measurable, time-limited, and specific.
- **Objectives (milestones)** are formal statements of the interim outcomes along the trajectory of recovery. Objectives must be clearly linked to targets and goals, and be measurable, time-limited, and specific and feed into adaptive management.
- **Indicators** are specific, quantifiable measures of attributes that directly connect longer-term goals and shorter-term objectives. Ecological indicators are variables that are measured to assess changes in the physical (e.g. turbidity units), chemical (e.g. nutrient concentration), or biotic (e.g. species abundance) ecosystem attributes as guided by the reference model. Thresholds of chosen indicators for attributes will provide the trigger for management actions to keep the project on the desired trajectory. Social–ecological or cultural indicators measure changes in human wellbeing such as participation.

## 4.3 Stage 1 – Scope

Key activities that should begin during the scoping phase of restoration project include:

- define the scope, targets, environmental outcomes, goals (or completion criteria) and objectives (or milestones) as appropriate
- define an appropriate reference ecosystem or model. Determine whether a climate-adapted reference is appropriate (see Table 3, AdaptNRM 2024)
- identify the project site
- negotiate land access and supply agreements
- identify partnership opportunities and commence engagement activities with stakeholders
- identify important site attributes and potential barriers to inform management and monitoring
- identify restoration activities that support the intended long-term land use (Appendix 4).

A restoration project scope should provide a description of the target and specific goals that characterise the projected end-state of the restoration project. Objectives are used to support the goals with short to medium term outcomes, such as reducing soil compaction or increasing the number of target species utilising habitat. Restoration goals and objectives should consider timelines appropriate to available resources and at a scale intended to achieve the recovery state (Gann et al. 2019). Project goals may not necessarily coincide with *full recovery* as, for instance, eucalypts in the Wheatbelt may require a multi-century time scale to mature sufficiently to develop hollows (Payne 2023).

Long-term land use is therefore an essential element when developing goals and should be considered for the duration of the restoration scope and longer term. For example, restoration targets and goals considering reversal of current threats to nature conservation should also consider appropriate long-term land use for enduring ecological benefit. Restoration activities that increase resilience of important remnant systems such as WWTEC should consider whether the restoration activities increase resilience of the system *in situ* (e.g. highly localised) to future climatic conditions, or if resilience restoration efforts *ex situ* (e.g. further afield) are more likely to result in a net ecological benefit.

The Australian Land Use Management (ALUM) classification system (ABARES 2016) can be used to consider the long-term land use of the proposed restoration site and assist with goal-setting. It provides a nationally systematic, logical and consistent method to present land use information across Australia in a hierarchical structure. There are six primary classes of land uses included in the classification: conservation and natural environments; production from relatively natural environments; production from dryland agriculture and plantations; production from irrigated agriculture and plantations; intensive uses; and water. Datasets maintained by Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) on land use and land use change based on ALUM classification provides valuable information for planning and site selection (ABARES 2024). Example primary and secondary land use classes relevant for the Wheatbelt are presented in Appendix 4.

### 4.3.1 Define restoration targets, goals and objectives

Restoration targets, goals and objectives are proportional to the degree of intervention needed on the restoration continuum. The trajectory of recovery is aligned with the SER 5-star recovery system (Figure 3). Realistic ecological targets should be identified, along with specific indicators to monitor progress and inform adaptive management (Box 2, Gann et al. 2019).

Restoration targets are important to identify the native ecosystem to be restored, whether that be identified and defined from a reference ecosystem or model. Once targets are established, goals (completion criteria) are linked to each attribute or sub-attribute of the Ecological Recovery Wheel describing the end state of key ecosystem characteristics. It may be appropriate to establish more than one goal per attribute, depending on the RAC.

Indicator types that measure improving ecological attributes through monitoring and adaptive management should be identified for the project site. Incorporating management actions against each of the six attributes increases the likelihood of restoring functional and resilient ecosystems. An assessment on the relevance of monitoring information is essential to inform the effectiveness of management actions and avoid unnecessary allocation of resources.

Table 1 assesses the importance of sub-attributes for restoring native ecosystems in the Wheatbelt. Suggested indicators and evidence for all sub-attributes presented in Appendix 10, along with example milestones and completion criteria presented in Appendix 13 provide guidance for developing a monitoring and evaluation framework with indicators, objectives (milestones) and goals (completion criteria) to meet restoration targets (Section 4.7.1).

The 'important' sub-attributes consider regional ecological conditions influencing restoration projects in the Wheatbelt. For example, habitat links is considered an important indicator as the cumulative effects of land clearing and habitat fragmentation can result in a site situated within intensive agriculture land use. Management actions developed for the habitat links attribute enhance connectivity to adjacent remnant patches and relate to other important attributes, such as the resilience/recruitment capacity of a site.

Appendix 5 presents a comparison of 'critical' indicators in the Global Biodiversity Standard (TGBS) assessed by Bartholomew and Mosyaftiani et al. (2024), including explanation where the WRS deviates from TGBS. Additionally, the indicators prescribed in the 'replanting native forest and woodland ecosystem' method for the Commonwealth Government's Nature Repair Market are assessed for projects applying the WRS framework and intending to register for biodiversity certificates.

**TABLE 1: Assessment requirements and suggested indicator types for RACs**

| SER Ecological Benefits Recovery Wheel | | Suggested requirement | Suggested minimum indicator types by RAC | | |
|---|---|---|---|---|---|
| Ecological attribute | Sub-attribute | | Values led | Market led | Regulatory compliance led |
| Absence of threats | Contamination | Preferable | – | – | Q |
| | Invasive species | Important | C | C | Q |
| | Overutilisation | Preferable | C | C | Q |
| | Other degradation drivers | Important | C | C | Q |
| Physical conditions | Water chemo-physical conditions | Important | Q | Q | Q |
| | Substrate chemical conditions | Important | Q | Q | Q |
| | Substrate physical conditions | Important | Q | Q | Q |
| Species composition | Desirable plants | Important | C | C/Q | Q |
| | Desirable animals | Important | C | C/Q | Q |
| | Rare and threatened species | Important | C | C/Q | Q |
| | No undesirable species | Important | – | C/Q | Q |
| | Provenance, genetic diversity and genetic resilience | Preferable | – | – | Q |
| Structural diversity | All vegetation strata | Important | Q | Q | Q |
| | All trophic levels | Preferable | – | – | Q |
| | Spatial mosaic | Important | Q | Q | Q |
| Ecosystem function | Productivity/cycling | If feasible | – | – | Q |
| | Habitat & interactions | Preferable | – | – | C/Q |
| | Resilience/recruitment | Important | C | C/Q | Q |
| External exchanges | Landscape flows | Preferable | – | C | C/Q |
| | Intraspecific gene flow | Preferable | – | C | C/Q |
| | Habitat links | Important | C | C | C/Q |

**C** = categorical – a qualitative attribute can be scored as present or absent and measured against a target.

**Q** = quantitative – the attribute may be scored and measured against a numerical target.

Articulating clear targets, goals, and objectives supports the development of project's value and perceptions on proposed benefits and trade-offs to stakeholders. It is important to note ambitions can change to meet evolving stakeholder needs, changing ecological conditions and uncontrollable resources making goals unachievable. The SER Social Benefits Wheel (Appendix 6) is a valuable tool for establishing performance metrics and to understand the benefits and potential trade-offs of management actions. A summary of suggested metrics by RAC is presented in Table 2, along with priority ranking for each attribute.

**TABLE 2: Social benefits attributes and sub-attributes, their suggested requirement for RACs**

| SER Social Benefits Recovery Wheel | Suggested requirement | Suggested minimum indicator types by RAC | | |
|---|---|---|---|---|
| Social attribute | | Values | Market | Regulatory compliance |
| Sustainable economies | Preferable | – | Q | – |
| Community wellbeing | Preferable | – | C | C |
| Stakeholder engagement | Important | C | C | C |
| Benefits distribution | Preferable | – | C | C |
| Knowledge enrichment | Preferable | – | C | C |
| Restoring natural capital | Preferable | – | Q | – |

**C** = categorical – a qualitative attribute can be scored as present or absent and measured against a target.

**Q** = quantitative – the attribute may be scored and measured against a numerical target.

Objectives (milestones) are established for each restoration goal (completion criteria) and provide direction, clarity and measurable observations of progress toward recovery over time. Adopted from *A framework for developing mine-site completion criteria for Western Australia* (Young et al. 2019) specific restoration goals and objectives should be:

- agreed
- evidence based
- SMART — Specific, Measurable, Achievable, Relevant, and Time-bound
- supporting the RAC.

Box 2 presents a hypothetical case study of WWTEC ecological restoration targeting 4-star recovery. An example of restoration milestones and completion criteria for the invasive species sub-attribute is included below, and a suite of example completion criteria across the sub-attributes developed for this case study is presented in Appendix 13. These examples may be selected or drawn from to develop milestones and completion criteria for a particular restoration project. While aimed at regulatory compliance RACs, values and market RACs can benefit from this framework as it provides points of evidence of progress, can inform adaptive management and demonstrate the value proposition of the project to stakeholders.

## Box 2.

## Hypothetical Wheatbelt restoration case study and example completion criteria

### Scope

Restoration of 150 ha of *Eucalyptus wandoo* Woodlands of the Western Australian Wheatbelt PEC providing habitat connectivity situated between Lake Magenta and Lake Bryde Nature Reserves. The project aims to restore ecological communities and habitats with high similarity to the adjacent reserves.

### Target

*Eucalyptus wandoo* Woodlands of the Western Australian Wheatbelt PEC with mature vegetation providing foraging habitat for Carnaby's Cockatoo (*Zanda latirostris*). Ecosystem integrity and resilience are evident. Flora and fauna communities working in their functional groups with trophic exchanges, and externally with the surrounding landscape or neighbouring ecosystems. Ecosystem recovery is at or above a four-star rating.

| Environmental outcomes | |
|---|---|
| Absence of threats | Direct degradation drivers do not exceed local levels. |
| Physical conditions | Landforms have high similarity to the reference in slope and topography, and physical and chemical conditions of substrates and hydrology highly similar to reference and suitable for sustained growth and recruitment of most characteristic native biota. |
| Species composition | Native species diversity in the upper, mid and ground strata present across the site have high similarity to the reference. Evidence of natural recruitment reflecting successional patterns. Diversity of non-native species have high similarity to the reference, and with <10% relative cover across the site. |
| Structural diversity | All strata of the reference present and high similarity of spatial patterning and trophic complexity relative to reference. |
| Ecosystem function | Physical and biological processes and functions relative to the reference have high similarity. |
| External exchanges | Positive exchanges with surrounding environment in place for characteristic species and processes have a high likelihood to be sustained. |

Example milestones and completion criteria for invasive species sub-attribute targeting a 4-star recovery is presented below. A suite of example 4-star milestones and completion criteria against all sub-attributes is presented in Appendix 13. These examples could be selected or drawn from developing criteria relevant to a specific project, noting not all examples would apply.


## SER sub-attribute invasive species

### *Implementation/germination milestone (Year 1)*

- Post-disturbance baseline assessment of invasive fauna at the restoration and reference sites has been completed and is understood.
- Invasive fauna management incorporating at minimum biannual control (e.g. baiting, trapping, shooting) over at minimum 3 nights unless absence is evidenced (e.g. comprehensive camera trapping detects no invasive fauna).

### *Establishment milestone (Year 4)*

- Monitoring demonstrates that target species control methods are effective in controlling impacts to the restoration site.
- Demonstrated coordination with regional feral control programs (e.g. Wheatbelt NRM) where practicable.

### *Maturation milestone (Year 7)*

- Monitoring demonstrates that target species control methods are effective in controlling impacts to the restoration site.
- Demonstrated coordination with regional feral control programs (e.g. Wheatbelt NRM) where practicable.

### *Completion criteria (Year 10)*

- Monitoring demonstrates that target species control methods are effective in controlling impacts to the restoration site.
- Invasive fauna are actively managed at the restoration site with abundances highly similar to reference sites.

Recognising dual notions in target setting and decision making avoids over-valuing one element over another, wasting resources and provides a clearer restoration pathway toward recovery. A polarity tool (Appendix 7) helps to identify where a particular project is situated within a suite of interconnected elements. The tool enables identification of key challenges, opportunities, costs, and important trade-offs (such as nature conservation and food production land use). It may also assist with identifying important values for meaningful engagement with local knowledge holders and stakeholders. A case study adopting the polarity tool is presented in Box 3.

## Box 3.

## Hypothetical case study: Using the polarity tool to inform restoration targets, goals and objectives


### Scope

An ecological restoration project intends to qualify as an early environmental offset (an offset established prior to undertaking a planned impact) with the relevant government agency (e.g. Department of Water and Environmental Regulation) for a portion of intact remnant WWTEC vegetation clearing in the future. The specific environmental outcomes of the offset project will require an assessment by the environmental regulator to confirm the quality of the proposed environmental offset is acceptable.

The polarity tool can inform restoration targets, goals and objectives for a particular project by:

- identifying elements or specific conditions that should be intentionally independent (i.e. selecting either end of the poles) to bring clarity to the scope
- identifying potential opportunities which can generate benefit from both elements, where feasible (i.e. selecting toward the centre of the poles)
- identifying specific outcomes which generate maximum benefits to incorporate into restoration targets, goals and objectives.

The example completed polarity tool below highlights specific conditions relevant for a regulatory compliance restoration project. For example, long-term environmental benefits consistent with the environmental approval condition is an essential element and requires scientific rigour to demonstrate compliance. The economic benefit of the project is typically derived from activities resulting in an environmental impact triggering an offset requirement. Other economic benefits (e.g. carbon offsets) are not possible while the compliance obligation is in progress.

Further, this example highlights site selection opportunities, knowledge systems informing approaches and management decisions to promote a resilient ecosystem that produces long-term environmental outcomes.

## 4.3.2 Reference ecosystems and models

A reference ecosystem or model primarily informs the target for restoration, which is usually the ecosystem which occurred at the site prior to land use change or degrading processes. All restoration activities benefit from incorporating a reference ecosystem or model as it helps to ascertain the attributes to be achieved, even if the goal is not ecological restoration. For example, selecting suitable local overstorey and understorey species appropriate for the soil type for values-led (e.g. farm production) or market-led RACs (e.g. a biodiverse carbon project) can be determined by a local reference ecosystem even if ecological restoration is not the goal. Nearby remnant ecosystems provide valuable reference information of species suited to local soil types and rainfall trends, their composition and structure.

Restoration managers should firstly identify potential baseline indicators for attributes and sub-attributes (see Table 6) for a reference ecosystem or model. An appropriate reference ecosystem or model should include information on composition (species), structure (how the vegetation is organised by height and cover) and function (processes and interactions), physical conditions and threats (Gann et al. 2019). Reference site soil microbiota composition may also be important if addressing soil physical, chemical and biological degradation targets for a particular site (Peddle et al. 2024). The degree of technical expertise in desktop or field-based assessments should be sufficient to identify the dominant species, including target and keystone species characterising a reference ecosystem or model as a minimum. Compliance RACs would be expected to engage qualified ecologists to identify all target, keystone and associated species to develop the reference ecosystem or model.

Additional methods may also be prescribed for market and regulatory compliance RACs. For example, benchmark values for canopy height, crown cover (by vegetation layers) and native species richness for trees, shrubs and grasses or forb species are prescribed to be collected by a suitably qualified person in the draft Nature Repair Market Method for replanting native forest and woodland ecosystems (DCCEEW 2024d).

Useful entry points for developing an appropriate reference ecosystem or model include:

- WWTEC tool (Appendix 12)
- IUCN global ecosystem classification, adopted by the Global Biodiversity Framework (Keith et al. 2020)
- thirteen reference 'ecosystem types' and their modified states for the Wheatbelt described by Prober et al. (2023a). Conceptual reference models for the nine main ecosystem types are included
- biodiversity values (such as habitat value, species richness and soil microbial biomass) for example revegetation projects in the Wheatbelt (Wheatbelt NRM 2015).

In addition, Prober et al. (2023a) and Standish et al. (2009) describe state and transition of eucalypt woodland communities in WA including degrading factors and common restorative activities to crossing ecosystem state thresholds. Technical expertise is required when developing appropriate reference models for a particular project.

The Wheatbelt landscape consists of a range of natural to highly modified ecosystems across a mosaic of landforms and soil types. Selecting an appropriate reference for a restoration project supporting mosaic landforms and soil types requires multiple reference sites to inform species composition and structure at different positions in the landscape, or alternative approaches if there are limitations. Figure 10 developed by McNellie et al. 2020, proposes a framework of historical, hybrid-historical and contemporary reference states for restoration managers to consider. While a reference ecosystem should ideally represent intact natural systems as the 'highest possible representation of ecosystem integrity and condition' for the project site (Gann et al. 2019), attaining a not an historic natural reference state may not be possible due to knowledge, finance or feasibility limitations and intended land use (Hobbs et al. 2014). Further, while a reference ecosystem or model is ideally derived from multiple reference sites (Bartholomew and Mosyaftiani et al. 2024), the ecosystem dynamics within sites coupled with climate change can limit the suitability of local reference ecosystems (SER 2004, Cramer et al. 2008, Gann et al. 2019). If a contemporary reference state is deemed appropriate, restoration managers should explicitly consider shifting baselines as it relies on contemporary data to evaluate change (UNCEEA 2021, McNellie et al. 2020).

Incorporating monitoring of the dynamic changes of reference ecosystem condition (Hiers et al. 2012) provides evidence of the normal ranges of population dynamics and regional ecosystem health trends (Figure 1) that may be important to the resilience of the project site. This information can inform adaptive management actions to maintain progress toward goals and targets.

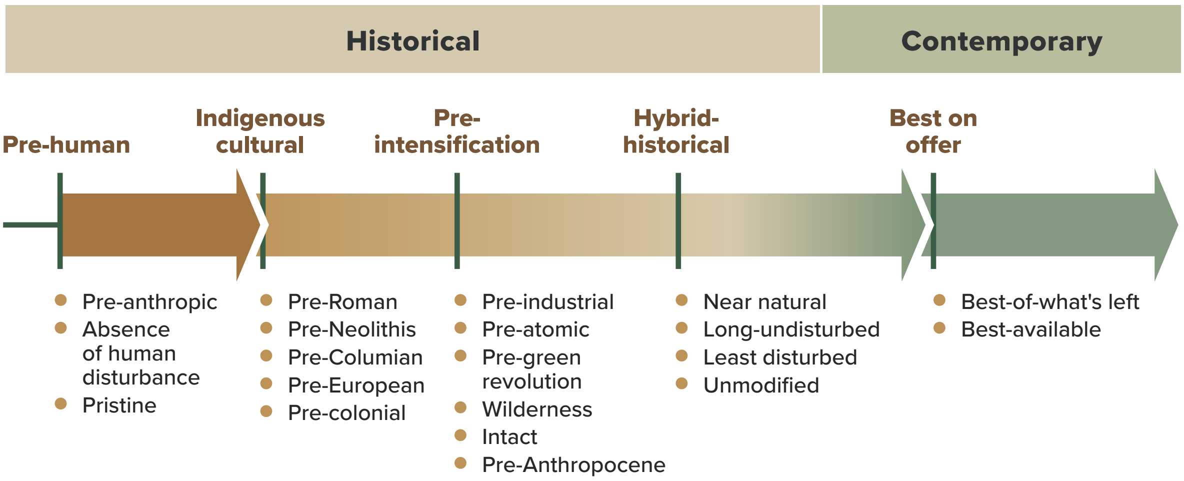



**FIGURE 10: Reference states framework developed by McNellie et al. 2020**

### 4.3.3 Site selection

Where the location of a restoration site is not yet known, a desktop assessment to consider several important elements can help identify suitable sites and identify stakeholders early. Gondwana Link restoration standard incorporates ecological factors for selecting restoration sites in the South-West of WA (Deegan et al. 2010), which have been incorporated in the site attributes listed below:

- size and shape of the project site
- limitations/caveats with accessing the project site
- transport and proximity to workforce
- infrastructure, utilities for on-ground and remote operations
- historic land use (e.g. clearing history, cropping/grazing land use history, fertiliser and other chemical application, fire and other disturbance events)
- land tenure and neighbouring land use
- broad landform and soil types
- whether remnant native vegetation is present
- proximity to and potential beneficial effects (and risks) of surrounding intact native vegetation
- proximity to high value, or sensitive areas such as permanent or semi-permanent freshwater or habitat important for significant flora and fauna
- position in the catchment as an indicator of hydrological regimes, salinity effects and vulnerability to drought or flooding
- suitability of the site for a target species
- suitability of the site for a target community
- proximity to degradation drivers (i.e. spray drift).

An assessment on the suitability of a site is dependent on the project scope and targets. For example, a particular scope may be to restore 150 ha of a particular WWTEC community type that is ‘relevant and proportional’ (Government of Western Australia 2014) to an area under environmental approval assessment. A site may be more suitable for this type of scope if remnant eucalypt woodland vegetation is present. Regional climate, vegetation, weeds, salinity, land use and biodiversity models also provide valuable information to model and refine site selection in the Wheatbelt. Table 3 presents a range of publicly available data types and sources to inform site selection.

Potential restoration sites may target those supporting remnant native vegetation including WWTEC (Section 3). Small, isolated remnants with high shape complexity hold measurably higher biodiversity value than linear remnants along road edges in cleared or degraded landscapes (Wintle et al. 2019). However, WWTEC more frequently occur as linear features, for example along roadsides, and therefore hold high conservation value as remnants and habitat for numerous threatened species (Commonwealth of Australia 2016). Selecting sites within and adjacent to patches or linear remnants should target restorative actions to increase the resilience and integrity.

**TABLE 3: Sources of publicly available maps and data maintained by multiple government agencies to inform site selection**

| Data type | Format | Source |
|---|---|---|
| Projected biodiversity changes by climate scenario for vegetation, plants and animals (1990–2050)<br><br>Modelling the potential degree of ecological change under climate scenarios<br><br>Invasive plant species distribution maps for climate adaptation planning | Map posters and GIS files | CSIRO **Data Access Portal** (DAP) Suggested search terms:<br>• 'adaptnrm': results in all AdaptNRM products, including Weeds and Climate Change, Implications for Biodiversity and Helping Biodiversity Adapt datasets and maps<br>• 'adaptnrm biodiversity': results in all AdaptNRM biodiversity products, including Implications for Biodiversity and Helping Biodiversity Adapt<br>• 'adaptnrm biodiversity' plus any of the measures of change and/or biological groups will limit your search to more specific datasets. For example, entering 'adaptnrm biodiversity disappearing' will result in datasets and maps for 'disappearing ecological environments' for each of the biological groups and climate scenarios. |
| Interactive groundwater and salinity map for the south-west agricultural region | Interactive GIS platform | Interactive groundwater and salinity map landing page |
| Soil landscapes, land systems, land capability, qualities, hydrology, native vegetation | Interactive GIS platform | NRInfo map application |
| Matters specially protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) | Interactive GIS plat-form | Protected Matters Search Tool – DCCEEW |
| Assessing ecosystem condition and biodiversity benefits, access prescribed vegetation maps for the Nature Repair market | Interactive GIS platform | Platform for Land and Nature Repair \| PLANR |
| Consolidated biodiversity, agricultural productivity, salinity risk, soil health, Indigenous land estate and tenure information | Interactive GIS plat-form | WA Carbon Farming and Land Restoration Program Co-benefits Portal CF-LRP Co-benefits Portal |
| Land resource maps and associated changes | Data packages and maps | Land use of Australia 2010–11 to 2020–21 - DAFF |
| National Vegetation Information System (NVIS) – Native vegetation distribution | Interactive GIS plat-form and GIS data packages | Explore Data \| Find Environmental Data |
| Endemic and introduced plants and animals potentially occurring at a particular site | Interactive platform and GIS data packages | Atlas of Living Australia – Open access to Australia's biodiversity data |
| WA Government environment data records such as native vegetation extent, fire history, TEC generalised locations, environmentally sensitive areas etc | GIS data packages | Data WA |

## *Landscape connectivity*

Restoring connectedness of ecological processes (ecological connectivity), connecting patches of habitat important for a target species (habitat connectivity) and connecting vegetation cover at a landscape scale (landscape connectivity) (Fischer and Lindenmayer 2007, Figure 11) help to reduce downward pressure on biodiversity (Ward et al. 2020).

