EKLIPSE

Knowledge & Learning Mechanism
on Biodiversity & Ecosystem Services

What is hampering current restoration effectiveness?

An EKLIPSE Expert Working Group report

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KEY FINDINGS

What is hampering the effectiveness of existing approaches that aim to restore biodiversity and ecosystem function and services?

Barriers to effective ecological restoration were identified by two methods:

a. three-stage Delphi process with European experts, and
b. a scoping review of the global literature.

What is effective ecological restoration?

Through a three-stage Delphi process, European Experts identified effective ecological restoration to be actions which:

a. Aim to enhance ecosystem services, functions and biodiversity.
b. Assist and hasten natural recovery towards self-sustaining systems.
c. Include prior assessment, monitoring and adaptive management.

The Key Findings of this Report refer to these understandings of effective ecological restoration.

Findings - Three- stage Delphi Process:

1. Restoration is complex, and barriers are numerous, diverse and interconnected.
2. **Four key groupings of barriers** for effective restoration are:
    a. Insufficient funding
    b. Low political priority for restoration
    c. Conflicting interests of different stakeholders
    d. Lack of integrated land use planning
1. **Key needs** to enable more effective ecological restoration by knowledge exchange:
    a. ***Overcome gaps*** in knowledge: understanding of the functioning, structure and dynamics of habitats, including key attributes and management requirements.
    b. ***Overcome a lack*** of best practice knowledge exchange, including platforms to create a collaborative approach in research and practice with continual updating and new insights.
    c. Overcome flaws in the implementation of restoration protocols: including clear long-term monitoring programmes to learn more about specific contributions and their effects, efficiencies and overall effectiveness of actions in terms of ecological, social, political, economic and governance contexts***.***

Findings- Global Scoping Review

1. Key areas for effective restoration are:
    a. Policy, economy and society
    b. Science
    c. Practice
    d. Environment
2. Key barriers for effective restoration are:
    a. The lack of a long-term monitoring of restoration outcomes
    b. The lack of a clearer definition of goals and planning
    c. The lack of effective research methodologies
3. Key enabling factors for effective restoration are:
    a. Use of appropriate and well-tailored restoration techniques
    b. Societal integration with the restoration project
    c. Success assessment and evaluation

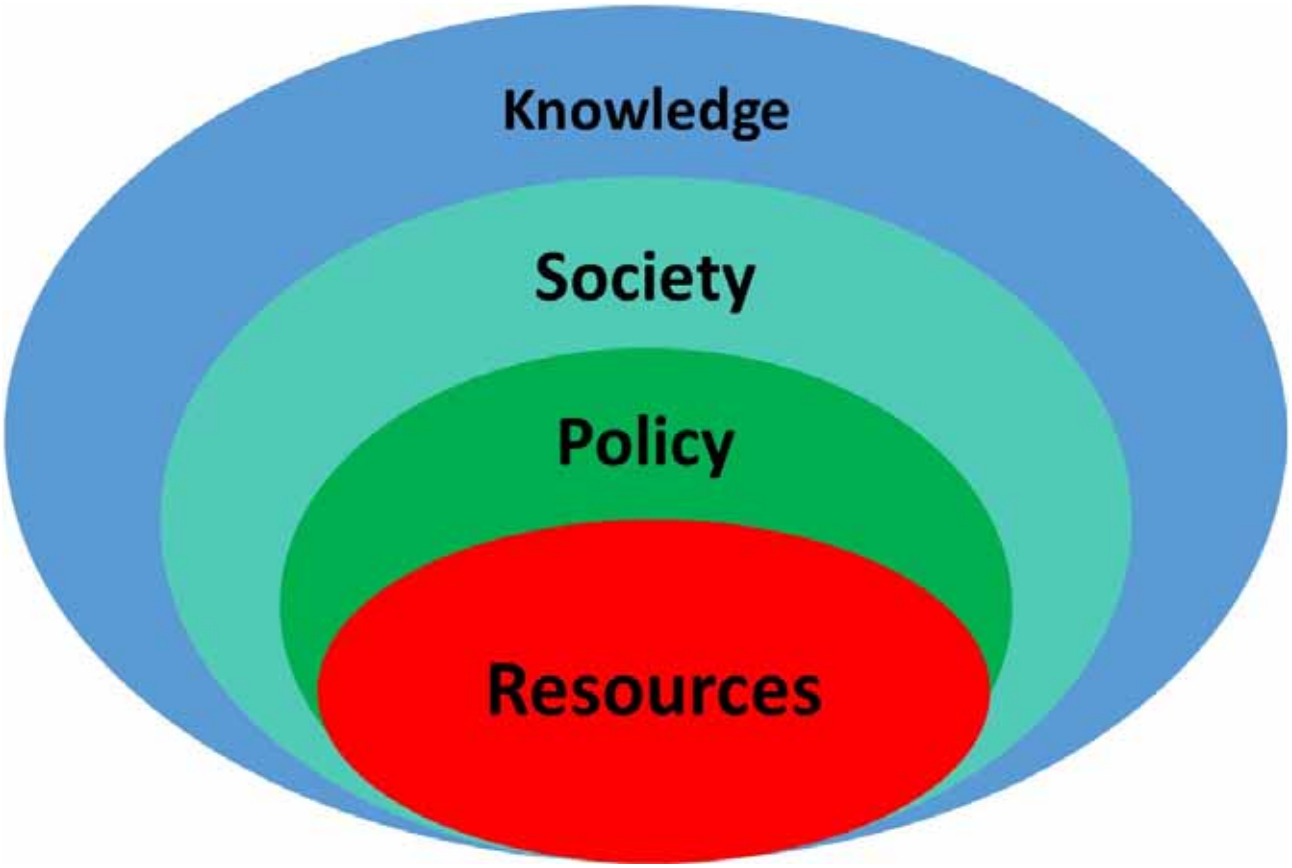
KEY RECOMMENDATIONS

Resourcing and Incentives – Make Restoration Possible (page 42)

Policy - Make Restoration Count (page 42)

Society – Make Restoration a Preferred Option (page 43)

Knowledge – Transfer, Link, Network and Facilitate Use of Knowledge (page 43)



Visual representation of the interactions between the four key groupings of barriers

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Glossary of Key Terms

Term	Definition
Adaptiveco-management	A governance approach to managing complex socio-environmental systems through successive cycles of participation, learning and doing
Brownfields	Abandoned lands, usually urban or industrial, barren and very often polluted
Ecosystem resilience	Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks. Walker, B., L. Gunderson, A. Kinzig, C. Folke, S. Carpenter, and L. Schultz**.** 2006. A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and Society* **11**(1):13. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art13/
Gene flow	"movement of genes among populations of species" For example, in plants, gene flow may occur through pollen grain, seeds, and vegetative propagules. While seed and pollen movement can be quite different and influence genetic structure differentially, for population demographic processes (i.e. colonization), seed dispersal, or dispersal of vegetative propagules for many species, can be the key. Consideration of gene flow and population fragmentation has crucial implications for ecological restoration at a landscape scale. http://www.nceas.ucsb.edu/~sork/
Governance	The structures and processes where policy makers, business actors, civil society scientists and others interact to make and implement decisions related to restoration.
Green infrastructure	A variety of environmental landscapes that operate at different scales and make part of an interconnected ecological network.
Knowledge	Facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject.
Mineralization	In this context, the decomposition of the organic matter in the soil to form soluble inorganic compounds available to plants
Silo effect	isolation and compartmentalisation resulting in lack of communication and collaboration
Social-ecological resilience	Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks. Ecological restoration can enhance ecological resilience for example by supporting ecosystem processes that help to sustain the ecosystem. Ecological restoration can also enhance social resilience for example by promoting public participation, learning, and creating new social networks.
Stakeholder	Anyone who has an interest in the restoration process. These may be landowners, business actors, people who live in the vicinity of the restored sites, or people who use the restoration site. Recently concept of right holder has emerged, and used for example in connection with indigenous people, who not have only an interest, but traditional/ customary rights on the area under restoration.

Term	Definition
Trophic relations	Networks of relationships between organisms that feed on each other.
Urban sprawl	Suburban expansion of cities and towns beyond their original limits, often characterized by low-density residential housing and single-use zoning
Water-smart solutions	Strategies and actions for sustainable water management

Report Summary

Target 2 of the EU Biodiversity Strategy states that "By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems".

The Biodiversity Strategy is the only EU policy document that contains a direct and quantitative target for restoration. However, many other European Union level policies, including the Birds and Habitats Directives, the Water Framework Directive, and the Common Agricultural Policy, relate to restoration aims in indirect ways.

The need to upscale restoration effectiveness across the European countries could never be more urgent. Numerous recent key Reports have identified restoration as key to overcoming biodiversity and climate challenges (eg Diaz et al 2019, Arnet et al 2019). At the closing statement of the UNCCD COP14 Climate Action Summit in September 2019, the Executive Secretary Mr. Ibrahim Thiaw, stressed that land restoration, at proper scale, is one of the cheapest solutions to address the global crises of climate and biodiversity loss.

As highlighted in the recent Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) Assessment Report on Land Degradation and Restoration (Scholes et al., 2018) Restoration actions occur across a diversity of ecosystem types and have the potential, if implemented effectively, to improve human well-being, improve ecosystem functions and biodiversity and enhance the wider natural environment;

Gaining a better understanding of the limitations to effective restoration can provide evidence to support more effective investments in restoration. This knowledge can also support stakeholders from wide ranging fields, with the outcomes being to reduce the degradation of landscapes. Reduced degradation provides opportunities to improve climate resilience and mitigation, improve food security and improve human well-being.

In this context, during the second call for requests (CfR.2/2017) the EKLIPSE project received a request from BiodivERsA[15], focused on the identification of knowledge gaps on ecosystem restoration. More specifically, the requester wanted to know *What is hampering the effectiveness of existing approaches that aim to restore biodiversity and ecosystem function and services?*

The topic of this request has gained high policy relevance and importance following the approval of the United Nations Decade on Ecosystem Restoration (2021 to 2030), by the General Assembly on the 1st March 2019. This initiative aims to promote the restoration of degraded or destroyed ecosystems globally as a means of combating the impact of climate change and biodiversity loss, and to increase food security and water supply. This offers an unprecedented opportunity from the European perspective to implement the findings from this Report, to advance restoration effectiveness across Europe in response to increasing global pressures to scale up restoration actions.

To respond to this request, EKLIPSE selected 12 experts from 8 European countries (Czech Republic, Finland, Greece, Ireland, Netherlands, Portugal, Spain, United Kingdom and 1 non-European Country (Australia), to form an Expert Working Group (EWG), which initially met in

[15] http://www.biodiversa.org

Brussels in July 2018 and continued to meet remotely, on a weekly basis until the completion of the Report.

Two distinct approaches were implemented to respond to this question: a scoping review of the global literature and a three stage Delphi process with additional European experts from a range of sectors and countries. The global literature scoping review identified three Key Barriers to effective restoration as:

a. The lack of a long-term monitoring of restoration outcomes.
b. The lack of a clearer definition of goals and planning.
c. The need for better research methodologies.

with the Key Enabling factors being:

a. Use of appropriate and well-tailored restoration techniques.
b. Societal integration with the restoration project.
c. Success assessment and evaluation.

The four Key Groupings of Barriers identified in priority order by the Delphi process were:

1. Insufficient funding.
2. Low political priority for restoration.
3. Conflicting interests of different stakeholders.
4. Lack of integrated land use planning.

During the Delphi process Experts identified key solutions to overcome these Barriers (1-4) above. Taking into consideration all the findings of our work, recommendations to overcome the barriers have been provided and grouped around the key groupings of barriers:

1. Resourcing and Incentives – make restoration possible.
2. Policy – make restoration count.
3. Society – make restoration a preferred option.
4. Knowledge - make it into life-long learning, link, network and facilitate use of knowledge.

We hope you enjoy reading our Report and making use of our findings during upcoming restoration actions across Europe.

1. Introduction

1.1 Background to the Report

A number of restoration targets and cross-sectoral actions aim to restore degraded ecosystems, both as natural heritage to safeguard biodiversity and as a natural asset vital to enhance ecosystem functioning and sustainable delivery of a range of ecosystem services in Europe. However, many of these efforts are not achieving their aims, with the reasons expected to be wide ranging, and broader than lack of, or poor access to relevant knowledge (Ockendon et al., 2018). Gaining understanding of the limitations to effective restoration investments can support stakeholders from a wide range of fields, such as restoration practitioners and specialists in ecological engineering, circular economy, water-smart solutions, species and landscape management, reducing degradation of landscapes, climate resilience/mitigation, food security and restoration technologies, providing opportunities to better contribute to the EU's industries and economic sectors that are dependent on these natural assets (e.g. water- and fibre-related/dependent industries), as well as improve human well-being (EKLIPSE Secretariat, 2018).

1.2 The Request

In this context, the EKLIPSE project (EKLIPSE 2018) received and accepted a request following the EKLIPSE second call for requests (CfR.2/2017). The requester was BiodivERsA, a network of national and regional funding organizations promoting pan-European research on biodiversity and ecosystem services and offering innovative opportunities for the conservation and sustainable management of biodiversity. The initial request focused on the identification of knowledge gaps on ecosystem restoration, asking "Is missing knowledge hampering the effectiveness of approaches that aim to restore biodiversity and ecosystem function and services?". In order to refine the request, EKLIPSE carried out scoping activities between October 2017 and May 2018 resulting in a Document of Work (EKLIPSE Secretariat, 2018) with a revised question:

"What is hampering the effectiveness of existing approaches that aim to restore biodiversity and ecosystem function and services"

Afterwards, EKLIPSE put out a call and ultimately selected 12 experts to form an Expert Working Group (EWG) from 8 European countries (Czech Republic, Finland, Greece, Ireland, Netherlands, Portugal, Spain, United Kingdom and 1 non-European Country (Australia). This EWG initially met in Brussels in July 2018 and again in October 2018 and continued to meet remotely, on a weekly basis until the completion of the Report. The EWG identified a structured process for responding to the Request, which is outlined under the section Methodological Approach. This document outlines the choice of methodology, details of the methodology and outcomes.

2. Context

2.1 Policy and legal framework at the European Level

To fully understand the interconnecting reasons for limited effectiveness of restoration, we required the perspectives and understandings of a wide range of stakeholders including, but not limited to, practitioners, landscape managers, business, specialists, academics, Non-government Organisations (NGO), Environmental Non-Government Organisations (ENGO), policy makers and decision makers, all of whom may be working across diverse fields such as climate responses, food

security, biodiversity, circular economies, restoration technologies, water-smart solutions and other industries and economic sectors. Restoration actions occur across a diversity of ecosystem types and have the potential, if implemented effectively, to improve human well-being, improve ecosystem function and biodiversity and enhance the wider natural environment. The recently completed Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) Assessment Report on Land Degradation and Restoration highlights this (Scholes et al., 2018).

Effective evaluation and monitoring of restoration projects have not occurred, which provides a barrier to understanding restoration outcomes, as restoration goals remain unassessed or unattained, (González et al., 2015; Suding, 2011). For example, in the case of water bodies subject to the Water Framework Directive, after two updates of River Basin Management Plans (in 1999 and 2015), country reports showed that a substantial proportion of Europe's freshwaters did not achieve 'good status' (European Waters: Assessment of Status and Pressures, 2018). Other Directives for which restoration is relevant include the European Union (EU) Bathing Water Directive for which a recent report outlines the current state of bathing water under this directive (European Environment Agency, 2019) and the Marine Strategy Framework Directive (The European Parliament and the Council of the European Union, 2008), which are concerned respectively with achieving good ecological status in lakes and rivers or good environmental status in marine waters, and the Birds, Habitats and Mining Waste Directives. Restoration of degraded ecosystems would also contribute significantly to the deployment of Green Infrastructure (Action 6b of the EU Biodiversity Strategy) and will be a major asset of the future proposals related to the Common Agricultural Policy (European Commission, 2018). However, there is limited commonality across these Directives and Strategies.

Target 2 of the European Union Biodiversity Strategy states that "By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems". A number of actions have been completed to address this Target (http://ec.europa.eu/environment/nature/biodiversity/strategy/target2/index_en.htm). The findings of the mid-term review of the European Union Biodiversity Strategy (2015) highlight that for Target 2 "Progress has been made on policy and knowledge improvement actions under this target, and some restoration activities have taken place in Member States. However, this has not yet halted the trend of degradation of ecosystems and services. National and regional frameworks to promote restoration and green infrastructure need to be developed and implemented" (Lammerant et al., 2014).

The European Union Biodiversity Strategy is the only policy document that contains a direct and quantitative target for restoration. However, many other European Union level policies, in addition to those mentioned above, relate to restoration aims in indirect ways with examples provided below (EKLIPSE Secretariat, 2018):

a. There is a very strong linkage between the 15% restoration objective included in Target 2 of the European Union Biodiversity Strategy and the achievement of Target 1, namely the full implementation of the Birds and Habitats Directives and associated Natura 2000 network.
b. Restoration of degraded ecosystems will contribute significantly to the deployment of Green Infrastructure (Action 6b of the biodiversity strategy).
c. Restoration of disused and derelict land in urban and peri-urban areas will ease the pressure for access to new land for development and reduce soil sealing and urban sprawl.

d. Restoration actions can also deliver jobs and growth and a variety of economic and social benefits. Restoration actions have been and continue to be supported through European Union funding mechanisms such as the European Regional Development Fund (ERDF), the European Agricultural Fund for Rural Development (EAFRD) and Horizon 2020.

e. Restoration can increase greenhouse gas uptake and the resilience of natural ecosystems and human settlements to the impacts of climate change and is an integral part of European Union policy on climate change adaptation.

f. The greening measures introduced into the revised Common Agricultural Policy (CAP) could provide opportunities for restoring the state of agri-ecosystems and optimizing the services delivered by these ecosystems and their resilience.

g. Ecological Restoration will contribute to the achievement of the good ecological status of water bodies as established by the Water Framework Directive.

2.2 Regional and International Context

In addition to European Union policies, restoration is highly relevant in the context of several international conventions such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, the United Nations Convention to Combat Desertification, the Land Degradation Neutrality target, the Ramsar Convention, UN Strategic Plan on Forests 2017 – 2030, and the Bonn Challenge (2011) to bring 150 million hectares of the world's deforested and degraded land into restoration by 2020, including 350 million hectares by 2030.

More recently, this request gains high policy relevance and importance following the approval of the United Nations Decade on Ecosystem Restoration (2021 to 2030), by the General Assembly on the 1st March 2019. This initiative aims to promote the restoration of degraded or destroyed ecosystems globally as a means of combating the impact of climate change and biodiversity loss, and to increase food security and water supply by incorporating the international community, including governmental and non-governmental actors, UN agencies and civil society. The declaration emphasises the scaling-up of restoration to address the severe degradation of landscapes, including wetlands and aquatic ecosystems worldwide. It is anticipated that there will be a boost in landscape restoration to the top of national agendas building on a public demand for action on issues such as climate change, biodiversity loss, and the resulting impacts on economies and livelihoods. Adding to previous efforts, the United Nations Decade on Ecosystem Restoration offers an unprecedented opportunity from the European perspective, to implement the findings from this EKLIPSE Report, to advance restoration effectiveness across Europe in response to increasing global pressures to scale up restoration actions.

The development of the methodologies for this Report and its findings have also provided opportunities for Restoration Experts to engage across disciplines, including interacting with those working in Policy formulation and implementation, which appears to have been a failing in restoration effectiveness in the past (Jørgensen et al., 2014).

2.3 Evaluation of restoration effectiveness

A number of approaches have been proposed to increase the effectiveness of restoration actions, such as the Society of Ecological Restoration Standards (Gann et al., 2019) and the IPBES Land Degradation and Restoration Assessment (Fisher et al., 2018), while other approaches such as the

Best Available Techniques (BAT) (Giljam, 2017) proposed for the European Union may well provide mechanisms to assess the effectiveness of restoration actions.

Much discussion has occurred around incorporating the ecosystem service concept into the science, practice and policies of ecological restoration (Tolvanen & Aronson, 2016). The methodology adopted by the EKLIPSE Expert Working Group (EWG) aims to identify barriers to effective restoration when linking interactions between restoration, ecosystem services and biodiversity and including wide ranging groupings of stakeholders and a multiplicity of disciplines. Bullock et al. (2011) provide examples of effective interactions between restoration, ecosystem services and biodiversity in i) the restoration of native jarrah forest on bauxite mines in Western Australia enhancing plant and vertebrate diversity as well as carbon sequestration and water storage, ii) restoration management of the Arkansas River, by the cessation of heavy metal inputs which has increased water quality and enabled the recovery of fish and invertebrate populations, and iii) the reinstatement of meanders in German rivers which has both decreased flooding risk and increased the diversity of the invertebrate fauna.

The reasons for the limited effectiveness of restoration are currently being explored at different levels including scientific, applied, ecological, social and economic perspectives (see, for example, Christian-Smith & Merenlender, 2010; Palmer et al., 2010; European Topic Centre on Inland Coastal and Marine, 2015; Nilsson et al., 2016; Gellie et al., 2018). Indeed, restoration projects have been considered a social phenomenon (Kondolf & Yang, 2008), as they cannot be properly undertaken without considering the socio-economic context of the ecosystem to be restored (Swart et al., 2018). The proper assessment of barriers and opportunities for improving ecosystem restoration needs to incorporate the identification of both knowledge gaps and the experience of relevant social actors in the planning, implementation and assessment of restoration.

