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GUIDELINES

Reference Ecosystem

SUMMARY

This document provides Developers with guidelines for selecting an appropriate Reference Ecosystem for ERS Project Certification and outlines the methodology for assessing the ecosystem's condition.ERS's approach to assessing the state of the Reference Ecosystem is based on *International Principles and Standards for the Practice of Ecological Restoration*, Gann, G. D. et al. (2019).

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Reference Ecosystem

Selection

DEFINITION

ERS adheres to the definition of a Reference Ecosystem as outlined in the International Principles and Standards for the Practice of Ecological Restoration[1]: A Reference Ecosystem typically represents a non-degraded version of the ecosystem, including its flora, fauna, other biota, abiotic elements, functions, processes, and successional states. The Reference Ecosystem reflects what might have existed at the Restoration Site if degradation had not occurred, adjusted for current or anticipated environmental conditions.

The Reference Ecosystem is materialised by a Reference Site, defined as a currently intact site with attributes and a successional phase similar to the restoration project site[2].

The Reference Ecosystem and Reference Site(s) are used to create the Reference Model, which depicts the expected condition of the Restoration Site if degradation had not occurred (concerning flora, fauna and other biota, abiotic elements, functions, processes, and successional states). This condition is not historic but reflects background and predicted changes in environmental conditions.

ERS's quantification methodology and ecological recovery planning and assessment under M001 are based on a reference model coupled with local, traditional, and scientific knowledge.

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1 Gann, G. D., et al. (2019). International Principles and Standards for the Practice of Ecological Restoration. Available at: URL

2 Gann, G. D., et al. (2019). International Principles and Standards for the Practice of Ecological Restoration. Available at: URL

GUIDING PRINCIPLES

Selection of the Reference Site

1. The Reference Site must:

    1.1. Be accessible for the Developer to collect reference data to inform the baseline and, when necessary, be validated during Validation.

    1.2. Have not undergone significant anthropogenic disturbance in the last ten years. ERS must monitor this using satellite imagery to assess land cover degradation.

2. The Reference Site must present the following **six key attributes**[3]:

    2.1. **Absence of threats:** direct degradation drivers impacting the ecosystem's health, such as over-utilisation, contamination, and invasive species, are minimal or effectively absent.

    2.2. **Physical conditions:** the properties required to sustain the ecosystem, such as soils, water, and topography, are present, and their physical and chemical conditions are appropriate.

    2.3. **Species composition:** the array and relative proportions of organisms, native species characteristic of the appropriate ecosystem are present, whereas invasive species are minimal or effectively absent.

    2.4. **Structural diversity:** the physical organisation of living and non-living elements (e.g. forest layers and food webs), the appropriate diversity of key structural components, including demographic stages, faunal trophic levels, vegetation strata, and spatial diversity, are present.

    2.5. **Ecosystem function:** when assessing the roles and processes arising from interactions among living and non-living elements, the appropriate levels of growth and productivity, nutrient cycling, decomposition, habitat, species interactions, and types and disturbance rates are present.

[3] The Reference Ecosystem guiding principles, including the six key attributes, the scoring systems, and the Recovery Wheel were drawn from Gann, G. D., et al. (2019). International Principles and Standards for the Practice of Ecological Restoration and adapted to ERS's needs by ERS.

2.6. **External changes:** the flows between sites and the surrounding environments of the ecosystem are appropriately integrated and connected to allow for abiotic and biotic flows and exchanges.

3. These attributes must be used to characterise the Reference Site, evaluate baseline conditions on the Reference Site(s), and provide key indicators for the Project's desired restoration outcomes.

METHODOLOGY

The Field Assessment must be completed at the Reference Site(s) to determine the Reference model. The assessment is performed using ERS's App.

Following the Field Assessment, an ERS Certification Agent must transfer the data imputed by the Developer into the Ecological Recovery Assessment Tool, resulting in the Recovery Wheel.

The Recovery Wheel is the assessment's visualisation tool. It helps track the progress of restoration efforts by comparing them to the Reference Site.

Below are the values and conditions adopted by ERS to rate all attributes.

Score/ Attribute	One	Two	Three	Four	Five
Absence of threats	Some direct degradation causes (e.g. over-harvesting, overgrazing, active contamination) are absent, but others remain high in number and extent.	Direct degradation causes (including, e.g., sources of invasive species) are intermediate in number and extent.	The number of direct degradation causes is low overall, but some may remain intermediate in extent.	Direct degradation causes, both external and in the project zone, are low in number and extent.	Threats from direct degradation causes are minimal or absent.

Physical conditions	Most physical properties of the site's substrates and hydrology (e.g. soil structure, nutrients, and hydrological conditions) differ greatly from those of the reference ecosystem.	The physical and chemical properties of substrates and hydrology remain at low similarity levels compared to the reference ecosystem but are capable of supporting some reference animal and plant life.	The physical and chemical properties of substrates and hydrology are intermediately similar to those of the reference ecosystem and capable of supporting the growth of many characteristic native animal and plant life.	The physical and chemical conditions of substrates and hydrology are highly similar to the reference ecosystem and suitable for the continuous growth of characteristic native animal and plant life.	The physical and chemical conditions of substrates and hydrology are highly similar to those of the reference ecosystem, and there is evidence that they can indefinitely sustain all characteristic species and processes.
Species composition	Very high levels of non-native invasive or undesirable species. Some colonising native species are present (~2% if compared with the reference ecosystem).	Moderate levels of non-native invasive or undesirable species. A small amount of characteristic native species are present (~10% if compared with the reference ecosystem).	A subgroup of key native species is present. (up to 40% compared with the reference ecosystem)	The site has a significant diversity of characteristic species (up to 60% compared with the reference ecosystem), representing a wide diversity of species groups.	There is a high diversity of characteristic species across the site, with high similarity to the reference ecosystem (>80% compared with the reference ecosystem). Potential for colonisation of more species over time.
Structural diversity	One horizontal layer of the	More than one layer of the	Most layers of the reference	All layers of the reference	All layers of the reference

	reference ecosystem is present, but the spatial arrangement and trophic complexity differ greatly from those of the reference ecosystem.	reference ecosystem is present, and there is some similarity in spatial arrangement and trophic complexity relative to the reference ecosystem.	ecosystem are present with intermediate similarity of spatial arrangement and trophic complexity relative to the reference ecosystem.	ecosystem are present, and there is substantial similarity in spatial arrangement and trophic complexity relative to the reference ecosystem.	ecosystem are present with high similarity of spatial arrangement and trophic complexity. Further complexity and spatial arrangement can self-organise to highly resemble the reference ecosystem.
Ecosystem function	Processes and functions are at a foundational stage only, highly different from the reference ecosystem.	Compared to the reference ecosystem, the number and level of physical and biological processes and functions (including growth, decomposition, and soil processes) are low.	Compared to the reference ecosystem, intermediate numbers and levels of physical and biological processes and functions (including reproduction and dispersal) are present.	Compared to the reference ecosystem, substantial levels of physical and biological processes and functions are present.	All functions and processes are on a trajectory towards the reference ecosystem levels and showing evidence of being sustained.
External exchanges	Positive exchanges and flows with the surrounding environment (e.g., species,	Positive exchanges with the surrounding environment exist for a few characteristic	Positive exchanges exist between the site and surrounding environment for	Positive exchanges with the surrounding environment are in place for	There is evidence that exchanges with the surrounding environment are highly

	genes, water, fire) exist for very few species and processes.	species and processes.	intermediate levels of characteristic species and processes.	most characteristic species and processes and are likely to be sustained.	similar to the reference ecosystem for all species and processes and are likely to be sustained.

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