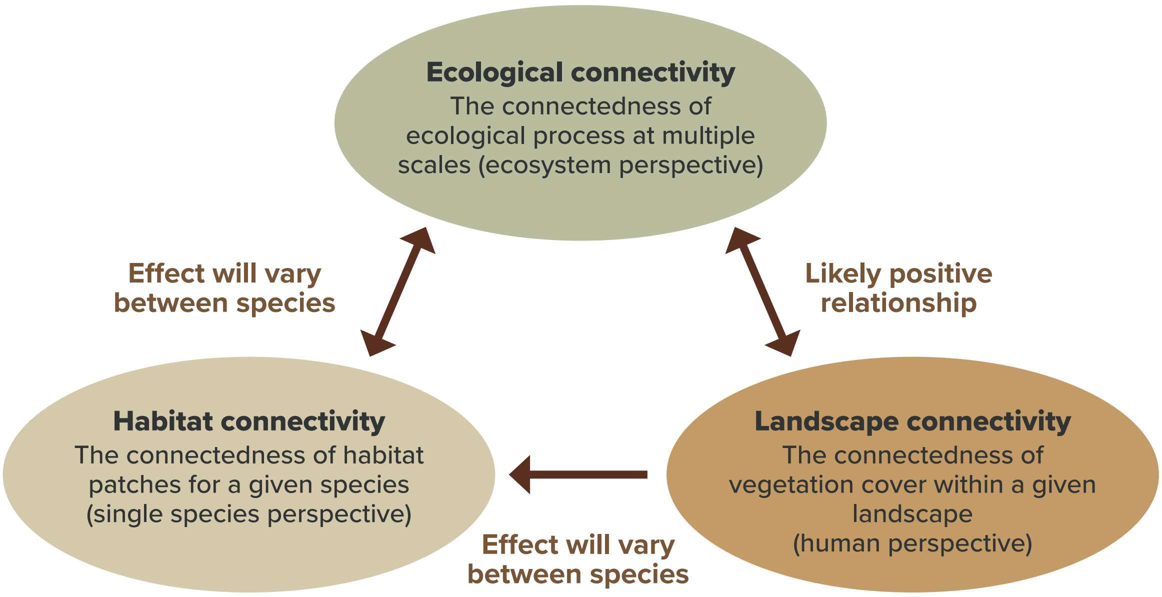



**FIGURE 11: Relationship between the three connectivity concepts: ecological, habitat and landscape (Fischer and Lindenmayer 2007)**

Connectivity promotes species adaptation to climate change by facilitating dispersal at a local scale and sustainable range shifts at a landscape scale (Standish and Parkhurst 2024). Potential ‘remnant, stepping-stone or continuous corridor’ sites situated within ‘natural areas’ (i.e. areas which are not heavily modified by human activities) are ‘easier’ for species movement. Proximity of potential sites to existing valuable natural areas such as creeks and rivers and linear infrastructure barriers such as roads are also valuable for restoration managers to consider (Keeley et al. 2021).

## *Social values*

Site selection may be influenced by social factors, in addition to environmental and economic considerations. For example, old climatically-buffered infertile landscape (OCBIL) uplands such as granite ridges and rocky hills are revered, being present in Noongar Dreaming stories. These communities also support significant biodiversity values with inherently low resilience (Hopper et al. 2021). Engaging with traditional ecological knowledge holders may help to prioritise restoration efforts in sites with values that may have initially been overlooked.

Potential impacts to landholder interests should be identified during site selection and safeguards considered. For example, accessing a site owned by a 3rd party with an intensive agricultural land use history may need to recognise the landholder's priorities addressing degraded wetlands, secondary saline areas, primary saline areas or soils with specific constraints such as being prone to erosion (Milne et al. 2024, Deane et al. 2023). Likewise, potential impacts to the recovery trajectory of a particular restoration site, such as spray drift should be considered as part of the site selection process. Figure 12 guides restoration managers through key steps in the site selection process.

Situating a restoration project appropriately within intensive agricultural landscapes in the Wheatbelt promotes environmental and economic co-benefits. Box 4 presents a case study of restoring degraded areas upland to improve the productivity and resilience of viable agricultural soils and hydrological processes, improving natural capital, and local biodiversity values.

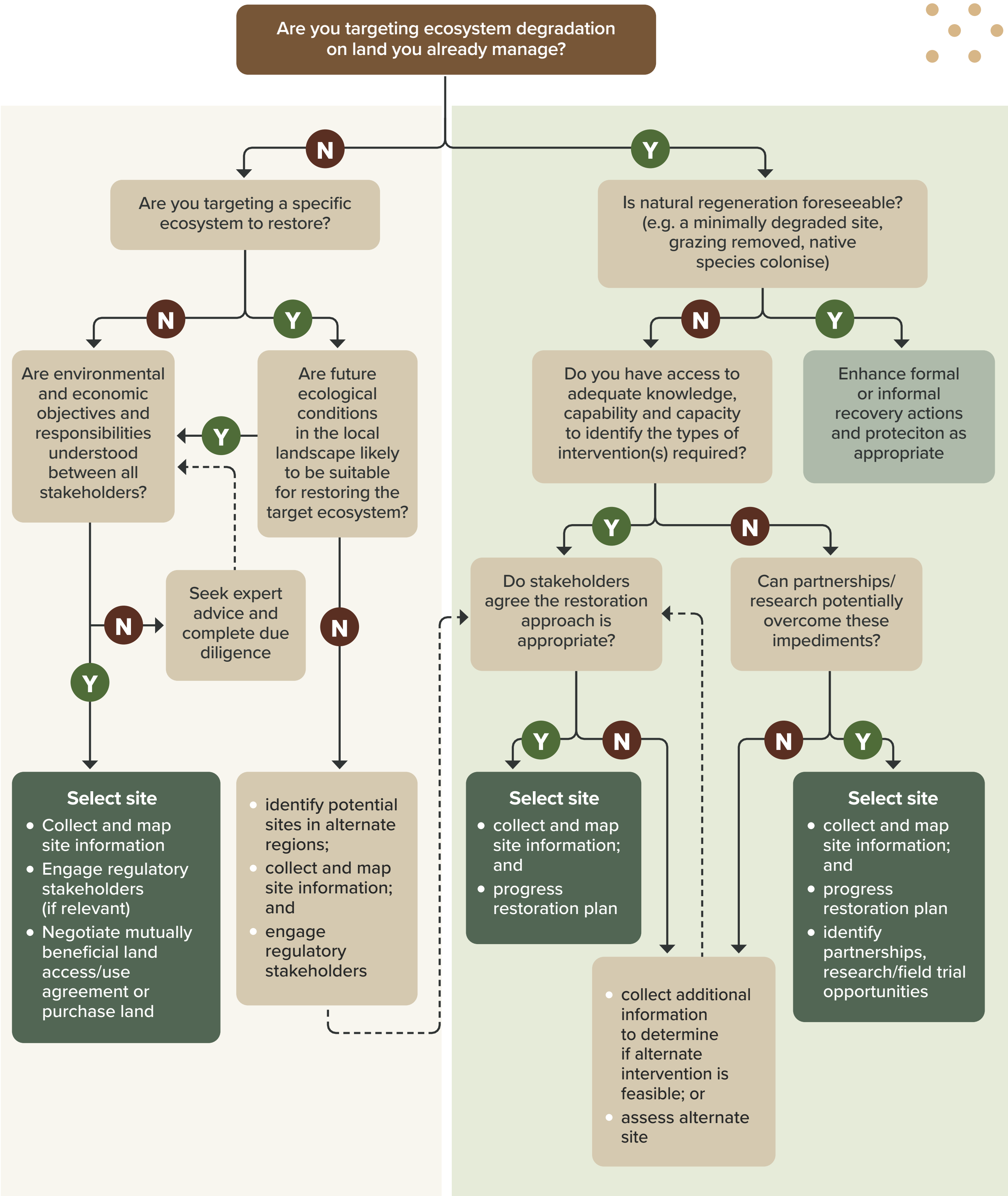
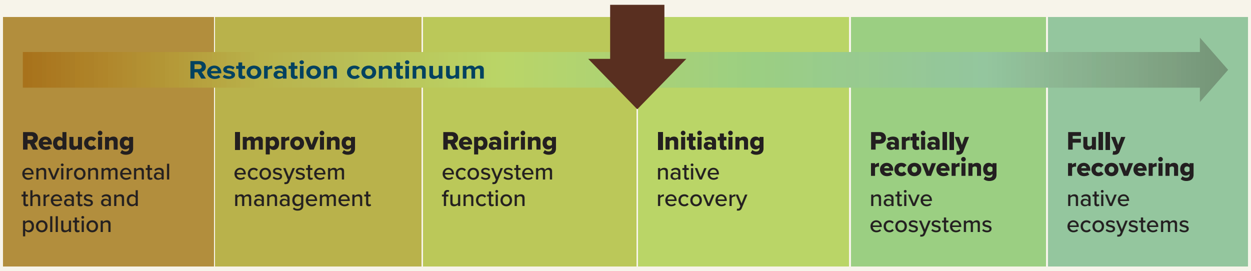



FIGURE 12: Key steps for assessing feasibility of sites and site selection

## Box 4: Case study

# Selecting degraded farmland for restoration, ameliorating soil physical and chemical constraints and improving natural capital

Bob and Amanda Nixon,
Kalannie, Western Australia




### Scope and vision

Grain growers Bob and Amanda Nixon purchased 1,400 ha of degraded farmland in the eastern Wheatbelt (300 mm low rainfall zone) with the aim of establishing a biodiverse carbon planting on 600 ha of the poor performing degraded zones higher in the landscape. Integrating biodiverse revegetation higher in the landscape reduces recharge and subsequently reduces the risk of salinity impacting the higher productivity farmland lower in the landscape. Additionally, 800 ha was improved for cropping through soil amelioration including lime treatment to address low pH and ripping and spading to remove compaction. These activities resulted in improved soil health, soil cover and subsequent crop productivity.

Removing poor performing zones has multiple co-benefits in whole of landscape management, these poor degraded zones often result in financial loss in a traditional cropping system with negative downstream ecological impact.

Bob and Amanda registered and own the project and resulting ACCU's. The services of revegetation consultancy Woodland Services were engaged to help manage compliance.

### Condition of the site

Low productivity areas were identified and demarcated for restoration. Degrading processes impacting biodiversity values and natural capital included soil compaction, low soil pH, wind erosion and salinity.

## Stakeholders

- Landholders – Bob and Amanda Nixon
- Clean Energy Regulator (project is registered for ACCUs)

## Restoration activities undertaken

Ground preparation in the sandy (Wodjil) soils included scalping for weed control, ripping a central planting channel and mounding either side promoting water infiltration. Planting included 15 different native species including *Eucalyptus* spp., *Melaleuca* spp., *Hakea* spp. and *Banksia benthamiana* (Priority 4 species). The remaining 800ha was extensively soil tested in increments 0 to 50cm depth, treated for soil compaction and acidity with deep ripping, spading and liming. This improved crop productivity, profitability, soil health and reduced salinity effects downstream.

## Monitoring

Monitoring methods were adopted from the Carbon Credits (Carbon Farming Initiative) (Reforestation by Environmental or Mallee Plantings—FullCAM) Methodology Determination 2014.

## Measures of progress/measures of success

Flowering and fruiting have been observed in planted species. Evidence of natural regeneration of native understorey species. Fauna are utilising available habitats and resources (e.g. burrowing spiders, ants, pollinating birds, native herbivores).

## Outcomes

- Integration of biodiverse revegetation into a low-rainfall zone cropping system in the Wheatbelt.
- Improving ecosystem function in the catchment through reduced wind erosion, water erosion, reduced salinity risk, improved soil health and biodiversity values.
- New Priority 4 Banksia benthamiana population for the locality.
- Future financial return through approximately 60 ACCUs p/ha over 25 years. This will give the business opportunity to either inset or offset for added income stream.
- Demonstration of sustainable, environmentally positive and profitable farming system with value for positive wider Australian grain trade and market access outcomes.
- Using carbon markets to fund positive farming systems and whole of landscape outcomes.

## Lessons learned and future directions

Ongoing consolidation of agricultural properties in the Wheatbelt has increased the average farm size. Agricultural production systems in the Wheatbelt are often a mosaic of degraded and higher-productive areas. Adoption of a collaborative, catchment-scale approach to land management, including targeted restoration to support recharge zones across tenure boundaries could reduce impacts of salinity and erosion while improving yields for productive paddocks.

The project accessed carbon farming funding to address land degradation drivers both in the project and downstream in the landscape. Utilising resources such as desktop geospatial datasets, harvest yield maps and satellite imagery can support site selection and lead to cooperation of biodiverse planting initiatives across tenure boundaries to improve biodiversity and natural capital across catchments.

*Example of ex-farmland restoration, 2 years post planting. Ground preparation for sandy soil types promoting water infiltration (top). Native understory species are re-colonising ex-degraded farmland in addition to planted native species (below).*

## 4.3.4 Engage stakeholders

Developing and maintaining trust with stakeholders and partners in a restoration project is fundamental to effective governance of all RACs. A clear understanding of accountabilities and transparency are required to develop mutually beneficial partnerships for the life of a project.

When initially identifying potential stakeholders and partners, restoration managers should consider:

- who would be most affected/connected to the intended ecological condition
- who are experts and knowledge holders
- who would receive benefit from the project
- who could provide necessary resourcing and capabilities.

### *Identifying stakeholders*

Restoration managers should identify the necessary resourcing requirements for communicating with and reporting on outcomes to stakeholders for inclusion in the restoration plan. For instance, monitoring metrics (see Stage 5) provides the evidence for restoration managers to communicate progress and effectiveness of management actions with stakeholders and other interested parties (Bartholomew and Mosyaftiani et al. 2024).

While restoration managers have a responsibility to engage with stakeholders with relevant interests in a project, stakeholders may have capacity constraints and may require additional time. Examples of stakeholders by RAC are presented in Table 4. A service provider directory maintained by DPIRD (2024b) supports market led RACs and provides valuable information for implementing value and regulatory compliance RAC projects in the Wheatbelt.

Strategic planning and engagement across RACs for upscaling restoration activities has the potential to provide exemplary environmental, social and economic outcomes for the Wheatbelt when implemented and maintained consistently and underpinned with standardised, reliable information. The WA Government's Native Vegetation Policy for Western Australia recognises the importance of all RACs to reverse the effects and impacts of climate change through 'coordination and stewardship across sectors to restore landscape and ecosystem function' (DWER 2022b). A new Wheatbelt native vegetation strategy is being drafted to enable a 'net gain in extent and condition of native vegetation, coordinating restoration funding (including offsets), conservation, roadside management and regulation (DWER 2022c).

Key stakeholders should be fully informed and aware of their rights in relation to a project and, based on the land tenure and equity structure of a project, restoration managers should seek free, prior and informed consent from any ownership and/or benefit rights holders. Market led RACs can add a layer of complexity to a restoration project (Martin, 2016) and stakeholders may require additional time and resourcing to access independent information and advice in relation to their rights and safeguards for exploring mutually beneficial outcomes.

**TABLE 4: Example stakeholders with a potential interest in a restoration project by RAC**

| Stakeholder interest type | Stakeholder description | RAC | | |
|---|---|---|---|---|
| | | Values | Market | Regulatory compliance |
| Supply chain | Machinery and equipment suppliers | X | X | X |
| | Nursery and seed suppliers | X | X | X |
| | Contractors and consultants | X | X | X |
| | Ecological practitioners | X | X | X |
| Community | Neighbouring landholders | X | X | X |
| | Aboriginal Prescribed Bodies Corporate | | X | X |
| | Cultural and traditional ecological knowledge authorities | X | X | X |
| | Noongar Ranger Groups | X | X | X |
| | Local community groups | X | X | X |
| | Wheatbelt NRM | X | X | X |
| Commercial | Financial investors | X | X | |
| | Landholder (if negotiating land access) | | X | X |
| Government regulatory stakeholders | Department of Primary Industries and Regional Development | X | X | |
| | Department of Water and Environmental Regulation | | | X |
| | Department of Biodiversity Conservation and Attractions | X | | X |
| | Local Government | X | X | X |
| | Shire Landcare Coordinators | X | X | X |
| Industry peak bodies* | Society for Ecological Restoration Australasia (SERA) | X | X | X |
| | Carbon Market Institute (Carbon Industry Code of Conduct) | | X | |
| | Aboriginal Carbon Foundation | | X | |
| | Aboriginal Carbon Environmental Services | | X | |
| | Carbon Market Institute | | X | |
| Research | Universities | X | X | X |
| | Government research agencies and departments | X | X | X |

* While industry peak bodies may not represent an interested stakeholder to a project, stakeholders may access independent information to enable constructive engagement with restoration managers

## *Project governance*

Demonstrating effective project governance may be equally important to building and maintaining trust with stakeholders. Examples of project governance that may be important to stakeholders include:

- a process to implement and maintain a restoration project
- an ability to demonstrate compliance with regulatory requirements
- defined roles and responsibilities
- key decision-making processes involving stakeholders (e.g. co-design)
- an agreed communication plan.

All RACs and associated restoration activities will be subject to a number of key legislations in Western Australia. restoration managers should seek advice to ensure appropriate governance of a restoration project is developed and maintained. Examples of key legislation applicable to restorative actions are presented in Table 5 (drawn from DEC 2012).

**TABLE 5: Example of key legislation applicable to restorative actions**

| Activity | Key legislation |
|---|---|
| Managing declared weeds | • *Biosecurity and Agriculture Management Act 2007* |
| Prescribed burns | • *Bush Fires Act 1954*<br>• *Environmental Protection Act 1986* |
| Application of herbicides | • *Biosecurity and Agriculture Management Act 2007* |
| Managing non-native animals | • *Biosecurity and Agriculture Management Act 2007*<br>• *Agriculture and Related Resources Protection Act 1976*<br>• *Animal Welfare Act 2002* |
| Managing and draining saline land to downstream wetlands | • *Soil and Land Conservation Act 1945* |
| Wetland restoration | • *Environmental Protection Act 1986* |

## *Community*

As Bradby (2023) articulates, community co-benefits from restoration activities can be highly positive, such as creating a sense of place and connection, cultural resilience, employment and attracting further investment for enhancing sustainable communities. Trade-offs at the local and community scale should be considered to facilitate constructive engagement on 'how co-benefits are designed, implemented and evaluated' (Dumbrell et al. 2024). Early engagement, for example before financing, allows time to build mutual understanding and an alignment of project and stakeholder priorities. The Social Benefits Wheel (Figure 9b) is a key tool for identifying and developing performance indicators for social, environmental and economic values important to stakeholders.

The Productivity Commission classifies environmental values through an economic lens based on use and non-use categories (Figure 13). Direct use values incorporate natural capital assets such as crops and livestock and natural areas 'used' for ecotourism or recreation benefits. Indirect values are environmental 'services' benefits derived from ecosystem functions such as pollination and water cycling (Baker and Ruting 2014). Altruism, bequest and existence values recognise the intrinsic links between communities and the environment. These non-monetary values may represent stakeholder perspectives and priorities of restoring natural landscapes such as visual amenity, maintaining cultural connection and enhancing climate resilience of the Wheatbelt to remain a liveable region (Wheatbelt Development Commission 2022).

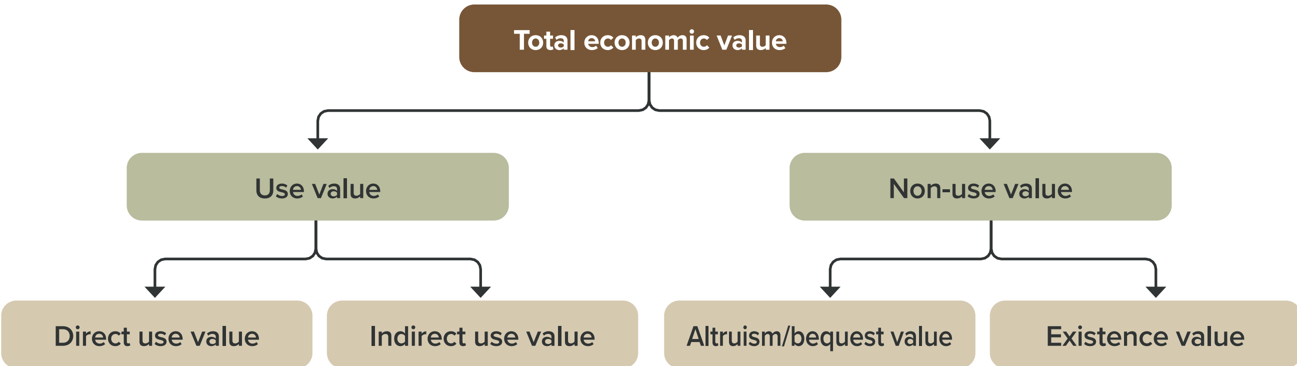



**FIGURE 13: Environmental values classification (Baker and Ruting 2014)**

## *Indigenous knowledge holders*

Western-science restoration managers should endeavour to share with Traditional Owners information that is collected and developed from a restoration project. Further, all RACs with substantial project sites should engage with Indigenous cultural and traditional ecological knowledge holders to identify culturally significant values where appropriate. While much Indigenous Knowledge (IK) is not accessible through scientific literature, IK may enhance climate adaptability and resilience of the restoration project (Dorji et al. 2024). Engaging or collaborating with IK holders may also support the production of culturally appropriate resources to underpin enduring restoration outcomes and cultural connection (Lullfitz 2019).

Restoration managers planning to engage with IK holders should understand and follow relevant consultation guidelines such as those developed by the South West Aboriginal Land and Sea Council (2018). The Koort Boodjar Mia Boodjar (My Heartland My Homeland) Action Plan 2021–2026 developed by the Noongar Elders Advisory Group with Wheatbelt NRM highlights a commitment to 'healthy soils, environments, an activated community and an Aboriginal community that is connected to Country' (Wheatbelt NRM 2021). The Action Plan identifies a number of priorities including 'working with land managers to identify sites of cultural significance and facilitate access' to 'heal Boodjar'. All restoration project sites have the potential to support culturally significant sites that may be managed in cooperation with cultural knowledge holders.

## 4.3.5 Tenure and land access

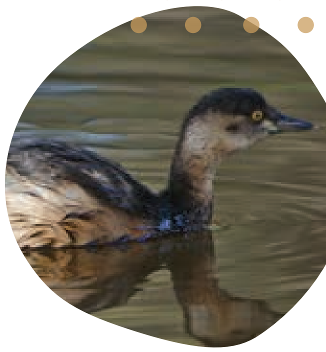
The Wheatbelt holds significant potential for third party investment in all RACs. Evaluating potential benefits and trade-offs to stakeholders and partners in a restoration project is likely to be a key enabler to negotiating land access agreements. The Social Benefits Wheel (Figure 9b) provides a starting point for establishing performance objectives and indicators associated with an agreement.

Agricultural methods and technologies identifying low-yield and degraded areas within broadacre landscapes provide incentive for exploring complementary RACs. For example, values or market led biodiverse environmental plantings and ecological restoration of WWTEC for advanced environmental offsets. Restorative actions enabled through land access agreements may also provide an instrument for Traditional Owners, restoration managers and land holders to conserve and enhance culturally significant sites.

With low rainfall zones forecasted to expand in the Wheatbelt, incorporating complementary RACs within agricultural landscapes may provide landholders access to improving natural capital. The landscape options and opportunities for carbon abatement calculator (LOOC-C) provides landholders and restoration managers with an evidence-based tool to support negotiating mutually beneficial land access (CSIRO 2024). The CF-LRP Co-benefits portal consolidates environmental, agricultural and tenure related information that can also support compatible RAC land-use negotiations, such as restoring conservation significant ecosystems, and manage degrading processes in the local landscape.

When negotiating agreements, engagements with landholders should consider the social equity elements identified during the site selection process. Introducing single or multipurpose co-benefit metrics in agreements should be prioritised and weighted in agreement with stakeholders (Baumber et al. 2019). Co-benefit examples include improving natural capital, protecting and enhancing cultural and environmental values, reducing groundwater recharge to control salinity and providing access to resources and technical expertise (Fleming et al. 2019). Potential resource challenges to ascertain and participate in the project should also be considered in engagement schedules.

The Carbon Market Institute provides contracts guidance and template agreement clauses for project development and service agreements. These resources provide a starting point for informing rights and responsibilities, equity share and risk under different business models (Carbon Market Institute 2024).



## 4.3.6 Identifying enablers and barriers to restoration

Land use legacies in the Wheatbelt present multiple challenges to ecosystem recovery and restoration, such as elevated concentrations of soil phosphorous (P), depletion of other nutrient concentrations, weed invasion, erosion and dryland salinity caused from tree removal and subsequent altered hydrology, soil compaction, access to viable seed, disturbance cues and spray drift from nearby agricultural areas (Parkhurst et al. 2022, Payne 2023). While all restoration actions on the continuum of recovery (Figure 3) have the potential to improve biodiversity, some actions alone (such as fencing to eliminate grazing pressure) may not be sufficient to restore target ecosystems such as eucalypt woodlands (Yates and Hobbs 1997). Further assessment may be needed on initial species richness at a particular site and the potential for natural regeneration to determine the likelihood of new species occurring with or without management action such as weed treatment (Prober et al. 2009).