3. Objectives of this Study

The aim of this report is to assess the current knowledge (from science and practice) on the reasons hampering restoration effectiveness across the European Union and to orient future research, policy and practice on ecosystems restoration. We propose that the findings of this Report will help identify the underlying reasons for the recognised barriers, and with an understanding of theses causes and their consequences, provide solutions to overcome them. The analysis includes both a review of produced knowledge (through a scoping review) and the integration of relevant restoration actors' experiences (through a Delphi process). The Delphi process included stakeholders and actors from a wide range of fields, including private landholders, landscape architects, ecological engineers, farmers and experts and practitioners in circular economy, water management, species and landscape management and restoration, policy and governance, to provide feedback which will better contribute to the European Union's Policy Frameworks, their implementation, governance and conservation strategies while assisting practitioners, researchers, industries and economic sectors that are dependent on the natural assets which benefit from restoration actions.

4. Methodological Approaches

The EWG, during its preliminary discussions recognised the importance of understanding the key ecological, social, governance, legislative, economic, financial, technical, cultural and political barriers which may hamper effective restoration. For this reason, the EWG decided to run two

parallel approaches to the widest view of the issue within the time frame and resources available. Restoration, when approached effectively, incorporates many domains. We aimed to ensure that we tackled the Request to cover as wide a range of sectors and disciplines as possible, thus avoiding problems often created by silo thinking and approaches.

The two parallel and complementary approaches employed were:

a. Literature Scoping Review.
b. Delphi process.

They were presented in a Draft Protocol, which was available for external comment on the EKLIPSE web site for one month. We received helpful responses from 18 reviewers, which were incorporated into the finalization of the Methodology. The two approaches were conducted in parallel and designed in a manner that the results were complementary to each other, with the Report conclusions resulting from a cross analysis of the two sets of findings. In some cases, different terms are used between the two approaches, for example key elements and key components, as we chose in the case of the Delphi to retain as much as possible the exact words used by the participants to keep maximum fidelity with their responses.

5. Scoping Review of the Literature

5.1 Methods

The scoping review utilised conventional reviews, systematic reviews, and meta-analyses with an aim to find strong evidence-based qualitative barriers hampering the performance of restoration globally. As we were searching for well supported barriers, our approach enabled us to access primary data of barriers supported by a large number of studies and prevented the review of a large number of individual studies which may not have led to robust findings.

The following search parameters were used in the Web of Science:

- Field 1: Topic: “ecosystem* and (review or meta-analysis)”
- Field 2: Title: “restor*”
- Years: custom range: 1999-2019.
- Database used: Web of Science Core, ticking on:
  - Science Citation Index – Expanded
  - Social Science Citation Index
  - Emerging Science Citation Index

Our initial search resulted in 339 hits, with papers then selected based on i) the match between the titles and the subject of the study (285 reviews), and ii) the match between the abstracts and the subject of the study (164 reviews).

5.1.1 Search variables

Two categories of required information were established for searches within these studies:

Barrier (B): A limitation in the application of restoration techniques or in the success of a restoration project in general.

Enabling factors (EF): elements determined as critical or essential in the development of the restoration project.

To establish if a given factor limits, i.e. is a barrier (e.g. deficient regulatory frameworks, dominance of social interests over ecological processes, prohibitive cost), or enables, i.e. is an enabling factor (e.g. facilitates regulatory frameworks, integration of stakeholder interests and ecological needs, affordable cost) it was required to be strongly supported by evidence both from a quantitative and a qualitative perspective.

Factors which were preceded by the terms "could be", "may be", or "might be", were rejected while those preceded by terms such as "it is" or "it has been" were accepted.

5.1.2 Review rejection criteria

The main reasons to reject reviews within the 164-paper selection were:

a. Lack of strong evidence. Some reviews mentioned barriers without providing clear support for them and with not enough evidence.
b. Lack of connection with restoration. Some articles showed a description of ecological processes with no restoration aims.
c. Lack of information about variables. The study did not provide information about any critical issues related to barriers or enabling factors.

5.1.3 Collection of information

The following were collected per selected study: author, year of publication, geographic range (included the countries, regions, states or provinces area included in the review), ecosystem type, ecosystem category (terrestrial, aquatic, mixed or marine), overall description, study type (review, systematic review, or meta-analysis), number of studies (number of papers included), number of sites (number of restoration projects or experimental programs included), time range (time frame covered), quantitative data (numerical value of the variable, when present).

5.1.4 Barriers and enabling factors

After applying the search criteria, 131 reviews (Appendix 1) were retained.

Extracted variables from the retained reviews were grouped according to the nature of the information as provided:

i. Policy, economy and society includes variables related to regulations and policy, socio-economic factors and social factors affecting the performance of restoration.
ii. iScience: Factors affecting restoration related with research methodologies.
iii. Practice: On the ground implementation of restoration efforts based on existing knowledge.
iv. Environment: Environmental factors, including interactions among organisms and between organisms and the environment, affecting the performance of the restoration.

5.1.5 Weight Assignment

We used factors as proxies to evaluate the importance of each key element against that factor. These were:

a. Bibliographic weight. The bibliographic weight is the combination of the number of variables (Nv) contained in each Key Element for Environmental Restoration (KEER), and the number of studies analysed within each review where Nv were found (Ns). This weighting factor is an estimation of the importance that authors give to each KEER throughout the existing literature. It assumes that the more times a variable is noted in the literature and the larger amount of the literature reinforces it, the higher is its importance and hence, its weight.

b. Time range: time period covered by the review, estimated as the publication date of the first and last study included in the review.

c. Geographic range: area covered by the studies included in the review. Area was measured at the level of country, state, region or province according to the information provided in the review.

These three factors were integrated into one combined analysis to obtain a total weighting of importance. A detailed explanation of these analyses can be found in Appendix 2. Limitations of the data analysis and interpretation are outlined in Appendix 3.

5.2 Results

From the 131 analysed reviews (Appendix 1), we extracted 579 variables (424 barriers and 155 enabling factors) that were grouped in 25 key categories (Table 1). Categories included barriers to restoration and key elements fostering restoration. Collectively, they were named as key elements for ecological restoration (KEER) and their descriptions can be found in Table 1. Eighty per cent of the analysed reviews were conventional reviews, 16% meta-analyses and 4% systematic reviews (Figure 1).

Table 1. Key elements (KEER) found to affect ecosystem restoration performance. B: barriers; EF: enabling factors.

KEER	Description of the information contained	B	EF	Total
Policy, economy and society				
1.Socio-economic knowledge	Economic cost considerations, cost-benefit analysis and economic valuation	7	1	8
2.Land-tenure rights	Different goals for different land owners	5	2	7
3.Economic costs of restoration	Economic cost resulting from the application of a technique or the use of a specific resource	12	4	16
4.Policies and governance	Political approaches, regulations, international cooperation and governance affecting restoration	18	7	25
5.Societal integration	Degree of stakeholder and local community involvement	18	20	38
6.Funding	External economic inflows to fund restoration	8	1	9
7.Payment for ecosystem services	Economic compensation to local communities in exchange for commitments with restoration efforts	5		5
Total		**73**	**35**	**108**
Science				
8. Geographic bias	Research bias towards specific regions (e.g. North America), versus other regions (e.g. tropical areas)	7		7

KEER	Description of the information contained	B	EF	Total
9. Integration of existing scientific knowledge	Application of current and available scientific knowledge within a project or technique	13	3	16
10. Knowledge on ecosystem structure and function	Level of knowledge about ecosystem structure (e.g. species interactions), processes (e.g. mineralization), and dynamics (e.g. trophic relations)	27	11	38
11. Knowledge on genetic	Level of knowledge about genetic diversity, population genetics, and gene flows	7	7	14
12. Methodological limitations	Methodological issues in restoration research related to field surveys, experimental design, data analysis or consistency of published results	23		23
13. ***Research about restoration practices***	Need of reinforcing the scientific evidence behind the restoration techniques and practices used	9		..9
Total		**86**	**21**	**107**
Practice				
14. ***Restoration techniques***	Use of certain types of techniques and the way in which these are applied	25	42	67
*15.***Success assessment and evaluation**	Use of available success assessment tools (e.g. monitoring techniques, indicators) and success evaluation criteria	45	12	57
16.Project planning and goal definition	Limitations, irregularities and critical points related to the definition of goals, project design, and action routes	27	6	33
17. Instruments, technology and resources	Availability of a required technology or material (e.g., seeds, seedlings)	10	2	12
18. Temporal scale	Duration of factors like implementation, funding, or monitoring	27	7	13
*19. Context-**specific** factor* ***consideration***	Integration of local factors and climate constraints	12	4	16
Total		**146**	**73**	**219**
Environment				
20. Historical land-use	Lagged effects like soil contaminants and paucity of seed bank	19		19
21. *Ongoing degradation*	Degradation processes act as a consequence of current activities as agriculture, water flow regulation, or tourism	23	5	28
22. Invasive species	Presence of non-native species leading to limited biodiversity and functionality	12		12
23. ***Intrinsic abiotic factors***	Abiotic elements (e. g. weather conditions or soil structure) constrain or favour recovery	14	8	22
24. ***Intrinsic biotic factors***	Biotic elements (e. g, predators or seed dispersion ability) constrain or favour recovery	37	6	43
25. Spatial scale	Effects of the spatial scale on the recovery process (e. g., landscape processes, watershed processes)	12	4	16
Total		**119**	**26**	**146**
Total		**424**	**155**	**579**

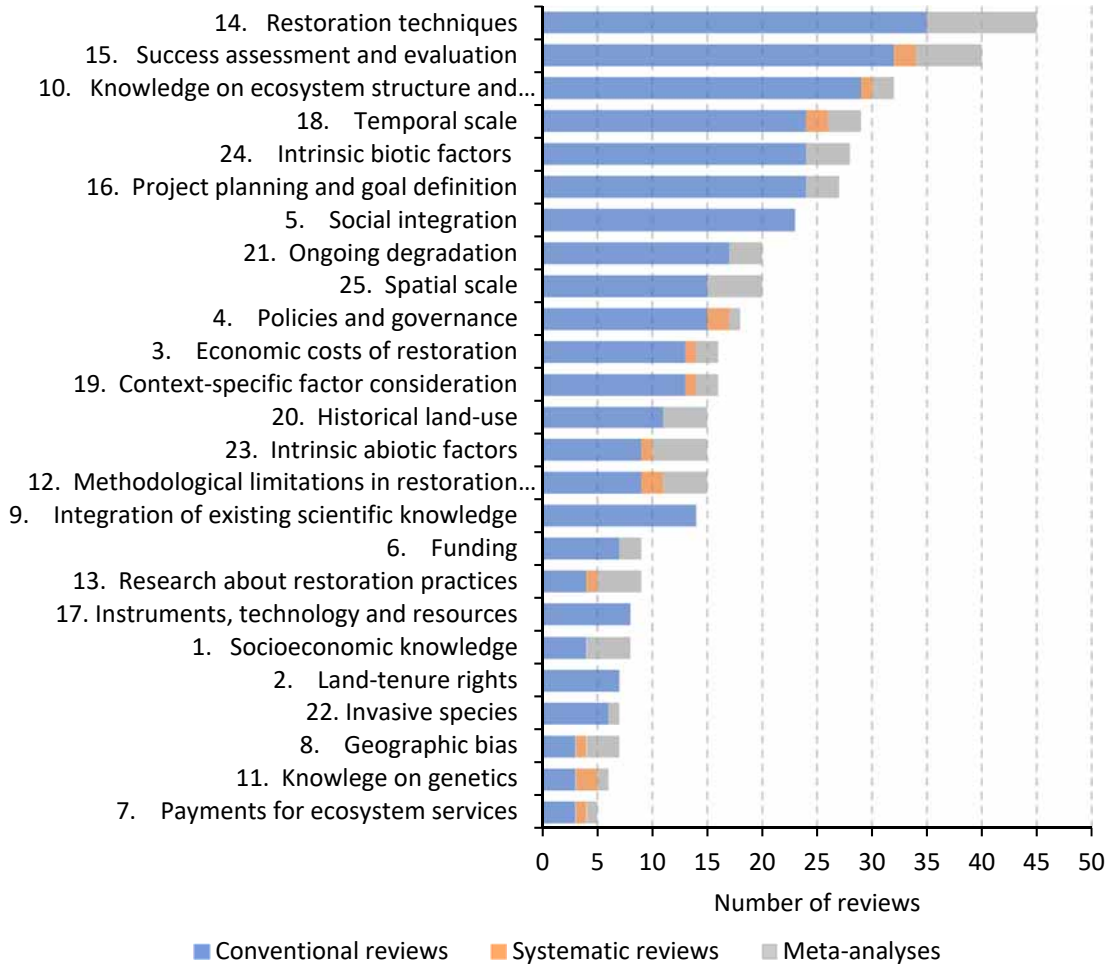


Figure 1. Number and type of reviews per Key Element for Environmental Restoration (KEER) and general composition of the database, some of the reviews addresses more than one KEER

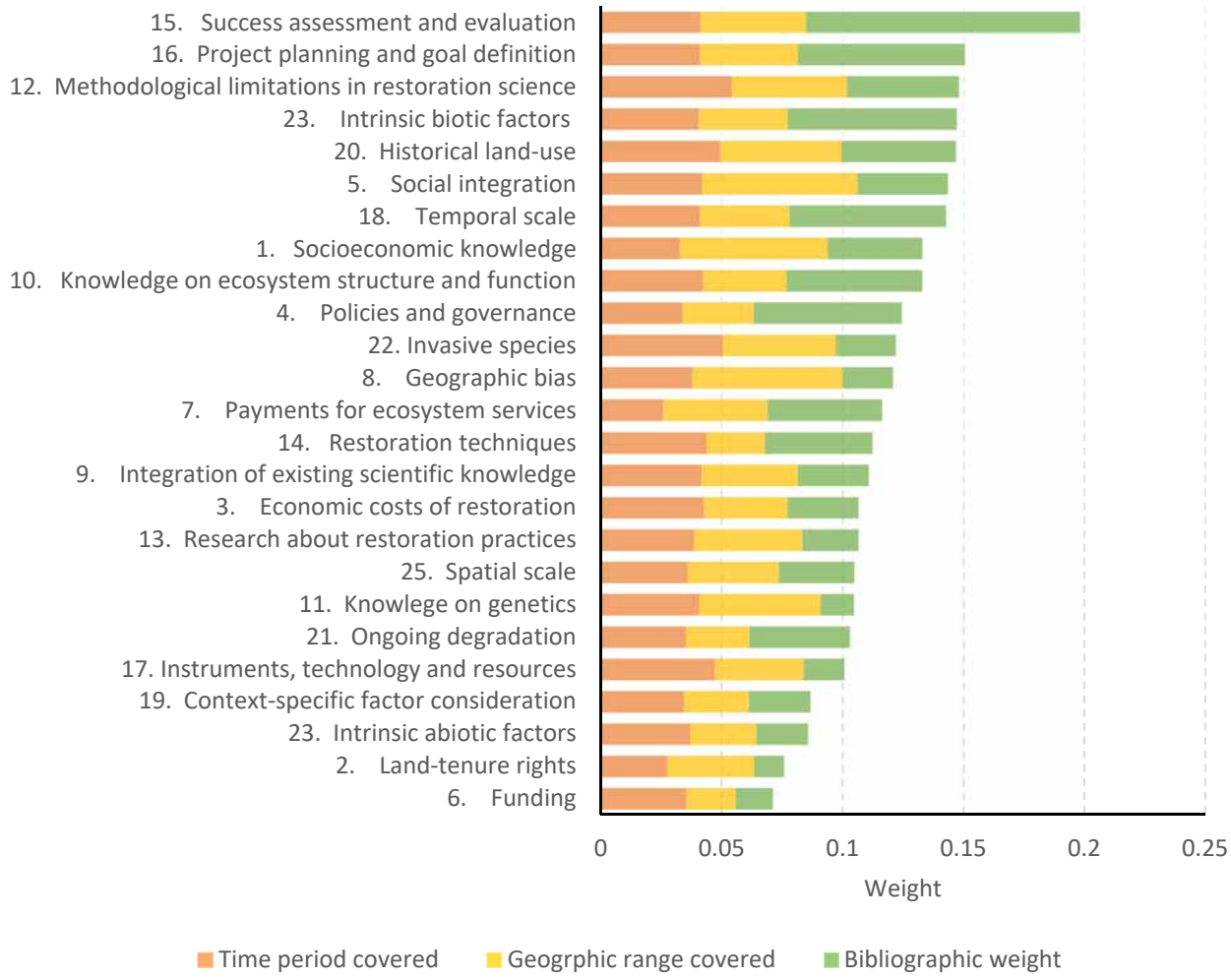


Figure 2. Relative weight assignments to the barriers found in reviews

The total assigned weight, representing the effect of time in years, geographic range and bibliographic weight to the barriers showed that the lack of success assessment and evaluation was the most weighted barrier (Fig. 2 and 3). It was followed by restoration planning and goal definition and by research methodologies. This last barrier was identified for the longest time and across a wide geographic range and has been repeatedly found in the literature. Societal integration was the most widely distributed barrier although it had a low bibliographic representation. Additionally, the analysis also highlighted important weights of biotic factors intrinsic to the restored area and the temporal scale at which restoration is planned. Results were consistent for the two weighting approaches used.

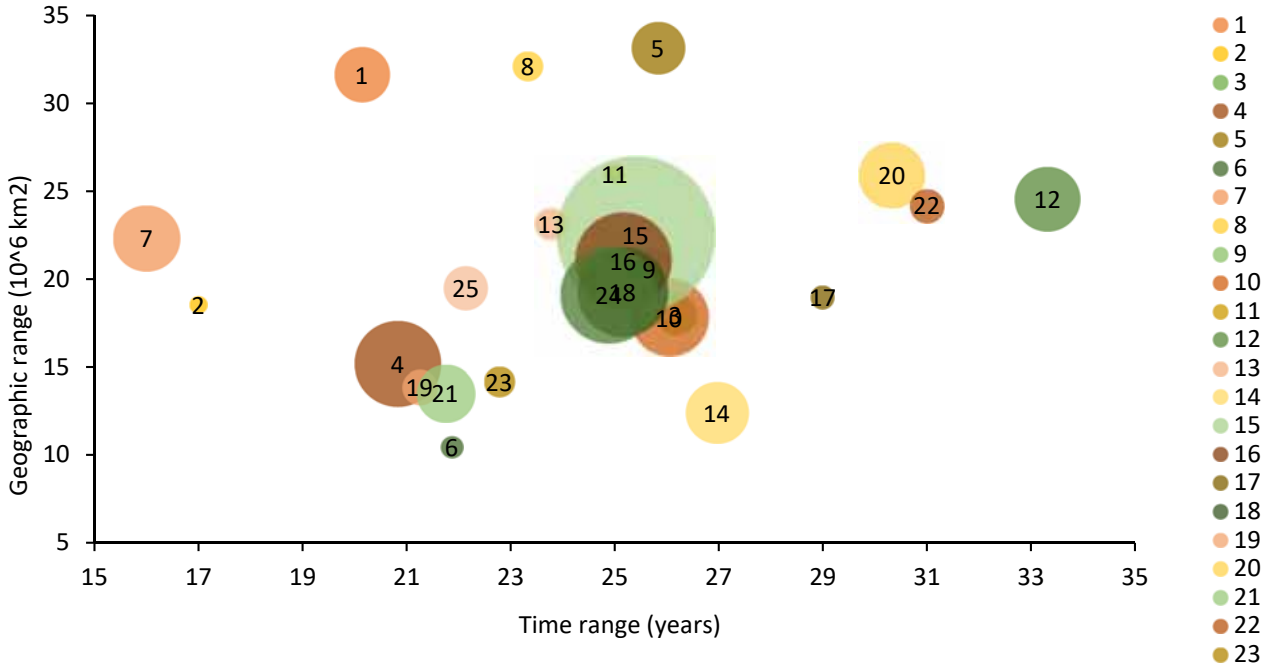


Figure 3. Weighting analysis for barriers found in the selected reviews. Assigned weights were time range covered by the review (X axis), geographic range (Y axis), and amount of time cited in the selected reviews.