The intensity of impediments to restoring native ecosystems may be influenced by the duration, extent and intensity of agricultural land use at a particular site. Where a site has been subject to limited cultivation, fertiliser use and is situated in proximity to remnant vegetation, biotic thresholds such as depleted native seed bank, limiting seed dispersal vectors and introduced species may be the only impediments requiring intervention. Increasing agricultural land use intensity legacy results in both biotic and abiotic thresholds crossed, such as soil phosphorous concentrations, altered hydrology and soil conditions requiring remedial action to restore ecosystem function (Parkhurst et al. 2024, 2021, Cramer et al. 2008). Figure 14 presents an expert-derived conceptual model of Wheatbelt eucalypt woodland communities including barriers and enablers to vegetation state transitions (see Prober et al. 2023a).

Strategic approaches to landscape-scale restoration in the Wheatbelt can enhance biological diversity, enable access to the restoration economy and avoid poorly performing land use (Young et al. 2023). The feasibility of restorative methods with increasing project scales may be reduced with increasing labour as a significant proportion of costs (Yong et al. 2023). Technology and engineering solutions developed by the agricultural industry are increasingly being adopted to overcome barriers in ecosystem restoration such as seed sowing, reducing weed competition and, targeted labour effort (Brancalion and Holl 2024, Young et al. 2023).

### *Restoration barriers checklist*

Understanding barriers to the intended environmental outcomes of a project is essential to inform monitoring and management actions. The restoration barriers and enablers checklist (Appendix 8) provides a starting point to identify elements that may present risk or opportunity to the success of a project. Each element is assessed with a significance and likelihood matrix and given a score. Moderate to high scores should prompt consideration in the restoration plan (Section 4.4.1). The elements included in the checklist may not be relevant to all projects, and some elements may have associations or dependencies with one another. Approaches to managing barriers and optimising enablers should consider planning, project management, collecting and managing information and research opportunities to address key knowledge gaps. Socialising a completed checklist with stakeholders and experts can address bias, identify key stakeholder perspectives early and support the site selection process (Section 4.3.3).

Box 5 presents a case study which applies the restoration barriers and enablers checklist to a Greening Australia project partnering with landholder Stephen Barrett improving areas affected by dryland salinity within an agriculture system in the central Wheatbelt.

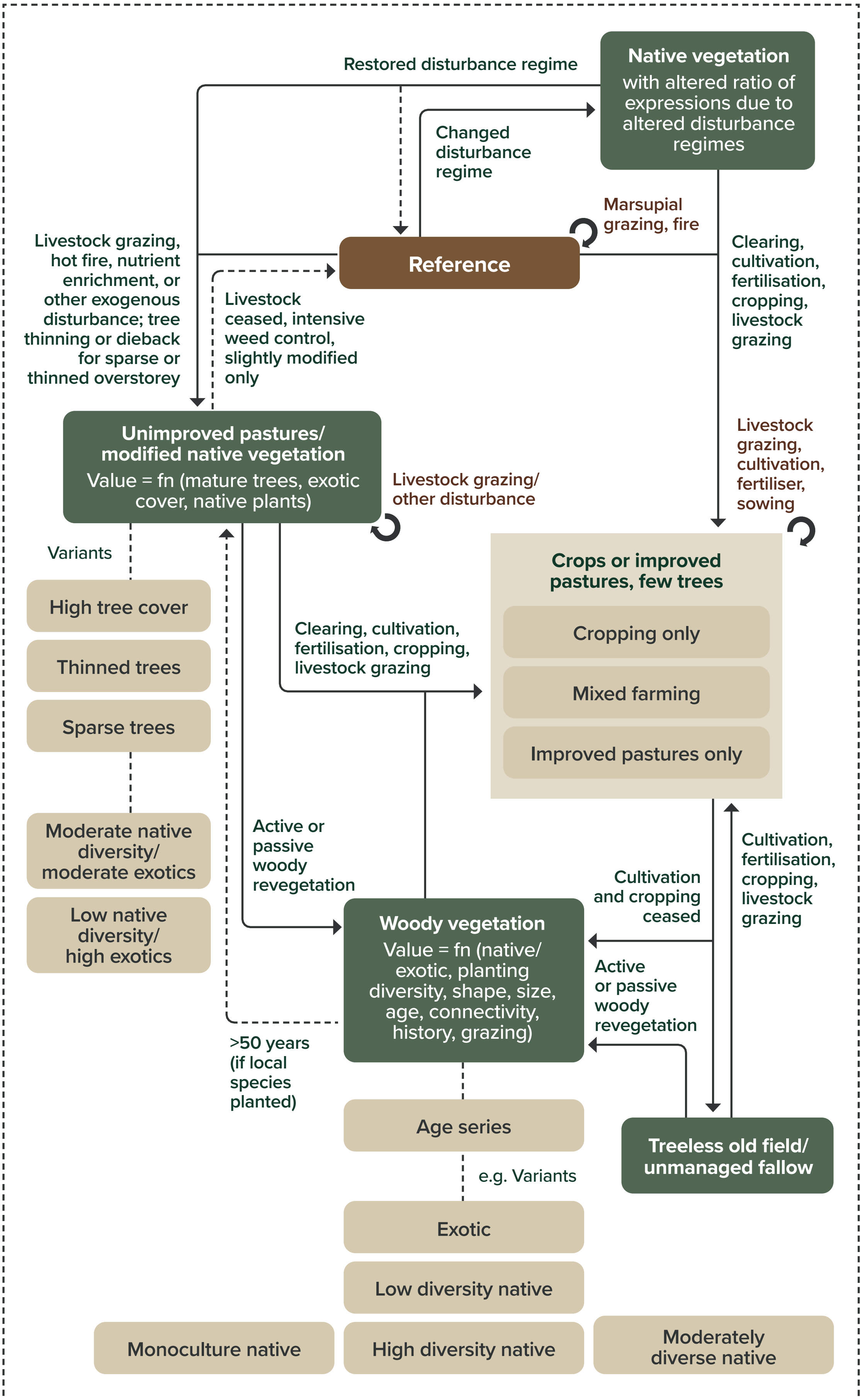
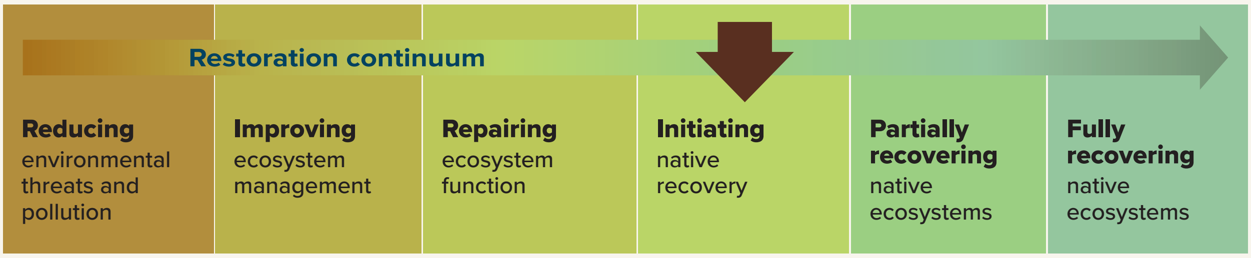



FIGURE 14: Generic state and transition model template for WA Wheatbelt ecosystem types (Prober et al. 2023b).

## Box 5: Case study

# Identifying barriers and enablers to restoring land affected by dryland salinity

Greening Australia and Stephen Barrett,
Katanning, Western Australia




### Scope and vision

Soil degrading processes and altered hydrological conditions have a direct impact on mixed livestock and cropping agricultural systems in the central Wheatbelt (300-600 mm rainfall). Waterlogging and soil salinity are common challenges in farming systems, creating areas of low productivity.

A shared vision was developed to realise multiple co-benefits with landowner Stephen Barrett and Greening Australia to improve land condition, manage salinity and waterlogging, enhance biodiversity values and provide resources for livestock.

An example restoration barriers checklist has been completed below for this case study, to retrospectively illustrate how key barriers and enablers can be identified early in the scoping phase of a project. These can then inform objectives and actions to be documented in a robust restoration plan in the design phase, thereby integrating and addressing priorities of stakeholders and improve the likelihood of success.

### Condition of the site

Legacy clearing of deep-rooted vegetation communities for farming led to increased episodic and localised recharge, resulting in elevated water tables across the Wheatbelt. Key degrading processes at the site included water logging, dryland salinity and erosion risks.

## Stakeholders

- Landholder – Stephen Barrett
- Biodiverse native revegetation – Greening Australia
- Project register and reporting to the Clean Energy Regulator – Canopy (a Greening Australia company)

## Restoration activities undertaken

Ground preparation included scalping and broadcast seeding in year(s) 2018–2022 with row spacing varying between ~1.5–4 m. Planting shelter belts (~25 m with 40 m between belts) comprising ~50 native species including salt-tolerant species (e.g. *Eucalyptus occidentalis*, *E. sargentii*, *Melaleuca adnata*, *M. cuticularis*, *M. hamulosa*) and fodder species (e.g. *Atriplex*, *Rhagodia* spp.).

## Monitoring

- Greening Australia monitoring methodology includes germination and survival/establishment indicators.
- Monitoring for carbon credits were adopted from the Carbon Credits (Carbon Farming Initiative) (Reforestation by Environmental or Mallee Plantings—FullCAM) Methodology Determination 2014.

## Measures of progress/measures of success

- area surviving
- connectivity
- stem density/survival vs planned
- flora composition
- vegetation condition

## Outcomes

- shade, shelter, fodder for livestock
- improved productivity on previously degraded farmland
- habitat creation and connectivity with remnant vegetation patches
- cost-effective improvement in land condition. Reduced water logging and soil salinity risks
- future financial return from the portion of planting area developed for carbon planting, approximately 60 ACCUs p/ha over 25 years

## Lessons learned and future directions

The checklist can help to identify potential barriers and enablers early and provide a preliminary assessment of significance and likelihood of impact to, or influence on a project. This can enable effective engagement by achieving collective understanding of significance amongst partners and stakeholders. Management strategies can then target high-ranking barriers and enablers.

Several high-rated barriers and enablers were identified for the elements assessed in the example checklist below. Some physical barriers such as soil electrical conductivity (EC) and hydrological processes such as waterlogging and salinity are common in Wheatbelt agriculture systems, presenting opportunity for coordinated land use approaches amongst landholders and restoration partners. Physical barriers identified for the site prompted additional, targeted resource allocation towards specific species and site preparation. This included additional infill and tubestock quantities in replacement of seed which, although increased initial cost and complexity, improved certainty of outcomes and mitigated wasted resources.

High-rated enablers highlighted the value of developing strong relationships and co-design the project for multiple outcomes. It also promoted the integration of specialist local and third party technical expertise to apply appropriate, reliable approaches and techniques to these challenging environments.

As this restoration project matures, further outcomes on shade, shelter, fodder value, improvements in land condition (salinity, waterlogging, ground cover) and fauna utilisation will be assessed as part of ongoing monitoring.

*Ground preparation and seeding completed in 2022. Photo courtesy Jesse Collins, Greening Australia*

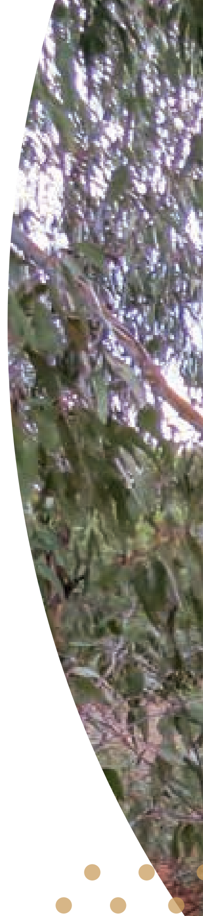
| Type | Element | Barrier or Enabler | Rating |
|---|---|---|---|
| Physical | Restoration project adaptability and resilience to climate change | Barrier | Medium |
| | Soil (e.g. type, compaction, EC, nutrient load, moisture, temperature) | Barrier | Medium |
| | Availability of suitable fauna microhabitats (e.g. tree hollows) | – | – |
| | Hydrological processes (e.g. salinity, waterlogging) | Barrier | Medium |
| Knowledge | Distribution, ecological condition and trend data on Wheatbelt Woodland TEC | Barrier | Low |
| | Technical capability and capacity to achieve restoration targets | Enabler | High |
| | Western scientific, indigenous and local and knowledge e.g. climate adaptation and resilience | Enabler | High |
| | Spatial distribution of ecosystem values associated with carbon storage, reduction of natural hazards, water quality/quantity | Enabler | Medium |
| | Information on how ecosystem restoration may benefit threatened species | Enabler | Low |
| | Complexity of the ACCU scheme, challenging to navigate the regulatory process | Enabler | Medium |
| | Perception of value and trust in sharing data with stakeholders | Enabler | High |
| Financial | Cost of land, land tenure | Enabler | High |
| | Significant initial investment, returns of variable restoration methods, benefit-sharing and cost of restoration failure | Barrier | High |
| | Whole of catchment land use, management and productivity | Enabler | High |

*Revegetation completed in 2018 now maturing, forming habitat and connectivity with adjacent remnant patch (background). Photo courtesy Jesse Collins, Greening Australia*

## 4.4 Stage 2 – Design

Key activities to design a restoration project for implementation include establishing an appropriate reference ecosystem or model, planning the methods and resources to implement and effectively manage the project to meet intended outcomes. Activities that should begin in the design stage include:

- develop a restoration plan incorporating the scope, targets, expected environmental outcomes, goals (completion criteria) and objectives (milestones) with time points of what should be observed at the site as restoration progresses
- develop a research plan to address knowledge barriers above moderate to high-risk threshold for a particular site
- develop a species list suitable for the project site (see Appendix 12 for WWTEC diagnostic characteristics including dominant and associated species) and determine lead times from suppliers
- develop key actions for effective project governance (e.g. legal approvals and obligations, develop a project schedule with personnel responsibilities, procedures, data management)
- investigate potential certifications to enhance a project's ecological and economic value.



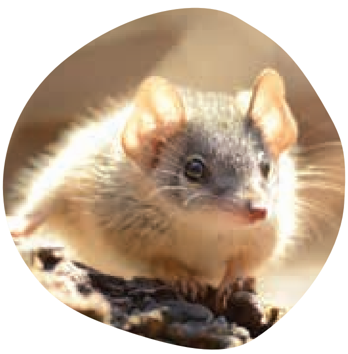
Restoration projects are likely to benefit from the co-design of core planning activities and any associated experimental elements with Indigenous and local knowledge holders. Collaboratively aligning with relevant Healthy Country Plans, incorporating culturally significant species in habitat restoration plans and culturally informed land management practices creates shared learning opportunities, enhancing biodiversity values and resilience in restoration projects (Goolmeer et al. 2022, Bartholomew and Mosyaftiani et al. 2024, Broadhurst et al. 2023). Engagement with key knowledge holders is discussed further in Section 4.3.4.

In the design stage restoration managers should consider what activities and actions are required to manage a project site, and the attributes that are to be measured to inform the trajectory recovery.

### 4.4.1 Develop a restoration plan

A restoration plan should incorporate the following items and consider relevant actions (drawn from Bradby and Cross 2023, Valderrábano et al. 2021, Gann et al. 2019, EPA 2025 in prep., DWER 2018 and Johnson 2010) to address key elements required for a restoration project (Figure 15):

- project restoration targets, goals, objectives and indicators align with the RAC
- an appropriate reference ecosystem/model
- description of the site(s) including plans, maps and photos (see also Section 4.6.1)
- methods for gathering data (baseline and monitoring) for assessment against attributes or sub-attributes (example restoration actions and methods are presented in Table 6). Resources to support restoration managers may include Terrestrial Ecosystems Research Network's (TERN) ecological field monitoring protocols (EMSA 2024) which provide standardised data collection templates and methods and Wheatbelt NRM for region-specific resources, however consideration of the method chosen for monitoring should come after the attributes of indicator(s) of change have been selected
- a monitoring and adaptive management plan. Management actions identified for restoration barriers with moderate to high risk to meeting environmental outcomes, including addressing knowledge barriers through research. where possible, consideration of environmental change based on an understanding of vegetation responses to climate induced drying
- a schedule of restoration actions and contingency (e.g. rainfall). A review schedule should be incorporated to constructively capture and communicate lessons learned
- project budget (inputs and returns)
- project team structure and responsibilities (as appropriate)
- key partners and stakeholders and key accountabilities/deliverables
- planting design to soil types and landscape positions, species selection and seed/tubestock quantities required
- hygiene practices and management for weed and pest control
- machinery and equipment resources
- data/information management resources, reporting and/or data sharing arrangements
- obligations associated with implementing and ongoing maintenance of the project (including following completion of the project).



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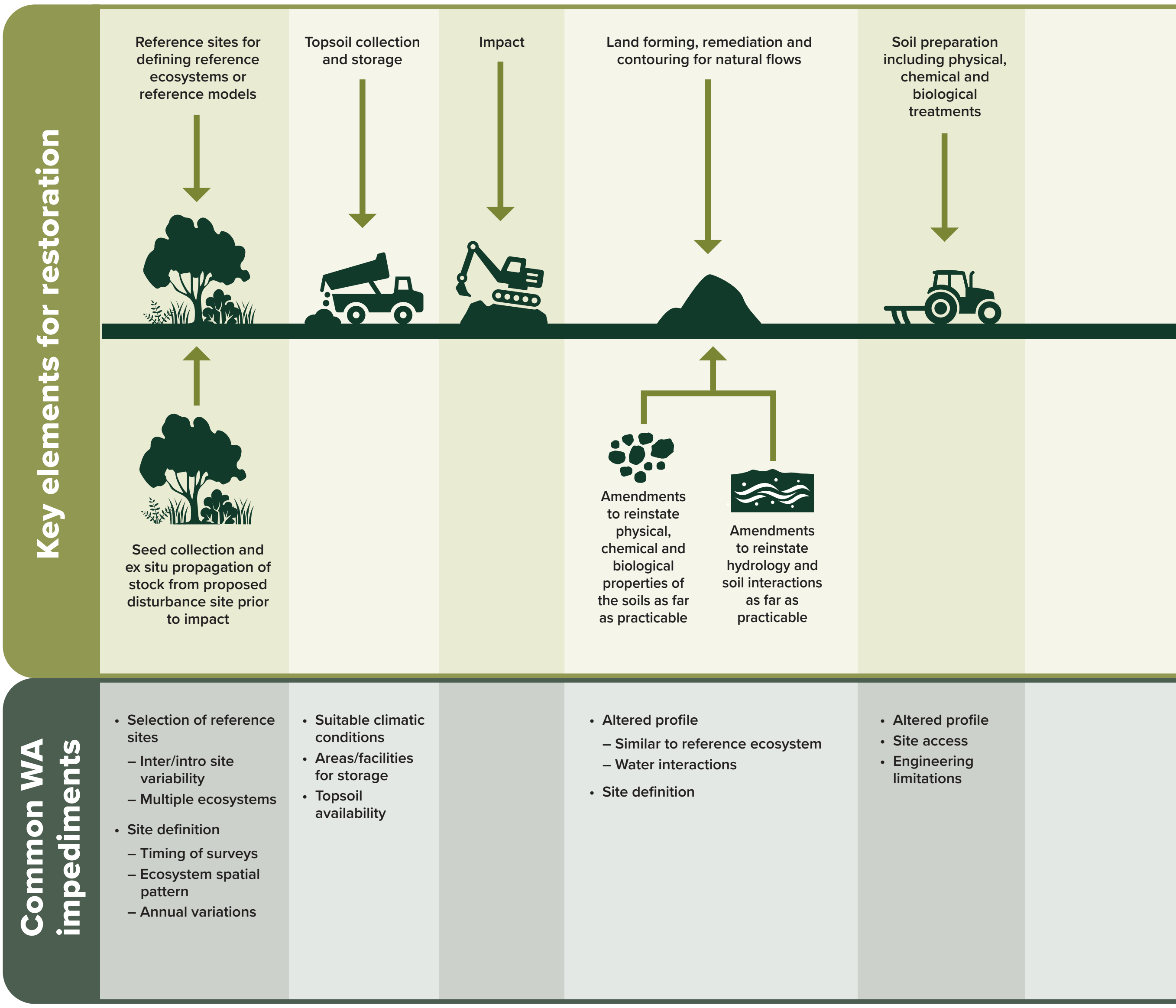



FIGURE 15: Example of key stages and elements required for biodiverse ecosystem restoration and common WA impediments. Modified from WABSI (2014), Broadhurst et al. (2023). Note this generalised figure is for all types of restoration projects in Western Australia. Not all elements or impediments may be relevant for each project.

**B.**

| Key elements for restoration | | | | | |
|---|---|---|---|---|---|
| Topsoil spread, seed distributed and/or seedlings planted | Trigger for germination (e.g. rainfall, fire) | Factors including 1st generation growth to maturity (e.g. soil chemistry, biota) | Second pass / infill planting | Factors influencing long-term viability/ resilience (e.g. reproductive success, species diversity etc.) | Animal recruitment via migration or translocation |
| Seed sourced from wild sites, seed farms and seed banks | | | | | |

| Common WA impediments | | | | | |
|---|---|---|---|---|---|
| • Seed availability<br>• Time to collect<br>– Impact on ecosystem<br>– Failed production years<br>• Wasting limited resources | • Unpredictable rainfall<br>• Seed dormancy<br>– Key species wont grow from seed<br>– Tissue culture<br>• Resources and time<br>– Key species research<br>– Production capacity | • Unpredictable rainfall<br>• Weed or legume dominance<br>• Substrate similarity to ecosystem<br>• Time (months to decades)<br>• Vegetation succession | • Unpredictable rainfall<br>• Seed/seedling availability<br>• Access to infill areas (without disturbing recruits)<br>• Wasting limited resources | • Unpredictable rainfall<br>• Weed or legume dominance<br>• Substrate similarity to ecosystem<br>• Time (months to decades)<br>• Vegetation succession | • Absence of corridors<br>• Habitat requirements<br>• Translocating permits |

**TABLE 6: Advantages and disadvantages of example restoration actions and methods in eucalypt woodlands and associated vegetation in the Wheatbelt region***

| Example restoration action (and method) | Advantages | Disadvantages |
|---|---|---|
| **Weed control** (e.g. scalping, spraying, hand pulling) | • Controls declared plant pests and weeds of national significance<br>• Effective for direct seeding<br>• Removes non-wetting soil<br>• Potential contour to collect surface water | • Removal of native seed, organic matter and soil microorganisms<br>• Exposure of clay on heavy soils<br>• Risk of wind and water erosion if scalping conducted over large areas<br>• Requires residual or pre-emergent herbicide to control virulent and colonising weeds<br>• Herbicides such as glyphosate can persist in the environment and harm soil microbes |
| **Address soil** degrading processes (e.g. microbial soil inoculation) | • Enhance woody vegetation growth<br>• Enhance carbon sequestration | • Knowledge gaps on the effectiveness and barriers to establishing microbiota communities |
| **Soil seed bank recruitment** (topsoil transfer) | • High plant diversity and abundance possible<br>• Access to species not available in nurseries<br>• Possible weed control as cover<br>• Local seed adapted to soil and climate conditions | • Target species may be absent<br>• Potential introduction of accumulated weeds/disease<br>• Timing of topsoil stripping may depress native seedling emergence<br>• Potential loss of viable seed and topsoil quality<br>• Transport cost |
| **Revegetation** (e.g. planting nursery tubestock) | • Cost effective<br>• Effective for targeting trees and other dominant plants (if available)<br>• Target seedling density to desired ecological structure and functional attributes | • Target species may be absent<br>• Labour intensive<br>• Summer mortality<br>• Herbivory protection may be needed<br>• Seedlings root growth challenges<br>• Reduced amount of genetic diversity<br>• Investment in propagation infrastructure and methods<br>• May require irrigation in year 1 |
| **Revegetation** (e.g. direct seeding using machinery or target broadcast by hand) | • Cost effective for large-scale<br>• Mixes can reflect desired native assemblages to defined 'vegetation associations' (Jonson 2010) to suit soil type, landform attributes and climate<br>• Effective for trees and other dominant plants (if available)<br>• Initial weed cover reduced in furrows<br>• Hand seeding rare or limited seed to targeted soil types | • Potential high mortality/poor germination<br>• Planting design in rows<br>• Challenging to access sufficient seed<br>• May require seed priming to restore native species in harsh conditions (e.g. salt affected areas) |

*(Continued following page)*

| Example restoration action (and method) | Advantages | Disadvantages |
|---|---|---|
| **Introducing micro-habitat for fauna** (e.g. artificial hollows, woody debris piles) | • Increased species richness<br>• Promotes threatened species recovery (targeted habitat restoration)<br>• Increased ecosystem function<br>• Restoration project more likely to be resilient to fire, pest and disease disturbances | • Labour intensive<br>• Persistence of target species influenced by specific habitat requirements<br>• Culturally significant species not well understood |
| **Pathogen control** (e.g. *Phytophthora* treatment) | • Phosphite treatment to improve plant resilience<br>• Hygiene protocols for access | • No known cure for *Phytophthora* dieback threats<br>• Costly treatment |

## *Planting design*

Restoring biodiverse Wheatbelt eucalypt woodland and associated native ecosystems should consider an overall planting design and spacing that promotes pollination, availability of food sources for fauna and improves seed production across all trophic levels. Planting designs with species suited to specific landforms and soils in the local area (such as upland, ecotone and lowland, damp areas) that encourage spatial heterogeneity are likely to promote composition and structure comparable to a native reference ecosystem (Bradby and Cross 2023).

Studies of seed production in revegetated eucalypts native to Western Australia indicate avoiding large or overly close (<4m) spacing of the same species incorporated with density (stems/ha) targets may improve pollination and seed set, enhancing long-term sustainability of revegetated populations (McCallum et al. 2019). The WWTEC tool provides restoration managers with species richness and cover information to inform composition and structure targets at a particular site. Jonson (2010) recommends a combination of broad-scale application of seed with discreet, close plantings of seedlings of species with low seed availability or specific germination requirements (such as Proteaceae).

## *Species selection*

Restoration managers should consider selecting overstorey and understorey species informed by reference ecosystems or models that are suited to the landform and soil types of the project site. This may include species unlikely to be present in topsoil seed bank and species linked to restoration targets, such as food plants for Carnaby's cockatoo. The WWTEC tool details the dominant overstorey, understorey and associated species for the eucalypt woodland ecological communities comprising the WWTEC, along with their associated landforms, soil types and average species richness.

Endemic species suited to the landforms and soils of the Wheatbelt may provide multipurpose co-benefits to a particular site. For example, Yate (*Eucalyptus occidentalis*) yields may enhance the value proposition of a project with comparable or higher carbon credits through sequestration to single-species plantings in biodiverse-woodland carbon plantings (Standish and Parkhurst 2024, Standish et al. 2022, Booth 2017). Yate (and other local eucalypts) endemic to saline areas in the Wheatbelt may improve a degraded soil legacy through phytoamelioration of salt-affected soils (DPIRD 2024a). Other benefits to local biodiversity, and shelter and forage for stock (Lefroy 1993) may also be important to a particular site.

As a starting point for value and market RACs, DPIRD 2024a provides a guide for selecting plant species of varying tolerance to saline conditions and Wheatbelt NRM (n.d.) provides a revegetation guide by soil type.

Functional groups play a crucial role in ecological restoration by representing groups of species with similar roles in ecosystem processes or similar responses to environmental conditions. Restoration efforts that focus on restoring functional groups, rather than just species, can enhance the resilience and stability of restored ecosystems. Table 7 presents the relationship between key functional groups and SER ecological attributes, noting evidence of ecosystem integrity and resilience should also be identified through other indicators as appropriate for a particular site.

**TABLE 7: Relationship between functional groups (from Clarke et al. 2010) and example SER sub-attributes that could be monitored**

| Functional group | Key ecological processes | Example functional group members | SER attribute | SER sub attribute |
|---|---|---|---|---|
| Primary producers | Energy flow, carbon cycling, soil stabilising, nutrient cycling, water filtration and cycling | Plants | Structural diversity | All vegetation strata |
| | | | Ecosystem function | Productivity, cycling |
| | | | Species composition | Desirable plants |
| | | | | No undesirable species |
| Pollinators | Pollination | Nectivorous birds, bats, insects, small mammals | Species composition | Desirable animals |
| Seed dispersers | Gene flow | Birds, ants | External exchanges | Intraspecific gene flow |
| Decomposers | Nutrient cycling, energy flow, carbon cycling | Soil microbiota, fungi, insects | Ecosystem function | Productivity, cycling |
| Nitrogen fixers | Nutrient cycling | Plants hosting rhizobial bacteria | Ecosystem function | Productivity, cycling |
| Consumers | Nutrient cycling, energy flow, gene flow | Herbivores (mammals) | Species composition | Desirable animals |
| | | Granivores (birds, insects) | | |
| | | Carnivores (birds of prey, snakes, spiders) | | |
| | | Insectivores (birds, bats) | | |
| | | Frugivores (some birds e.g. emus) | | |
| | | Nectarivores (some birds, small mammals, insects) | | |
| | | Omnivores (generalist birds) | | |

### *Native seed and propagules*

Fragmented, remnant native vegetation in the Wheatbelt is likely to be under increasing pressure from seed harvesting and from the cumulative effects of climate change (Broadhurst et al. 2017). The current reliance on wild-harvested seed to supply the restoration industry may be significantly constrained to meet future demand (Hancock et al. 2020). The capacity of specialist seed suppliers servicing the restoration industry is also in high demand. Accessing the desired species, volume, and quality in mixes or as tubestock for a suitable planting window requires pragmatic planning to maximise value from seed/native tubestock supply. The sustainability of diverse, commercially available seed stocks to meet demand has been raised as a concern for over 15 years (Broadhurst et al. 2017). Further, a recent study by Andres et al. 2024 concluded just 12% of native species are available nationally across seed supply chains with grasses, sedges and herbs being the least represented. While early consultation with suppliers can initially challenge project schedules, planning adequate lead times (potentially >12-months) to increase the number and volume of seed and tubestock species availability within sowing/planting windows over multiple seasons will enhance biodiversity values and improve resilience. Upscaling restoration could be enabled through cooperative resourcing for a future restoration seedbank in the Wheatbelt region.

Native seed viability is highly variable and sourcing commercially available products lacking quality testing can result in wasted resources and sub-optimal results in restoration project sites. Seed quality should be 'assessed by an independent seed testing laboratory, familiar with native seeds or by the supplier' (Pedrini et al. 2022). Native seed supply quality assurance can be improved with commercial suppliers demonstrated compliance with the international principles and standards for native seed in ecological restoration (Pedrini and Dixon 2020) and with membership to the Revegetation Industry Association of WA.

Native seed treatment has the potential to provide benefits to the restoration industry parallel with the agriculture industry. Priming and coating seed may promote germination and performance of seeds by targeting specific inhibitors such as drought, soil chemistry, pests and diseases (Pedrini et al. 2020a, 2020b) when applied at an economically feasible scale.

## *Topsoil*

If topsoil transfer is deemed appropriate for restoring a specific ecosystem type, donor sites (that are not WWTEC) with the following criteria would be considered appropriate (drawn from Stevens et al. 2016).

- The site contains high native species richness, abundance, frequency and/or cover.
- The site has no weeds or minimal weed species present.
- The site has no disease present, particularly dieback (*Phytophthora cinnamomi*).
- The site has not been subject to fire for 5–7 years to ensure adequate build-up of the topsoil seedbank.

Technical advice is recommended for identifying appropriate donor sites and specific regulation applicable to native vegetation clearing, stockpile and transfer of topsoil material, including specific considerations for WWTEC restoration targets.

Wheatbelt soil legacies such as changes to soil structure limiting water infiltration, water logging, soil chemistry (salinity) and quality (herbicides and pesticides) can have a significant influence on seed germination and recruitment (Prober and Smith 2009). Restoration managers should consider seeking technical advice on methods, including experimental approaches, to improve the likelihood of meeting targets and goals.

## *Habitat complexity*

All RACs may benefit from introducing microhabitats suitable for native fauna such as coarse woody debris, burrowing, denning, roosting or food resources, provided management is integrated for non-native species movement such as rabbits. Increasing diversity of microhabitats will improve the likelihood of species richness, ecosystem function and may promote threatened species recovery, provided that specific habitat requirements are understood and managed (Prober and Smith 2009). Native woodlands and biodiverse restoration plantings are also more likely to be resilient to fire, pests and disease disturbances (Standish and Parkhurst 2024). It is recommended that expert western scientific and traditional ecological advice is sought on restorative actions that may promote diversity and abundance of functionally important species.

It is important to note the absence of a conservation framework to recognise, protect, monitor and manage species of cultural significance in the Wheatbelt (known as Culturally Significant Entities) (Goolmeer et al. 2022). Opportunities to support recognition of culturally significant species in restoration planning includes co-design with Indigenous knowledge holders and Indigenous-led restoration.

## *Research opportunities*

Actions identified in restoration plans may include exploring research opportunities to manage knowledge gaps. Collaborating with stakeholders on specific research opportunities may produce benefits to restoration projects through sharing research priorities, reducing resourcing burden, sharing risk, and optimising research outcomes at a landscape scale. *Guidelines for embedded experiments in ecological restoration and management in Australia* provide support with planning and with integrating effective, outcomes focused experiments in ecological restoration and management (Broadhurst et al. 2023).

## 4.5 Stage 3 – Finance

Initiating a restoration project may require a significant investment in various elements such as land, removal of activities providing a return (e.g. stock removal), applying environmental regulations, labour, and materials, presenting initial financial barriers (Brancalion and Holl 2024, Perry 2023). International, national and state policy frameworks enabling emissions offset and nature-related risk management activities have introduced a range of incentives to upscale the national Nature Repair Market and the restoration economy in WA (Hatfield-Dodds 2023, Young et al. 2023). Natural capital accounting and ecosystem accounting methods for estimating flow and benefit of ecosystem services may support a value proposition of restoring natural capital in the Wheatbelt region (such as carbon and biodiversity credits) and improve biodiversity (Richards et al. 2023).

Land based carbon sequestration through vegetation remains the ‘key source of Australian Carbon Credit Units’ (ACCUs) (Carbon Market Institute 2024), providing opportunities to reverse the cost of land degradation and improve productivity (e.g. DPIRD 2021, Lefroy et al. 1993). Grants and programs incentivising restorative activities in the Wheatbelt region include:

- the Australian Agriculture Biodiversity Stewardship Program
- the WA Carbon Farming and Land Restoration Fund
- the Australian Government’s identification of remnant WA Wheatbelt Woodlands as one of 20 priority places with restoration as a priority action, in support of the Threatened Species Action Plan (TSAP), with a commitment of $224 million that supports implementation of the Action Plan 2022–2032 (DCCEEW 2022)
- landcare programs
- natural resource management grants
- impact and philanthropic investments.

Fair and clear commercial arrangements between landholders and restoration managers may overcome risk perceptions of landholders entering into Nature Repair markets, such as ‘uncertainty over demand, prices, financial returns, and other risks’ (Marsden Jacob Associates 2023). Similarly, combining government incentives with transparent assessment of risk in commercial arrangements with stakeholders may overcome barriers to value and market led RAC implementation.

The interconnected nature of RACs (Figure 6) present multiple value propositions (and opportunity cost) for restoration managers and stakeholders to consider. Assessing perceptions of risk through the Restoration Polarity Tool (Appendix 7) provides a starting point for capital allocation, operating costs, project, and partnership funding considerations in the:

- initial and ongoing costs of land
- cost of implementation
- cost of infill planting, maintenance and adaptive management actions
- returns on carbon or biodiversity credits/certificates
- returns and productivity of agriculture products, including farmed native seed production approaches servicing the restoration industry.

A successful restoration project is dependent on investing in planned adaptive management beyond the implementation phase (Section 4.3.5). For example, annual costs associated with monitoring and control actions for high-risk restoration barriers such as weeds and rabbits could be measured against a potential loss of carbon sequestration functions if effective controls were not in place.

### 4.5.1 Economics at different scales

The Wentworth Group of Concerned Scientists' blueprint calculated that an annual investment of $7B over 30 years is required to repair ecological degradation to a regional scale. Actions to improve water quality, soil health and restore ecosystems to a minimum of 30% of their pre-1750 extent will 'also increase agricultural productivity'. The blueprint also recognises the importance of quality land-based carbon sequestration in the repair pathway (Wentworth Group 2024).

Monetising restoration value such as carbon and biodiversity unit returns, agricultural profits, climate-adjusted productivity and land value through environmental economic accounting methods provides benefits at local and regional scale in the Wheatbelt. Identifying and quantifying all costs in a project budget can be easier than valuing expected returns (Perry 2023) and can be challenging to extrapolate between projects with multiple variables.

Yong et al. (2023) modelled multiple threat abatement strategies (TAS) including (but not limited to) habitat restoration, invasive animal, weed control, disease management and hydrology management costs across Australia. The costs of restorative actions can be highly variable with a significant proportion being labour costs (average 49% across all TASs). Cost models developed by Yong et al. (2023) provide a starting point for restoration managers implementing any RAC to develop applicable budget inputs, assumptions and consider the availability of expertise and materials required.

The Platform for Land & Nature Repair online tool can be used by proponents to meet specific requirements of the new Nature Repair Market as outlined in approved methods (DCCEEW 2024b). The Full Carbon Accounting Model (FullCAM) incorporates several methods for developing Australian Carbon Credit Units, including environmental plantings (DCCEEW 2024c).

The WA Government's Carbon Farming and Land Restoration Program (CF-LRP) includes a costings calculator to guide market led RACs on common costs associated with site preparation, planting and tree protection (DPIRD 2024c). The Farming Landscapes for the Future Tool (FLFT) developed through a partnership between Wheatbelt NRM, CSIRO and AvonGro provides market led RACs with information on the economic values of various agricultural production systems (including agroforestry) within different climate scenarios (Carter 2013).

## 4.6 Stage 4 – Implementation

Implementing a restoration project requires more detailed assessments and mapping of project site information to inform monitoring of restoration progress, ground preparation, topsoil translocation (where relevant), seeding, planting and initial site maintenance. Key activities in the implementation stage include:

- completing a detailed assessment of the project site biophysical and land use attributes, the reference ecosystem and topsoil donor site (where relevant)
- mapping the restoration design to the site landform and soil types, delineating land use areas where relevant, such as conservation and cultural value, production value and restoration
- pre-treating and preparing ground for topsoil translocation or seeding and planting
- conducting initial site maintenance activities.

### 4.6.1 Detailed site assessment and mapping

Baseline information at the project and reference sites should be captured for all RACs. Information from the site selection process (see Section 4.3.2) and site assessment elements suggested for each RAC presented in Table 8 can be utilised and incorporated in the detailed assessment (Gann et al. 2019, Jonson 2010, Farming for the Future 2024). While complementary, the suggested elements are not intended for meeting compliance requirements for market or regulatory compliance RACs. Prescribed attributes and methodologies, for example the replanting native forest and woodland ecosystems method of the Nature Repair Market (DCCEEW 2024d), or regulatory conditions should be considered where relevant.

Investing in an appropriate level of assessment during optimal seasonal conditions is likely to reduce uncertainty in the restoration pathway and mitigate wasted resources due to knowledge gaps. Data collection on the absence of values provides evidence of ecosystem condition and may be equally as important as recording presence for all RACs.

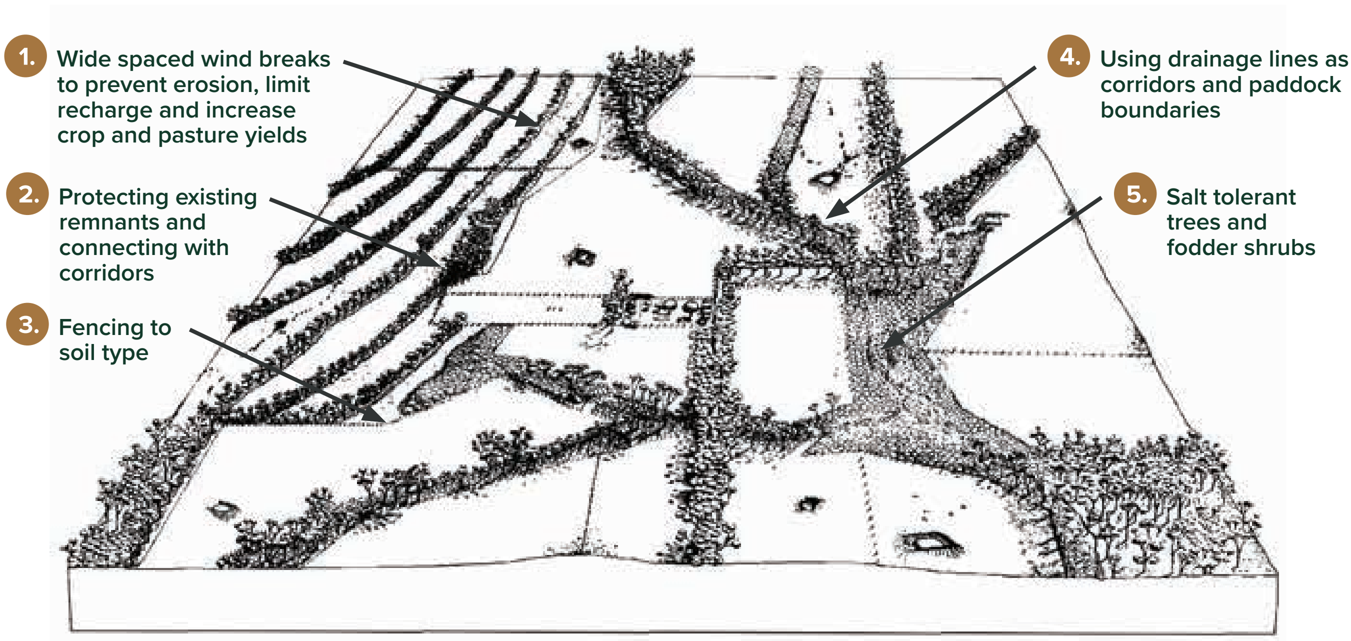
If the restoration goal is to conduct conservation restoration to enhance resilience of remnant native ecosystems (such as reducing edge effects of significant remnant vegetation and/or connecting refugial populations of significant flora or fauna), relevant key values should be captured as part of the initial baseline data collection to substantiate metrics against restoration goals and targets (Valderrábano et al. 2021).

SER Ecological Recovery Wheel templates (Appendix 6) may be introduced at this stage to evaluate baseline conditions against a 5-star system (Appendix 9). SER's Social Benefits Wheel (Appendix 6) may also be utilised as a key tool for capturing and understanding key social values and identifying potential limitations or objections early. For example, market and regulatory compliance led RACs should consider identifying and mapping areas of cultural significance (see Section 4.3.3 for engaging with cultural knowledge holders and Table 4).

Methods for capturing baseline information through field surveys, remote sensing, photos and assessment of existing spatial and non-spatial information should be considered in the restoration planning stage. TERN's ecological field monitoring protocols, methodologies and their associated resource requirements are suggested for capturing baseline values for key indicators as presented in Table 1 (EMSA 2024).

Mapping baseline biophysical information and important values together with planned restoration actions, land use and associated infrastructure provides a valuable tool for adaptive management. It provides a valuable tool for communicating the intended environmental, economic and social outcomes with stakeholders (Figure 16). Generating or linking a project with interactive restoration project platforms may provide greater visibility of the project and present opportunities for knowledge sharing, investment and other forms of support.

A.




B.

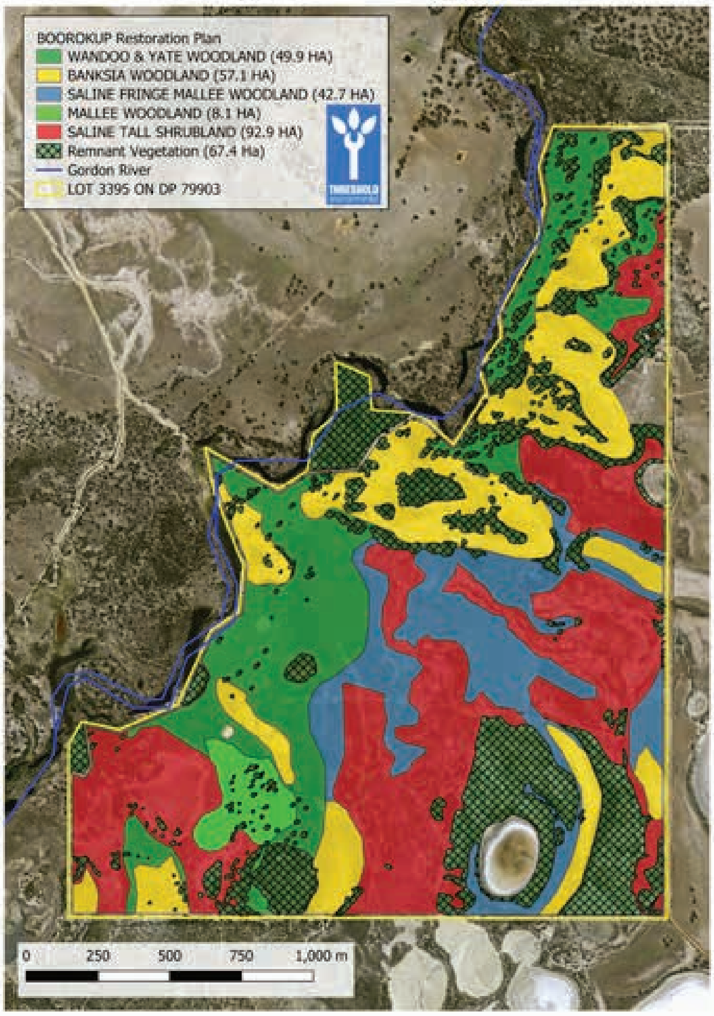



FIGURE 16: Examples of restoration maps a) Lefroy et al. 1993, b) Jonson 2024

**TABLE 8: Guidance for capturing site assessment information and the suggested application of each element for RACs**

| SER ecological attribute | Site assessment element | Suggested application by RAC | | |
|---|---|---|---|---|
| | | Values | Market | Regulatory compliance |
| Absence of threats | Identify disease/dieback areas<br>Identify contaminants or contaminant sources (chemical or biological) | X | X | X |
| Physical conditions | Map the extent of landform and soils characteristics into distinct units. EMSA (2024) soils module characterises the soil profile to >1m depth (A and B horizon) or to the depth of an impermeable layer, consistent with Jonson (2010). Stuart-Street et al. (2020) provides guidance and field templates for restoration managers to characterise soils at the local scale and publicly available interactive GIS maps (see Table 3) provide soil information at the landscape scale. Note that units encompassing large areas should consider multiple reference ecosystems and monitoring points as appropriate | X | X | X |
| Physical conditions | Identify and map hydrological features (Table 3) | | X | X |
| Species composition<br>Structural diversity<br>Absence of threats | Identify the characteristic flora species representing canopy and understorey as distinct vegetation types (see Appendix 12);<br>• canopy trees – composition, cover, health of native and weed species<br>• understory – composition, cover, health of native and weed species<br>• condition (identify and map disturbance where relevant e.g. grazing pressure, ringbarking from galahs, evidence of disease/dieback)<br>• presence of coarse woody debris | X | X* | X* |
| Species composition | Identify the characteristic fauna functional group members and habitats (e.g. nesting hollows, coarse woody debris) and threats (Table 6) | | | X |
| Ecosystem function | Describe the characteristic ecosystem function attributes (e.g. nutrient cycles, characteristic disturbance regimes, plant–animal interactions) (Table 6) | X | X | X |
| External exchanges | Describe the project sites connectivity (e.g. patch or landscape) to natural habitats such as other remnants, corridors or other restoration sites (Table 6) | X | X | X |

* All vegetation strata

## 4.6.2 Prepare site and resources

Common activities for preparing previously cleared sites in the Wheatbelt include soil preparation, land forming such as creating battered slopes, weed control and reducing or removing grazing pressure. Soils previously used in intensive agriculture often require multiple amelioration actions to promote stability and can depend on the soil types that are present. For example, ripping compacted soils on or near the contour and spading to mix soils may promote water infiltration and healthy root development, depending on the soil profile and chemistry. Soil amelioration research in the Wheatbelt shows deep ripping fine-textured soils and some duplex soils may be limited for root development and long-term water repellence. Mound ploughing may also be used to reduce the effects of waterlogging and salinity on seedlings. DPIRD and DBCA guidance is available for managing soil constraints such as water repellence, soil compaction and soil acidity and preparing site soil conditions for revegetation in the Wheatbelt region (DPIRD 2024d, Mullan and White 2002).