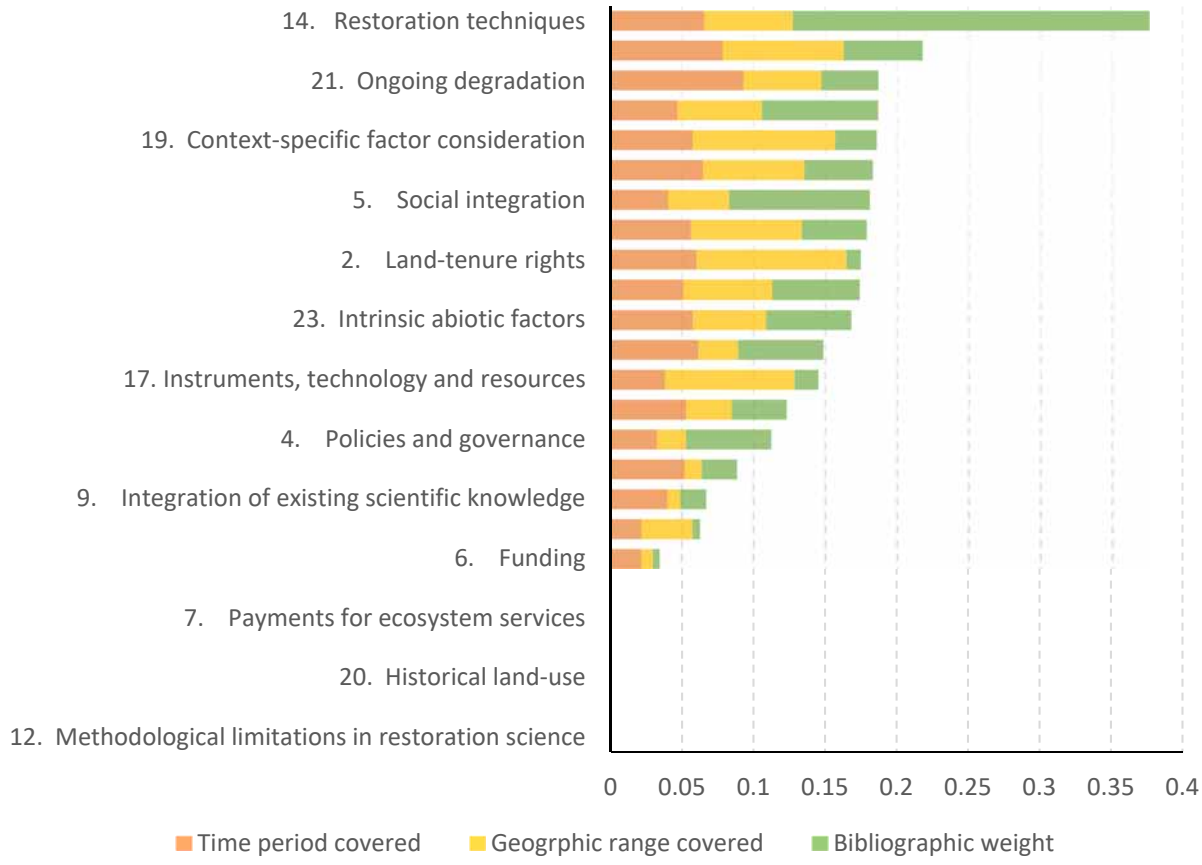


Figure 4. Weight assignment to the enabling factors found in the selected reviews. Only the bibliographic weight is included in this figure.

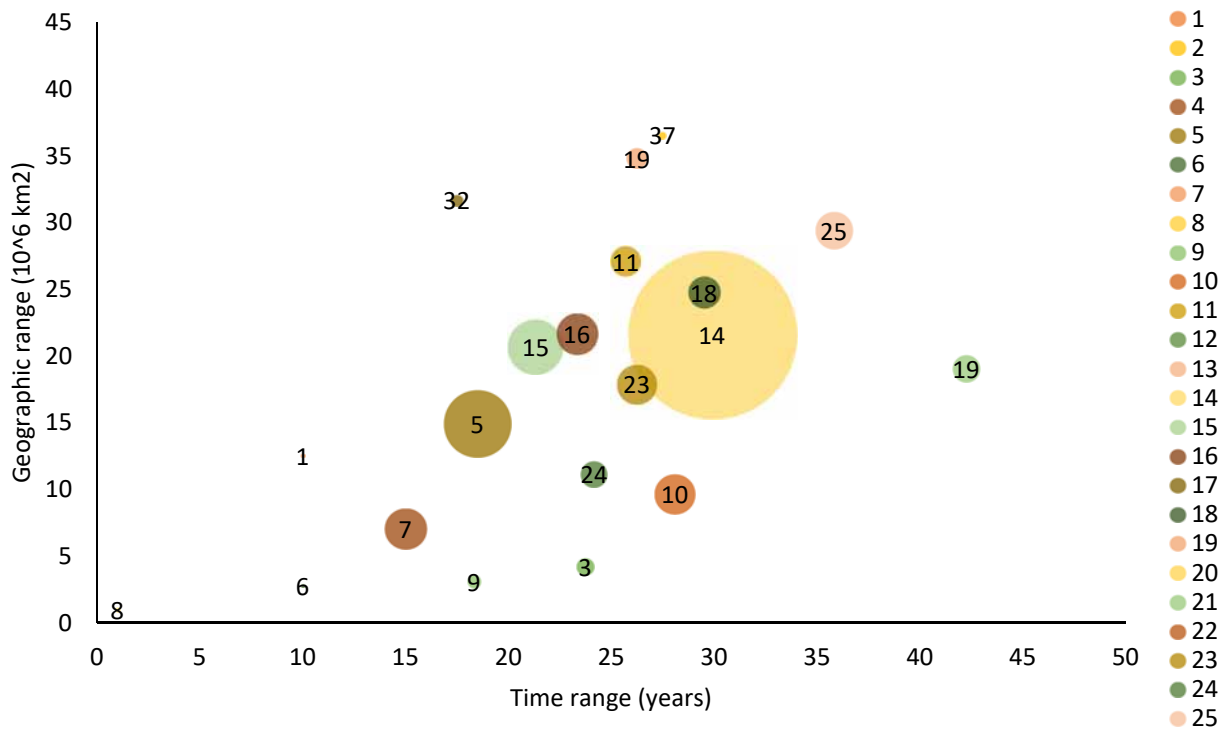


Figure 5. Weighting analysis for enabling factors found in the selected reviews. Assigned weights were time range covered by the review (X axis), geographic range (Y axis), and amount of time cited in the selected reviews.

Both weighting approaches highlighted the effect of the use of the correct restoration technique as the main enabling factor (Fig. 4 and 5). At a large distance, the second enabling factor was the spatial scale of the restoration project.

5.3 Methodological Considerations

Based on the geographic range, only eight reviews (6%) containing 50 variables (9%) could be directly matched with European restoration projects, meaning that there is insufficient evidence to make an individual analysis for Europe. There are another 9 reviews (7%) containing 49 variables (9%) where at least half of the information relates to European data, with most of these reviews focusing on Europe and North America.

6. Delphi Process

The Delphi technique represents one of the most rigorous approaches to eliciting expert knowledge and achieving formal consensus. It combines the knowledge of multiple, carefully selected experts into either quantitative and/or qualitative assessments (Mukherjee et al. 2015). In this study, we used the Delphi technique to identify an understanding of what effective ecosystem restoration is, and create lists of key components, barriers and knowledge gaps to achieve more effective restoration.

6.1 Methods

6.1.1 Establishment of the experts' platform

We defined participants' profiles in terms of their approach(es) to ecological restoration, and the sector(s) they specialized in. EWG members recognised categories of experts and approaches which included (1) policy and governance, (2) science, education and research, (3) technical biophysical aspects of restoration practice, (4) participatory processes and social interaction, and (5) users that were not involved in any of the previous activities. Sectors were derived from Corine Land Cover Classes by considering land cover, but they also integrated the type of degradation, and the techniques used for ecological restoration. Sectors are characterized by specific scientific and local knowledge, values and rules (Colloff et al., 2017). Thus, practitioners in different sectors may differ. We differentiated 8 sectors: Forestry, Rivers and Wetlands, Agricultural systems, Grasslands, Mining-industrial areas, Urban environments and Civil works, Coastal-Marine environments, and Arctic and Alpine areas. Table 2 describes the approaches and sectors in further detail.

Table 2. Labels used to define the profiles of the experts participating in the consulting process, and comments included in the registration file to facilitate the use of the template. The file also contained examples for each label.

	Label	Comments
Contact data	Contact person	Surname, Name
	Location	City, Country
	E-mail	Official e-mail address for further contact
	Organization	Name of the organization she/he is representing, if any
	Type of organization	Approach to nature management and ecological restoration
	Gender	Gender the contact may want to be identified with
Expert approach to ER	Policy/Governance	Involved in policy-and decision-making at local, sub-national, national, regional or European level
	Science/Education	Generating and/or communicating knowledge on natural or social systems, directly or indirectly related to ecological restoration (ER)
	Practice-Technical	Involved in technical aspects of the implementation of ER; dealing with biotic and/or abiotic elements, NOT people
	Practice-Participation	Involved in participatory aspects of ER, including environmental education, volunteer coordination and training, facilitating participatory processes, etc.
	Users	Significant users which may have an opinion on the issue discussed (e.g. Nature leisure organizations, hunters' associations, etc.) NOT included in other sectors
Sector	Forests, scrubland, grasslands	Areas covered by trees, scrublands, ungrazed grasslands, including sand dunes and areas with scarce woody vegetation
	Rivers-Wetlands	Inland water bodies and banks, coastal wetlands, estuaries, tidal plains
	Agriculture	Arable land, permanent crops and heterogeneous agricultural areas
	Pastures	Grasslands where grazing is a common practice
	Mining-industrial	Open pit mines including surrounding areas affected by extracting activities, industrial areas

	Label	Comments
	Urban-Civil works	Urban and peri-urban areas, including brownfields, land strips along transportation and energy networks.
	Marine	Deep and shallow marine waters
Notes	Notes	Additional information on the abilities of the contact person to provide the information sought

EWG members were invited to identify experts covering the widest array of approaches and sectors, and the widest geographical scope. Searches were gradually targeted towards profiles that were less represented. At the end of the process, we generated a list of 145 experts, 141 of them from 18 European countries, and 4 of them from countries outside Europe (Figure 6). We note that, despite efforts to cover the maximum geographic scope, large regions and countries were under-represented, e.g. Eastern European countries, Baltic countries and Italy. The number of males and females in the platform was 91 and 54, respectively. The number of experts who used the different approaches to ecological restoration ranged from 23 for Users, to 92 for Practitioners dealing with technical aspects of ecological restoration (Table 3). Most experts embraced different approaches. Similarly, experts focused their work on different sectors (Table 4). Most of them were involved in the restoration of continental aquatic environments (rivers, wetlands; 50%) and forests (36%). The number of experts in Arctic and Alpine restoration was much lower (1%).

Figure 6. Geographic distribution of the experts invited to participate in the Delphi process. Dot surface area is proportional to the number of experts in each country. Three experts were based outside Europe (two in Canada, one in Malaysia).

Table 3. Absolute and relative number of experts using the different approaches to ecological restoration. Some experts used various approaches, which explains a total percentage above 100%.

Approach	Number	(%)
Practice-Technical	92	63
Science	76	52
Policy-Governance	70	48
Practice-Participation	52	36
Users	23	16

Table 4. Absolute and relative number of experts working in the different sectors of ecological restoration, and studies included in the scoping review across habitat types. Some experts developed their activity in various sectors, which explains a total percentage above 100%.

Sector	Number of experts	(%)	Number of studies	(Ç%)
Rivers-Wetlands	72	50	176	32
Forestry	52	36	180	33
Grasslands	44	30	54	10
Agriculture	30	21	33	6
Mining-industrial	25	17	17	3
Urban-Civil works	23	16	0	0
Coastal-Marine	13	9	82	15
Arctic/Alpine	2	1	0	0

Experts worked for a large diversity of entities, including Foundations, Universities, Public, Private and Public-private companies, European, national and sub-national government agencies, Non-Government Organisations (NGO)'s, Research centres and others.

6.1.2 Participatory approach

The participatory protocol was utilised to define effective ecological restoration (EER) in the European context and obtain a ranked list of barriers for the implementation of ecological restoration in Europe as perceived by the participants. The EWG together with the EKLIPSE Knowledge Coordination Body (KCB) and the requester, agreed to adopt the Delphi technique to carry out the consultation process, which consisted of a structured, anonymous and iterative survey where all experts were invited to participate (Mukherjee et al. 2015; Fig. 7).

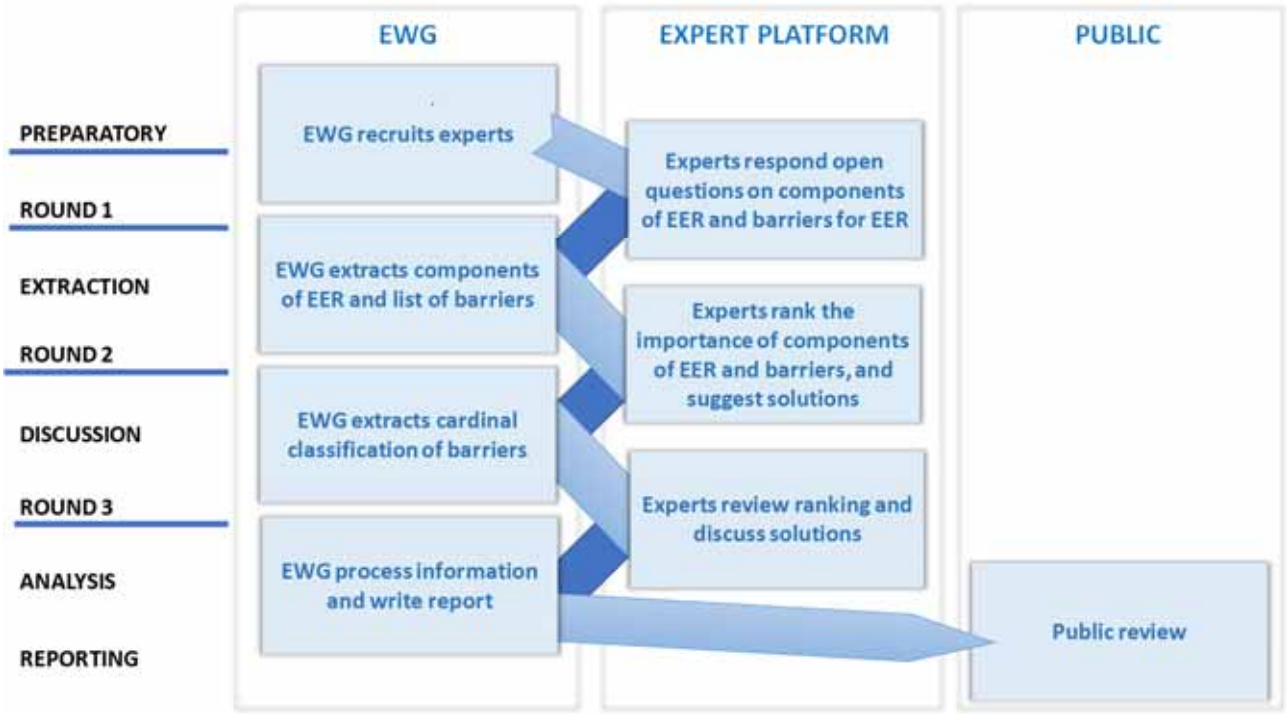


Figure 7. Workflow describing the successive steps of the Delphi process and the involvement of the EWG, the expert platform and the public. EER: effective ecological restoration.

6.1.3 Delphi Process Round 1

The Delphi process was managed electronically through the SurveyMonkey® platform. Experts were invited to participate in the first round of the Delphi process by direct mail on March 26th, 2019. We gathered no evidence of wrong e-mail addresses. Reminders were sent on March 29th and April 4th using the same means. The initial deadline (April 1st) was postponed to April 5th to encourage participation.

The survey began with a set of open-ended questions, developed by the EWG, to extract participants' opinions on components of and barriers for EER, and knowledge gaps for the application of EER (Appendix 4). We analysed participants' responses using inductive qualitative analysis (Hsiu-Fang and Shannon, 2005; Elos and Kyngäs, 2007). Due to the large amount of information obtained, we used Atlas.ti® software to analyse barriers for EER and knowledge gaps (Muhr, 2004). The resulting lists of components and barriers were then refined and classified, after iterative discussions amongst EWG members to reach consensus. Although responses to the survey were anonymous, participants were asked to describe their involvement in ecological restoration by identifying the type of organization they worked for, the type of restoration with which they were most familiar, the country of origin and work, and the duration of their involvement (Table 2, Appendix 5, Appendix 6).

6.1.4 Delphi Process Round 2

Similarly, to Round 1, for Round 2 we implemented an online survey using the SurveyMonkey® platform. Invitations were sent by direct e-mail on May 6th to the complete experts' platform,

including those that did not respond to the previous round. A single reminder was sent on May 13th. The deadline for completing the survey was extended from May 13th to May 15th.

As previously, participants were asked to describe their involvement in ecological restoration, and then rate the importance of the different components of and barriers for EER identified in the previous step, using Likert scales (Appendix 7). Boxes allowed participants to comment on their rating. Finally, we asked participants to suggest solutions for the major barriers that they had previously identified.

6.1.5 Delphi Process Round 3

Round 3 followed a similar procedure to Round 2, including questions to describe experts' involvement in ecological restoration. Experts were invited to respond to the third online survey on June 13th. The deadline for submitting responses was extended from June 20th to June 22nd by sending them a reminder on June 18th.

In this final round, we sent the survey to all members of the experts' platform. Experts that participated in Round 2 were informed of the results of this round (assessment of the importance of each barrier showing the results on Likert scales and experts' comments), asked to describe their involvement in EER, and were asked to rate again the barriers using the same Likert scale as in Round 2. We asked them to explain the reasons for their rating by filling an open box. Then, we asked them to provide specific solutions for the 3 main barriers identified in Round 2, or to any other barrier that they perceived as important. Finally, we asked experts to identify a key ecological knowledge gap, which, if answered, could improve the effectiveness of restoration (Appendix 8).

Experts that did not participate in Round 2, were asked to describe their involvement in ecological restoration, and then directly directed towards the last section of the survey, where we asked them about solutions and gaps in knowledge.

6.1.6 Normalizing the scores

We used frequencies of responses in Round 2 to estimate the weight that the participants gave to each component of EER following this procedure:

1. Discrete value of each question We established a Likert scale ranging from 1 to 7, where 1 was the minimum value of the scale and 7 was the maximum, and assigned these values to the labels of the response options: 1 = Strongly disagree, 2 = Somewhat disagree, 3 = Slightly disagree, 4 = Neither agree nor disagree, 5 = Slightly agree, 6 = Somewhat agree and 7 = Strongly agree. In this way, the minimum scores of the numerical scale represented a very unfavourable tendency toward that object or the attitude, the maximum scores represented a very favourable tendency towards the object, and the midpoint implied that the respondent did not have elements of judgment to be at favour or against the object.
2. Total weight of each question: We multiplied discrete values by the frequency of each response option for each question. Then, we added the total weights of each answer option, to obtain the total weight of each question.
3. Maximum possible total score: We calculated the maximum possible total score, as the total number of respondents multiplied by the maximum value of the 1-7 scale and divided the

total weight of each question (as calculated in #2) by the maximum possible score to normalize the values.

4. Normalized values: We divided the total weight of each question (as calculated in #2) by the maximum possible total score to normalize the values."
5. The same procedure was used to normalize the re-rating of barriers in round 3 and obtain the final rank. We applied the same procedure to weight and normalize the responses to questions concerning the relative importance of the barriers for effective ecological restoration, but in this case the Likert scale was 1-5, where 1 = No importance, 2 = Low importance, 3 = Medium importance, 4 = High importance, 5 = Extreme importance.

6.2 Results

6.2.1 Experts' platform

The number of experts agreeing to participate in Round 1 of the Delphi process was 71 (49% of the platform). Of those, the number of experts responding to questions related to the components of EER, barriers for EER and knowledge gaps was 48 (which corresponds to 33 % of the platform). Experts participating in round 1 based their activity in 14 countries (plus 3 experts working in three different countries outside Europe). The countries with the highest representation were Spain, France and Ireland (Appendix 6). In general, experts lived in the same country where they concentrated most of their activity (51%). Yet, some experts expanded their activity to other areas, mostly neighbouring regions.

A total of 33 experts (22.7% of the platform) participated in Round 2 of the Delphi process. Almost all of them (32, 22.1% of the platform) completed the survey. The countries with the highest representation in this round were Spain and Ireland, followed by France, Greece and Norway. The number of countries represented in this round was 11. As in Round 1, most experts were based and focused their activity in the same country (50%). Forty-two experts responded to our invitation to access Round 3 of the Delphi process. Of these, 15 had also participated in round 2 and thus reviewed and re-rated the importance of barriers for EER. They were based on 8 different countries.

One third of the experts participating in Round 1 were employed by academic institutions (Appendix 5). Sectors with the lowest representation were private and public companies, and NGOs. In Round 2, most experts were employed by academic institutions, other research institutions and government-associated agencies and public bodies. In Round 2, there was no representative of governments or government-associated companies. In Round 3, the number of experts from government agencies and public bodies was similar to that of previous rounds, but they represented almost 50% of the participants. As in Round 2, there were no representatives of the government or government companies.

Almost all experts who completed Round 1 focused their work on more than one system (Appendix 9). Rivers and wetlands were the most common systems, whereas coastal and marine systems were the least common. Similarly, many experts who completed Rounds 2 and 3 focused their work on forests and shrublands, and rivers and wetlands. Coastal, and marine systems were the least represented.

Technical practice and implementation of ecological restoration by managing biotic and abiotic elements (not people) were the main approaches used by the experts participating in Round 1 (Appendix 10). Other common approaches were science and education, and policy and governance. Participants in Round 2 showed similar profiles, most of them focusing their work on technical practice, science and education. The pattern was similar in the Round 3.

All experts in Round 1 had a strong background in ecological restoration: 75% of them had been involved in restoration activities between 11 and 30 years, while 2.1% dedicated to restoration for 31 years or more (Appendix 11). Only 22.9% of the experts had an experience of less than 10 years. Experts participating in the Rounds 2 and 3 showed similar profiles in terms of experience in ecological restoration.

6.2.2 Components of effective ecological restoration

Experts mentioned 10 components of effective ecological restoration concerning project goals, knowledge and techniques needed, degradation drivers and transfer of results (Table 5).

Table 5. Components of effective ecological restoration identified by the experts' platform in Round 1 of the Delphi process. Components refers to the wording used in Round 2 (Appendix 7).