Scalping the top 5–10 cm of weed burden present in the topsoil seed bank, approximately 1 m from planting rows or an alternative method appropriate for soil types can be cost effective for large scale restoration projects (with access to machinery and equipment) and may eliminate the need for pre-planting weed treatment. Topsoil transferred to a project site may also enable short-term weed suppression in combination with other weed control methods (e.g. Brundrett et al. 2020). The use of machinery across restoration project sites should consider hygiene methods to control identified weeds and pathogens across the site. Technical expertise is recommended for determining appropriate topsoil collection, handling, and transfer methods, associated seasonal timing and logistics.

Ground disturbance methods such as deep ripping within Wheatbelt Woodland TEC remnants or areas with cultural heritage values may cause significant or irreversible damage to environmental and/ or cultural values. Seeking expert advice on appropriate site preparation methods within sensitive areas is likely to avoid risk of negative impacts to values, project cost or reputation.

Restoration goals and targets relating to the functional return of key faunal groups or species recovery may introduce habitat during implementation such as log piles or artificial hollows. Planning and ensuring adequate resourcing for ongoing maintenance requirements is recommended to promote species return during restoration (e.g. Saunders et al. 2023, Grigg et al. 2011). Technical expertise is recommended to determine appropriate methods and logistics for introducing fauna habitats and associated maintenance.

## 4.6.3 Threat abatement actions

Adaptive approaches with managing threats to seedling establishment associated with weed recruitment, grazing pressure and seasonal variabilities in temperature and rainfall may be required in the initial 1-2 years. Utilising selective herbicides with or without scalping may be necessary to manage competition and promote suitable soil moisture conditions for seedlings. Prioritising weed species for control based on their invasiveness and ability to out-compete native species is recommended for utilising available resources (Brundrett et al. 2020). Technical advice is recommended to determine the appropriate weed treatment method for site preparation and follow up management, particularly for areas previously dominated by weeds. Managing grazing pressure through pest control measures or native animal and stock restriction during the first 18 months to 5 years, depending on whether fodder shrubs are introduced in the restoration site is also recommended (Wheatbelt NRM n.d.).

Threat abatement actions associated with restoring remnant Wheatbelt Woodlands TEC should consider key threats specified in the approved conservation advice for the TEC and associated critical habitats for conservation significant flora and fauna (Department of the Environment 2015), such as:

- inappropriate application of chemicals, including inorganic fertilisers to create improved pastures; or pesticide/herbicide spray drift from agricultural lands adjacent to a patch
- soil acidification
- altered fire regimes
- potential impact of plant diseases such as *Phytophthora* sp. on species diversity and structure
- potential impacts of climate change, including altered fire and flooding regimes, decline in tree health due to prolonged drought and heat stress, and poor regeneration and recruitment.

### 4.6.4 Seeding and planting

Technical advice on adopting a planting method appropriate to the soil types and scale of restoration will optimise the seeding or planting effort. Planting windows are likely to become narrower with warming and drying climate conditions creating challenges for planting to ensure valuable seed and other resources are utilised effectively. Deferring planting and seeding activities may be appropriate if conditions are unlikely to support establishment, including viable additional intervention such as artificial watering.

Technical advice for planning an adequate window for collecting, stockpiling, and spreading topsoil reserves to the restoration site may reduce seed viability loss, germination during the topsoil transfer process and sub-optimal sowing timing prior to summer (Stevens et al. 2016). To achieve the intended composition and structure, including those required by target species, infill planting may be required in subsequent seasons or after disturbance events such as fire or drought.

### 4.6.5 Site maintenance

Initial site maintenance activities focus on maintaining access to the site and promoting suitable ecological conditions for seedling establishment. Ongoing adaptive management measures to support recovery toward intended goals and targets are discussed further in Section 4.7.2. Common initial site maintenance actions benefitting restoration projects may include:

- access and fencing maintenance as required
- initial weed control
- inspecting and maintaining fauna habitats (Stevens et al. 2016, DCCEEW 2024d).

## 4.7 Stage 5 – Monitor

Dynamics such as ecosystem responses to climate induced drying add to uncertainties for restoration projects along the recovery trajectory (FAO, IUCN CEM & SER, 2021). Monitoring provides important evidence points for timely response to, and prioritising, resource allocation when adopting, expanding, changing or discontinuing adaptive management actions and methods. It is an important instrument for building and maintaining stakeholder and community trust and for demonstrating the project's ongoing value proposition. Information collected during monitoring can contribute to state and national databases informing research and policy priorities for the region (Prach et al. 2019, Gann et al. 2019).

The first step is to determine the activities or management required to manage a project site, and what attributes and indicators should be measured to inform the recovery trajectory. Methods for monitoring should be chosen after determining the milestones or trigger points for management action. The timing and frequency of recording indicators should also be considered.

Suggested monitoring methods will differ depending on the scope and targets of a particular project. Consider the following for measures of restoration progress and success through chosen attributes and indicators.

1. **Measures of ecosystem condition improvement (objectives/milestones)**
   - Ecological indicators demonstrate ecosystem integrity is increasing.
   - Ecological indicators demonstrate ecological resilience is increasing.
2. **Measures of success (goals/completion criteria)**
   - Goals or completion criteria have been achieved.
   - The goal state is relevant and proportional to the reference ecosystem.

A monitoring and adaptive management plan should be developed for each project. Co-designing and implementing a plan through partnerships and engagement with stakeholders on the 'ecological values and natural capital (including ecosystem services)' should be undertaken to ensure regulatory and social expectations are understood and agreed upon for the project's expected outcomes (Gann et al. 2019). The development of a monitoring plan could be guided by the questions posed in the polarity tool (Appendix 6), and then monitoring questions refined to ensure the monitoring plan adequately captures the target values within the restoration project.

A monitoring plan involves an assessment of progress toward ecological targets from a baseline and informed by information collected from a reference ecosystem. Tucker et al. (2023) recommends that a monitoring plan includes:

(i) **control** – part of the degraded site where no restorative actions are applied

(ii) **treatment** – where restorative actions are applied

(iii) **target** – typically a remnant of the reference ecosystem.

Establishing monitoring sites across these elements determines the 'effectiveness' of restorative actions 'relative to natural regeneration' by comparing (i) and (ii) above. It also determines the progress toward restoration goals and informs trigger points for management actions (Tucker et al. 2023).

Monitoring methods may range in complexity from assessing a single indicator to multiple indicators on the Ecological Recovery Wheel. Examples of indicators against milestones and completion criteria are presented in Appendix 13. Table 1 provides suggested minimum indicator types and the criticality of each ecological recovery sub-attributes for each RAC. Depending on the level of technical rigour, technical expertise to develop appropriate baseline and monitoring indicators, methods and data trigger points for management action may need to be outsourced to appropriately qualified personnel. A directory of service providers such as environmental consultants, restoration practitioners and soil analysis is maintained by DPIRD (2024b), providing a starting point for restoration managers in the Wheatbelt.

While the primary purpose of a monitoring plan is to measure restoration progress and inform trigger points for management actions, it should also consider information management and sharing 'lessons learned' early with partners and stakeholders (Valderrábano et al. 2021). Undertaking a review of elements that are working well and those which require improvement (and why) provides project managers with critical information to support the ecological, social and economic sustainability of the project by triggering management actions that will keep the project on the trajectory towards its stated goals. For example, Moore et al. (2023) reported declining condition of a vegetation type that was not well suited to a rockier substrate, providing a catalyst to create a biodiverse seed mix with root systems suited to thinner and rocky soil conditions, improving outcomes over the longer term.

Monitoring information can be collected and made accessible to national biodiversity databases such as the Atlas of Living Australia by using BioCollect (2024) and the Biodiversity Data Repository (BDR) using TERN's ecological monitoring resources. Aggregating ecosystem restoration and specifically WWTEC restoration, rare and threatened species recovery and other biodiversity values enables access to contemporary biological information. This in turn can inform research priorities relating to ecological restoration and regional policy frameworks supporting resilient ecosystems, communities and economies in the region.

## 4.7.1 Monitoring and evaluation framework

Monitoring methods will be determined by the selected indicators of ecosystem condition and trajectory toward intended goals. Methods should be tailored to the specific site and ecological conditions and consider the rate and magnitude of change that's expected over time. Examples of suggested indicators for ecological attributes are shown in Appendix 10. All RACs will benefit from utilising the Ecological and Social Recovery Wheels with selected indicators and associated data points (see Appendix 6). Adoption of Recovery Wheels for monitoring across RACs enables a consistent approach to evaluating ecosystem condition improvement. While capturing information is yet to be standardised for Wheatbelt RACs, there is significant potential and value in achieving consistent and standardised information.

Common indicators across RACs may use variable methods and data points depending on the level of intensity and frequency prescribed in the monitoring plan. Generally, the degree of technical rigour is greater for regulatory compliance projects and similar for values and market RACs as evidenced by suggested indicators shown in Table 1. Restoration managers may select from a standard list of suggested indicator types, dependent on the relevance to their specific site parameters.

The timing of data capture is recommended when the attribute or indicator is likely to be apparent. For example, this may be when seasonal conditions are optimal to accurately record key indicator or target species, including non-native species. Monitoring should be undertaken at similar times and intervals that inform progress toward restoration goals and milestones.

The 5-star system is a best-practice approach to identify the intended level of recovery and evaluate a project's recovery relative to a reference (see Gann et al 2019, Gann et al. 2024) (Figure 3). Measuring datapoints with the 5-star system requires a range for each score corresponding with the Recovery Wheel. Some guidance of targets and ranges in accordance with the 5-star system are provided within Gann et al. 2019, 2024 and Bartholomew and Mosyaftiani et al. 2024 and will need tailoring to a specific site and ecological conditions. Example ranges for scoring data points of the presence and abundance of weeds (absence of threats) are presented in Table 9. Appendix 10 presents examples of ecological recovery indicators, their purpose and associated example data points.

**TABLE 9: Example of data point ranges for scoring weed abundance in a monitoring plot**

| Recovery Wheel score | 5-star attribute rating | Example data point ranges – abundance of weeds observed in a monitoring plot (% cover) |
|---|---|---|
| 0 | 0 – High numbers and degrees of direct degradation drivers present (e.g. overharvesting, erosion, active contamination). Conservation status may not be secured | 80–100 |
| 1 | ★ – Some direct degradation drivers absent and conservation status secured, but others remain high in number and degree | 60–80 |
| 2 | ★★ – Direct degradation drivers (including sources of invasive species, absence of appropriate natural disturbance regimes) intermediate in number and degree | 40–60 |
| 3 | ★★★ – Number of direct degradation drivers low but some may remain intermediate in degree | 20–40 |
| 4 | ★★★★ – Direct degradation drivers, both external and on-site, low in number and degree | 10–20 |
| 5 | ★★★★★ – Known threats from direct degradation drivers minimal or effectively absent | 0–10 |

Approaches to in-field monitoring assessments may involve establishing one, or a number of monitoring points across a project site for adequate representation. Quantifiable data and associated collection methods are preferred for statistical robustness and increased certainty of conclusions drawn. Larger restoration projects should consider establishing multiple monitoring sites in representative landforms and soil types to obtain a more adequate level of assessment.

Qualitative data collection methods (e.g. photo monitoring points) may assist where other less intrinsic outcomes would be beneficial (e.g. to aid in community engagement), however they cannot be relied upon to provide measurable records of change. All RACs require careful consideration of data collection methods and their appropriateness for informing management to meet ecosystem restoration, or market, or regulatory compliance goals.

Remote sensing data may be collected across a range of scales, such as through satellite imagery and unmanned aerial vehicles (UAVs) and may provide a cost-effective, ecologically feasible approach to conducting initial assessments and monitoring progress over larger spatial and temporal scales than field assessments, as well as capturing some attributes of natural variability within reference conditions. Remotely sensed monitoring can provide powerful observational information, particularly when used in combination with field observations to record systematic comparison of the capacity of different ecosystems to respond to stress such as climate induced drying (Cavender-Bares et al. 2022). Any monitoring method selected should be able to detect the change in the chosen indicator to trigger management action for the project to remain on the desired trajectory.

McKenna et al. 2023 highlights 'strong potential for remote sensing assessments' for '11 out of 18 sub-attributes' of the Ecological Recovery Wheel. Limitations with remote sensing can include detection of new species to western science and understanding of gene flows. Technical expertise should be sought for operation requirements, data capture and interpretation methods, spatial, temporal or sensor resolution limitations to assess restoration targets for a project site, such as evidence of target species.

### 4.7.2 Adaptive management

It is essential for restoration managers to develop adaptive management strategies and actions to manage complexity and address key challenges to enduring restoration (Frietsch et al. 2023). Adaptive management provides the ability to solve complex ecological, social and economic issues in a way that integrates diverse values, priorities and knowledge.

Adaptive management is the continuous improvement of restorative actions following new knowledge. As acknowledged above, the restoration process does not often follow a linear trajectory toward recovery, and adaptive management approaches are often required for less certain, dynamic or complex situations. Access to new knowledge through consultation and partnering with Indigenous and local knowledge holders may have an important influence over adaptive management decisions. Monitoring and associated research also provides important feedback to this process. For example, research is required to test whether undesirable understory herb species may be outcompeted over time as restoration of eucalypt woodlands with endemic trees, shrubs and understory grasses and herbs mature and produce seed following weed control during establishment years (Parkhurst et al. 2021).

The likelihood of an adaptive management action achieving a positive response may need to be taken into consideration with other actions such as fencing, weed control and seeding, together with variables such as rainfall, land use history and nutrient enrichment (Rumpff et al. 2011). Monitoring information from the reference ecosystem can help restoration managers to identify whether ecosystem condition scores may be attributed to natural variability as seen in the reference or attributed to adaptive management (Section 4.7.1.).

A plan for adaptive management should include criteria for identifying when a response is needed due to monitoring showing that recovery is off-track. Consideration of which indicators of improvement or decline of ecological attributes should be identified for the site and monitoring intervals planned for when changes to these indicators are likely to be apparent. Monitoring enables proactive response and early stakeholder engagement to validate the assessment and agree on when any pre-determined management actions should be applied. Maintaining a project toward the intended future goal state requires collaborative adaptive management approaches agreed with key stakeholders such as regulatory agencies, scientific and local communities.

### 4.7.3 Completion and handover

Land use legacies associated with restoration activities will continue to reflect the complex social, environmental, and economic dynamics in the Wheatbelt in the future. Complementary land use within intensive agricultural landscapes that enhances natural capital and biodiversity values may require a multi-generational vision that considers future land use. The polarity tool (Appendix 7) can assist restoration managers when considering future values associated with maturing ecosystem recovery. Examples of completion criteria presented in Appendix 13 can inform the development of specific criteria to evaluate the success of a project against targets and goals. While these examples target regulatory compliance projects, values and market RACs are likely to benefit from this framework with stakeholder engagements or demonstrating a project value proposition at handover.

Achieving ecological recovery of eucalypt woodlands and associated ecosystems in the Wheatbelt may exceed the project's timeframe. Successional changes to Wheatbelt ecosystem states and transitions (Good et al. 2024, Standish et al. 2009) may also involve non-sequential replacement of species as vegetation matures. Monitoring can provide the necessary evidence points and measuring success of the restoration project should be able to be determined against the project goals by approximately year 7, the example timeframe presented in the WRS framework (e.g. whether there is minimal or substantial evidence of partial or full recovery). Clear links should be provided between monitoring and the required changes to management, to maintain the restoration trajectory.

Options for maintaining the security and integrity of a restoration project should ideally be assessed during the development of the restoration plan to manage risk of regression to a more degraded state (Section 4.4.1, Gann et al. 2019). Mitigating risk of this regression may involve the 'permanence period' for carbon sequestration-based market RACs or conservation covenants incentivised through the *Nature Repair Act 2023* through tradeable biodiversity certificates (Richardson et al. 2024). Climate adapted restoration is also fundamental to maintaining the integrity of restoration. If the desired outcome is transferred to the conservation estate (e.g. as a part of advanced offsets), demonstration of the environmental value and integrity of the system would be required between landowner/proponent and regulatory agencies.

Restoration managers should consider the longer-term social and ecological impacts after a restoration project has been implemented, such as any rights and benefits that may continue, and accountabilities for maintaining the site and addressing concerns.

## 4.8 Next steps

### 4.8.1 Knowledge and research gaps

The restoration process contains ubiquitous uncertainty involving complex ecological interactions and exposure to a diverse range of threats including climate-induced drying. Stakeholder contribution to the development of the WRS provided valuable information on knowledge gaps to optimise restoration outcomes across the Wheatbelt. Suggested research priorities are presented in Table 10. In addition, the approved conservation advice for the WWTEC provides a list of research priorities relating to improving monitoring and management outcomes (DoE 2015).

## 4.9 Final note

The urgency to reversing ecosystem degradation to combat climate change and prevent mass extinctions globally is increasing. Developing restoration standards and complementary tools enables a consistent approach to transitioning degraded ecosystems to be functioning, socially accepted and economically productive for the region. Because of this, the WRS recognises all restoration efforts are intrinsically linked to long-term social-ecological outcomes for the region.

The vision for the Wheatbelt Restoration Standard is to recognise the combined contribution of historic and current land use legacies and the interconnectedness of people and nature. The Standard provide guidance for all restoration activities to improve the consistency and quality of outcomes relevant to the social, ecological and economic dynamics in the region. Adopting the framework and principles can enable the accumulation of experience, knowledge and a shared understanding of restoring resilient ecosystems to achieve exemplary landscape-scale restoration outcomes for the Wheatbelt region.

**TABLE 10: Suggested research priorities to optimise restoration outcomes for the Wheatbelt**

| Theme | Objective | Rationale |
|---|---|---|
| Ecosystem processes and threats | Assess the adaptive capacity and vulnerability of WWTEC subcommunities to climate change | The ability for endemic eucalypt woodlands in the Wheatbelt to adapt to climate change requires effective management solutions. Restoring connectivity at a landscape scale for flora and fauna refugia supports range shifts, migration and adaptive processes of metapopulations in response to climate change. |
| Restoration ecology | * Investigate restoration interventions for residual phosphorous concentrations in agricultural landscapes | Residual phosphorous (P) concentrations in the Wheatbelt presents a significant barrier to ecosystem restoration, inhibiting native plant establishment and persistence (Parkhurst et al. 2022). New restoration practices aimed at reducing P concentrations are needed to overcome this common barrier. |
| | Develop a robust understanding of the recovery trajectory timeframe for restoration projects in the Wheatbelt | The WRS assumes an assessment on ecosystem recovery is likely to be informative around seven years post commencement for ecosystems in the Wheatbelt. Further research is required to develop a robust understanding of timeframes and variables. |
| | * Develop an understanding of natural regeneration potential of degraded soils/seed bank in the Wheatbelt | The current condition of topsoil reserves in the Wheatbelt is not well understood. Research on the viability and biodiversity contribution to restoration in the Wheatbelt can inform management solutions to protect and enhance these assets. |
| | Develop a robust understanding of the keystone species for monitoring ecosystem recovery in the Wheatbelt | For each IBRA subregion in the Wheatbelt, develop a list of keystone species that may be important indicators of ecosystem function. |
| | * Effectiveness of interacting restorative interventions in eucalypt woodlands | Franklin et al. 2025 conducted a meta-analysis on the effectiveness of restorative actions on degraded eucalypt woodlands. This analysis highlighted the need for understanding the interactive effects of restorative actions and adaptive management approaches to improve restoration outcomes for eucalypt woodlands. |
| | Effectiveness and barriers to establishing soil microbiota communities | Soil degrading processes are a common barrier resulting from legacy land use in agricultural landscapes. Research is needed to understand the effectiveness of restorative actions associated with introducing soil microbiota communities to improve soil conditions for native plant establishment (Peddle et al. 2024). |
| Information management systems | Restoration Manager user interface | A user interface linked to an appropriate biodiversity database such as the Australian Government Biodiversity Data Repository will enable monitoring data to be consolidated to an appropriate biodiversity database, producing a valuable asset for planning and research. |
| | * Mapping the extent of WWTEC occurrence | Updated spatial dataset of WWTEC occurrences in the Wheatbelt, including identification of high-priority remnants. |

* Priorities informed by the approved conservation advice for the WWTEC (DoE 2015)

# 5.

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# Appendix 1

## Best practice guidance and principles informing the WRS framework

### Society for Ecological Restoration (SER) International Principles and Standards for the Practice of Ecological Restoration

The SER framework was informed by the Society for Ecological Restoration Australasia (SERA) (McDonald et al. 2016). The SER framework includes both an ecological Recovery Wheel, informed by the SER primer (SER 2004), as well as a new Social Benefits Wheel to track against goals (Gann et al. 2019). The Social Benefits Wheel highlights the importance of stakeholder engagement particularly to restoration projects which are complex in terms of land use or level of degradation. The eight guiding principles outlined in the SER standards provide a framework to 'explain, define, guide and measure the outcomes of restoration practice', informed by international research and practice (Gann et al. 2019).

### Standards of Practice (SoP) to Guide Ecosystem Restoration and Principles for Ecosystem Restoration to Guide the UN Decade 2021-2030

The SoP's were developed from the recommendations of the Science Taskforce for the UN Decade aimed at scaling up global restoration efforts by addressing socio-ecological issues and leveraging knowledge from current practices. The SoPs include a list of ten guiding principles (partially overlapping SER) (Nelson et al. 2024, FAO IUCN CEM & SER 2021) and are adopted in this framework.

### The Global Biodiversity Standard (TGBS): Manual for assessment and best practices

This standard and associated methods for TGBS certification are aimed at improving biodiversity outcomes for restoration projects. The standard supports multiple global targets set by the Convention on Biological Diversity's Global Biodiversity Framework (GBF), including Target 1 calling for participatory effective management of biodiversity and ecological integrity, and Targets 2 and 11 calling for restoration to repair damage already caused (Bartholomew and Mosyaftiani et al. 2024).

## World Resources Institute (WRI) handbook

The WRI handbook provides a step-by-step guide for landscape restoration planners and practitioners and provides systematic approaches to the key stages and sub-steps/ subcomponents of restoration practice (Kakani et al. 2024).

## UN System of Environmental Economic Accounting – Ecosystem Accounting (SEEA-EA)

The SEEA-EA is a globally recognised framework connecting nature and the economy through accounting principles as a way of measuring ecosystem change. The framework captures spatial and temporal changes across four key areas: extent and type, ecosystem condition, services, and benefits (UNCEEA 2021, Farrell et al. 2022).

## Gondwana Link Restoration Standards

Gondwana Link is a multi-partnership program operating since 2002 and achieving land-scape scale restoration outcomes in the south-west of Western Australia. Gondwana Link has produced an initial Guide for restoration which utilises contemporary methods adopted in their restoration projects and applying relevant principles and methods of the Society for Ecological Restoration Australasia (SERA) guidelines (Bradby and Cross 2023).

# Appendix 2

## Glossary of key restoration terms, concepts and acronyms

### Definitions

Definitions and terms in this WRS are adopted from the SER Standard Glossary of Terms (Gann 2019) with supplementary information derived from SERA (2021).

**Adaptive management:** An ongoing process for improving management policies and practices by applying knowledge learned through the assessment of previously employed policies and practices to future projects and programs. It is the practice of revisiting management decisions and revising them in light of new information.

**Desirable species:** Species from the reference ecosystem (or sometimes non-native nurse plants) that will enable the native ecosystem to recover.

**Disturbance:** Any process that effects ecosystem, community, or population structure, and/or individuals within a population either directly or indirectly via changes to the biophysicalconditions.

**Ecological restoration:** The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. (Ecosystem restoration is sometimes used interchangeably with ecological restoration, but ecological restoration always addresses biodiversity conservation and ecological integrity, whereas some approaches to ecosystem restoration may focus solely on the delivery of ecosystem services.)

**Ecological restoration program:** A larger composite of many restoration projects.

**Ecological restoration project:** Any organised effort undertaken to achieve substantial recovery of a native ecosystem, from the planning stage through implementation and monitoring. A project may require multiple agreements or funding cycles. A project may also be one of many projects in a long-term restoration program.

**Ecosystem:** Assemblage of biotic and abiotic components in water bodies or on land in which the components interact to form complex food webs, nutrient cycles, and energy flows. The term ecosystem is used in the Standards to describe an ecological assemblage of any size or scale.

**Ecosystem integrity:** The ability of an ecosystem to support and sustain characteristic ecological functioning and biodiversity (i.e. species composition and community structure). Ecological integrity can be measured as the extent that a community of native organisms is maintained. Also referred in the WRS as 'ecological integrity'.

**Ecosystem resilience:** The degree, manner and pace of recovery of ecosystem properties after natural or human disturbance. In plant and animal communities this property is highly dependent on adaptations by individual species to disturbances or stresses experienced during the species' evolution. Also referred in the WRS as 'ecological resilience'.

**Ecosystem services:** The direct and indirect contributions of ecosystems to human wellbeing. They include production of clean soil, water, and air; moderation of climate and disease; nutrient cycling and pollination; provisioning of a range of goods useful to humans; and potential for the satisfaction of aesthetic, recreation, and other human values. These are commonly referred to as supporting, regulation, provisioning, and cultural services.

**Goals:** Formal statements of the medium to long-term desired ecological or social condition, including the level of recovery sought. Goals must be clearly linked to targets.

**Indicators (of recovery):** Characteristics of an ecosystem that can be used for measuring the progress toward ecological and social restoration goals or objectives at a particular site (e.g. qualitative scores of presence/absence and quantitative measures of biotic or abiotic components of the ecosystem).

**Local Ecological Knowledge (LEK):** Knowledge, practices, and beliefs regarding ecological relationships that are gained through extensive personal observation of and interaction with local ecosystems and shared among local resource users.

**Natural capital:** Stocks of natural resources that are renewable (ecosystems, organisms), non-renewable (petroleum, coal, minerals, etc.), replenishable (the atmosphere, potable water, fertile soils), and cultivated (landraces, heritage crops, and the know-how attached to them), and from which flow ecosystem services.

**Natural regeneration:** Recovery or recruitment of species from in-situ propagules or propagules that have colonised a site without human intervention. Natural regeneration from these propagules can occur spontaneously or after facilitation other than direct human reintroduction of propagules.

**Nature-based solutions:** Actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human wellbeing and biodiversity benefits.

**Objectives:** Formal statements of the interim outcomes along the trajectory of recovery. Objectives must be clearly linked to targets and goals.

**Restoration manager:** An individual or organisation responsible for applying resources, skills and knowledge to plan, implement and monitor ecological restoration activities at a project site.

**Project site:** Discrete area or location. Can occur at different scales but is generally at the patch or property scale (i.e. smaller than a landscape).

**Reconstruction:** A restoration approach where the appropriate biota need to be entirely or almost entirely reintroduced as they cannot regenerate or recolonise within feasible timeframes, even after expert facilitated regeneration interventions. Site earthworks may or may not be needed. An example of reconstruction is the mass revegetation of trees, shrubs and groundcovers on previously cropped agricultural lands (including mature successional phase species) or the complete rebuilding of a coral reef (including mature successional phase species).

**Reference ecosystem:** A representation of a native ecosystem that is the target of ecological restoration (as distinct from a reference site). A reference ecosystem usually represents a nondegraded version of the ecosystem complete with its flora, fauna, and other biota, abiotic elements, functions, processes, and successional states that might have existed on the restoration site had degradation not occurred and adjusted to accommodate changed or predicted environmental conditions.

**Reference model:** A model that indicates the expected condition that the restoration site would have been in had it not been degraded (with respect to flora, fauna and other biota, abiotic elements, functions, processes, and successional states). This condition is not the historic condition, but rather reflects background and predicted changes in environmental conditions.

**Rehabilitation:** Management actions that aim to reinstate a level of ecosystem functioning on degraded sites, where the goal is renewed and ongoing provision of ecosystem services rather than the biodiversity and integrity of a designated native reference ecosystem.

**Recovery:** The process by which an ecosystem regains its composition, structure and function relative to the levels identified for the reference ecosystem. In restoration, recovery usually is assisted by restoration activities — and recovery can be described as partial or full.

**Restoration activities:** Any action, intervention, or treatment intended to promote the recovery of an ecosystem or component of an ecosystem, such as soil and substrate amendments, control of invasive species, habitat conditioning, species reintroductions and population reinforcements.

**Restorative continuum:** A spectrum of activities that directly or indirectly support or attain at least some recovery of ecosystem attributes that have been lost or impaired.

**Restoration ecology:** The science that provides concepts, models, methodologies and tools for the practice of ecological restoration. It also benefits from direct observation of and participation in restoration practice.

**Scope:** The broad geographic or thematic focus of a project.

**Self-organising:** A state whereby all the necessary elements are present, and the ecosystem's attributes can continue to develop toward the appropriate reference state without outside assistance. Self-organisation is evidenced by patterns and processes such as growth, reproduction, ratios between producers, herbivores, and predators and niche differentiation, relative to characteristics of the reference ecosystem. It does not readily apply to the restoration of traditional cultural ecosystems.

**Stratum, strata:** Vegetation layer or layers in an ecosystem; often referring to vertical layering such as trees, shrubs and herbaceous layers.

**Substrate:** The soil, sand, rock, shell, debris or other medium where organisms grow and ecosystems develop.

**Targets:** Identify the native ecosystems to be restored at a site as informed by the reference model, along with any social outcomes or constraints expected of the project.

**Threshold (ecological):** A point at which a small change in environmental or biophysical conditions causes a shift in an ecosystem to a different ecological state. Once one or more ecological thresholds have been crossed, an ecosystem may not easily return to its previous state or trajectory without major human interventions, or at all if the threshold is irreversible.

**Traditional Ecological Knowledge (TEK):** Knowledge and practices learned from experience and observation, and passed from generation to generation informed by strong cultural memories, sensitivity to change, and values that include reciprocity.

**Vision:** A general summary of the desired condition attempted to achieve through the work of the restoration project. A good vision is relatively general, inspiring and brief.

# Appendix 3

## RAC fact sheets

Factsheet 1. Wheatbelt Restoration Standards

**Values-led ecosystem restoration**

A practical approach to guide consistent, scalable and science-based restoration in the Western Australian Wheatbelt.

Download the Standard and tools

**Values-led restoration is based on personal or community values, such as conservation and cultural significance.**

It offers a valuable opportunity to repair environmental damage, restore biodiversity and integrate nature-positive practices into degraded systems. These initiatives are often led by landholders or communities committed to achieving long-term environmental outcomes. Projects may be self-funded or supported through philanthropic and impact investment. Values-led restoration may focus on lower-productivity areas of farmland, land with high environmental and/or cultural heritage significance, and areas that enhance ecological connectivity or climate adaptation.

The Wheatbelt Restoration Standard guides native and modified (novel) ecosystem restoration in predominately agricultural landscapes using a restorative continuum and a 5-star recovery system. It accounts for local environmental, social and economic conditions, with a focus on restoring the Eucalypt Woodlands of the Western Australian Wheatbelt Threatened Ecological Community (WWTEC).

1

The Western Australian Biodiversity Science Institute

Factsheet 2. Wheatbelt Restoration Standards

**Market-led ecosystem restoration**

A practical approach to guide consistent, scalable and science-based restoration in the Western Australian Wheatbelt.

Download the Standard and tools

**Market-led restoration is based on the integration of climate and nature-related sustainable development goals.**

It offers a valuable opportunity to unlock restoration-related investment through partnerships to deliver a range of environmental, social and economic co-benefits for the Wheatbelt. Government policy frameworks are incentivising nature-based solutions through carbon and/or biodiversity schemes. The Wheatbelt Restoration Standard compliments this via consistent, repeatable and scalable approaches to repair environmental damage and recover biodiversity values. The scope for economic return present opportunities to deliver landscape-scale ecological benefits, with comparatively less emphasis on targeting discrete values or areas in the landscape.

The Standard guides native and modified (novel) ecosystem restoration in predominately agricultural landscapes using a restorative continuum and a 5-star recovery system. It accounts for local environmental, social and economic conditions, with a focus on restoring the Eucalypt Woodlands of the Western Australian Wheatbelt Threatened Ecological Community (WWTEC).

1

The Western Australian Biodiversity Science Institute

Factsheet 3. Wheatbelt Restoration Standards

**Regulatory compliance-led ecosystem restoration**

A practical approach to guide consistent, scalable and science-based restoration in the Western Australian Wheatbelt.

Download the Standard and tools

**Regulatory compliance-led restoration plays a critical role in restoring endangered ecological communities and their associated values.**

Environmental offsets are an important mechanism to restoring critically endangered ecological communities in the Wheatbelt region of Western Australia. Achieving the highest level of recovery possible involves a significant degree of technical rigour to manage complex ecological challenges successfully. A strategic opportunity exists for implementing offsets at scale, improving the integrity and resilience of Eucalypt woodlands and associated endemic ecological communities[1].

The Wheatbelt Restoration Standard supports regulatory processes and enables consistent, repeatable and scalable approaches, using a restorative continuum and 5-star recovery system. It accounts for local environmental, social and economic conditions, with a focus on restoring the Eucalypt Woodlands of the Western Australian Wheatbelt Threatened Ecological Community (WWTEC). To demonstrate that environmental offsets may meet intended environmental outcomes, guidance is provided on ecological assessments, completion criteria, monitoring and evaluation frameworks and adaptive management.

[1] Regulatory compliance-led ecosystem restoration would also apply when ecological restoration is required following disturbance that has been approved via the Environmental Impact Assessment (EIA) pathway.

1

The Western Australian Biodiversity Science Institute

**Download Factsheets**

# Appendix 4

## Australian Land Use Management (ALUM) primary classes and examples of secondary land use classes

| Primary class* | Definition | Secondary (tertiary) classes |
|---|---|---|
| **Class 1:** Conservation and Natural Environments | Land is used primarily for conservation purposes, based on the maintenance of essentially natural ecosystems already present | Nature Conservation (e.g. habitat/species management area; protected landscape; other conserved area) |
| | | Managed Resource Protection (e.g. biodiversity; surface water supply, groundwater; landscape; traditional indigenous uses) |
| | | Other Minimal Use (e.g. residual native cover; rehabilitation) |
| **Class 2:** Production from relatively natural environments | Land is used mainly for primary production based on limited change to the native vegetation | Grazing Native Vegetation |
| | | Production Native Forests (e.g. wood production forestry, other forest production) |
| **Class 3:** Production from dryland agriculture and plantations | Land is used mainly for primary production, based on dryland farming systems | Plantation Forests (e.g. hardwood/ softwood plantation, environmental forest plantation) |
| | | Grazing Modified Pastures (e.g. native pasture, woody fodder plants) |
| | | Land In Transition (e.g. degraded land, land under rehabilitation, abandoned land) |
| **Class 4:** Production from irrigated agriculture and plantations | Land use where water is applied to promote additional growth over seasonally dry periods | Irrigated Plantation Forests (e.g. irrigated environmental forest plantation) |
| | | Irrigated Land in Transition (e.g. Irrigated land under rehabilitation) |
| **Class 5:** Intensive uses | Land uses that involve high levels of interference with natural processes | Intensive horticulture |
| **Class 6:** Water | Bodies of water | Lake (e.g. conservation; saline) |
| | | River (e.g. conservation) |
| | | Marsh/wetland (e.g. conservation; saline) |

*For the full ALUM Classification see ABARES 2016

# Appendix 5

## Comparison of important indicator types between the global biodiversity standard (TGBS), the 'replanting native forests and woodland ecosystems' method under the Nature Repair Market, and as suggested by the WRS

| SER Ecological Benefits Recovery Wheel | | | | | |
|---|---|---|---|---|---|
| **Ecological attribute** | **Sub-attribute** | **TGBS** | **Nature Repair Method** | **WRS** | **WRS** |
| Absence of threats | Contamination | If feasible | | | **Overutilisation**<br>**Nature repair method** – while not a prescribed indicator for ecosystem condition, the monitoring assessment requires overutilisation threats to be recorded.<br>**WRS** – while overutilisation is important, the WRS assumes stock and over-utilising drivers have been removed and as such prioritises invasive species and degradation (e.g. soil erosion) as important for the Wheatbelt. Appendix 13 presents example milestone and completion criteria for projects incorporating indicators for this attribute. |
| | Invasive species | Critical | | | |
| | Overutilisation | Critical | | | |
| | Other degradation drivers | Preferable | | | |
| Physical conditions | Water chemo-physical conditions | If feasible | | | **Water chemo-physical and substrate chemical conditions**<br>**WRS** – both indicators are important measures of degrading processes and restoration barriers in the Wheatbelt e.g. salinity, nutrient concentrations (particularly phosphorous and nitrogen), soil compaction and water logging. |
| | Substrate chemical conditions | Preferable | | | |
| | Substrate physical conditions | Critical | | | |

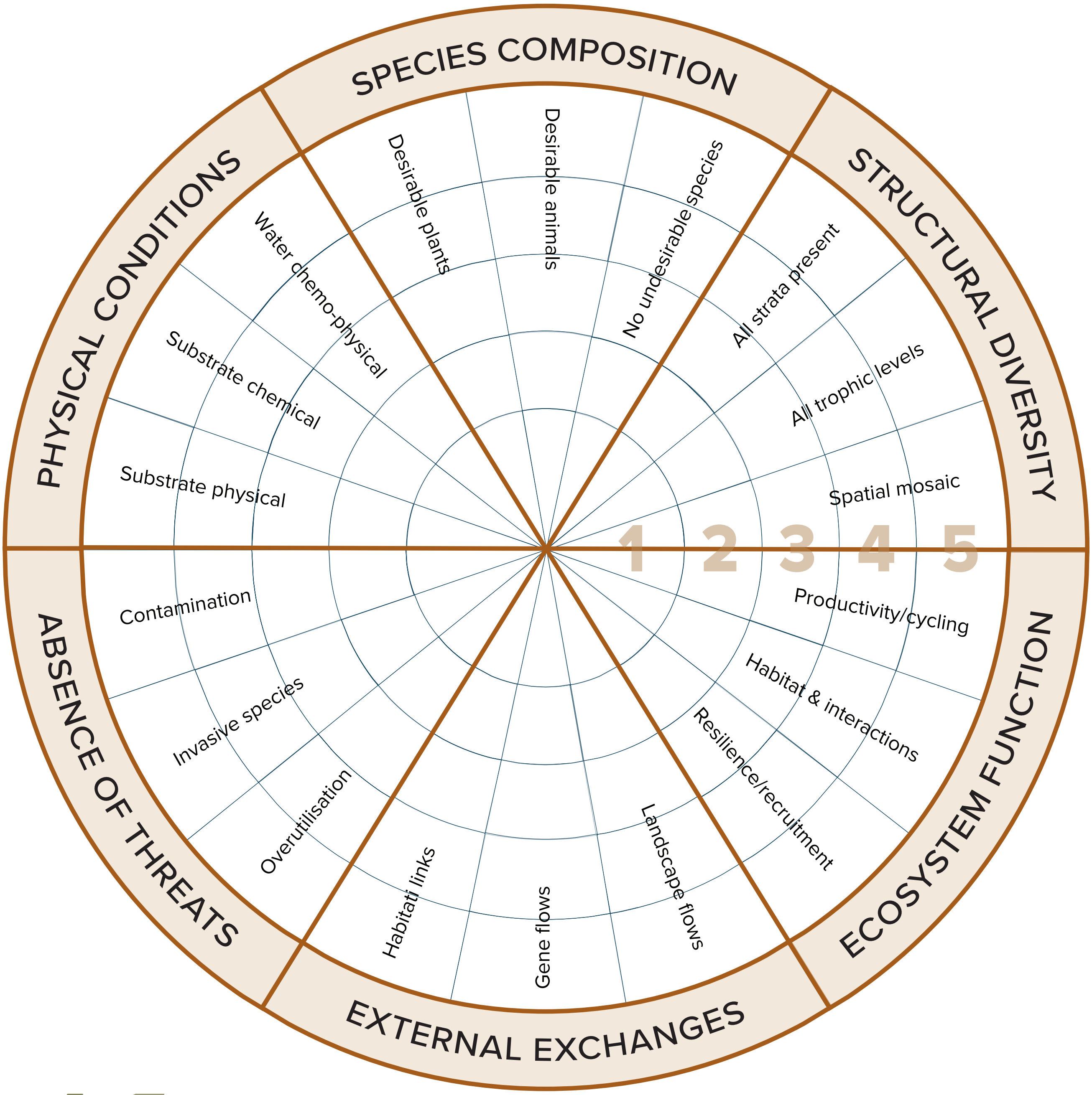
*(Continued following page)*

| SER Ecological Benefits Recovery Wheel | | | | | |
|---|---|---|---|---|---|
| **Ecological attribute** | **Sub-attribute** | **TGBS** | **Nature Repair Method** | **WRS** | **WRS** |
| Species composition | Desirable plants | Critical | | | **Desirable animals**<br>**Nature repair method** – fauna values are not prescribed indicators for ecosystem condition or required in monitoring assessments.<br>**Provenance, genetic diversity/resilience**<br>**WRS** – while seed provenance and genetic while seed provenance and genetic diversity is important for resilience, the WRS prioritises native species diversity, composition and establishment of habitat requirements for desirable species for the Wheatbelt. It also prioritises control of undesirable species. Appendix 13 presents example milestone and completion criteria for projects incorporating indicators for this attribute. |
| | Desirable animals | Critical | | | |
| | Rare and threatened species | Critical | | | |
| | No undesirable species | Critical | | | |
| | Provenance, genetic diversity and genetic resilience | Critical | | | |
| Structural diversity | All vegetation strata | Critical | | | **Spatial mosaic**<br>**Nature repair method** – recognises multiple target reference ecosystems may be necessary (based on the PLANR vegetation map), although does not assess the spatial distribution of vegetation communities or habitats. |
| | All trophic levels | Preferable | | | |
| | Spatial mosaic | Critical | | | |
| Ecosystem function | Productivity/ cycling | If feasible | | | – |
| | Habitat & interactions | Preferable | | | |
| | Resilience/ recruitment | Critical | | | |
| External exchanges | Landscape flows | Preferable | | | **Intraspecific gene flow**<br>**WRS** – while gene flow between the restoration site and surrounds is important, other attributes such as desirable animals, resilience/recruitment and habitat links categorised as critical could offer a proxy for this attribute.<br>**Habitat links**<br>**WRS** – while seed provenance and geneticgiven the high degree of fragmentation of vegetation and fauna habitats in the Wheatbelt significantly reducing native species populations, this is categorised as a critical element for restoration projects in the region. |
| | Intraspecific gene flow | Critical | | | |
| | Habitat links | Preferable | | | |

# Appendix 6

## SER Ecological Recovery and Social Benefits Project Evaluation Templates

### Recovery Wheel template:



## Evaluation of ecosystem recovery

**Site:** ______________________________

**Assessor:** ______________________________

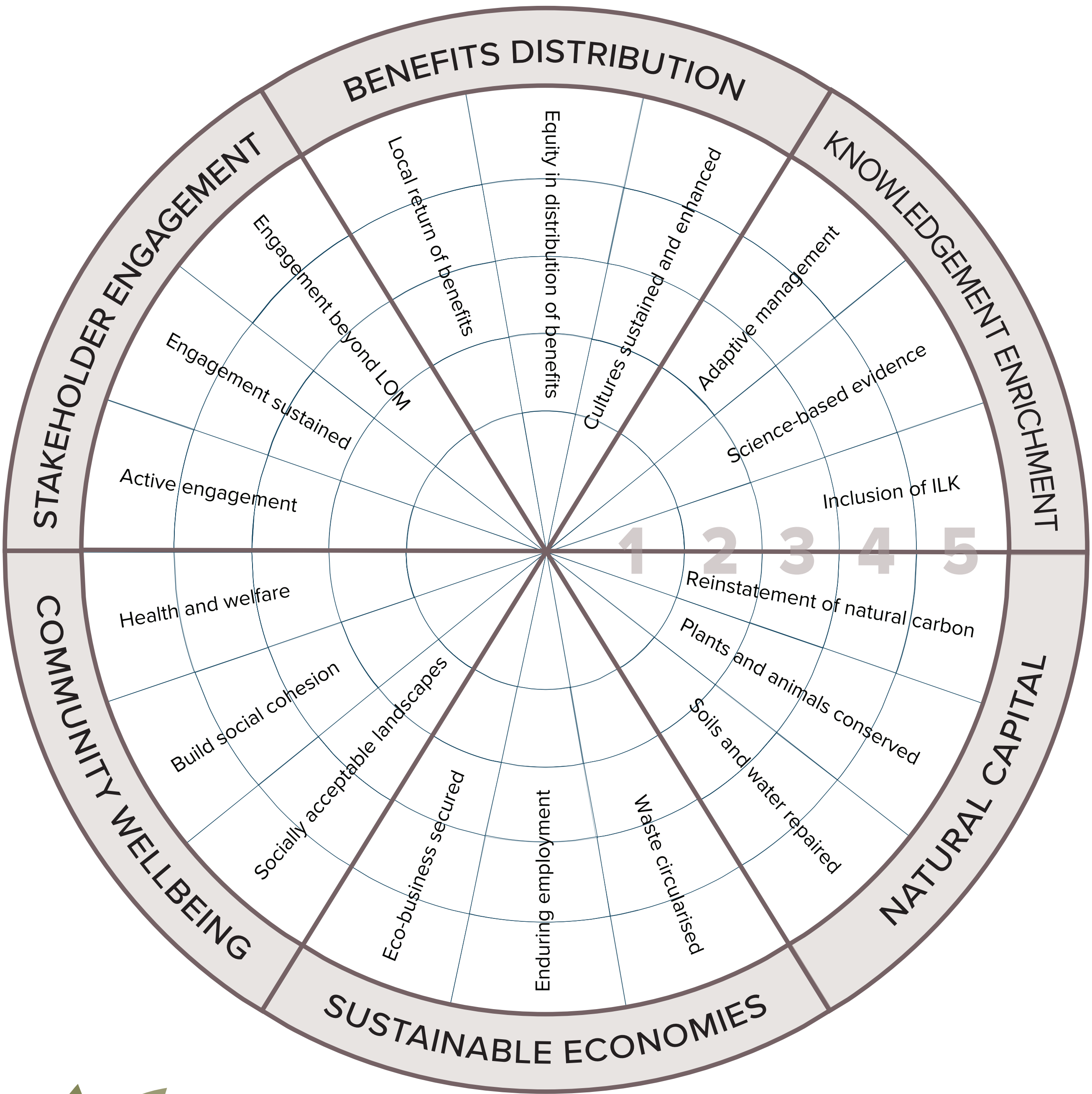
**Date:** ______________________________

**Reference ecosystem:**

| Attribute category | Recovery level (1–5) | Evidence for recovery level |
|---|---|---|
| **Attribute 1. Absence of threats** | | |
| Overutilisation | | |
| Invasive species | | |
| Contamination | | |
| **Attribute 2. Physical conditions** | | |
| Substrate physical | | |
| Substrate chemical | | |
| Water chemo-physical | | |
| **Attribute 3. Species composition** | | |
| Desirable plants | | |
| Desirable animals | | |
| No undesirable species | | |
| **Attribute 4. Structural diversity** | | |
| All strata present | | |
| All trophic levels | | |
| Spatial mosaic | | |
| **Attribute 5. Ecosystem function** | | |
| Productivity, cycling | | |
| Habitat and interactions | | |
| Resilience, recruitment | | |
| **Attribute 6. External exchanges** | | |
| Landscape flows | | |
| Gene flows | | |
| Habitat links | | |

This is an example of a Social Benefits Wheel to assist in tracking the degree to which an ecological restoration project or program is attaining its social development targets and goals. This can be customized to suit the specific targets and goals of any ecological restoration project program. It compliments the Ecological Recovery Wheel used to evaluate ecological recovery progress compared to the project's reference model. For symmetry of design, six attributes and three sub-attributes are used in this example, but there may be more or fewer needed depending on the project. For more information on the five star system and this Wheel, see the SER International Principles and Standards for the Practice of Ecological Restoration. Second Edition. (Gann et al. 2019).