Components of effective ecological restoration
Effective restoration aims to enhance ecosystem services, functions and biodiversity
Effective restoration assists and hastens natural recovery towards self-sustaining systems
Effective restoration is based on sound knowledge of the ecosystem including the soil
Effective restoration includes prior assessment, monitoring and adaptive management
Effective restoration relies on a solid participatory process and involves landowners
Effective restoration sets and achieves ambitious goals aligned with legal and socio-economic contexts
Effective restoration tackles degradation factors and assists in deterring further ecosystem degradation
Effective restoration uses minimum intervention and optimizes cost-benefit and cost-effectiveness
Effective restoration transfers results to society
Effective restoration considers large temporal and spatial scales (landscape-scale restoration)

6.2.3 Barriers for effective ecological restoration

Identification and classification of barriers described by experts was complex, as the number of barriers was high, and the perspectives were diverse (Table 6). The EWG agreed on a final list of 33 barriers, including barriers related to economy, policy and governance, legal and ownership issues, management, environmental conditions and socio-cultural aspects. The EWG classified the barriers for effective restoration into 6 groups (Table 6).

Table 6. Barriers for effective ecological restoration identified by the experts' platform in Round 1 of the Delphi process. Grouping was performed by the EWG.

Group	Barriers
Economics	Harmful subsidies favouring degradation
	Insufficient funding
	Lack of appropriate compensation and financial returns on restoration
Environmental	Conflicts between restoration goals, e.g. biodiversity, climate change mitigation, nutrient retention
	Constraints due to abiotic characteristics of the area, e.g. climate, topography, water availability
	Constraints due to biotic challenges e.g. concerning species dispersal rates, inter-specific interactions, etc.
	High level and rate of degradation
	Lack of quality plant material (including lack of suitable species and genotypes)
Legal and ownership issues	Complexity of the legal framework
	Difficulty in obtaining legal or property rights over the area to implement restoration
	Lack of integrated land use planning
	Perceived complexity of implementing restoration
Management	Lack of coordination between decision-makers in different domains and Administration Departments
	Lack of evaluation, monitoring and documentation
	Lack of skilled professionals to perform restoration
	Lack of involvement of the private sector
	Lack of motivation in decision-makers to incorporate innovation
	Lack of prior evaluation, assessment and design
	Lack of relevant ecological knowledge and experience
	Lack of standards against which progress can be measured
	Lack of suitable technology
	The timing of restoration projects does not correspond to ecological and social time-scales
	Unrealistic or unclear project goals
	Lack of knowledge about soils
Policy and governance	Inadequate implementation of current policies
	Low political priority for restoration
	Unsuitable policies and lack of enabling policy instruments
Socio-cultural	Conflicting interests of different stakeholders
	Lack of collaboration between different stakeholders
	Lack of effective knowledge exchange
	Lack of sense of identity, attachment to the landscape
	Lack of societal awareness and engagement
	Lack of understanding and collaboration across different aspects of restoration, e.g. ecology, engineering, social sciences, etc.

6.2.4 Knowledge gaps for effective ecological restoration

Experts surveyed in the first round of the Delphi process also identified what hinders the exchange of knowledge in the restoration community and the additional knowledge needed to achieve a more effective restoration. This part of the survey was completed by 48 participants. Experts identified many items, which were analysed and categorized by the EWG using an inductive qualitative analysis.

Experts indicated that the lack of time, the lack of funding, lack of effective platforms for knowledge exchange, lack of interdisciplinary approach (legal, economic, social, environmental) and the tender and publication constraints (difficulties to communicate results and experiences through suitable channels) were the biggest obstacles for knowledge exchange in the restoration community (Table 7). Participants identified 101 items that the EWG classified into 16 categories.

Table 7. Fifteen barriers to the exchange of knowledge in the restoration community. Frequency refers to the percentage of items included in each category compared to the total number of items, not a measure of their importance.

Categories	Frequency (%)
Lack of time	9.9
Lack of funding hampers acquisition and dissemination of knowledge	8.9
Lack of effective platform for knowledge exchange	8.9
Lack of interdisciplinary approach (legal, economic, social, environmental)	7.9
Tender and publication constraint (difficulties to communicate results and experiences through suitable canals)	7.9
Lack of funding for long-term monitoring programs hampers the acquisition and sharing of knowledge	6.9
Lack of success experiences, best practices and success measures	6.9
Lack of communication and collaboration among stakeholders	5.9
Lack of interaction between scientific knowledge and restoration practice	5.9
Nothing hampers the exchange of knowledge	5.9
Restoration is not a priority	5.9
Lack of documentation	5.0
Old approaches and bad practices	5.0
Language barriers	4.0
Self-interest and silo effect	3.0
Distance	2.0

There was no consensus on what is needed to achieve more effective ecological restoration, as the number of items identified by the experts' platform was large (Table 6). Good understanding of the functioning, structure and dynamics of the habitats, including key attributes and management requirements to achieve more effective ecological restoration, would help to achieve more effective restoration. Exchange of knowledge, best practices and skills were also identified. Participants mentioned 117 items that were classified into 18 categories. Categories belonged to three different domains: knowledge gaps, deficient knowledge exchange and procedural flaws (Table 8).

Table 8. Needs identified by the experts' platform to achieve more effective ecological restoration. They are grouped as gaps in knowledge, lack of knowledge exchange, and flaws in the implementation protocols. Frequency refers to the percentage of items included in each category compared to the total number of items, not a measure of their importance.

Domain	Categories	Frequency (%)
Gap	Good understanding of the functioning, structure and dynamics of habitats, including key attributes and management requirements	18.8
Exchange	Exchange of knowledge, best practices and skills	14.5
Procedure	Specific and long-term monitoring programmes to know more about efficiency and usefulness of some measures	8.6
Exchange	More forums, databases, practical guides and other platforms needed to create a collaborative approach in research and in practice	8.6
Procedure	Experience and appropriate techniques to implement restoration projects	7.7
Gap	Greater knowledge about economic factors and sources of financing	7.7
Gap	Greater knowledge about the plant material used in restoration	6.0
Procedure	Implementation of multi-scale processes	5.1
Exchange	Interact with society, stakeholders and politicians to increase social awareness and public participation	5.1
Procedure	Work in connection with policy makers and private companies	4.3
Gap	Reference condition	3.4
Procedure	Simplification of policies and bureaucracy	2.6
Procedure	Identification of stakeholders and priority places for restoration	1.7
Gap	The knowledge of the surrounding institutional (policy, administration, legislation) and socioeconomic environment	1.7
Gap	How to take climate change into account in restoration planning	1.7
Procedure	Have more time for restoration	0.9
Gap	How could we best support the green infrastructure outside protected areas	0.9
Procedure	More resources in the design and construction to oversee the works	0.9

6.2.5 Ranking the components of effective ecological restoration

There was a general agreement on the importance of the different components of EER (Fig. 8, Appendix 12). Only 6 of the 18 components of effective ecological restoration were not considered of some importance by only one respondent.

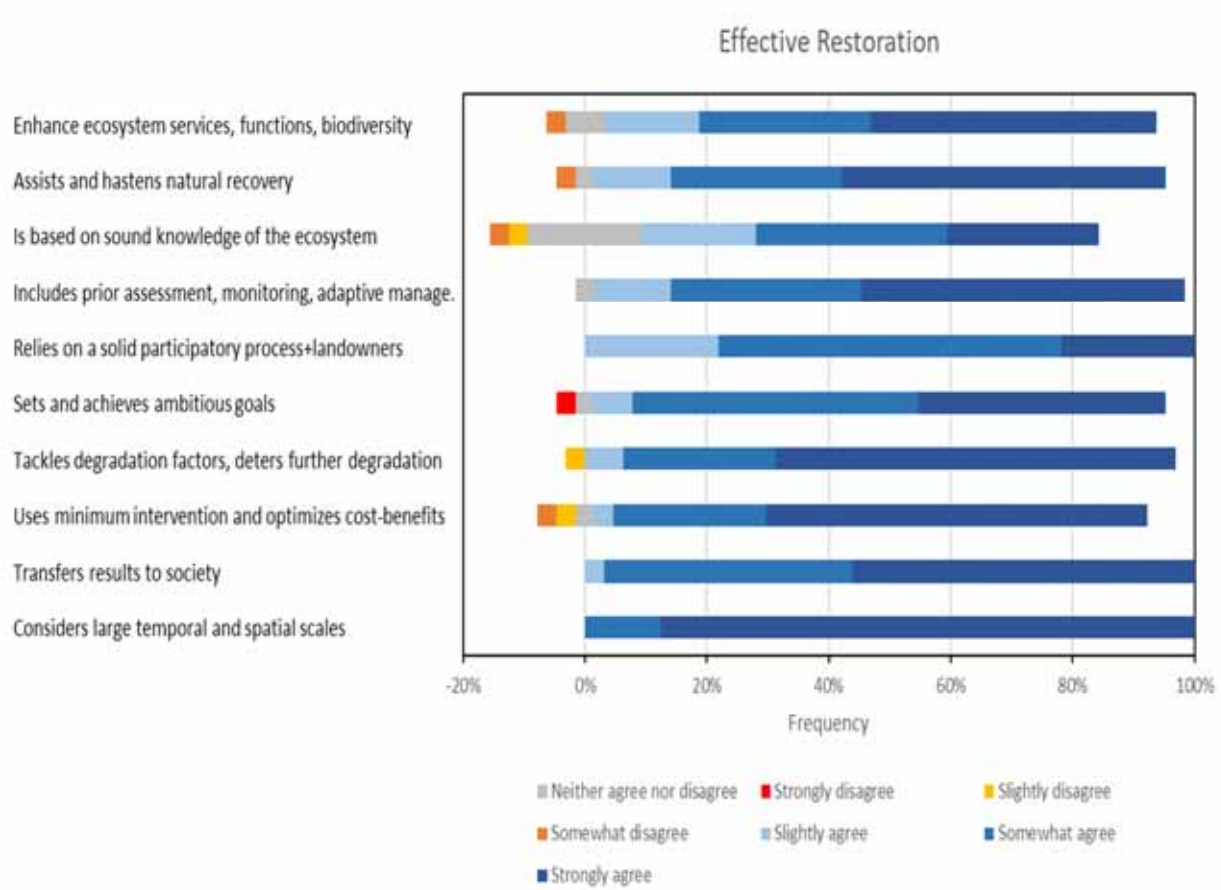


Figure 8. Graphical representation of the degree of agreement on the importance of the different components of effective ecological restoration. The number of respondents to all questions was 32. The frequency of respondents who agree with each statement is shown to the right of the zero line. Those who disagree are shown to the left. Respondents who neither agree nor disagree are split down the middle and are shown in a neutral colour (Table 5).

In accordance with the previous results, the scores of the different components of effective ecological restoration were all high, ranging from 0.781 to 0.982 (Table 9). Considering that effective restoration aims to enhance ecosystem services, functions and biodiversity was strongly agreed by almost all respondents. At a lower level of agreement, respondents considered that effective restoration should (i) assist and hasten natural recovery towards self-sustaining systems, (ii) include prior assessment, monitoring and adaptive management, (iii) tackle degradation factors and assist in deterring further ecosystem degradation, and (iv) be based on sound knowledge of the ecosystem including the soil. In contrast, the components considered of lesser importance concerned (i) large temporal and spatial scales (landscape-scale restoration), (ii) ambitious goals aligned with legal and socio-economic contexts, and particularly (iii) minimum intervention and optimization of cost-benefit and cost-effectiveness.

Table 9. Standardized weight of the different components of effective ecological restoration conferred by the experts' platform.

Questions	Weight
Aims to enhance ecosystem services, functions and biodiversity	0.982
Assists and hastens natural recovery towards self-sustaining systems	0.933
Includes prior assessment, monitoring and adaptive management	0.929
Tackles degradation factors and assists in deterring further ecosystem degradation	0.906
Is based on sound knowledge of the ecosystem including the soil	0.902
Transfers results to society	0.888
Relies on a solid participatory process and involves landowners	0.875
Considers large temporal and spatial scales (landscape-scale restoration)	0.866
Sets and achieves ambitious goals aligned with legal and socio-economic contexts	0.857
Uses minimum intervention and optimizes cost-benefit and cost-effectiveness	0.781

6.2.6 Ranking the barriers for effective ecological restoration

Most experts participating in Round 2 considered that most barriers were important to some degree (Fig. 9, Appendix 13). All experts considered five barriers to have a high importance level: Complexity of the legal framework, Conflicting interests of different stakeholders, Lack of collaboration between different stakeholders, Harmful subsidies favouring degradation and Lack of appropriate compensation and financial returns on restoration.

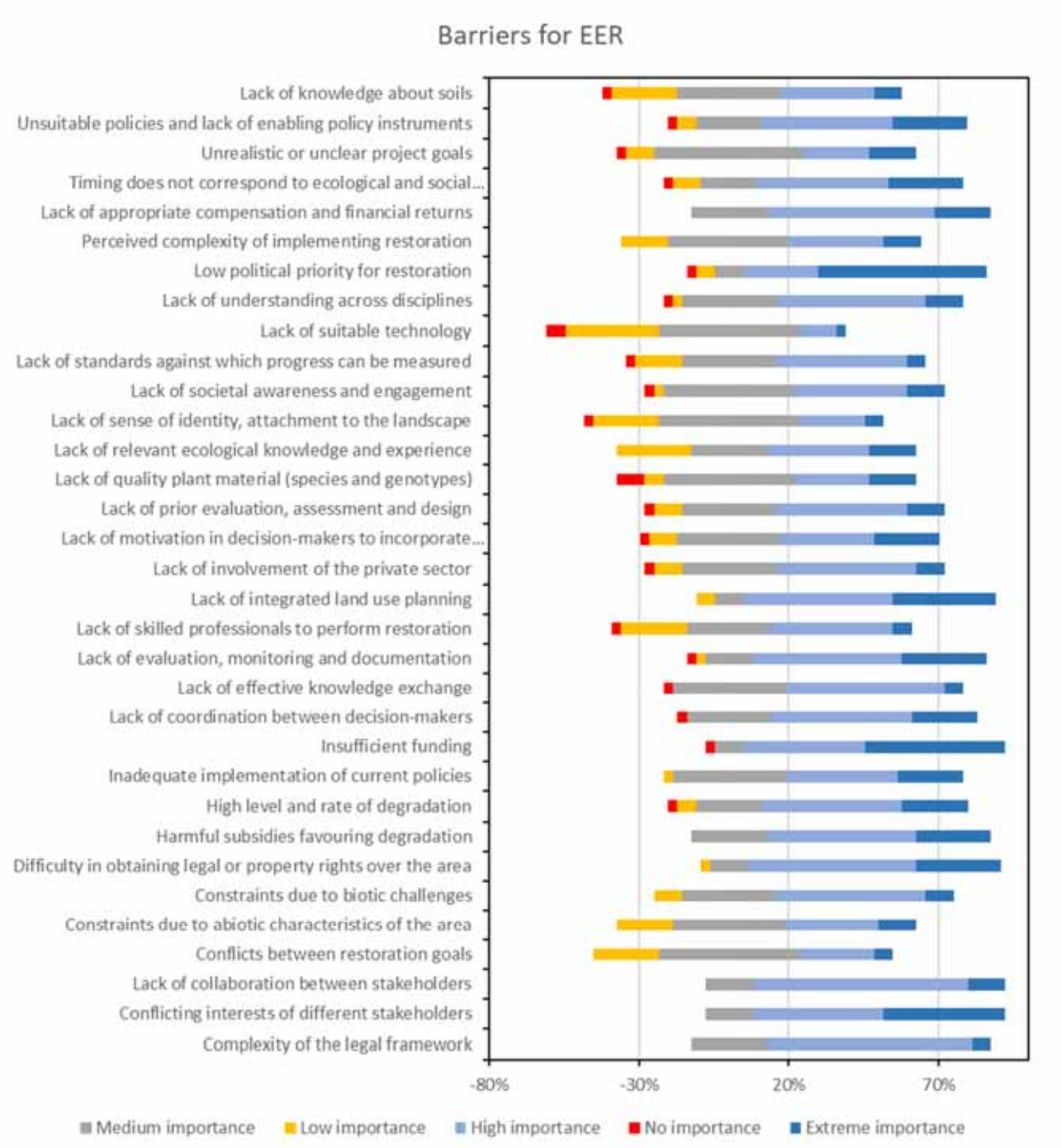


Figure 9. Graphical representation of the degree of agreement to questions concerning the importance different barriers for effective ecological restoration. The number of respondents to all questions was 32. The frequency of respondents who agreed with each statement are shown to the right of the zero line. Those who disagreed are shown to the left. Respondents who neither agreed nor disagreed are split down the middle and are shown in a neutral colour.

Participants identified that the main barriers for EER in the EU were: Insufficient funding, Conflicting interests of different stakeholders, and Low political priority for restoration (Table 10). Most experts identified low political priority for restoration as extremely important. The 12 most

important barriers were of socio-economic character. The first ecological barrier, concerning the level and rate of degradation, scored 13th. Most barriers related to the availability of knowledge, human resources and materials, and project goals were of relative lesser importance.

The weights assigned to the 33 barriers in Round 3 were similar to those of Round 2 (Fig. 10). Only three barriers felt beyond the 95% confidence interval. Timing of restoration projects not corresponding to ecological and social timescales and Lack of motivation in decision-makers to incorporate innovation showed a decrease in their ratings, whereas Lack of skilled professionals to perform restoration increased its perceived importance. These barriers showed the largest difference (-0.12) between successive rounds.

Table 10. Standardized weight of the different barriers for effective ecological restoration conferred by the experts' platform.

Barrier	Round 2 weight	Round 3 weight	Difference
Insufficient funding	0.856	0.92	-0.06
Conflicting interests of different stakeholders	0.850	0.88	-0.03
Low political priority for restoration	0.850	0.93	-0.08
Lack of integrated land use planning	0.825	0.87	-0.05
Difficulty in obtaining legal or property rights over the area to implement restoration	0.819	0.85	-0.03
Harmful subsidies favouring degradation	0.800	0.77	0.03
Lack of collaboration between different stakeholders	0.794	0.80	-0.01
Lack of evaluation, monitoring and documentation	0.794	0.84	-0.05
Lack of appropriate compensation and financial returns on restoration	0.788	0.77	0.02
Lack of coordination between decision-makers in different domains and administrative departments	0.769	0.79	-0.02
Complexity of the legal framework	0.763	0.83	-0.07
Unsuitable policies and lack of enabling policy instruments	0.763	0.79	-0.03
High level and rate of degradation	0.756	0.72	0.04
Inadequate implementation of current policies	0.756	0.71	0.05
The timing of restoration projects does not correspond to ecological and social timescales	0.756	0.68	0.08
Lack of understanding and collaboration across different aspects of restoration, e.g. ecology, engineering, social sciences, etc.	0.731	0.75	-0.02
Constraints due to biotic challenges e.g. concerning species dispersal rates, inter-specific interactions, etc.	0.719	0.72	0.00
Lack of effective knowledge exchange	0.719	0.79	-0.07
Lack of motivation in decision-makers to incorporate innovation	0.719	0.64	0.08
Lack of prior evaluation, assessment and design	0.706	0.73	-0.02
Lack of societal awareness and engagement	0.706	0.80	-0.09
Lack of involvement of the private sector	0.700	0.69	0.01
Lack of relevant ecological knowledge and experience	0.681	0.76	-0.08
Perceived complexity of implementing restoration	0.681	0.69	-0.01
Constraints due to abiotic characteristics of the area, e.g. climate, topography, water availability	0.675	0.72	-0.04
Unrealistic or unclear project goals	0.675	0.69	-0.01
Lack of standards against which progress can be measured	0.669	0.68	-0.01
Lack of quality plant material (including lack of suitable species and genotypes)	0.663	0.67	-0.01
Lack of skilled professionals to perform restoration	0.650	0.77	-0.12
Lack of knowledge about soils	0.644	0.65	-0.01
Conflicts between restoration goals, e.g. biodiversity, climate change mitigation, nutrient retention	0.631	0.63	0.00
Lack of sense of identity, attachment to the landscape	0.613	0.65	-0.04
Lack of suitable technology	0.550	0.59	-0.04

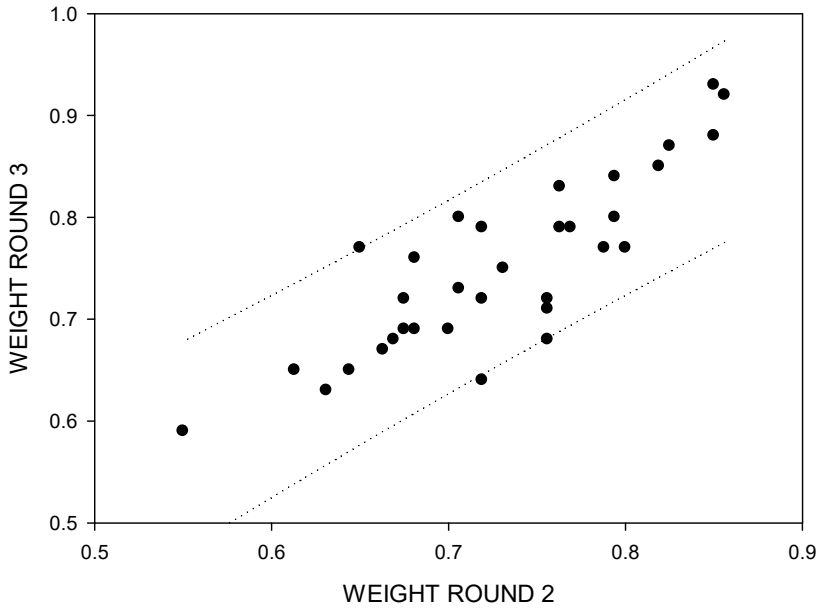


Figure 10. Changes in the weight of the 33 barriers between Rounds 2 and 3 of the Delphi process. Both rounds were highly correlated (Pearson r^2=0.720). Dotted lines correspond to lower and upper 95% confidence intervals.