## Social Benefits Wheel template:



## Evaluation of social benefits

**Project:** ______________________________

**Assessor:** ______________________________

**Date:** ______________________________

| Attribute category | Level (1–5) | Notes |
|---|---|---|
| **Attribute 1. Stakeholder engagement** | | |
| Involvement attracted | | |
| Support maintained | | |
| Capacity increased | | |
| **Attribute 2. Benefits distribution** | | |
| Local benefits ensured | | |
| Opportunity equalised | | |
| Culture conserved | | |
| **Attribute 3. Knowledge enrichment** | | |
| Knowledge innovated | | |
| Science drawn upon | | |
| TEK reinforced | | |
| **Attribute 4. Restoring natural capital** | | |
| Soils and water repaired | | |
| Plants and animals conserved | | |
| Carbon managed | | |
| **Attribute 5. Sustainable economies** | | |
| Waste circularised | | |
| Employment generated | | |
| Eco-business secured | | |
| **Attribute 6. Community wellbeing** | | |
| Sense of place improved | | |
| Social bonding improved | | |
| Health and wellfare improved | | |

# Appendix 7

## Polarity tool template

# Appendix 8

## Example restoration barriers checklist

### Instructions

1. For elements identified as potential barriers or enablers to a particular project, tick the corresponding box in the 'barrier or enabler' column, or leave blank for non-applicable elements.
2. Determine a preliminary rating using the matrix based on likelihood impact values below. The scope of the assessment is characterised as the likelihood and significance of the restoration barrier or enabler impacting the environmental outcomes for a project.
3. Barriers and enablers with 'Medium' and 'High' rating should be considered in the project monitoring plan.

| Impact ↑ / Likelihood → | | | |
|---|---|---|---|
| | Medium | Medium | High |
| | Low | Medium | High |
| | Low | Low | Medium |

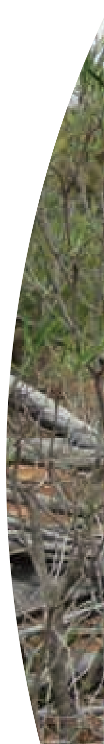
Likelihood

### Likelihood Values

| | | |
|---|---|---|
| Low Likelihood | 0 – 30% probability | Events with a low likelihood are those that are unlikely to occur, but they are still possible. |
| Moderate Likelihood | 30% – 70% probability | Events with a moderate likelihood are neither strongly likely nor unlikely. These events are plausible, and their occurrence depends on a variety of factors or conditions. |
| High Likelihood | 70% – 100% probability | Events with a high likelihood are those that are very likely to occur under normal or expected conditions. |

### Impact Values

| | |
|---|---|
| Low Impact | Little to no impact on environmental outcomes |
| Medium Impact | Impact may be observable but is not critical to environmental outcomes |
| High Impact | Significant measurable impact to environmental outcomes |



## Useful references

| Barrier type | Reference |
|---|---|
| Biological | Standish et al. (2007), Bird et al. (2024), Ludwig et al. 1997, DCCEEW (2022), Parkhurst et al (2021), Fischer and Lindenmayer (2007), EPA (2024) |
| Physical | EPA (2024), Parkhurst et al. (2021), Jonson (2010), Hobbs (2007), Standish and Parkhurst (2024), Hobbs (2007) |
| Social | Valderrábano et al (2021), WABSI (2022), CCA (2024) |
| Knowledge | EPA (2024), Valderrábano et al (2021), Ward et al. (2024), Dorji et al. (2024), Valderrábano et al (2021), CCA (2024), Samuel 2020 |
| Financial | Valderrábano et al (2021), CCA (2024), Wentworth Group of Concerned Scientists (2024) |
| Governance | EPA (2024), (WABSI (2022), Samuel 2020 |
| Supply chain | Hancock et al. (2020), CSIRO (2022) |

# Example restoration barriers checklist template

| Type | Element | Barrier or Enabler | Rating |
|---|---|---|---|
| Ecological | Native seed dispersal and recruitment | | |
| | Soil biota diversity and abundance | | |
| | Seasonal outlook, seeding/planting window | | |
| | Weeds (outcompeting native spp.) | | |
| | Pests and pathogens | | |
| | Establishment of native understorey | | |
| | Ecological, habitat and landscape connectivity to support species recovery, movement and migration | | |
| Physical | Restoration project adaptability and resilience to climate change | | |
| | Soil (e.g. type, compaction, EC, nutrient load, moisture, temperature) | | |
| | Availability of suitable fauna microhabitats (e.g. tree hollows) | | |
| | Hydrological processes (e.g. salinity, waterlogging) | | |
| Social | Social and institutional considerations, including employment and income, cultural values | | |
| | Competing land-use perspectives (e.g. environmental offsets situated on viable agricultural land) | | |
| | Large-scale shifts in land-use influencing regional population declines | | |
| Knowledge | Distribution, ecological condition and trend data on Wheatbelt Woodland TEC | | |
| | Technical capability and capacity to achieve restoration targets | | |
| | Western scientific, indigenous and local and knowledge e.g. climate adaptation and resilience | | |
| | Spatial distribution of ecosystem values associated with carbon storage, reduction of natural hazards, water quality/quantity | | |
| | Information on how ecosystem restoration may benefit threatened species | | |
| | Complexity of the ACCU scheme, challenging to navigate the regulatory process | | |
| | Perception of value and trust in sharing data with stakeholders | | |
| Financial | Cost of land, land tenure | | |
| | Significant initial investment, returns of variable restoration methods, benefit-sharing and cost of restoration failure | | |
| | Whole of catchment land use, management and productivity | | |
| Governance | Ability to demonstrate a genuine effort to offset impacts to WWTEC through restoration | | |
| | Distance of environmental offset to impact site | | |
| | Strategy for prioritising environmental offset sites | | |
| | Separate carbon-focused and biodiversity-focused markets | | |
| Supply chain | Lead time for nurseries and seed suppliers | | |
| | Availability of labour, skills | | |
| | Supply of viable target seeds and/or tube-stock in desired volumes | | |

# Appendix 9

## SER 5-star system attributes ratings table

The 5-star system attributes rating table modified to reflect the unique environments and biodiversity of Western Australia. Attribute ratings are used to measure progress along a trajectory of recovery. This 5-star scale represents a gradient from either no (zero) or very low to very high similarity to the reference and is applicable to any level of recovery.

This is a generic framework for users to develop indicators to monitor the specific ecosystem and sub-attributes they identify. (Note: The starting point of an attribute can be zero or any star level, and examples in the table accumulate along the restoration continuum) (modified from Gann et al. 2024).

## Zero stars to two stars (★★)

| Attributes | 0 | ★ | ★★ |
|---|---|---|---|
| Absence of threats | High numbers and degrees of direct degradation drivers present (e.g., overharvesting, erosion, active contamination). Conservation status may not be secured. | Some direct degradation drivers absent and conservation status secured, but others remain high in number and degree. | Direct degradation drivers (including sources of invasive species, absence of appropriate natural disturbance regimes) intermediate in number and degree. |
| Physical condition | Landforms and most physical and chemical properties of the site's substrates and hydrology (e.g., soil structure, nutrients, pH, salinity, depth to water table) are highly dissimilar to the reference. | Landforms and most physical and chemical properties of the site's substrates and hydrology still highly dissimilar to reference but some showing improved similarity. | Landforms and physical and chemical properties of substrates and hydrology, remain at low similarity levels relative to reference but capable of supporting some biota of reference. |
| Species composition | Absence or very low presence of colonising native species (e.g., <5% of the reference). Extremely high abundance of nonnative invasive or undesirable species (e.g., >80% relative cover). | Some colonising native species present (e.g., >5% of the reference). Very high levels of nonnative invasive or undesirable species (e.g., <80% relative cover). | A small subset of characteristic native species present (e.g., >25% of the reference) across site. High to intermediate levels of nonnative invasive or undesirable species (e.g., <60% relative cover). |
| Structural diversity | No stratum of the reference present, and spatial patterning and community trophic complexity dissimilar or highly dissimilar to the reference. | At least one stratum of the reference present but spatial patterning and community trophic complexity still largely dissimilar to reference. | Multiple strata of the reference present but some similarity of spatial patterning and trophic complexity relative to reference. |
| Ecosystem function | Processes and functions (e.g., water and nutrient cycling, habitat provision, natural disturbance regimes) absent or severely diminished compared to the reference. | Processes and functions at a very foundational stage only compared to the reference. | Low numbers and levels of physical and biological processes and functions relative to the reference are present (incl. plant growth, decomposition, soil processes). |
| External exchanges | No or very limited positive exchanges and flows with the surrounding environment (e.g., species, genes, water, fire, other ecological processes). | Positive exchanges and flows with surrounding environment in place for only very low numbers of species and processes. | Positive exchanges with surrounding environment in place for a few characteristic species and processes. |

*(Continued following page)*

## Three stars (★★★) to five stars (★★★★★)

| Attributes | ★★★ | ★★★★ | ★★★★★ |
|---|---|---|---|
| Absence of threats | Number of direct degradation drivers low but some may remain intermediate in degree. | Direct degradation drivers, both external and on-site, low in number and degree. | Known threats from direct degradation drivers minimal, effectively absent or can be demonstrated to be effectively controlled and contained. |
| Physical condition | Landforms and physical and chemical properties of substrates and hydrology stabilized within intermediate range of reference and capable of supporting growth and development of many characteristic native biota. | Landforms very similar to the reference, and physical and chemical conditions of substrates and hydrology highly similar to reference and suitable for sustained growth and recruitment of most characteristic native biota. | Landforms very similar to reference, and physical and chemical conditions of substrates and hydrology very highly similar to that of the reference with evidence they can indefinitely sustain all characteristic species and processes. |
| Species composition | A subset of key native species present (e.g., >50% of the reference, with some similarity in abundance ratios) over substantial proportions of the site. Intermediate to low levels of nonnative invasive or undesirable species (e.g., <25% relative cover). | Substantial diversity of characteristic native species present (e.g., >75% of the reference with moderate similarity in abundance ratios) across the site and representing a wide diversity of functional groups with evidence of natural recruitment reflecting successional patterns. Low to very low levels of nonnative invasive or undesirable species (e.g., <10% relative cover). | High diversity of characteristic native species present (e.g., >95% of the reference with high similarity in abundance ratios), with high similarity to the reference ecosystem and high potential for self-organisation and recruitment potential reflecting successional patterns . Very low to nil invasive or undesirable species (e.g., <2% relative cover). |
| Structural diversity | Most strata of the reference present and intermediate similarity of spatial patterning and trophic complexity relative to reference. | All strata of the reference present and substantial similarity of spatial patterning and trophic complexity relative to reference. | All strata present and spatial patterning and trophic complexity high. Further complexity and spatial patterning able to self-organize to highly resemble the reference. |
| Ecosystem function | Intermediate numbers and levels of physical and biological processes and functions relative to the reference are present. | Substantial levels of physical and biological processes and functions relative to the reference are present. | All functions and processes (including natural disturbance regimes) are present and show evidence of being sustained. |
| External exchanges | Positive exchanges with surrounding environment in place for intermediate levels of characteristic species and processes. | Positive exchanges with surrounding environment in place for most characteristic species and processes and highly likely to be sustained. | Evidence that exchanges with the surrounding environment are highly similar to the reference for all species and processes and are sustained. |

# Appendix 10

## Example indicators, purpose and associated data points for monitoring attributes

Example measurable indicators, their purpose and examples of evidence for SER/TGBS attributes and sub-attributes (modified from Bartholomew and Mosyaftiani et al. (2024), Campbell et al. (2024), Tedesco et al. (2023), Keeley et al. (2021), Gann et al. (2019), DCCEEW (2024), Lindenmayer and Burgman (2005). This list is not exhaustive. Additional example measurable indicators and examples of evidence are provided in Bartholomew and Mosyaftiani et al. (2024).

| SER Attribute | SER/TGBS sub-attribute | Example measurable indicator | Indicator purpose | Example of evidence |
|---|---|---|---|---|
| Species composition | Overutilisation | • Species composition<br>• Tree damage<br>• Richness and abundance of undesirable species<br>• Vegetation % cover | Threats from overgrazing, over-harvesting | • Comparison of species diversity among ecosystems/ habitats<br>• Number of trees damaged<br>• Grazing records |
| | Contamination | • Concentration of pollutants or harmful substances<br>• Area of exposure/ existing contaminant | Detect harmful pollutants in soil and water | • Organic pollutants (e.g. oil hydrocarbons, chlorinated compounds)<br>• Heavy metals in the soil (e.g. Pb, As, Cu, etc.)<br>• High nutrient level (e.g. nitrogen, phosphorus)<br>• Total estimated area/points/ routes of exposure |
| | Invasive species | • Presence of invasive species<br>• Richness and abundance of invasive species<br>• Level of risk | Identify potential threats to native species | • Number of invasive species detected, species richness<br>• Abundance of invasive species<br>• Area of occurrence/size of patches<br>• Density of individual patches<br>• Risk rating |
| | Other disturbance drivers (AS RELEVANT) | • Level of disturbance<br>• Spatial disturbance properties<br>• Temporal disturbance properties | Threats from direct disturbance | • Species composition, richness or abundance of biological indicators<br>• Intensity or severity of disturbance<br>• Area affected by disturbance<br>• Duration, frequency of disturbance/driver |

*(Continued following page)*

| SER Attribute | SER/TGBS sub-attribute | Example measurable indicator | Indicator purpose | Example of evidence |
|---|---|---|---|---|
| Physical conditions | Substrate physical conditions | • Soil parameters<br>• Biological indicators<br>• Hydrological conditions | Physical properties of soil substrates to support native plant growth | • Soil texture<br>• Soil compaction<br>• Moisture content<br>• Soil structure<br>• Presence/abundance of earthworms<br>• Water logging |
| | Substrate chemical conditions | • Soil chemical properties | Chemical properties of soil substrates to support native plant growth | • pH<br>• Soil salinity (EC)<br>• Rates of litter mass loss<br>• Soil nutrient levels (e.g., nitrogen, phosphorus) |
| | Water chemo-physical conditions | • Chemical condition<br>• Physical condition | Hydrological features and function of the site | • pH<br>• Dissolved oxygen<br>• Surface, groundwater electrical conductivity (EC)<br>• Hardness<br>• Water temperature<br>• Turbidity<br>• Total dissolved solids (TDS) |
| Species composition | Desirable plants | • % compositional similarity<br>• Cover-abundance<br>• Species richness<br>• Species diversity<br>• Species occurrence<br>• Species metrics | Native species characteristic of the appropriate ecosystem are present as an indicator of diversity and potentially function | • Presence of key indicator species<br>• Species richness and abundance<br>• Vegetation cover<br>• Vegetation condition<br>• Number of endemic species<br>• Number of protected species (local/national/international) |
| | Desirable animals | • % compositional similarity<br>• Species richness<br>• Species diversity<br>• Species abundance<br>• Species occurrence<br>• Species metrics | Native species characteristic of the appropriate ecosystem are present as an indicator of diversity and potentially function | • Presence of key indicator species<br>• Species richness and abundance<br>• Number of vertebrate species<br>• Number of endemic species<br>• Quality and condition of habitat features<br>• Number and distribution of invertebrate species |
| | No undesirable species | • Species presence/ absence<br>• Species abundance<br>• Species metrics | Presence of undesirable species (flora, fauna, pathogens) | • Presence/absence of negative indicator species<br>• Density<br>• Frequency<br>• Species richness |

*(Continued following page)*

| SER Attribute | SER/TGBS sub-attribute | Example measurable indicator | Indicator purpose | Example of evidence |
|---|---|---|---|---|
| Species composition (cont.) | Rare and threatened species (AS RELEVANT) | • Species presence/ absence<br>• Species abundance<br>• Species metrics | Suitable habitat for target species | • No. of conservation significant species planted<br>• No. of species persisting<br>• Conservation significant species abundance and richness |
| | Provenance, genetic diversity and genetic resilience (AS RELEVANT) | • Seed source location and corresponding characteristics<br>• Seed quantity<br>• Plante species provenance<br>• Genetic composition | Genetic diversity and resilience | • Use of seed matching software application or use of ecological model<br>• Number of collection sites<br>• Number of provenance seed species<br>• Number of seed sources<br>• Number of seeds on each planted species<br>• Number of planted native seeds<br>• Genetic structure<br>• Genetic diversity |
| Structural diversity | All vegetation strata | • Vegetation structure | Evidence of complex trophic levels e.g. primary producers, primary consumers, predators | • Native overstorey and midstorey crown cover<br>• Leaf area index<br>• Vegetation cover by layer<br>• % native ground cover |
| | All trophic levels | • Trophic level | The spatial distribution of key features e.g. vegetation and fauna habitats | • Observation or secondary evidence of predator – prey interaction<br>• Presence, abundance, density of host-nectar plants for pollinators<br>• Trophic diversity |
| | Spatial mosaic | • Land and vegetation structure and compositions<br>• Patch metrics | Genetic diversity and resilience | • Size shape and connectivity of habitat patches<br>• Spatial mosaic similarity |
| Ecosystem function | Productivity/ cycling | • Primary productivity<br>• Nutrient cycling | Growth, productivity and nutrient cycling functioning evident | • Index of productivity<br>• Index of nutrient cycling<br>• Coarse woody debris decay |
| | Habitat & interactions | • Nesting<br>• Coarse woody debris | Available habits for native species | • Number/density of nests<br>• CWB habitat quality index<br>• Available microhabitats for fauna |
| | Resilience/ recruitment | • Seedling recruitment<br>• Food web interactions<br>• Resilience to disturbance | Potential to recovery from natural disturbance or sustaining species populations | • No. of seedlings through natural recruitment<br>• Seed abundance<br>• Trophic gradient<br>• Growth rates and fecundity after disturbance |

*(Continued following page)*

| SER Attribute | SER/TGBS sub-attribute | Example measurable indicator | Indicator purpose | Example of evidence |
|---|---|---|---|---|
| External exchanges | Landscape flows | • Movement of matter<br>• Movement of organisms | Synergies within the larger landscape | • Foraging observations<br>• Natural recruitment of native species<br>• Rate and quality of surface and groundwater flow |
| | Gene flow | • Genetic connectivity<br>• Species proxy | Gene flow between the site and surrounds | • Observed pollinators (e.g. insects, birds) and travel distance<br>• Genomic data |
| | Habitat links | • Habitat buffer<br>• Habitat corridor<br>• Species networks | Enabling species movement and migration to access seasonally available resources and promote resilience | • Patch area and boundaries<br>• Distance between patches<br>• Width of buffer strip<br>• Habitat within buffer |

# Appendix 11

## Acknowledgements

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# Appendix 12

## WWTEC tool

Available in Microsoft Excel format at: https://wabsi.org.au/wheatbelt-restoration-standards/

# Appendix 13

## Example completion criteria

These examples help as a guide for the development of specific completion criteria required under regulatory environmental approval process. They are intended to support the development of detailed monitoring, evaluation and reporting following the WRS framework. Example criteria are provided for all six attributes and their sub-attributes in the Recovery Wheel for values typically associated with restoring endemic eucalypt woodland communities. These examples are not exhaustive and are expected to evolve as further research, assessments and decision-making processes make environmental data available.

*(See table following pages)*

| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Absence of threats** | | | | | | | |
| Contamination | Direct contamination drivers, both external and onsite, low in number and degree. | Concentration of nutrients or altered soil chemistry | Nutrient concentration (e.g. nitrogen, phosphorus) | Post-disturbance baseline nutrient concentrations at the restoration and reference sites are understood and an assessment on predicted impacts to the establishment and growth of selected species with elevated nutrient concentrations recorded is undertaken. | Nutrient levels at the restoration site are effectively managed with application of treatment (e.g. lime) if deemed necessary.<br>Species vulnerable to elevated nutrient concentrations are exhibiting evidence of healthy growth. | Nutrient levels at the restoration and reference sites have been assessed to determine if concentrations are the same or have lowered from post-disturbance baseline.<br>Species vulnerable to elevated nutrient concentrations are exhibiting evidence of healthy growth. | Excess nutrients in the soil (N, P) are controlled effectively (e.g. application of lime to support germination, establishment and maturation of target species with minimal attrition) and demonstrated to be lower than the post-disturbance baseline (desirable) prior to handover (est. 10 years).<br>Species vulnerable to elevated nutrient concentrations are exhibiting evidence of healthy growth. |
| | Direct contamination drivers, both external and onsite, low in number and degree. | Concentration of pollutants or altered soil chemistry | Hazardous chemical concentrations (e.g. hydrocarbons, heavy metals) | Soil sampling across the restoration sites identify if there is a presence of hydrocarbons. Management actions for removal, treatment or containment have been developed and are being implemented. | Evidence that any identified hydrocarbons and toxic heavy metals have been removed, treated or contained. Risk of spread or wider impact unlikely. | Evidence that any identified hydrocarbons and toxic heavy metals have been removed, treated or contained. Risk of spread or wider impact unlikely. | Any identified hydrocarbons and toxic heavy metals are removed, treated or contained. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Absence of threats (cont.)** | | | | | | | |
| Invasive species | Threats from direct invasive species drivers, both external and onsite, very low in number and degree (e.g., <2% relative cover of reproductive invasive species). | Richness and abundance of invasive species | Richness and abundance of invasive fauna species | Post-disturbance baseline assessment of invasive fauna at the restoration and reference sites has been completed and is understood.<br>Invasive fauna management plan developed that includes at minimum bi annual control (e.g. baiting, trapping, shooting) over at minimum 3 nights unless absence is evidenced (e.g. comprehensive camera trapping detects no invasive fauna).<br>Alignment with regional control programs evidenced where appropriate. | Records of invasive fauna management plan being implemented. Control measures are implemented in response to monitoring intensity (e.g. trapping nights).<br>Monitoring demonstrates that target species control methods are effective in controlling impacts to the restoration site.<br>Invasive fauna are actively managed at the restoration site with abundances stable or in a downward trend.<br>Demonstrated coordination with regional feral control programs (e.g. Wheatbelt NRM) where practicable. | Records of invasive fauna management plan being implemented. Control measures are implemented in response to monitoring intensity (e.g. trapping nights).<br>Monitoring demonstrates that target species control methods are effective in controlling impacts to the restoration site.<br>Invasive fauna are actively managed at the restoration site with abundances stable or in a downward trend.<br>Demonstrated coordination with regional feral control programs (e.g. Wheatbelt NRM) where practicable. | Records of invasive fauna management plan being implemented.<br>Monitoring demonstrates that target species control methods are effective in controlling impacts to the restoration site.<br>Invasive fauna are actively managed at the restoration site with abundances highly similar to reference sites.<br>Demonstrated coordination with regional feral control programs (e.g. Wheatbelt NRM) where practicable.<br>Arrangements/ agreement in place for ongoing management post-handover. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Absence of threats (cont.)** | | | | | | | |
| Overutilisation | Direct overutilisation drivers, both external and onsite, low in number and degree. | Richness and abundance of undesirable species | Richness and abundance of undersirable target species.<br>Vegetation % cover and condition. | Potential undesirable species for overgrazing at the restoration sites have been identified and management actions identified for implementing at germination and early establishment.<br>Survival rate of at least 70% of the seedlings initially planted to be established. | Over utilisation of native and non-native undesirable species are monitored biannually.<br>If triggers are exceeded control measures are demonstrated to effectively minimise risk of reduced recovery outcome. | Over utilisation of native and non-native undesirable species are monitored biannually.<br>If triggers are exceeded control measures are demonstrated to effectively minimise risk of reduced recovery outcome. | Control measures are demonstrated to effectively minimise risk of reduced recovery outcome as a result of over grazing. |
| Other degrading drivers | Direct degradation drivers, both external and onsite, low in number and degree. | Spatial and temporal disturbance properties | Duration, frequency of disturbance/ driver | Post-disturbance assessment of wind speeds and risk of erosion have been completed.<br>Wind erosion risk understood with measures identified to reduce risk if deemed necessary. | Restoration site being monitored for wind erosion. Effective control measures in place to minimise impact | Vegetation cover sufficient to reduce wind speed at ground level. Wind erosion at the restoration site is minimal or absent. | Vegetation cover sufficient to reduce wind speed at ground level within 10 years post-disturbance. Wind erosion at the restoration site is minimal or absent. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Physical conditions** | | | | | | | |
| Water chemo-physical conditions | Physical and chemical conditions of hydrology within a high range of the reference and suitable for ongoing growth and recruitment of most characteristic native biota. | Chemical condition | Surface, groundwater electrical conductivity (EC) | Post-disturbance assessment of salinity (EC) at the reference and restoration site and assessment of source, risk of increase or spread and concentration has been completed.<br>Consideration of salt tolerance from plant population is sourced is included in the restoration plan where necessary.<br>Management actions to reduce risk of salinity increase, spread and germination are being implemented.<br>Survival rate of >70% of the seedlings initially planted to be established. | Monitoring demonstrates that control methods to manage concentration and extent of salinity are in place.<br>Risk of spread or increasing soil EC concentrations with low likelihood.<br>>75% plant species exhibiting evidence of healthy growth. | Monitoring demonstrates that control methods to manage concentration and extent of salinity are in place.<br>Risk of spread or increasing soil EC concentrations with low likelihood.<br>Maturing vegetation communities of moderate similarity to, or on a stable trajectory towards, those of the reference ecosystem. | Within 10 years post-disturbance, salinity (EC) concentrations are sufficient to support a maturing vegetation communities of high similarity to, or on a stable trajectory towards, those of the reference ecosystem. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Physical conditions (cont.)** | | | | | | | |
| Substrate chemical conditions | Chemical conditions of substrates within a high range of the reference and suitable for ongoing growth and recruitment of most characteristic native biota. | Soil chemical properties | Soil nutrient levels (e.g., nitrogen, phosphorus), pH | Post-disturbance assessment of Nutrient concentrations (e.g. Nitrogen, Phosphorous) and pH levels across the restoration site are understood.<br>Management actions to change the substrate chemical conditions towards the reference are being implemented.<br>Germination barriers associated with soil nutrients and pH to selected species for restoration are understood and effectively managed.<br>Survival rate of >70% of the seedlings initially planted to be established. | Monitoring demonstrates that control methods to effectively manage nutrient concentrations and pH at the site are in place.<br>>75% plant species exhibiting evidence of healthy growth | Monitoring demonstrates that control methods to effectively manage nutrient concentrations and pH at the site are in place.<br>>75% plant species exhibiting evidence of healthy growth.<br>Maturing ecological community analogous to the reference. | Within 10 years post-disturbance, mean soil nutrient concentrations (e.g. Nitrogen, Phosphorous) and pH levels across the restoration site of high similarity to, or on a stable trajectory towards, those of the reference ecosystem. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Physical conditions (cont.)** | | | | | | | |
| Substrate physical conditions | Physical conditions of substrates within a high range of the reference and suitable for ongoing growth and recruitment of most characteristic native biota. | Soil parameters | Soil texture and soil structure.<br>Soil compaction.<br>Porosity and water retention. | Assessment of the physical properties of the substrate at the reference site and the post-disturbance restoration site has been completed.<br>Limitations (e.g. soil compaction, porosity or water retention) that may impact the planned restoration reference community have been identified.<br>Management actions to reduce risk are being implemented.<br>Survival rate of >70% of the seedlings initially planted to be established. | Monitoring demonstrates that control methods to manage physical conditions limiting vegetation establishment at the site are effective.<br>>75% plant species exhibiting evidence of healthy growth | Monitoring demonstrates that control methods to manage physical conditions limiting vegetation establishment at the site are effective.<br>>75% plant species exhibiting evidence of healthy growth<br>Maturing ecological community analagous to reference sites. | Within 10 years post-disturbance, physical conditions across the site are demonstrated to have high similarity to, or on a stable trajectory towards, those of the reference ecosystem.<br>Degraded physical properties of the soils within the project site have been effectively controlled and no longer require active intervention.<br>The number of soil samples and plots is sufficient to capture variation across the land units and soil types in the restoration site. At least three consecutive sample rounds is required to establish a trend. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Physical conditions (cont.)** | | | | | | | |
| Substrate physical conditions | Physical conditions of substrates within a high range of the reference and suitable for ongoing growth and recruitment of most characteristic native biota. | Hydrological conditions | Ground and surface water quality.<br>Water logging | Post-disturbance assessment of the hydrological conditions of the site has been completed.<br>Ground or surface water management actions to address degradation (e.g. water logging, water quality) are being implemented. | Monitoring demonstrates that control methods to manage hydrological conditions limiting vegetation establishment at the site are effective.<br>>75% plant species exhibiting evidence of healthy growth. | Monitoring demonstrates that control methods to manage degraded hydrological conditions limiting vegetation establishment at the site are effective.<br>>75% plant species exhibiting evidence of healthy growth.<br>Maturing ecological community analagous to reference sites. | Within 10 years post-disturbance, hydrological conditions are demonstrated to be stable or on a trajectory towards reference ecosystem conditions (desirable).<br>Monitoring methods are sufficient to capture degraded hydrological conditions across the site. At least three consecutive sample rounds is required to establish a trend. |
| Substrate physical conditions | Physical conditions of substrates within a high range of the reference and suitable for ongoing growth and recruitment of most characteristic native biota. | Landform | Visual assessment | The post-disturbance landscape profiles is visually integrated into the surrounding landforms | No significant change to the post-disturbance landscape profiles and these remain integrated into the surrounding undisturbed landforms | No significant change to the post-disturbance landscape profiles and these remain integrated into the surrounding undisturbed landforms | The post-disturbance landform slope and topography is integrated into the surrounding undisturbed landscape.<br>Post-disturbance slope and topography is within +/- 1.0m of the approved restoration design for 95% of the disturbance area. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Species composition** | | | | | | | |
| Desirable plants | Substantial diversity of characteristic native plant species and genes present (e.g., >75% richness and evenness of the reference) across the site and representing a wide diversity of functional groups.<br>Evidence of natural recruitment reflecting successional patterns | Species composition (or Species richness and abundance) | % compositional similarity (or species richness and abundance including presence of key indicator species) | Post-disturbance baseline flora diversity across the restoration and reference sites is understood.<br>The restoration plan incorporates >70% of species recorded in reference sites, including the dominant canopy species are selected for planting.<br>Planting design to achieve average species richness highly similar with reference sites.<br>Seed provenance of tree species suited to future warmer and drier conditions. Survival rate of at least 70% of the seedlings initially planted to be established.<br>Vegetation communities are positioned in the landscape to correlate with landform and soil type features.<br>Average vegetation condition in good or better condition across the site. | Native species diversity and composition (trees and shrubs) with moderate to high similarity of the mean of reference sites in >50% of restoration monitoring sites.<br>Flora species exhibiting evidence of healthy growth.<br>Average vegetation condition in good or better condition across the site. | Native species diversity and % composition (trees and shrubs) with moderate to high similarity of the mean of reference sites in >50% of restoration monitoring sites.<br>Native groundstory is present.<br>>50% of the dominant native species characterising the target vegetation community are observed to flower and fruit in the restoration site.<br>Average vegetation condition in very good condition across the site. | Native species diversity and composition (trees and shrubs) with moderate similarity of the mean of reference sites in >80% of restoration monitoring sites, or with high similarity at >60% of the restoration monitoring sites.<br>A multistrata canopy is present.<br>A native groundstory is present.<br>>50% of the dominant native species characterising the target vegetation community are observed to flower and fruit in the restoration site.<br>The restoration site has been assessed to have the properties of a self-sustaining system by a qualified expert. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Species composition (cont.)** | | | | | | | |
| Desirable animals | Substantial diversity of characteristic native species and genes present (e.g., >75% richness and evenness of the reference) across the site and representing a wide diversity of functional groups with demonstrated high levels of residency compared to the reference. | Species composition (or Species richness and abundance) | % compositional similarity for target species<br>species richness and abundance including presence of key indicator species | Baseline fauna assemblages and relative abundance across the reference sites is understood.<br>An assessment identifying at least 20 target fauna species to be monitored from key fauna groups based on sampling methods and species detectability is undertaken by a qualified expert.<br>Annual monitoring of diversity, community composition and species occupancy in restoration and reference sites commences within 2 years of implementation. | Monitoring at the restoration site demonstrates the presence and ongoing establishment of habitat requirements for target species.<br>Assemblages and relative abundance of target fauna of moderate similarity to, or on a trajectory towards, those of the reference ecosystem.<br>Monitoring program sufficiently robust to provide reliable comparitive data. | Monitoring at the restoration site demonstrates the ongoing establishment of habitat requirements for target species.<br>Assemblages and relative abundance of target fauna of moderate to high similarity to, or on a trajectory towards, those of the reference ecosystem.<br>Monitoring program sufficiently robust to provide reliable comparitive data. | Assemblages and relative abundance of target fauna of high similarity to, or on a stable trajectory towards, those of the reference ecosystem.<br>Monitoring program sufficiently robust to provide reliable comparitive data. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Species composition (cont.)** | | | | | | | |
| Rare and threatened species | Substantial diversity of characteristic rare and threatened species and genes present (e.g., >75% richness and evenness of rare and threatened species of the reference) across the site and representing a wide diversity of functional groups. | Species presence/ absence and abundance | Conservation significant fauna species abundance and richness | At least 50% of endemic species known to occur within 12km of the site and comprises foraging, nesting or roosting resources for Carnaby's Cockatoo (CC) are identified.<br>Remnant trees within the site with a diameter at breast height (DBH) of ≥50cm and for salmon gum and wandoo ≥30cm are recorded and inspected for hollows.<br>Target species suited to the site's landforms and soils are incorporated in the restoration plan.<br>Provenance of tree species seed suited to future warmer and drier conditions where possible.<br>An assessment on the suitability of installing artificial hollows attached to trees with leafy canopies and additional actions influencing survival rates is determined by a qualified expert with experience in Black Cockatoo assessments. | Target species to provide foragaing, nesting or roosting resources for CC exhibiting evidence of healthy growth.<br>Average species richness of target conservation significant species in suitable habitats represents 50% of the average species richness recorded from reference sites.<br>Annual monitoring within and near the site observe scats or signs of foraging activity and/or direct observations of CC.<br>Condition of artificial hollow habitat assessed annually prior to breeding season and maintenance occurring as required.<br>Evidence of occupation recorded and actions implemented influencing survival rates. | Target species to provide foragaing, nesting or roosting resources for CC exhibiting evidence of healthy growth.<br>Average species richness of target species in suitable habitats represents 70% of the average species richness recorded from reference sites.<br>>50% of the target species population are observed to flower and fruit in the restoration site.<br>Annual monitoring between within and near the site observe scats or signs of foraging activity and/ or direct observations of CC.<br>Condition of artificial hollow habitat assessed annually prior to breeding season and maintenance occurring as required. Evidence of occupation recorded and actions implemented influencing survival rates. | Target species richness occupying suitable landforms and soil types is >70% of the average species richness recorded from reference sites.<br>>50% of the target species population are observed to flower and fruit in the restoration site and demonstrated to be actively recruiting.<br>Evidence of CC foraging within the restoration site (e.g. scats or signs of foraging activity and/or direct observations) in at least 3 consecutive monitoring rounds. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Species composition (cont.)** | | | | | | | |
| No undesirable species | Low to very low levels of nonnative, invasive or other undesirable plants (e.g., <5% relative species richness, abundance, or cover) or nonnative or undesirable animals. | Species presence/ absence and abundance | Number of weeds and abundance | Reference site and post-disturbance baseline assessment of weeds completed.<br>Weed management plan developed that includes control measures to limit risk of spread of weeds into the restoration site (e.g. particularly during pre-seeding) and strategies to effectively control weeds during germination/ early stages of establishment.<br>Weed density average across the restoration site is <20% within 2 years following ground preparation.<br>Alignment with regional weed management programs evidenced where appropriate. | Evidence of effective weed control ongoing, maintaining average weed cover of <20% in all 20 m X 20 m monitoring plots across the restoration site.<br>Control methods effectively reducing weed cover to <20% within 2 years following a disturbance event (fire).<br>WONS, Priority Alert, High Impact or Rapid invasiveness on the DBCA Wheatbelt Region Impact and Invasiveness Ratings list are effectively controlled to <2% cover across the site.<br>Abundance across the site is on a trajectory toward the reference site. | Evidence of effective weed control ongoing, maintaining average weed cover of <15% in all 20 m X 20 m monitoring plots across the restoration site.<br>Control methods effectively reducing weed cover to <20% within 2 years following a disturbance event (fire).<br>WONS, Priority Alert, High Impact or Rapid invasiveness on the DBCA Wheatbelt Region Impact and Invasiveness Ratings list are effectively controlled to <2% cover across the site.<br>Abundance across the site is on a trajectory toward the reference site. | Weed cover of grassy and perennial pasture weeds average <10% in all 20 m X 20 m monitoring plots across the restoration site.<br>WONS, Priority Alert, High Impact or Rapid invasiveness on the DBCA Wheatbelt Region Impact and Invasiveness Ratings list have been eradicated from the site.<br>Vegetation is sufficiently established to hinder new weeds establishing or increasing in abundance at the site. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Species composition (cont.)** | | | | | | | |
| Provenance, genetic diversity and genetic resilience | Adequate genetic diversity and resilience for an intermediate to high proportion of native species (e.g., >75% of the reference) across the site. | Seed source location and corresponding characteristics | Number of collection sites | Documentation of collection sites of selected species ensuring compliance with best practice, ensuring adequate genetic diversity, provenance where possible and avoiding overharvesting. | As previous | As previous | Species included in the restoration plans include local provenance seeds and propagation material, unless modified climate regimes suggest modified genotypes. Number of sites and collection rates are provided. Where local seeds and propagation materials are unavailable, locations of collections are included. |
| **Structural diversity** | | | | | | | |
| All vegetation strata | All strata of the reference present, within a high range of the reference and suitable for ongoing growth and recruitment of most characteristic native biota. | Vegetation structure | Native overstorey and midstory crown cover and % native ground cover | For each target ecosystem type, the species diversity and seeding rates are constructed to produce a vegetation community that is characterised by the presence of all strata and supports structurally significant species that has high similarity with the reference ecosystem. | >50% of restoration monitoring sites demonstrate evidence of species composition, vegetation structure and covers on a trajectory towards moderate to high similarity with reference sites | Monitoring in >50% of restoration monitoring sites demonstrates evidence of species composition, vegetation structure and covers are on a trajectory towards high similarity with reference sites | Within 10 years post-disturbance, for each target ecosystem type, >80% of monitoring sites demonstrates the species diversity and composition across tree and shrub strata have high similarity to, or on a stable trajectory towards, those of the reference ecosystem. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Structural diversity (cont.)** | | | | | | | |
| All trophic levels | Substantial similarity of trophic complexity relative to reference in terms of primary producers, primary consumers, secondary consumers, tertiary consumers, apex predators, and decomposers. | Trophic level | Observation or secondary evidence of predator – prey interaction, pollination | Restoration is planned to provide habitat and resources that support all trophic levels of the reference ecosystem. | Monitoring at the restoration site demonstrates native species representing at least three trophic levels are establishing.<br>Trophic levels not evidenced, predicted to develop. | Key fauna within multiple trophic levels (e.g. native predator and pollinator interactions) are present and with moderate to high similarity with reference.<br>Characteristic assemblages - primary producers, primary consumers, secondary consumers, tertiary consumers, apex predators, and decomposers are present with moderate similarity to reference sites. | Within 10 years post-disturbance, key representative species occupancy (primary producers, primary consumers, secondary consumers, tertiary consumers, apex predators, and decomposers) with moderate similarity to the mean of reference sites at >80% of restoration monitoring sites, or with high similarity at >60% of the restoration monitoring sites. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Structural diversity (cont.)** | | | | | | | |
| Spatial mosaic | Substantial similarity of spatial distribution of features relative to reference throughout the site. | Land and vegetation structure and compositions | Size shape and connectivity of habitat patches | The restoration plan characterises habitat complexity within reference sites (e.g. canopy complexity, understory and shrub layer complexity, ground cover, log abundance, leaf litter cover) important for key WWTEC fauna groups.<br>The restoration planting design establishes ecological communities with habitat complexity of high similarity with reference sites.<br>For large restoration projects, the restoration plan considers the spatial mosaic of the communities to form a heterogeneous vegetation complex within the landscape. | Monitoring at the restoration site demonstrates the formation of multiple vegetation communities are on a trajectory towards targeted complexity of moderate similarity with reference sites. | Monitoring at the restoration site demonstrates the formation of multiple vegetation communities are on a trajectory towards targeted complexity of moderate to high similarity with reference sites. | Within 10 years post disturbance, >70% of restoration monitoring sites demonstrate vegetation communities have reached complexity with high similarity to, or on a stable trajectory towards the reference ecosystem.<br>Patch metrics are highly similar to, or on a secure trajectory towards that of the reference ecosystem.<br>For large restoration projects, the spatial mosaic of vegetation communities with high similarity to the reference sites with size, shape and connectivity of patches and bare ground. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Ecosystem function** | | | | | | | |
| Productivity/ cycling | Substantial levels of physical and biological processes and functions, relative to the reference are present. | Nutrient cycling | Soil organic matter formation and turnover | The restoration plan considers management actions that provide a catalyst for soil organic matter formation during establishment stages (e.g. addition of woody debris, innoculation of microbes and fungi increasing soil organic carbon concentrations). | Monitoring at the restoration site demonstrates evidence in >50% of restoration monitoring sites of;– accumulation of leaf litter and organic matter- decomposition of litter– presence of soil microbiota and saprophytic fungi.<br>Monitoring demonstrates management of degrading processes to soil organic matter formation and turnover (e.g. erosion) is effective. | Monitoring at the restoration site demonstrates evidence in >50% of restoration monitoring sites of;– accumulation of leaf litter and organic matter- decomposition of litter–presence of soil microbiota and saprophytic fungi.<br>Monitoring demonstrates management of degrading processes to soil organic matter formation and turnover (e.g. erosion) is effective. | Within 10 years post disturbance, >70% of restoration monitoring sites demonstrate evidence of;– accumulation of leaf litter and organic matter- decomposition of litter– presence of soil microbiota and saprophytic fungi.<br>Monitoring demonstrates management of degrading processes to soil organic matter formation and turnover (e.g. erosion) is effective. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Ecosystem function (cont.)** | | | | | | | |
| Habitat and interactions | Substantial levels of habitat provision relative to the reference are present. | Available habits | Plant species richness and evenness | The planting design incorporates key plant species at abundances and cover with high similarity to the reference sites as habitat to support functional groups (e.g. nectivors, ground-dwelling omnivores, granivors and herbivors).<br>Connectivity requirements key for functional groups (including insectivors and predators) are considered in the restoration plan.<br>An assessment on the suitability of installing artificial habitat such (e.g. hollows attached to trees with leafy canopies) and additional actions influencing occupancy is determined by a qualified expert.<br>Barriers (e.g. species dependent on hollows) for at least 50% of target species occurring across reference sites are addressed in the restoration plan. | Species richness at >80% of monitoring sites of low to moderate similarity of the mean of reference sites. | Species richness at >80% of monitoring sites of moderate similarity of the mean of reference sites. | Within 10 years post-disturbance species richness at >80% of monitoring sites of moderate to high similarity of the mean of reference sites, or on a stable trajectory toward the reference ecosystem. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Ecosystem function** | | | | | | | |
| Resilience/ recruitment | Substantial levels of resilience and recruitment relative to the reference (including return of appropriate disturbance regimes) are present. | Seedling recruitment | No. of seedlings through natural recruitment;<br>Growth rates and fecundity after disturbance | Restoration plan identifies obligate and facultative seeders characteristic of the reference ecosystem, their time to maturity and to establish a resilient ecosystem able to withstand significant disturbance event (e.g. fire, drought). | Monitoring of vegetation demonstrates healthy individuals on a trajectory towards a resilient community.<br>Evidence of target native species flowering with fecundity aligned to individuals of the reference ecosystem.<br>Evidence of a seed bank forming.<br>Non-native seedling recruitment minimal (+/- <5%) | >50% of the dominant native species characterising the target vegetation community (trees and shrubs) are observed to flower and fruit in the restoration site, or are on a trajectory toward maturity and natural recruitment<br>Obligate seeders have formed a seed bank.<br>Non-native seedling recruitment minimal (+/- <5%) | Within 10 years post-disturbance species richness at >80% of monitoring sites of moderate to high similarity of the mean of reference sites, or on a stable trajectory toward the reference ecosystem.<br>Wihtin 10 years post-disturbance, >50% of the dominant native species characterising the target vegetation community (trees and shrubs) are observed to flower and fruit in the restoration site, or are able to following disturbance.<br>Evidence of natural regeneration and dispersal, including dispersing fauna (e.g. pollinators, emus, small mammals) present in the restoration site.<br>Obligate seeders have formed a seed bank.<br>Non-native seedling recruitment minimal (+/- <5%) |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **Ecosystem function (cont.)** | | | | | | | |
| Resilience/ recruitment | Substantial levels of resilience and recruitment relative to the reference (including return of appropriate disturbance regimes) are present. | Resilience to drought | Eucalyptus wandoo canopy | | | | Woodland ecosystem demonstrates survival and recovery from drought under natural conditions with moderate to high similarity to the reference ecosystem |
| Resilience/ recruitment | Substantial levels of resilience and recruitment relative to the reference (including return of appropriate disturbance regimes) are present. | Fire resilience | Eucalyptus wandoo survival | | | | Vegetation demonstrates resilience with high similarity to reference sites in response to fire. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **External exchanges** | | | | | | | |
| Landscape flows | Positive exchanges and flows with the surrounding environment in place for most characteristic species and processes (e.g., >75% of the reference) and highly likely to be sustained. | Movement of organisms | Foraging observations | Baseline fauna assemblages across the reference sites is understood.<br>An assessment identifying at least 20 target species to be monitored from key fauna groups based on sampling methods and species detectability is undertaken by a qualified expert.<br>The restoration plan identifies habitat requirements (e.g. flowering Eucalypts, insects in trees, varied woodland types) to support foraging and movement of animals within the restoration site and interactions with the surrounding landscape/remnant vegetation patches. | Monitoring across all sites demonstrates evidence of foraging of >50% target fauna, or is on a trajectory towards increasing forgaging of all target species. | Monitoring across all sites demonstrates evidence of foraging of >75% target fauna, or is on a trajectory towards increasing forgaging of all target species. | Within 10 years post-disturbance, monitoring across all sites demonstrates evidence of foraging of >75% target fauna, or is on a stable trajectory towards increasing forgaging for all target species<br>Absence of physical barriers (i.e. fences) between the retoration project and adjacent Nature Reserve so the potential for external exchanges is highly similar to, or on a secure trajectory towards, that of the reference ecosystem, as far as is practicable. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **External exchanges (cont.)** | | | | | | | |
| Gene flow | Positive genetic flow with the surrounding environment in place for most characteristic species (e.g., >75% of the reference) and likely to be sustained. | Species proxy | Observed pollinators (e.g. insects, birds) and travel distance. | Suitable flowering plants of high similarity with the reference ecosystem and that support geneflow between species are identified and locations and abundances considered in the restoration plan. | Habitat resources support (or are on trajectory to support) viable populations of target species.<br>>50% of the target species population are observed to flower and fruit in >50% of monitoring sites and demonstrated to be actively recruiting or on a trajectory toward maturity.<br>Observations of pollinators at >50% of monitoring sites. | >50% of the target species population are observed to flower and fruit in >80% of monitoring sites and demonstrated to be actively recruiting or on a maturing trajectory.<br>Habitat resources support (or are on trajectory to support) viable population of target species.<br>Observations of pollinators at >50% of monitoring sites with respresentatives of all major pollinator groups recorded across the site.<br>Evidence of natural regeneration and dispersal, including dispersing fauna (e.g. pollinators, emus) in the restoration site. | Phenology of vegetation (including flowers, seeds and fruit) is highly similar to, or on a secure trajectory towards, that of the reference ecosystem.<br>Observations of pollinators at >80% of monitoring sites with respresentatives of all major pollinator groups recorded across the site.<br>Evidence of natural regeneration and dispersal, including dispersing fauna (e.g. pollinators, emus) in the restoration site. |

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| Completion criteria | SER 4 star rating | Indicator | Evidence | Implementation/ Germination milestone criteria (e.g. yr 1-3) | Establishment milestone criteria (e.g. yrs 4-7) | Maturation milestone criteria (e.g. yr >7) | Completion criteria (e.g. 10 years) |
|---|---|---|---|---|---|---|---|
| **External exchanges (cont.)** | | | | | | | |
| Habitat links | Positive habitat links with the surrounding environment in place for most characteristic species (e.g., >75% of the reference) and likely to be sustained. | Habitat corridor | Distance between patches | Landscape mapping completed to identify and undertake strategic restoration form habitat corridors, incorporating adjacent remnant vegetation and linking to surrounding Nature Reserves.<br>Broadcast seeding and/or planting of corridors has been undertaken. | Distance between patch sizes between the restoration site and nearby remnant vegetation reduced from post-disturbance baseline.<br>Monitoring across all sites demonstrates evidence of foraging in connected habitats for >50% target fauna, or is on a trajectory towards increasing utilisation for all target species. | Distance between patch sizes between the restoration site and adjacent remnant vegetation of moderate to high similarity with the reference ecosystem.<br>Monitoring across all sites demonstrates evidence of foraging in connected habitats for >50% target fauna, or is on a trajectory towards increasing utilisation for all target species. | Within 10 years post-disturbance, the ecological communities and habitats at >80% of monitoring sites is of high similarity to, or on a stable trajectory towards, those of the adjacent Lake Bryde or Lake Magenta Nature Reserves.<br>Habitat connectivity within the restoration site is highly similar to, or on a stable trajectory towards that of the reference ecosystem.<br>Monitoring across all sites demonstrates evidence of foraging in connected habitats for >75% target fauna, or is on a trajectory towards increasing utilisation for all target species. |

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