6.2.7 Delphi Process Statistical Analyses

We carried out further statistical analyses to assess which barrier ratings were significantly different from each other in Rounds 2 and 3. All analyses were performed in R (R Core Team, 2018). Barrier names are abbreviated for brevity, with abbreviations found in Appendix 14. First, we produced boxplots of each of the barriers (Fig. 11). The ratings do not change greatly from Rounds 2 to 3 (see also Fig.10). As such, we focus largely on our results in Round 2.

The Friedman rank sum test was used to assess whether any barriers were rated significantly differently. The p-values obtained were 2.2×10^{-16} for Round 2 and 1.093×10^{-15} for Round 3. This indicates that some barriers were rated differently but it is not known which; the Wilcoxon signed rank test (WSRT) was used to identify these pairs for Round 2. A Bonferroni correction was applied to account for multiple testing, which led to an adjusted p-value threshold for significance.

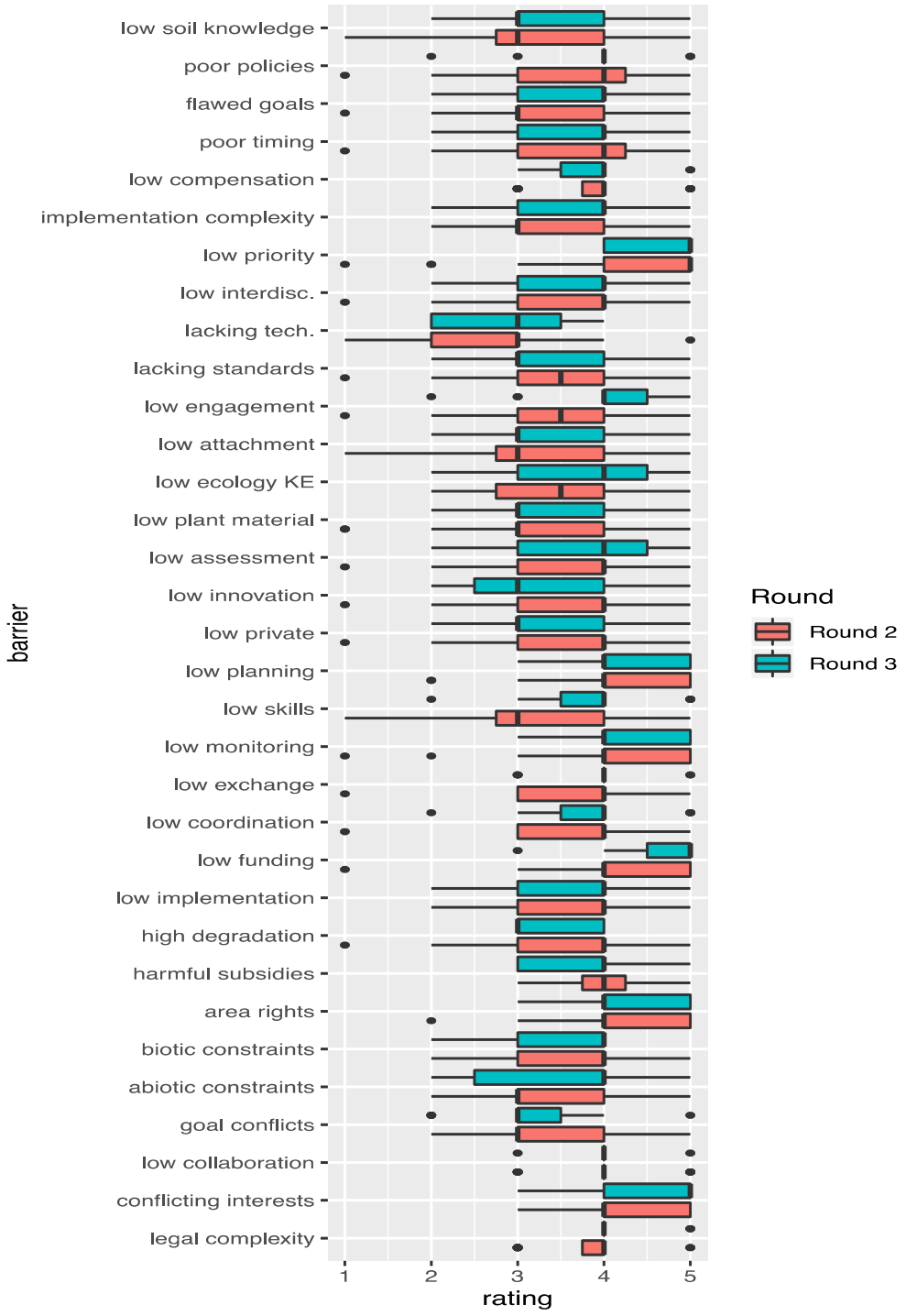


Figure 11: Boxplots of the barrier ratings in Rounds 2 and 3 of the Delphi process. Results for Round 2 are in orange and for Round 3 in turquoise. The lower and upper hinges correspond to the first and third quartiles (the 25th and 75th percentiles)

For Round 2, Table 11 contains the pairs of barriers which are significantly different from each other, with respect to Barrier 1 in the first column. It is notable that barrier importance ratings generally did not change greatly between Rounds 2 and 3. Fewer participants took part in Round 3 than in Round 2.

Table 11: Round 2 barriers whose ratings were significantly different from each other, according to the Wilcoxon signed rank test

Barrier 1	Barrier 2	Barrier 3	Barrier 4	Barrier 5	Barrier 6	Barrier 7	Barrier 8	Barrier 9
lacking technology	conflicting interests	area rights	harmful subsidies	low collabor-ation	low compen-sation	low funding	low planning	low priority
low attachment	conflicting interests			low collabor-ation		low funding	low planning	low priority
low skills	conflicting interests							

“Lack of suitable technology” was rated significantly differently from "Conflicting interests of different stakeholders", "Difficulty in obtaining legal or property rights over the area to implement restoration", "Harmful subsidies favouring degradation", "Lack of collaboration between different stakeholders", "Lack of appropriate compensation and financial returns on restoration", "Insufficient funding", "Lack of integrated land use planning", and "Low political priority for restoration". This likely reflects the relatively low rating given to this barrier. This allows us to conclude that the likely least important barriers identified in the Delphi process are “Lack of suitable technology”, "Lack of sense of identity, attachment to the landscape" and "Lack of skilled professionals to perform restoration".

"Lack of sense of identity, attachment to the landscape" was rated significantly differently from "Conflicting interests of different stakeholders", "Lack of collaboration between different stakeholders", "Insufficient funding", "Lack of integrated land use planning", and "Low political priority for restoration", likely reflecting the relatively low rating given to this barrier.

"Lack of skilled professionals to perform restoration" was significantly different from "Conflicting interests of different stakeholders", likely reflecting the lower rating of the former compared to the latter.

This analysis allows us to conclude that the likely least important barriers identified in the Delphi process are “Lack of suitable technology”, "Lack of sense of identity, attachment to the landscape" and "Lack of skilled professionals to perform restoration".

This analysis was a subjective assessment based on EWG expert opinion, and future work should include validation.

Although our methodology did not allow for a detailed analysis of cause-effect interactions, a causal model may be inferred using the 15 most important barriers listed in Table 7 (all barriers with a relative weight above 0.750; Fig. 12). This analysis was a subjective assessment based on EWG expert opinion, and future work should include validation, and it may be helpful to explore the causes underpinning major barriers for EER. According to the proposed model, lack of political priority for EER is at the basis of unsuitable policies, lack of policy instruments, inadequate implementation of current policies, and lack of coordination between decision-makers from

different departments. The political context may favour subsidies for activities impacting negatively on ecosystems' integrity and add complexity to the legal framework, which, together with conflicting interests of different stakeholders, hampers collaboration. Insufficient funding to confront current degradation trends is the result of the lack of compensation and financial returns, and flaws in sector policies, which also hamper the implementation of integrated land use plans. As a collateral effect, projects are not evaluated, monitored and documented.

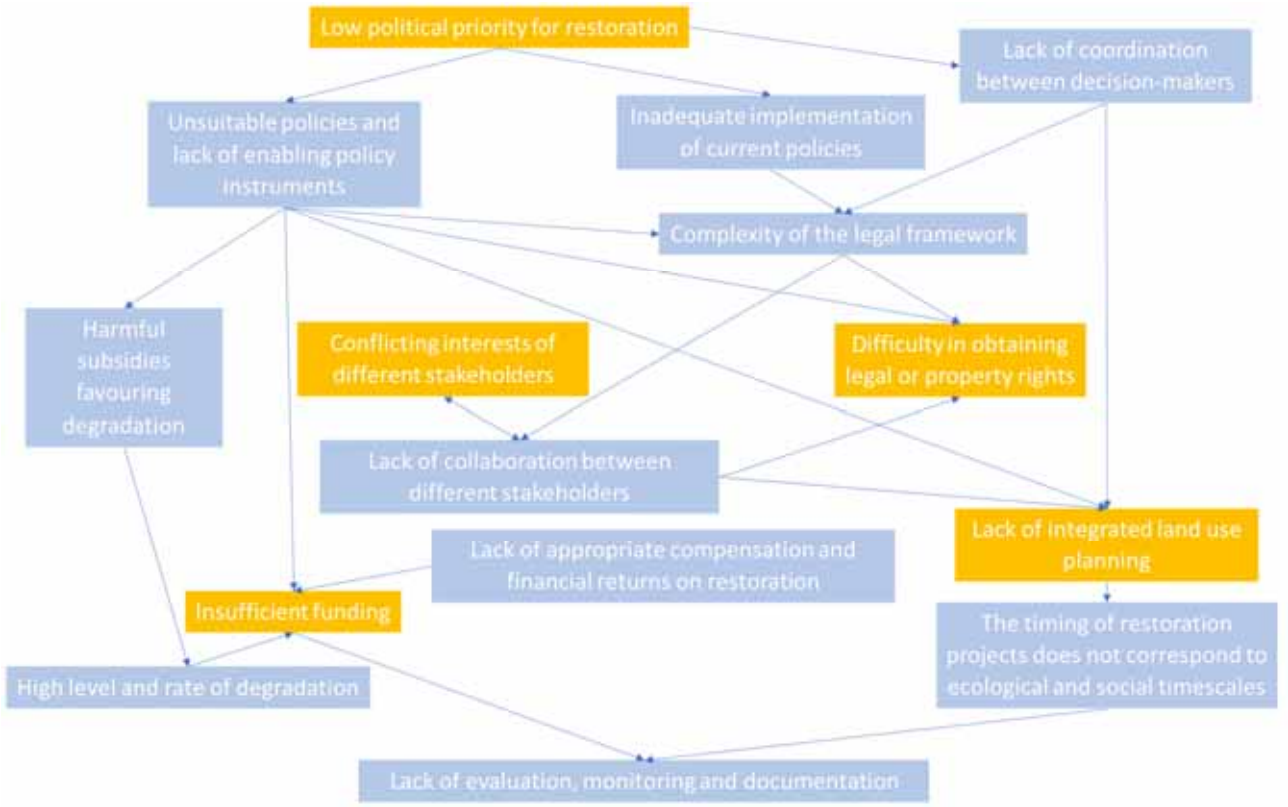


Figure 12. Proposed model to explain causal relationships between the 15 major barriers for the implementation of effective ecological restoration (EER) in Europe. Their minimum weight is 0.750. The 5 top barriers are coloured in orange.

6.3 Methodological considerations

As a result of the diversity of the ER community in Europe, the number of participants in the Delphi process was relatively large (145). The number of participants in Rounds 1 and 2 (48 and 32, respectively), and their distribution across various sectors, approaches and countries ensure representativity. Further, most of them have been involved in ER for a long time. Low representation from some areas (Eastern Europe, Italy, Baltic countries) may reflect poor development of this discipline in those European regions, characterized by other academic schools or traditions.

Due to the nature of the consulting process and time constraints, there was no chance to interact iteratively with all experts' in the panel and reach unanimous consensus. As a result, the number of participants in Round 3 of the Delphi process was relatively low, which may have biased the

results (compared to Round 2). Yet the low levels of discrepancy mentioned above suggest a high level of consensus in the identification and rating of barriers.

We built causal relationships between major barriers based on EWG expert opinion. Further studies on the causes and consequences of the barriers (i.e. causal modelling) could provide new insights and help identify target barriers that if solved, could boost ER in Europe.

The complexity of the ER community in Europe was integrated in our project by defining a social matrix where the EWG identified sectors, approaches and geographic scopes, and contacting a wide range of experts covering the widest variability in these three axes. However, the number of experts that the Delphi process could approach, and the intensity of the interaction with them was limited by time and resource constraints. Our ability to analyse the results of the process for the different sectors, approaches and geographic scopes was thus limited. We recommend that this analysis is carried out separately for different sectors and countries, as this could increase our accuracy in identifying barriers and corresponding solutions.

We must consider the possibility that experts failed to identify barriers that are not evident in their daily practice. For example, failure to consider the Lack of quality plant material (including lack of suitable species and genotypes) as a major barrier, may reflect a lack of regulations for the use of local species and genotypes, rather than confidence in the availability of local materials. These barriers may emerge as others are solved, and the sector develops.

7. Findings

7.1 Main Findings

The European Union ecological restoration community is highly diverse. There are a wide range of sectors, approaches and geographic scopes. This diversity leads to a wide range of views and sensibilities. In our study some geographic areas were under-represented, despite additional attempts to seek feedback from these regions. The 10 Components of effective ecological restoration identified by the experts (Table 5) were largely similar to those identified by the Society for Ecological Restoration (SER) at a global level (Gann et al., 2019). These components call for a comprehensive approach to ER based on sound and integrative knowledge that takes all ecosystem components and dynamics into account, and is framed by adaptive management. Both European experts and SER mentioned the socio-economic context, but they used different approaches. SER standards explicitly refer to the amount of resources allocated, economic incentives, partnership and multiple-benefit projects, whereas European experts highlighted the importance of participatory processes, ownership, prioritization, cost effectiveness and knowledge transfer. There are a number of other standards of relevance for Ecological Restoration, including Nature Based Standards for solutions for societal needs and the Green List of Standards for the Management of Protected Areas both of which have relevance to the findings from this Research, particularly with their focus on the integration of societal systems (WWF, 2012; IUCN, 2016; IUCN and World Commission on Protected Areas (WCPA), 2017).

Table 12. Attributes of effective ecological restoration as described in the *International Standards and Principles for the Practice of Ecological Restoration* 2nd edition (Gann et al 2019)

Attribute
Initiates and supports a process of recovery carried out by the organisms themselves
Accounts for the broad scale context and prioritizes resilient areas
Applies approaches best suited to the degree of impairment
Addresses all biotic components
Draws rigorous, relevant, and applicable knowledge from a dynamic interaction between science and practice
Is improved by a workforce knowledgeable about local ecosystems and the results of past successes and failures
Takes an adaptive management approach
Requires systematic site assessment and planning
Is adequately resourced
Takes advantage of economic incentives and efficiencies offered by partnerships and multi-benefit projects

A large and diverse set of barriers were identified by the European experts through the Delphi process. They concerned economic limitations, environmental constrains, laws and ownership issues, management planning and implementation, policy and governance constraints, and the socio-cultural context. Such heterogeneity may indeed be a constraint for consensus.

Barriers identified for knowledge exchange were mostly related to the limited funds allocated for this purpose, the manner in which projects are designed and implemented (lack of time and interdisciplinary approach, poor long-term monitoring programs, lack of collaboration, inertia), and the lack of tools and procedures for knowledge exchange (effective platforms and documentation for knowledge exchange, tender and publication constraints, lack of success experiences, practices and metrics, and language diversity).

The needs identified by the experts to achieve more effective ER occurred in three areas (Table 8):

a. gaps in knowledge (in terms of a deeper understanding of habitats' structure, functioning and dynamics; including information on sources of funding, and institutional and socio-economic environment),
b. procedural constraints (including economic resources), and
c. failures in knowledge exchange, however this was identified by a minority of experts.

Agreement on the components of EER was unanimous (Table 9), reflecting consensus on a comprehensive approach to EER, where the 10 components were all highly valued. It is worth noting that the three most valued components describe EER as a process that aims at enhancing ecosystem services, functions and biodiversity by assisting and hastening natural recovery towards self-sustaining systems, based on prior assessment, monitoring and adaptive management.

By contrast, experts showed larger differences in their valuation of the importance of the barriers which hamper the implementation of EER in Europe (Table 10). Whereas the weights of Insufficient funding, Conflicting interests of different stakeholders and Low political priority for

restoration were close to 0.9, Lack of knowledge about soils, Conflicts between restoration goals, Lack of a sense of identity attachment to the landscape and, particularly, Lack of suitable technology were below 0.65. Statistical analyses revealed that Lack of suitable technology, Lack of sense of identity, attachment to the landscape and Lack of skilled professionals to perform restoration were significantly lower rated than other barriers. The large number of barriers and the relative high weight of many of them reflect the diversity of perceptions and may be itself partly responsible for the slow progress towards identifying and solving these barriers.

Major barriers concerned the domains of a) economy, b) policy and c) governance. Causal relationships between different barriers are inferred and illustrated in Figure 12. According to this network of interactions, an increased political commitment should:

i. analyse current policies concerning ecological restoration
ii. identify lacking and unsuitable policies
iii. identify harmful subsidies favouring degradation
iv. define the legal framework
v. simplify and clarify the chain of responsibility, authority and accountability.

Measures implemented to overcome the above barriers should facilitate collaboration with the private sector, particularly fostering public-private agreements, and deploy the resources needed to harmonize stakeholder aims and aspirations and foster collaboration. Legal and financial instruments should promote a better integration of ER into land use planning and allow for project timescales that are ecologically and socially meaningful and integrate project evaluation, monitoring and documentation. These advances will not be possible without further allocation of funds to ER programs.

There was a high level of consensus in experts' opinions:

i. no barrier rating showed strong discrepancy between experts (i.e. large number of experts for and against the importance of a particular barrier), and
ii. barrier rating was not substantially modified between Rounds 2 and 3.

Experts considered that the expertise and tools to perform EER are largely available. But, in addition, they are probably aware of the uncertainties of the interactions between biodiversity and climate change, and how this will affect ecosystem functions and the provision of services, and other gaps in knowledge. Thus, we must consider this as reflecting current ER practice with its limitations. We anticipate that, as major barriers may be solved, others will be elicited.

7.2 Solutions proposed by the Experts involved in the Delphi process

Experts engaged with the Delphi process were asked to suggest solutions to the identified barriers (Table 10). Their suggested solutions are provided in Table 13 in the order by which they prioritised the barriers. By presenting the solutions in this prioritised order we may propose that the Solutions at the top end of Table 13, particularly numbers 1-16, the highest weighted barriers, may be the ones to prioritise when implementing solutions improve effective ecological restoration for biodiversity, ecosystem function and services across European countries.

Table 13: Solutions proposed by experts presented in the order of barrier prioritization developed from the weighting process

1.Insufficient funding	Additional funds to support implementation, monitoring and enforcement. Shift from degrading subsidies to supportive financial assistance. Balance funds allocated for protection and EER, for urban vs. rural environments. Find innovative funding solutions. Identify and stop subsidizing actions that cause degradation. Use these funds for ER projects. Integrate ER into major funding programs (2021-2027 Multiannual Financial Framework, CAP, Structural Funds, etc). Promote public-private partnerships at high-levels. Engage big private stakeholders in sectors such as energy, foods, environment, etc. Implement tax-deduction and payment for ecosystem services schemes. Increase tax-deductions to donations to NGOs involved in ER. Developers should set aside funds for ER as a compensation for the use of land and resources. Increase the cost effectiveness of the investments, including improved planning and identifying priority areas for restoration.
2.Conflicting interests of different stakeholders	Promote pragmatic transparent, participatory approaches by expert mediators, with stakeholder mapping, analysis and socio-economic assessment, taking nature and ecosystem services into account, analyze and discuss trade-offs. Deploy communication and awareness raising campaigns before the onset of ER projects. Identify and solve conflicting guidelines from different government departments and different authorities. Create a restoration agency. Integrate ER into land use planning and social development programs. Promote community-based approaches (e.g. Community Supported Agriculture).
3.Low political priority for restoration	Enforce the UN Decade of Ecosystem Restoration 2021-2030. Develop a solid basis to sustain political action. Increase the pressure from EU institutions regarding national reporting of ER actions to bring habitats and species to favourable conditions (Biodiversity directives). Incorporate biodiversity conservation programs into formal education programs. Promote studies relating healthy environments and socio-economic benefits. Create and diffuse examples of good practices. Promote collaboration between researchers, NGO's and public agencies to educate decision-makers and policy-makers' assistants. Promote ER in urban areas where people can readily perceive the benefits. Develop a solid communication strategy with the public media. Link ER with rural development programs and the tourism sector (e.g. rewilding programs).
4.Lack of integrated land use planning	Explicitly integrate ER into land-use planning.

5.Difficulty in obtaining legal or property rights over the area to implement restoration	Legal and property rights should be integrated into a legal framework for ER. Clarify property rights (Mediterranean).
6.Harmful subsidies favouring degradation	The decision-making process for allocating subsidies is too general: it must downscale to increase success at the local project scale. Identify and reform directives having a negative impact on nature. Allocate specific subsidies for ER projects.
7.Lack of collaboration between different stakeholders	Identify stakeholders with common objectives. Promote participatory multi-level, multi-disciplinary collaboration.
8.Lack of evaluation, monitoring and documentation	Support adaptive management, including evaluation, monitoring and documentation. Allocate funds to support long-term monitoring of restoration success.
9.Lack of appropriate compensation and financial returns on restoration	Implement mechanisms for compensation and financial return of restoration works, and a projection/explanation of the additional benefits of ER, not only monetary benefits.
10.Lack of coordination between decision-makers in different domains and administrative departments	Master-planning and high-level mission statements for government down to local governing bodies. Create and enforce communication channels and networking activities. Clarify competences of different authorities.
11.Complexity of the legal framework	Analyze and simplify the legal framework, particularly at large scales, including defining specific legislation for ER Identify and promote opportunities for ER using current legal framework.
12.Unsuitable policies and lack of enabling policy instruments	Design and implement regulatory and compliance mechanisms. Incorporate ER into the CAP. Communicate the benefits of ER to policymakers.
13.High level and rate of degradation	Identify areas where restoration is either unaffordable or would face excessive social conflict. Prioritize restoration of large degraded areas and highly degraded areas
14.Inadequate implementation of current policies	Promote means to implement ER (funds, available plants, human resources, etc.). Identify and amend badly targeted policies.
15.The timing of restoration projects does not correspond to ecological and social timescales	Explain the long-term dynamics of restoration actions to society. Increased attention to short- and medium-term effects of restoration actions.
16. Lack of understanding and collaboration across different aspects of restoration, e.g. ecology, engineering, social sciences	Promote multi-disciplinary, multi-stakeholder approaches. Develop common terminology.

17.Constraints due to biotic challenges e.g. concerning species dispersal rates, inter-specific interactions	Understand and integrate biotic constraints. Adaptive management to face unexpected interactions.
18.Lack of effective knowledge exchange	Support adaptive management integrating citizen science. Rate the quality of the knowledge that is shared. Create efficient systems to share knowledge that will cross language and discipline barriers. Publish and diffuse Best Practice Guidelines. Help users find the knowledge needed (e.g. by creating a portal).
19.Lack of motivation by decision-makers to incorporate innovation	Find ways to motivate decision-makers.
20.Lack of prior evaluation, assessment and design	None for this barrier.
21.Lack of societal awareness and engagement	Communicate the potential impacts of ER.
22.Lack of involvement of the private sector	Promote public-private partnerships. Engage the private sector in large-scale ER.
23.Lack of relevant ecological knowledge and experience	Develop and transfer site-specific ecological knowledge. Favour trans-disciplinary collaboration.
24.Perceived complexity of implementing restoration	Ecological restoration projects must be explained.
25.Constraints due to abiotic characteristics of the area, e.g. climate, topography, water availability	Understand and integrate abiotic constraints.
26.Unrealistic or unclear project goals	Make sure ER projects include well defined realistic goals, including time scales and efforts required.
27.Lack of standards against which progress can be measured	Develop flexible standards that can be adapted to different situations, to be revised periodically. Define sets of Key Performance Indicators. Implement quality management procedures (e.g. ISO 9000).
28.Lack of quality plant material (including lack of suitable species and genotypes)	Define the boundaries of seed production zones. Rules and enforcement for the use of native genotypes (particularly eastern and southern Europe).
29.Lack of skilled professionals to perform restoration	Support initiatives aiming at training local communities involved in ER, including NGOs' staff. Identify gaps in know-how.
30.Lack of knowledge about soils	None for this barrier.

31.Conflicts between restoration goals, e.g. biodiversity, climate change mitigation, nutrient retention	Define clearly and agree on restoration goals. Find win-win conditions.
32.Lack of sense of identity, attachment to the landscape	None for this barrier.
33. Lack of suitable technology	Technological advances should aim at identifying the lowest level of intervention needed (e.g. direct sowing when feasible).

8. Synthesis, Recommendations and Conclusions

Our key findings indicate that lack of political priority for effective ecological restoration (EER) is at the basis of unsuitable policies, lack of policy instruments, inadequate implementation of current policies, and lack of coordination between decision-makers from different sectors and departments. The political context may favour subsidies for activities impacting negatively on ecosystems' integrity and add complexity to the legal framework, which, together with conflicting interests of different stakeholders, hampers collaboration. Insufficient funding to confront current degradation trends is the result of the lack of compensation and financial returns, and flaws in sector policies, which also hamper the implementation of integrated land use plans. As a collateral effect, projects are not evaluated, monitored and documented. The Solutions presented in Table 13 reflect this finding.

Both the scoping review and the Delphi process imply that knowledge gaps are hampering restoration across a number of sectors. Knowledge gaps are evident in the financing sectors, inadequate policy and supportive legislative frameworks, diverse and often conflicting interests and understandings of different sectors of society, a limited understandings of the socio-economic and socio-ecological contexts and the contributions which restoration can make to ecosystem services, biodiversity enhancement and benefits to society. Supporting these three groupings is the need for the development of new knowledge to ensure these gaps and the proposed solutions can be implemented.

New knowledge can play a key role in identifying the policy and governance approaches required for effective ecological restoration while emphasising the role of science, stakeholder inclusion in knowledge production, and the links between policy practice and knowledge and learning by doing.

Moving forward for solutions, bringing experts together in the different aspects of ecological restoration, from science to policy, a variety of social actors and scientists, to local communities and societies interested in ecological restoration seems to be a priority. It is well known that direct contact with successful experiences is an effective and efficient method of knowledge transfer. Stimulating mobility for field visits to restoration activities and in-situ communication with leading restoration actors through mid-term exchange of experts might help to progress action. A significant part of the practical knowledge on good and (non-negligible) bad practices in ecological restoration is in the hands of non-scientific actors who are not in a position to transfer their

expertise through the procedure of scientific publication. In this sense, grey literature that gathers empirical knowledge should be dignified and brought to light.

8.1 Recommendations

We provide a set of Key Recommendations sketched across the 4 Key areas required to enhance effective ecological restoration to overcome the identified barriers (Table 10), while incorporating the expert's suggested solutions (Table 13).

8.1.1 Resourcing and Incentives – Make Restoration Possible

1. Ensure restoration is adequately resourced with funding and skills adequate to address socio- ecological complexity and to provide for ecosystem-oriented implementation, science-based knowledge, monitoring evaluation, restoration techniques and technology. This may be achieved by integrating ecological restoration into major European Union funding programs (e.g. 2021-2027 Multiannual Financial Framework, CAP, Structural Funds), engaging big private stakeholders in sectors such as energy, foods, environment, implement tax-deductions and payment for ecosystem services (PES), engaging developers to set aside funds for ecological restoration as a compensation for the use of land and resources, and promoting public-private partnerships at high-level.
2. Underpin restoration by ensuring that the natural supporting systems, including those in the hinterland/catchment of the restoration action, are not compromised.
3. Seek to design incentives that recognize the value of Natural Capital and the benefits of Nature- Based Solutions.

8.1.2 Policy – Make Restoration Count

1. Formulate clear policy goals incorporating ecological, social and economic needs in order to raise the political priority of restoration while integrating regulatory and compliance mechanisms.
2. An increased political commitment through enhanced policy can be achieved by:
    i. Analyzing current policies concerning ecological restoration
    ii. Identifying lacking and unsustainable policies
    iii. Identifying harmful subsidies that favour degradation
    iv. Defining the legal framework with specific legalities linked to restoration
    v. Simplifying and clarifying the chain of responsibility, authority and accountability.
3. Develop and implement national and regional frameworks to promote restoration and green infrastructure.
4. Bring disconnected policies together, with restoration of natural capital and ecosystem services as a linking mechanism. Seek synergies and design "policy mixes" that combine incentives, regulation and participatory practices to enhance motivation for restoration, interlinking ecological, social and economic needs.
5. Integrated Land Use Planning to ensure that restoration only proceeds in circumstances where the natural supporting systems in the catchment of the restoration actions are not compromised. This requires integrated land use planning to ensure ongoing restoration actions and/or protection of environments are linked to the natural supporting systems. This

includes recognition of the value of Natural Capital in strategic environmental assessment and land use and spatial planning and implemented through planning permissions and other measures.

6. Implement holistic governance structures including the design of governance instruments and policies that respect and maintain the sustainability of socio-ecological systems
7. Enhance coordination to boost implementation of high-level restoration goals at transnational, national and local level.

8.1.3 Society – Make Restoration a Preferred Option

1. Incorporate stakeholder engagement, participatory processes and collaboration throughout the planning, design and implementation of the restoration process. To ensure that restoration is not compromised by competing objectives, consider property rights.
2. Consider the socio-economic context of the landscape and ecosystems to be restored incorporating interdisciplinary and transdisciplinary approaches to understand restoration constraints linked to social, economic and cultural factors.
3. Create conditions for knowledge exchange platforms and mechanism for communicating, implementing and demonstrating best practices, while recognizing and respecting legitimately diverse stakeholders, including landowners, incorporating appropriate mechanisms for interaction and trust building.
4. Promote ecological restoration in all areas including urban areas, and link ecological restoration with rural development programs and across sectors a variety of sectors
5. Highlight the contributions of restoration to ecosystem services and illustrate how they benefit society.

8.1.4 Knowledge – Transfer, Link, Network and Facilitate Use of Knowledge

1. Develop and implement transdisciplinary socio-ecological restoration projects incorporating political decision makers and the range of relevant stakeholders.
2. Apply principles of adaptive co-management including comprehensive site pre-restoration baseline measures and ongoing monitoring of ecological, social and economic effectiveness of actions.
3. Recognize the ecological and social complexities of the restoration site and processes involved across different spatial and temporal scales.
4. Facilitate knowledge production and use in areas identified as the most limiting such as effects of biotic factors (provenance of restoration materials including species and genetic diversity materials, community assembly processes, species interactions, landscape processes), effects of soil processes, effects of historical land-use, effects of the temporal and spatial scales of restoration, effects of the social integration, ecosystem structure and functioning, conservation genetics, and invasive species.
5. Consider experience-based, practice-based, local knowledge and stakeholders' knowledge as legitimate in addition to scientific knowledge to gain a more holistic picture on restoration and factors explaining successes and failures in restoration.

6. Develop flexible standards that can be adapted to different situations, to be revised periodically, including evaluation and monitoring protocols, while documenting restoration projects, and supporting adaptive management.

8.2 Conclusions

The EKLIPSE Delphi process and scoping review provided a consensual list of key components required for effective ecological restoration. Interdisciplinarity and transdisciplinary approaches are needed when assessing barriers to effective ecological restoration. The EWG for this EKLIPSE Restoration project is both multi and transdisciplinary. These wide-ranging knowledge, experience sources and extensive networks across differing domains of the restoration communities strongly benefitted the development, implementation and interpretation of the approaches, thinking and knowledge applied to tackle this highly complex question.

Once a restoration programme is implemented, in order to maintain the impetus and effectiveness of that restoration, effective approaches to measure pre baseline ecological, social, and economic conditions are implemented to provide an understanding of ecological, economic and social change over time. As political priorities change these baseline measures are able to demonstrate the ecological and economic effectiveness of restoration investments while providing the opportunity to adapt management actions. These underlying measures provide the prospects to increase investment over time (Fisher et al 2019). Incorporating adaptive co-management into the restoration programme emphasises learning by doing and using state of the art knowledge in decision making provides opportunities to deal with conflicting property rights, while participatory and collaborative approaches provide methods to deal with other conflicting interests. The “co” in adaptive co-management implies the requirement for collaboration and knowledge co-creation in restoration projects. Knowledge across all these domains delivers crucial evidence particularly when it is co-produced and applied into policy and governance decisions.

References

Almut Arneth, Humberto Barbosa, Tim Benton, K., Calvin, Eduardo Calvo, S. C., Edouard Davin, F. D. G., Renée van Diemen, Fatima Driouech, A. E.,, Jason Evans, Marion Ferrat, J. H., Eamon Haughey, Mario Herrero, J. H., Mark Howden, Margot Hurlbert, Gensuo Jia, T. G. J., Jagdish Krishnaswamy, Werner Kurz, C. L., Soojeong Myeong,Nagmeldin Mahmoud, V. M.-, Delmotte, Cheikh Mbow, P. M., Alisher Mirzabaev, Angela Morelli, W. M.-O., Dalila Nedjraoui, Suvadip Neogi, Johnson Nkem, N. De, Noblet-Ducoudré, Lennart Olsson, Minal Pathak, J. P., Ramón Pichs-Madruga, Elvira Poloczanska, A. P., Hans-Otto Pörtner, Joana Portugal Pereira, P. P., Andy Reisinger, Debra C. Roberts, C., Rosenzweig, Mark Rounsevell, E., Panmao Zhai, Z. Z. (2017). IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems Summary for Policymakers. Research Handbook on Climate Change and Agricultural Law. https://doi.org/10.4337/9781784710644

Bullock, J. M., Aronson, J., Newton, A. C., Pywell, R. F., & Rey-Benayas, J. M. (2011). Restoration of ecosystem services and biodiversity: Conflicts and opportunities. Trends in Ecology and Evolution, 26(10), 541–549. https://doi.org/10.1016/j.tree.2011.06.011

Christian-Smith, J., & Merenlender, A. M. (2010). The disconnect between restoration goals and practices: a case study of watershed restoration in the Russian river basin, California. Restoration Ecology, 18, 95–102.

Colloff, M. J., Lavorel, S., van Kerkhoff, L. E., Wyborn, C. A., Fazey, I., Gorddard, R., Mace, G.M., Foden, W.B., Dunlop, M., Prentice, I.C., Crowley, J., Leadley, P., Degeorges, P. (2017). Transforming conservation science and practice for a post normal world. Conservation Biology 31(5): 1008-1017.

Sandra Díaz, Josef Settele, Eduardo Brondízio, Hien T. Ngo, Maximilien Guèze, John Agard, Almut Arneth, Patricia Balvanera, Kate Brauman, Stuart Butchart, Kai Chan, Lucas A. Garibaldi, Kazuhito Ichii, Jianguo Liu, Suneetha Mazhenchery Subramanian, Guy F. , C. Z. (2019). Summary for Policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. https://www.ipbes.net/system/tdf/ipbes_7_10_add.1_en_1.pdf?file=1&type=node&id=35329

EKLIPSE Secretariat. (2018). EKLIPSE Document of work: Restoration Effectiveness Request (BiodivERsA).

Elo, S., & Kyngas, H. (2007). The Qualitative Content Analysis Process. Journal of Advanced Nursing, 62, 107–115.

European Commission. (2018). Proposal for a Regulation of the European Parliament and of the Council establishing rules on support for strategic plans to be drawn up by Member States under the Common agricultural policy (CAP Strategic Plans).

European Environment Agency. (2019). European bathing water quality in 2018. European Environment Agency Reports. https://doi.org/10.2800/1804

European topic centre on inland coastal and marine. (2015). European Freshwater Ecosystem Assessment: Cross-walk between the Water Framework Directive and Habitats Directive types, status and pressures. Magdeburg.

European Waters: Assessment of Status and Pressures. (2018).

Fisher, J., Montanarella, L., and Scholes, R. Chapter 1: Benefits to people from avoiding land degradation and restoring degraded land. In IPBES (2018): The IPBES assessment report on land degradation and restoration. Montanarella, L., Scholes, R., and Brainich, A. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany, pp.1-51

Fisher, J.L., Papavassiliou, M. Mason, L (2019). Best Practice Guide to Restoration of ecosystems understanding ecological and economic effectiveness of actions over time, IUCN Commission on Ecosystem Management Ecosystems and Invasive Species.

Gann, G., McDonald, T., Walder, B., Aronson, J., Nelson, C.R., Jonson,J., Hallett, J.G., Eisenberg, C., Guariguata, M.R., Liu, J., Hua, F., Echeverría, C., Gonzales, E., Shaw, N., Decleer, K., & Dixon, K:W. (2019). International standards and principles for the practice of ecological restoration. Second edition. Restoration Ecology, September 2019, Vol 27 S1-S46

Gellie, N., Breed, M., Mortimer, P., Harrison, R., Xu, J., & Lowe, A. (2018). Networked and embedded scientific experiments will improve restoration outcomes. Frontiers in Ecology and the Environment, 16, 288–294.

Giljam, R. A. (2017). Extended application of 'best available techniques' as a means to facilitate ecological governance. Journal of Energy & Natural Resources Law, 36(2), 181–208. https://doi.org/10.1080/02646811.2017.1327266

González, E., Sher, A. A., Tabacchi, E., Masip, A., & Poulin, M. (2015). Restoration of riparian vegetation: A global review of implementation and evaluation approaches in the international, peer-reviewed literature. Journal of Environmental Management, 158, 85–94.

Hsiu-Fang, H., & Shannon, S. E. (2005). Three Approaches to Qualitative Content Analysis. Qualitative Health Research, 15(9), 1277–88.

IUCN. (2016). Nature based Solutions for Societal Needs - a standardised approach for design and verification of interventions Nature based Solutions for Societal Needs - a standardised approach for design and verification of interventions.

IUCN and World Commission on Protected Areas (WCPA). (2017). IUCN Green List of Protected and Conserved Areas: Standard, Version 1.1, 1–43.

Jørgensen, D., Nilsson, C., Hof, A. R., Hasselquist, E. M., Baker, S., Chapin, F. S., Eckerberg, K., Hjältén, J., Polvi, L., & Meyerson, L. A. (2014). Policy language in restoration ecology. Restoration Ecology, 22(1), 1–4. https://doi.org/10.1111/rec.12069

Kondolf, G. M., & Yang, C. N. (2008). Planning River Restoration Projects: Social and Cultural Dimensions. In S. Darby and D. Sear (Eds.) (Ed.), River Restoration (pp. 41–60). John Wiley & Sons, Ltd. Retrieved from doi:10.1002/9780470867082.ch4

Lammerant, J., Peters, R., Snethlage, M., Delbaere, B., Dickie, I., & Whiteley, G. (2014). Implementation of 2020 EU Biodiversity Strategy: Priorities for the restoration of ecosystems' and their services in the EU. Retrieved from www.arcadisbelgium.be

Muhr, T., & Friese, S. (2004). User's manual for ATLAS. Scientific Software Development, Berlin.

Muhr, T. (2004). Atlas.ti V5. 0: user´s guide and reference; the knowledge workbench; visual qualitative data analysis & knowledge management in education, business, administration & research. Scientific Software Development.

Mukherjee, Nibedita, Hugé, Jean, Sutherland, William J., McNeill, Jeffrey, Van Opstal, Maarten, Dahdouh-Guebas, Farid, & Koedam, Nico. (2015). The Delphi technique in ecology and biological conservation: applications and guidelines. *Methods in Ecology and Evolution, 6*(9), 1097-1109. doi: doi:10.1111/2041-210X.12387

Nilsson, C., Aradottir, A. L., Hagen, D., Halldórsson, G., Høegh, K., Mitchell, R. J., Raulund-Rasmussen, K., Svavarsdóttir, K., Tolvanen, A., & Wilson, S. D. (2016). Evaluating the process of ecological restoration. Ecology and Society, 1, 41.

Ockendon, N., Thomas, D. H. L., Cortina, J., Adams, W. M., Aykroyd, T., Barov, B., Boitani, L., Bonn, A., Branquinho, C., Brombacher, M., Burrell, C., Carver, S., Crick, H. Q. P., Duguy, B., Everett, S., Fokkens, B., Fuller, R. J., … Sutherland, W. J. (2018). One hundred priority questions for landscape restoration in Europe. Biological Conservation, 221(March), 198–208. https://doi.org/10.1016/j.biocon.2018.03.002

Palmer, M. A., Menninger, H. L., & Bernhardt, E. S. (2010). River restoration, habitat heterogeneity and biodiversity: a failure of theory or practice? Freshwater Biology, 55, 205–222.

R Core Team. (2018). R: A language and environment for statistical computing. Vienna. Retrieved from https://www.r-project.org/.

Robbins, Naomi B.&. Heiberger, Richard M (2011). Plotting Likert and Other Rating Scales. Section on Survey Research Methods – JSM. Available in: http://www.montana.edu.pdf

Scholes, R., Montanarella, L., Brainich, A., Barger, N., Brink, B. ten, Cantele, M., Erasmus, B., Fisher, J., Gardner, T., Holland, T. G., Kohler, F., Kotiaho, J. S., Maltitz, G. Von, Nangendo, G., Pandit, R., Parrotta, J., Potts, M. D. (eds.), L. W. (2018). Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany.

Suding, K. N. (2011). Toward an era of restoration in ecology: successes, failures and opportunities ahead. Annual Review of Ecology and Systematics, 42, 465–487.

Swart, J. A., Zevenberg, J., Ho, P., Cortina, J., Reed, M., Mchich, D., Vella, S., Zhao, H., & van der Windt, H. J. (2018). Involving society in restoration and conservation. Restoration Ecology, 26((S1), S3-S6.).

The European Parliament and the Council of the European Union. (2008). Marine Strategy Framework Directive.

Tolvanen, A., & Aronson, J. (2016). Ecological restoration, ecosystem services, and land use: A European perspective. Ecology and Society, 21(4). https://doi.org/10.5751/ES-09048-210447

Walker, B., L. Gunderson, A. Kinzig, C. Folke, S. Carpenter, and L. Schultz. 2006. A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and Society* **11**(1):13. http://www.ecologyandsociety.org/vol11/iss1/art13/

WWF (2012). Estándares de WWF para la Certificación de Proyectos de Restauración de Sistemas Forestales. WWF España. Madrid

Appendices

Appendix 1: Analysed Scoping Review Reference List

1. Aavik, T. & Helm, A. Restoration of plant species and genetic diversity depends on landscape-scale dispersal. *Restor. Ecol.* **26**, S92–S102 (2018).
2. Adams, C., Rodrigues, S. T., Calmon, M. & Kumar, C. Impacts of large-scale forest restoration on socioeconomic status and local livelihoods: what we know and do not know. *Biotropica* **48**, 731–744 (2016).
3. Andersen, R. *et al.* An overview of the progress and challenges of peatland restoration in Western Europe. *Restor. Ecol.* **25**, 271–282 (2017).
4. Angelopoulos, N. V., Cowx, I. G. & Buijse, A. D. Integrated planning framework for successful river restoration projects: Upscaling lessons learnt from European case studies. *Environ. Sci. Policy* **76**, 12–22 (2017).
5. Aronson, J. *et al.* Are Socioeconomic Benefits of Restoration Adequately Quantified? A Meta-analysis of Recent Papers (2000-2008) in Restoration Ecology and 12 Other Scientific Journals. *Restor. Ecol.* **18**, 143–154 (2010).
6. Asmelash, F., Bekele, T. & Birhane, E. The potential role of arbuscular mycorrhizal fungi in the restoration of degraded lands. *Front. Microbiol.* **7**, 1–15 (2016).
7. Baker, A. G. & Catterall, C. Managing fire-dependent vegetation in Byron Shire, Australia: Are we restoring the keystone ecological process of fire? *Ecol. Manag. Restor.* **17**, 47–55 (2016).
8. Bakker, E. S., Van Donk, E. & Immers, A. K. Lake restoration by in-lake iron addition: a synopsis of iron impact on aquatic organisms and shallow lake ecosystems. *Aquat. Ecol.* **50**, 121–135 (2016).
9. Barak, R. S. *et al.* Taking the long view: Integrating recorded, archeological, paleoecological, and evolutionary data into ecological restoration. *Int. J. Plant Sci.* **177**, 90–102 (2016).
10. Bechara, F. C. *et al.* Neotropical rainforest restoration: comparing passive, plantation and nucleation approaches. *Biodivers. Conserv.* **25**, 2021–2034 (2016).
11. Belder, D. J., Pierson, J. C., Ikin, K. & Lindenmayer, D. B. Beyond pattern to process: current themes and future directions for the conservation of woodland birds through restoration plantings. *Wildl. Res.* **45**, 473 (2018).
12. Blignaut, J. *et al.* Establishing the links between economic development and the restoration of natural capital. *Curr. Opin. Environ. Sustain.* **5**, 94–101 (2013).
13. Bosire, J. O. *et al.* Functionality of restored mangroves: A review. *Aquat. Bot.* **89**, 251–259 (2008).
14. Browne, M., Fraser, G. & Snowball, J. Economic evaluation of wetland restoration: a systematic review of the literature. *Restor. Ecol.* **26**, 1120–1126 (2018).
15. Bullock, J. M., Aronson, J., Newton, A. C., Pywell, R. F. & Rey-Benayas, J. M. Restoration of ecosystem services and biodiversity: conflicts and opportunities. *Trends Ecol. Evol.* **26**, 541–9 (2011).
16. Burton, P. J. & Ellen Macdonald, S. The restorative imperative: Challenges, objectives and approaches to restoring naturalness in forests. *Silva Fenn.* **45**, 843–863 (2011).
17. Cao, S. Impact of China's large-scale ecological restoration program on the environment and society in arid and semiarid areas of China: Achievements, problems, synthesis, and applications. *Crit. Rev. Environ. Sci. Technol.* **41**, 317–335 (2011).
18. Cao, S. *et al.* Excessive reliance on afforestation in China's arid and semi-arid regions: Lessons in ecological restoration. *Earth-Science Rev.* **104**, 240–245 (2011).
19. Chen, F., Yao, Q. & Tian, J. Review of Ecological Restoration Technology. *Eng. Rev.* **36**, 115–121 (2016).

20. Chen, L., Wang, W., Zhang, Y. & Lin, G. Recent progresses in mangrove conservation, restoration and research in China. *J. Plant Ecol.* **2**, 45–54 (2009).
21. Chimner, R. A., Cooper, D. J., Wurster, F. C. & Rochefort, L. An overview of peatland restoration in North America: where are we after 25 years? *Restor. Ecol.* **25**, 283–292 (2017).
22. Cortina, J. *et al.* The restoration of vegetation cover in the semi-arid Iberian southeast. *J. Arid Environ.* **75**, 1377–1384 (2011).
23. Costantini, E. A. C. *et al.* Soil indicators to assess the effectiveness of restoration strategies in dryland ecosystems. *Solid Earth* **7**, 397–414 (2016).
24. Crouzeilles, R. & Curran, M. Which landscape size best predicts the influence of forest cover on restoration success? A global meta-analysis on the scale of effect. *J. Appl. Ecol.* **53**, 440–448 (2016).
25. Crouzeilles, R. *et al.* A global meta-Analysis on the ecological drivers of forest restoration success. *Nat. Commun.* **7**, (2016).
26. De Steven, D. & Gramling, J. M. Diverse characteristics of wetlands restored under the wetlands reserve program in the Southeastern United States. *Wetlands* **32**, 593–604 (2012).
27. Djenontin, I. N. S., Foli, S. & Zulu, L. C. Revisiting the factors shaping outcomes for forest and landscape restoration in Sub-Saharan Africa: A way forward for policy, practice and research. *Sustainability (Switzerland)* **10**, 906 (2018).
28. Elliott, M. *et al.* Ecoengineering with Ecohydrology: Successes and failures in estuarine restoration. *Estuar. Coast. Shelf Sci.* **176**, 12–35 (2016).
29. Espeland, E. K. *et al.* Evolution of plant materials for ecological restoration: insights from the applied and basic literature. *J. Appl. Ecol.* **54**, 102–115 (2017).
30. Feld, C. K. *et al. From Natural to Degraded Rivers and Back Again. A Test of Restoration Ecology Theory and Practice*. *Advances in Ecological Research* **44**, (Elsevier Ltd., 2011).
31. Fernandes, K. *et al.* DNA metabarcoding—a new approach to fauna monitoring in mine site restoration. *Restor. Ecol.* **26**, 1098–1107 (2018).
32. Flávio, H. M., Ferreira, P., Formigo, N. & Svendsen, J. C. Reconciling agriculture and stream restoration in Europe: A review relating to the EU Water Framework Directive. *Science of the Total Environment* **596**–**597**, 378–395 (2017).
33. Fox, H. & Cundill, G. Towards increased community-engaged ecological restoration: A review of current practice and future directions. *Ecol. Restor.* **36**, 208–218 (2018).
34. France, R. L. From land to sea: Governance-management lessons from terrestrial restoration research useful for developing and expanding social-ecological marine restoration. *Ocean Coast. Manag.* **133**, 64–71 (2016).
35. Gatica-Saavedra, P., Echeverría, C. & Nelson, C. R. Ecological indicators for assessing ecological success of forest restoration: a world review. *Restor. Ecol.* **25**, 850–857 (2017).
36. Glenn, E. P., Nagler, P. L., Shafroth, P. B. & Jarchow, C. J. Effectiveness of environmental flows for riparian restoration in arid regions: A tale of four rivers. *Ecol. Eng.* **106**, 695–703 (2017).
37. Gómez-Aparicio, L. The role of plant interactions in the restoration of degraded ecosystems: A meta-analysis across life-forms and ecosystems. *J. Ecol.* **97**, 1202–1214 (2009).
38. González, E., Sher, A. A., Tabacchi, E., Masip, A. & Poulin, M. Restoration of riparian vegetation: A global review of implementation and evaluation approaches in the international, peer-reviewed literature. *J. Environ. Manage.* **158**, 85–94 (2015).
39. Guidetti, B. Y., Amico, G. C., Dardanelli, S. & Rodriguez-Cabal, M. A. Artificial perches promote vegetation restoration. *Plant Ecol.* **217**, 935–942 (2016).
40. Gulati, R. D. & Van Donk, E. Lakes in the Netherlands, their origin, eutrophication and restoration: State-of-the-art review. *Hydrobiologia* **478**, 73–106 (2002).
41. Hamilton, S. K. Biogeochemical time lags may delay responses of streams to ecological restoration. *Freshw. Biol.* **57**, 43–57 (2012).
42. Harzé, M. *et al.* Towards a population approach for evaluating grassland restoration—a systematic review. *Restor. Ecol.* **26**, 227–234 (2018).

43. Hein, M. Y., Willis, B. L., Beeden, R. & Birtles, A. The need for broader ecological and socioeconomic tools to evaluate the effectiveness of coral restoration programs. *Restor. Ecol.* **25**, 873–883 (2017).
44. Higgs, E. *et al.* The changing role of history in restoration ecology. *Front. Ecol. Environ.* **12**, 499–506 (2014).
45. Hu, J., Lü, Y., Fu, B., Comber, A. J. & Harris, P. Quantifying the effect of ecological restoration on runoff and sediment yields: A meta-analysis for the Loess Plateau of China. *Prog. Phys. Geogr.* **41**, 753–774 (2017).
46. Huang, C., Zhou, Z., Peng, C., Teng, M. & Wang, P. How is biodiversity changing in response to ecological restoration in terrestrial ecosystems? A meta-analysis in China. *Sci. Total Environ.* **650**, 1–9 (2019).
47. Hughes, F. M. R. & Rood, S. B. Allocation of River Flows for Restoration of Floodplain Forest Ecosystems: A Review of Approaches and Their Applicability in Europe. *Environ. Manage.* **32**, 12–33 (2003).
48. Hulvey, K. B. *et al.* Restoration islands: a tool for efficiently restoring dryland ecosystems? *Restor. Ecol.* **25**, S124–S134 (2017).
49. Iftekhar, M. S., Polyakov, M., Ansell, D., Gibson, F. & Kay, G. M. How economics can further the success of ecological restoration. *Conserv. Biol.* **31**, 261–268 (2017).
50. James, J. N. *et al.* The effects of forest restoration on ecosystem carbon in western North America: A systematic review. *For. Ecol. Manage.* **429**, 625–641 (2018).
51. Jiang, T. ting, Pan, J. fen, Pu, X. M., Wang, B. & Pan, J. J. Current status of coastal wetlands in China: Degradation, restoration, and future management. *Estuar. Coast. Shelf Sci.* **164**, 265–275 (2015).
52. Jones, H. P. *et al.* Restoration and repair of Earth's damaged ecosystems. *Proc. R. Soc. B Biol. Sci.* **285**, (2018).
53. Jones, H. P. & Kress, S. W. A review of the world's active seabird restoration projects. *J. Wildl. Manage.* **76**, 2–9 (2012).
54. Jouquet, P., Blanchart, E. & Capowiez, Y. Utilization of earthworms and termites for the restoration of ecosystem functioning. *Appl. Soil Ecol.* **73**, 34–40 (2014).
55. Kildisheva, O. A., Erickson, T. E., Merritt, D. J. & Dixon, K. W. Setting the scene for dryland recovery: an overview and key findings from a workshop targeting seed-based restoration. *Restor. Ecol.* **24**, S36–S42 (2016).
56. King, S. L., Sharitz, R. R., Groninger, J. W. & Battaglia, L. L. The ecology, restoration, and management of southeastern floodplain ecosystems: A synthesis. *Wetlands* **29**, 624–634 (2009).
57. Klimkowska, A., Van Diggelen, R., Grootjans, A. P. & Kotowski, W. Prospects for fen meadow restoration on severely degraded fens. *Perspect. Plant Ecol. Evol. Syst.* **12**, 245–255 (2010).
58. Koch, J. M. Restoring a jarrah forest understorey vegetation after bauxite mining in Western Australia. *Restor. Ecol.* **15**, 137–144 (2007).
59. Kollmann, J. *et al.* Integrating ecosystem functions into restoration ecology—recent advances and future directions. *Restor. Ecol.* **24**, 722–730 (2016).
60. Lamers, L. P. M. *et al.* Ecological restoration of rich fens in Europe and North America: from trial and error to an evidence-based approach. *Biol. Rev. Camb. Philos. Soc.* **90**, 182–203 (2015).
61. Lave, R. Stream restoration and the surprisingly social dynamics of science. *Wiley Interdiscip. Rev. Water* **3**, 75–81 (2016).
62. Lavoie, C., Grosvernier, P., Girard, M. & Marcoux, K. Spontaneous revegetation of mined peatlands: An useful restoration tool? *Wetl. Ecol. Manag.* **11**, 97–107 (2003).
63. Le Houerou, H. N. Restoration and rehabilitation of arid and semiarid mediterranean ecosystems in north africa and west asia: A review. *Arid Soil Res. Rehabil.* **14**, 3–14 (2000).

64. Lithgow, D. *et al.* Linking restoration ecology with coastal dune restoration. *Geomorphology* **199**, 214–224 (2013).
65. LosChiavo, A. J. *et al.* Lessons learned from the first decade of adaptive management in comprehensive everglades restoration. *Ecol. Soc.* **18**, (2013).
66. M.P., B., J.M., R. B., P., M. & N.O., M. Quantifying the impacts of ecological restoration on biodiversity and ecosystem services in agroecosystems: A global meta-analysis. *Agriculture, Ecosystems and Environment* **202**, 223–231 (2015).
67. Madsen, M. D., Davies, K. W., Boyd, C. S., Kerby, J. D. & Svejcar, T. J. Emerging seed enhancement technologies for overcoming barriers to restoration. *Restor. Ecol.* **24**, S77–S84 (2016).
68. Majer, J. D., Brennan, K. E. C. & Moir, M. L. Invertebrates and the restoration of a forest ecosystem: 30 years of research following bauxite mining in Western Australia. *Restor. Ecol.* **15**, 104–115 (2007).
69. Maltz, M. R. & Treseder, K. K. Sources of inocula influence mycorrhizal colonization of plants in restoration projects: A meta-analysis. *Restor. Ecol.* **23**, 625–634 (2015).
70. Mansourian, S. & Vallauri, D. Restoring forest landscapes: Important lessons learnt. *Environ. Manage.* **53**, 241–251 (2014).
71. Matthews, J. W., Spyreas, G. & Endress, A. G. Trajectories of vegetation-based indicators used to assess wetland restoration progress. *Ecol. Appl.* **19**, 2093–2107 (2009).
72. McAlpine, C. *et al.* Integrating plant- and animal- based perspectives for more effective restoration of biodiversity. *Front. Ecol. Environ.* **14**, 37–45 (2016).
73. McKergow, L. A., Matheson, F. E. & Quinn, J. M. Riparian management: A restoration tool for New Zealand streams. *Ecol. Manag. Restor.* **17**, 218–227 (2016).
74. Meli, P. *et al.* A global review of past land use, climate, and active vs. passive restoration effects on forest recovery. *PLoS One* **12**, 1–17 (2017).
75. Meli, P., Rey Benayas, J. M., Balvanera, P. & Martínez Ramos, M. Restoration enhances wetland biodiversity and ecosystem service supply, but results are context-dependent: a meta-analysis. *PLoS One* **9**, e93507 (2014).
76. Melo, F. P. L. *et al.* Priority setting for scaling-up tropical forest restoration projects: Early lessons from the Atlantic forest restoration pact. *Environ. Sci. Policy* **33**, 395–404 (2013).
77. Mijangos, J. L., Pacioni, C., Spencer, P. B. S. & Craig, M. D. Contribution of genetics to ecological restoration. *Mol. Ecol.* **24**, 22–37 (2015).
78. Moreno-Mateos, D., Power, M. E., Comín, F. A. & Yockteng, R. Structural and functional loss in restored wetland ecosystems. *PLoS Biol.* **10**, e1001247 (2012).
79. Moreno-Mateos, D. *et al.* Ecosystem response to interventions: Lessons from restored and created wetland ecosystems. *J. Appl. Ecol.* **52**, 1528–1537 (2015).
80. Newcomer Johnson, T., Kaushal, S., Mayer, P., Smith, R. & Sivirichi, G. Nutrient Retention in Restored Streams and Rivers: A Global Review and Synthesis. *Water* **8**, 116 (2016).
81. Nsikani, M. M., van Wilgen, B. W. & Gaertner, M. Barriers to ecosystem restoration presented by soil legacy effects of invasive alien N2-fixing woody species: implications for ecological restoration. *Restor. Ecol.* **26**, 235–244 (2018).
82. Oweis, T. Y. Rainwater harvesting for restoring degraded dry agro-pastoral ecosystems: A conceptual review of opportunities and constraints in a changing climate. *Environmental Reviews* **25**, 135–149 (2017).
83. Palma, A. C. & Laurance, S. G. W. A review of the use of direct seeding and seedling plantings in restoration: What do we know and where should we go? *Appl. Veg. Sci.* **18**, 561–568 (2015).
84. Palmer, M. A., Hondula, K. L. & Koch, B. J. Ecological Restoration of Streams and Rivers: Shifting Strategies and Shifting Goals. *Annu. Rev. Ecol. Evol. Syst.* **45**, 247–269 (2014).
85. Pander, J. & Geist, J. Ecological indicators for stream restoration success. *Ecol. Indic.* **30**, 106–118 (2013).

86. Parry, L. E., Holden, J. & Chapman, P. J. Restoration of blanket peatlands. *J. Environ. Manage.* **133**, 193–205 (2014).
87. Perring, M. P. *et al.* Advances in restoration ecology: Rising to the challenges of the coming decades. *Ecosphere* **6**, (2015).
88. Reid, A. M., Morin, L., Downey, P. O., French, K. & Virtue, J. G. Does invasive plant management aid the restoration of natural ecosystems? *Biol. Conserv.* **142**, 2342–2349 (2009).
89. Ren, Y., Lü, Y. & Fu, B. Quantifying the impacts of grassland restoration on biodiversity and ecosystem services in China: A meta-analysis. *Ecol. Eng.* **95**, 542–550 (2016).
90. Ren, Y., Lü, Y., Fu, B. & Zhang, K. Biodiversity and Ecosystem Functional Enhancement by Forest Restoration: A Meta-analysis in China. *L. Degrad. Dev.* **28**, 2062–2073 (2017).
91. Rey Benayas, J. M., Bullock, J. M. & Newton, A. C. Creating woodland islets to reconcile ecological restoration, conservation, and agricultural land use. *Front. Ecol. Environ.* **6**, 329–336 (2008).
92. Rey Benayas, J. M., Newton, A. C., Diaz, A. & Bullock, J. M. Enhancement of biodiversity and ecosystem services by ecological restoration: A meta-analysis. *Science (80-.).* **325**, 1121–1124 (2009).
93. Reyes-García, V. *et al.* The contributions of Indigenous Peoples and local communities to ecological restoration. *Restor. Ecol.* **27**, 3–8 (2019).
94. Rinkevich, B. Conservation of coral reefs through active restoration measures: Recent approaches and last decade progress. *Environ. Sci. Technol.* **39**, 4333–4342 (2005).
95. Romañach, S. S. *et al.* Conservation and restoration of mangroves: Global status, perspectives, and prognosis. *Ocean Coast. Manag.* **154**, 72–82 (2018).
96. Roni, P., Beechie, T. & Bilby, R. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. *North Am. J. Fish. Manag.* **22**, 1–20 (2002).
97. Rouillard, J. *et al.* Protecting and Restoring Biodiversity across the Freshwater, Coastal and Marine Realms: Is the existing EU policy framework fit for purpose? *Environ. Policy Gov.* **28**, 114–128 (2018).
98. Ruiz-Jaen, M. C. & Aide, T. M. Restoration success: How is it being measured? *Restor. Ecol.* **13**, 569–577 (2005).
99. Sánchez Meador, A., Springer, J. D., Huffman, D. W., Bowker, M. A. & Crouse, J. E. Soil functional responses to ecological restoration treatments in frequent-fire forests of the western United States: a systematic review. *Restor. Ecol.* **25**, 497–508 (2017).
100. Sapkota, R. P., Stahl, P. D. & Rijal, K. Restoration governance: An integrated approach towards sustainably restoring degraded ecosystems. *Environ. Dev.* **27**, 83–94 (2018).
101. Schultz, E. T., Johnston, R. J., Segerson, K. & Besedin, E. Y. Integrating Ecology and Economics for Restoration: Using Ecological Indicators in Valuation of Ecosystem Services. *Restor. Ecol.* **20**, 304–310 (2012).
102. Shimamoto, C. Y., Padial, A. A., Da Rosa, C. M. & Marques, M. C. M. Restoration of ecosystem services in tropical forests: A global meta-analysis. *PLoS One* **13**, 1–16 (2018).
103. Simenstad, C., Reed, D. & Ford, M. When is restoration not? Incorporating landscape-scale processes to restore self-sustaining ecosystems in coastal wetland restoration. *Ecol. Eng.* **26**, 27–39 (2006).
104. Smith-Ramírez, C., Vargas, R., Castillo, J., Mora, J. P. & Arellano-Cataldo, G. Woody plant invasions and restoration in forests of island ecosystems: lessons from Robinson Crusoe Island, Chile. *Biodivers. Conserv.* **26**, 1507–1524 (2017).
105. Stanturf, J. A., Palik, B. J. & Dumroese, R. K. Contemporary forest restoration: A review emphasizing function. *For. Ecol. Manage.* **331**, 292–323 (2014).
106. Stapanian, M. A., Lewis, T. E., Palmer, C. J. & Amos, M. M. Assessing accuracy and precision for field and laboratory data: A perspective in ecosystem restoration. *Restor. Ecol.* **24**, 18–26 (2016).

107. Su, B. & Shangguan, Z. Decline in soil moisture due to vegetation restoration on the Loess Plateau of China. *L. Degrad. Dev.* **30**, 290–299 (2019).
108. Suding, K. N. Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead. *Annu. Rev. Ecol. Evol. Syst.* **42**, 465–487 (2011).
109. Taddeo, S. & Dronova, I. Indicators of vegetation development in restored wetlands. *Ecol. Indic.* **94**, 454–467 (2018).
110. Thomas, E. *et al.* Genetic considerations in ecosystem restoration using native tree species. *For. Ecol. Manage.* **333**, 66–75 (2014).
111. Thomas, S. C. & Gale, N. Biochar and forest restoration: a review and meta-analysis of tree growth responses. *New For.* **46**, 931–946 (2015).
112. Timpane-Padgham, B. L., Beechie, T. & Klinger, T. A systematic review of ecological attributes that confer resilience to climate change in environmental restoration. *PLoS One* **12**, 1–23 (2017).
113. Uprety, Y., Asselin, H., Bergeron, Y., Doyon, F. & Boucher, J.-F. Contribution of traditional knowledge to ecological restoration: Practices and applications. *Écoscience* **19**, 225–237 (2012).
114. van Katwijk, M. M. *et al.* Guidelines for seagrass restoration: Importance of habitat selection and donor population, spreading of risks, and ecosystem engineering effects. *Mar. Pollut. Bull.* **58**, 179–188 (2009).
115. van Katwijk, M. M. *et al.* Global analysis of seagrass restoration: The importance of large-scale planting. *J. Appl. Ecol.* **53**, 567–578 (2016).
116. Walker, L. R., Velázquez, E. & Shiels, A. B. Applying lessons from ecological succession to the restoration of landslides. *Plant Soil* **324**, 157–168 (2009).
117. Wang, F. Occurrence of arbuscular mycorrhizal fungi in mining-impacted sites and their contribution to ecological restoration: Mechanisms and applications. *Crit. Rev. Environ. Sci. Technol.* **47**, 1901–1957 (2017).
118. Wang, L. *et al.* An extensive review on restoration technologies for mining tailings. *Environ. Sci. Pollut. Res.* **25**, 33911–33925 (2018).
119. Wang, X., Wang, Y. & Wang, Y. Use of exotic species during ecological restoration can produce effects that resemble vegetation invasions and other unintended consequences. *Ecol. Eng.* **52**, 247–251 (2013).
120. Wohl, E., Lane, S. N. & Wilcox, A. C. The science and practice of river restoration. *Water Resour. Res.* **51**, 5974–5997 (2015).
121. Wortley, L., Hero, J. M. & Howes, M. Evaluating ecological restoration success: A review of the literature. *Restor. Ecol.* **21**, 537–543 (2013).
122. Xi, W. *et al.* Challenges to Sustainable Development in China: A Review of Six Large-Scale Forest Restoration and Land Conservation Programs. *J. Sustain. For.* **33**, 435–453 (2014).
123. Yamagawa, H., Ito, S. & Nakao, T. Restoration of semi-natural forest after clearcutting of conifer plantations in Japan. *Landsc. Ecol. Eng.* **6**, 109–117 (2010).
124. Yeemin, T., Sutthacheep, M. & Pettongma, R. Coral reef restoration projects in Thailand. *Ocean Coast. Manag.* **49**, 562–575 (2006).
125. Young, C. N., Schopmeyer, S. A. & Lirman, D. A review of reef restoration and Coral propagation using the threatened genus Acropora in the Caribbean and western Atlantic. *Bull. Mar. Sci.* **88**, 1075–1098 (2012).
126. Yu, L., Huang, Y., Sun, F. & Sun, W. A synthesis of soil carbon and nitrogen recovery after wetland restoration and creation in the United States. *Sci. Rep.* **7**, 1–9 (2017).
127. Zamboni, T., Di Martino, S. & Jiménez-Pérez, I. A review of a multispecies reintroduction to restore a large ecosystem: The Iberá Rewilding Program (Argentina). *Perspect. Ecol. Conserv.* **15**, 248–256 (2017).
128. Zamparas, M. & Zacharias, I. Restoration of eutrophic freshwater by managing internal nutrient loads. A review. *Sci. Total Environ.* **496**, 551–562 (2014).

129. Zhang, Y. S. *et al.* A global synthesis reveals gaps in coastal habitat restoration research. *Sustain.* **10**, 3–5 (2018).
130. Zhao, Q. *et al.* A review of methodologies and success indicators for coastal wetland restoration. *Ecol. Indic.* **60**, 442–452 (2016).
131. Zhu, Y. *et al.* Ecosystem restoration and conservation in the arid inland river basins of Northwest China: Problems and strategies. *Ecol. Eng.* **94**, 629–637 (2016).

Appendix 2 - Scoping Review Analyses: Calculations of weighting for Key Elements in Ecosystem Restoration (KERR)

To understand the importance of each KEER, we identified three ways to weigh them according to the information collected during the reading of the reviews: the bibliographic weight (BW), the time range (TR) covered by the study, and the geographic range (GR). It must be acknowledged that these must be only used as proxies of the real importance of each category, and thus must be carefully interpreted.

1. Bibliographic weight.

The bibliographic weight is called to the combination of number of variables (Nv) contained in each KEER, and the number of studies analysed within each review where Nv were found (Ns). This weighting factor is an estimation of the importance that authors give to each KEER thought the existing literature. It assumes that the more times a variable is noted in the literature and the larger amount of literature reinforcing it, the higher is its importance and hence, its weight. To estimate the BW, we used the formula

$$B_W = \frac{N_V}{N_{VT}} + \frac{\sum N_S \cdot F_O}{N_{ST}}$$

where NVT is the total amount of variables (579), NST is the total amount of studies found (14,761), and FO is the overlap factor. Few considerations must be taken related to this equation. First, both addends have been normalized in values between 0 and 1. Second, ∑N_S is calculated by discarding duplicated data (i.e. reviews that contains more than 1 variable). Third, to avoid double-counting of studies repeated in different reviews, we estimated an overlapping factor (FO). We estimated the real overlap existing among 10% of the reviews of the database, randomly selected. The correction factor was estimated as,

$$F_O = \frac{A - C}{A}$$

where addition (A) is the total amount of studies of all the selected reviews (1,142) and counting (C) is the count of all studies that do not overlap among papers (1082). The Fo value resulting was 5,25%.

2. Time range

We used the time range (TR) as weighting factor assuming that variables deriving from reviews covering more expanded time lapses will be more representative than those coming from shorter time lapses. This is defined by the authors as the time frame (years) between the year of

publication of the review and the year of publication of the oldest analysed study within that review. If this time range is explicitly included in the review, it is directly taken. If it provides a range (e. g., 1980's), 1985 is used as the reference year. If there is supplementary data (usually in systematic reviews or meta-analysis) showing the reviewed studies, we take the oldest one in the list as a reference. If there is not supplementary data appendix, we used the oldest article that specifically addresses restoration as a reference. After this process there were 4 reviews containing 10 variables that did not showed a clear TR and were not included in the analysis were this factor was considered. Once that the time range data is obtained and assigned to every review, and consequently to each variable extracted from it, an average TR was calculated per each KEER.

3. Geographic range

The geographic range (GR) is the fragment of terrestrial surface (106 km2) covered by each review. We assume that variables coming from reviews covering wider geographical ranges will be more significative than those acting at smaller spatial scales. With this purpose, the total surface of the countries, regions or locations covered by each review was accounted. In the other hand, we used the range "global" if the review clearly stated it, if it showed a world map with studies globally distributed, if it included a description of multiple biomes or ecosystem types and finally if it could be assumed from the information provided. To prevent unjustifiably high ranges for global reviews without further specification of data sources, we used the geographic range of the largest range provided by any review instead of the surface of all emerged land in the Earth. This was reported in Crouzeilles et al. 2016 and the value is 54.870.139 km2. After this process, there were 4 studies containing 19 variables that did not showed a clear geographic range and were not included in the analysis were this factor was considered. Once that the GR data is obtained and assigned to every review, and consequently to each variable extracted from it, an average geographic range was calculated per KEER.

4. Total weight

A total weight (TW) can be estimated by integrating the three factors into one value. However, since these factors have no specific relation between them, any mathematical approach trying to match them together must be carefully interpreted. Having this under consideration, for each KEER we decided to sum the factors prior to normalize them in values between 0 and 1 to make these equally "heavy" and thus, potentially comparable. This way we have that

$$T_W = B_W^* + T_R^* + G_R^*$$

where the asterisk indicates the normalization of the factor.

Appendix 3: Limitations and special considerations of the Scoping Review

Type of analysed reviews. The major part of the reviews has been Conventional Reviews (Crev), representing the 80% of the 131 analysed papers (Fig. 2). This suppose a limitation since the extraction of data process has been drastically more difficult when it came to CRev mainly because: 1) these usually have non-canonical scientific structure (i.e. methods, discussion, conclusion), making the seeking of barriers and enabling factors a longer and more complex process; 2) the studies analysed within the CRev and from which the results were obtained hardly ever were specifically appointed, so the assignment of these has had to be done most of the times

manually by focusing on the references cited within the discussion of the results. Consequently, quality of the data obtained from these Crev can be considered lower than that obtained from Systematic Reviews and Meta-analysis.

Qualitative data and its analysis. The 579 variables collected from the 131 reviews are qualitative data, what led us to follow an approach lacking statistical analysis.

Categorization and definition of KEER's. The categorization and latest definition of each KEER has been carried out essentially following the evidence and the interpretations showed by the reviews where the variables where found. However, there can be synergies and relations of causality between some of them that have not been strictly appointed. For example, "19. Scientific knowledge of ecosystem processes/dynamics/structure" could be interpreted as the cause of several KEER's like "5. Restoration techniques" and "6. Success assessment and evaluation" since the lack of deeper knowledge of ecosystems can potentially lead to fail at applying certain restoration techniques and also to being incapable of effectively measuring the success of the restoration because we do not know precisely the final state to where we should go. Therefore, the way the KEER's are showed in the bibliography can be seen as a limitation itself.

Time range (TR). 4 reviews containing 10 variables couldn't be assigned with a specific time range. Since the building of the database has been a continuous process that was developed during its own making, at the first moment the TR was supposed to give just a general idea and we didn't plan to use it the way we finally did. This, added to the fact that the TR in many cases was difficult to assigned (most of the times when it came to CRev where the oldest study was difficult to differentiate) made us to give to time range approached values grouped in frames with 5 years of difference between them. This is: <5 years, <10 years, <15 years, <20 years… <+5. This can be a limitation because it reduces the resolution of the time range.

Geographic range (GR). 4 reviews containing 19 variables couldn't be assigned with a specific GR. At the time of assigning the GR we had specific considerations for the biggest countries (i.e. those >5 million km2). If some of the studies analysed within a review had place in one of these countries and there was no further resolution appointed, we could reject it in order to avoid an overestimation of the G_R

N	*Country*	*10^6 km²*
1	Russia	17,01
2	Canada	9,98
3	China	9,59
4	United States	9,37
5	Brazil	8,51
6	Australia	7,74

Table 14. Biggest countries with more than 5 million km²

European data. The methodological approach followed during this review (i.e. focused just in reviews) and the way of assigning the GR may have disregarded the representation of some regions of the world like Europe.

Bibliographic weight (B_W). The mathematical way of approaching this factor follows no specific criteria but the goal of matching the number of variables contained within a KEER and the amount of studies supporting the reviews where these variables where found.

Weighing process. As it has been appointed along the methodology and the results, the interpretation of the weighing process that has been followed in this report should be carefully interpreted.

Appendix 4: Delphi Survey template of round 1

EKLIPSE Restoration - Delphi Process Round 1: Identifying Barriers

In the framework of the EKLIPSE request "What is hampering the effectiveness of existing approaches that aim to restore biodiversity and ecosystem function and services", we are interested in your views as an expert, practitioner or other.

This is the first round of a three-stage Delphi process in which you will identify and rank barriers to restoration.

Here, we understand **restoration as any intentional activity that initiates or accelerates the recovery of an ecosystem from a degraded state. A barrier is something which significantly hampers the process of restoration.**

* 1. EKLIPSE requests relevant personal data in order to assess questionnaires appropriately. EKLIPSE is a science research project in the public interest and the lawful basis for processing your personal data under the EU's General Data Protection Regulation (GDPR) will be a public task. Our privacy policy (www.ceh.ac.uk/privacy-policy) contains further information on the purpose and lawful basis for processing your personal data.

By participating in this study, you agree that EKLIPSE will collect data on your background in restoration and views on barriers limiting the effectiveness of restoration. No personally identifying information will be recorded.

☐ I agree to take part

☐ I do not agree to take part

In this round you will identify barriers and in the second and third rounds you will be able to suggest solutions to the most important barriers. Please answer concisely and feel free to provide links to scientific or grey literature.

It will take you approximately 15 minutes to answer the questions in this round. If you have limited time, please focus on sections A, C and D.

Text boxes will expand as you type.

A: Current Role

*2. What is the main focus of your work?

*3. Which country are you based in?

*4. Which country or region do you focus on, if different from above?

*5. Please identify your main employer:

☐ Academic institution, e.g. university

☐ Other research institution

☐ Non-governmental organization or charity

☐ Government

☐ Private company

☐ Government-associated agency or public body

☐ Government-associated company

* 6. Please choose which systems you focus on. You may select several options.

☐ Agricultural, including arable land, permanent crops and heterogeneous agricultural areas

☐ Arctic or alpine

☐ Coastal or marine

☐ Forest or scrub, including natural ungrazed grassland, sand dunes, areas with scarce woody vegetation

☐ Mining or industrial areas, including surrounding affected areas

☐ Rivers or wetlands, including inland water bodies and banks, coastal wetlands, estuaries, tidal plains

☐ Urban or peri urban areas, including brownfields, land strips along transport and energy infrastructure

☐ Pasture or rangelands, with frequent livestock grazing

☐ No specific system

□ Other (please specify)

*7. Please select the approaches that best fit your work. You may select several options.

□ Policy or governance

□ Science or education

□ Technical practice, implementation of restoration through dealing with biotic and/or abiotic elements but not focused on people

□ Participatory practice, including environmental education, volunteer coordination and training, facilitating participatory processes, etc.

□ Other concerned user, such as a member of a nature leisure organization, hunters' association, etc.

□ Other (please specify)

*8. How many years have you been involved in activities related to restoration? Please select

from the dropdown menu.

□ 0-5

□ 6-10

□ 11-20

□ 21-30

□ 31 or more

B: Effectiveness of restoration

Now, please consider what makes restoration effective. Based on your experience:

*9. What is effective restoration and what are its key components

C: Barriers to restoration

Now, based on your personal experience of working in restoration, please consider the barriers to effective restoration. We understand a barrier to be something which significantly hampers the process of restoration.

Barriers may include environmental, social, legal, policy and any other aspects which affect restoration. Please consider a wide range of barriers and be as specific as possible regarding the type of barrier and its effects.

Unless you specify otherwise, we consider that any barrier you list will impact biodiversity, ecosystem services and ecosystem function (all three).

*10. Please list all your barriers here, using a new paragraph for each barrier.

D: Knowledge gaps/needs for restoration

Please consider the role of knowledge, knowledge gaps and communication in restoration efforts. From your personal experience of working in restoration...

*11. What would you need to know to achieve more effective restoration?

* 12. What hampers the exchange of knowledge in the restoration community?

Appendix 5. Distribution of experts participating in rounds 1, 2 and 3 of the Delphi process per employment sector. Percentages refer to the total number of participants in each round, considering that experts may use several approaches.

Employment	Round 1		Round 2		Round 3	
	Number of participants	(%)	Number of participants	(%)	Number of participants	(%)
Academic institution, e.g. university	16	33.3	8	25.0	4	26.7
Government-associated agency or public body	7	14.6	7	21.9	7	46.6
Other research institution	6	12.5	7	21.9	1	6.7
Government	6	12.5	0	0.0	0	0.0
Non-governmental organisation or charity	5	10.5	4	12.5	1	6.7
Private company	4	8.3	6	18.7	2	13.3
Government-associated company	4	8.3	0	0.0	0	0.0

Appendix 6. Countries represented in the experts' platform in rounds 1, 2 and 3 of the Delphi process. Figures are absolute and relative number of experts per country. Percentages refer to the total number of participants in each round, considering that experts may be specialized in various sectors.

Country	Round 1: Number of participants	(%)	Round 2: Number of participants	(%)	Round 3: Number of participants	(%)
Spain	12	25.0	8	25.0	4	26.5
France	6	12.5	3	9.4	1	6.7
Ireland	6	12.5	5	15.5	3	20.0
Greece	4	8.3	3	9.4	3	20.0
Norway	4	8.3	3	9.4	1	6.7
Finland	3	6.3	2	6.3	0	0
Germany	3	6.3	1	3.1	1	6.7
Portugal	2	4.2	2	6.3	1	6.7
UK	2	4.2	1	3.1	0	0
Belgium	1	2.1	0	0	0	0
Hungary	1	2.1	1	3.1	1	6.7
Sweden	1	2.1	0	0	0	0
Switzerland	1	2.1	0	0	0	0
Italy	0	0.0	2	6.3	0	0
EU	0	0.0	1	3.1	0	0
Non-EU	2	4.2	0	0	0	0
TOTAL	48	100	32	100	15	100

Appendix 7: Delphi Survey Template of Round 2

Survey template of round 2

EKLIPSE Restoration - Delphi Process Round 2: First Rating of Barriers

In the framework of the EKLIPSE request "What is hampering the effectiveness of existing approaches that aim to restore biodiversity and ecosystem function and services", we are interested in your views as an expert, practitioner or other.

This is the second round of a three-stage Delphi process in which you will identify and rank barriers to restoration and suggest solutions.

* 1. EKLIPSE requests relevant personal data in order to assess questionnaires appropriately. EKLIPSE is a science research project in the public interest and the lawful basis for processing your personal data under the EU's General Data Protection Regulation (GDPR) will be a public

task. Our privacy policy (www.ceh.ac.uk/privacy-policy) contains further information on the purpose and lawful basis for processing your personal data.

By participating in this study, you agree that EKLIPSE will collect data on your background in restoration and views on barriers limiting the effectiveness of restoration. No personally identifying information will be recorded.

☐ I agree to take part

☐ I do not agree to take part

Current Role

*2. What is the main focus of your work?

*3. Which country are you based in?

*4. Which country or region do you focus on, if different from above?

*5. Please identify your main employer:

☐ Academic institution, e.g. university

☐ Other research institution

☐ Non-governmental organization or charity

☐ Government

☐ Private company

☐ Government-associated agency or public body

☐ Government-associated company

* 6. Please choose which systems you focus on. You may select several options.

☐ Agricultural, including arable land, permanent crops and heterogeneous agricultural areas

☐ Arctic or alpine

☐ Coastal or marine

□ Forest or scrub, including natural ungrazed grassland, sand dunes, areas with scarce woody vegetation

□ Mining or industrial areas, including surrounding affected areas

□ Rivers or wetlands, including inland water bodies and banks, coastal wetlands, estuaries, tidal plains

□ Urban or peri urban areas, including brownfields, land strips along transport and energy infrastructure

□ Pasture or rangelands, with frequent livestock grazing

□ No specific system

□ Other (please specify)

*7. Please select the approaches that best fit your work. You may select several options.

□ Policy or governance

□ Science or education

□ Technical practice, implementation of restoration through dealing with biotic and/or abiotic elements but not focused on people

□ Participatory practice, including environmental education, volunteer coordination and training, facilitating participatory processes, etc.

□ Other concerned user, such as a member of a nature leisure organization, hunters' association, etc.

□ Other (please specify)

*8. How many years have you been involved in activities related to restoration? Please select

from the dropdown menu.

□ 0-5

□ 6-10

□ 11-20

□ 21-30

□ 31 or more

We first ask you to rate several components of effective restoration, depending on how much you agree with each statement.

*9. Effective restoration aims to enhance ecosystem services, functions and biodiversity

Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
○	○	○	○	○	○	○

*10. Effective restoration assists and hastens natural recovery towards self-sustaining systems

Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
○	○	○	○	○	○	○

*11. Effective restoration is based on sound knowledge of the ecosystem including the soil

Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
○	○	○	○	○	○	○

*12. Effective restoration includes prior assessment, monitoring and adaptive management

Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
○	○	○	○	○	○	○

*13. Effective restoration relies on a solid participatory process and involves landowners

Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
○	○	○	○	○	○	○

*14. Effective restoration sets and achieves ambitious goals aligned with legal and socio-economic contexts

Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
○	○	○	○	○	○	○

*15. Effective restoration tackles degradation factors and assists in deterring further ecosystem degradation

Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
○	○	○	○	○	○	○

*16. Effective restoration uses minimum intervention and optimizes cost-benefit and cost-effectiveness

Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
○	○	○	○	○	○	○

*17. Effective restoration transfers results to society

Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
○	○	○	○	○	○	○

*18. Effective restoration considers large temporal and spatial scales (landscape-scale restoration)

Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
○	○	○	○	○	○	○

Now, please consider the barriers to ecological restoration identified by the participants in Round 1, and rate each according to its importance. Here we use "important" to indicate the degree to which the barrier impedes effective restoration, in your experience. At the end of each question, you will have the opportunity to be more specific about the barrier and your rating.

*19. Complexity of the legal framework

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

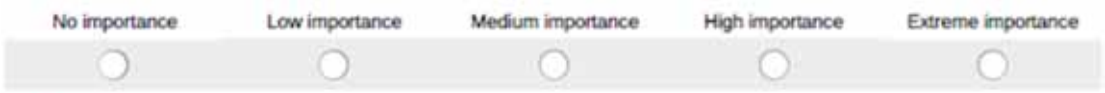
Explanation

*20. Conflicting interests of different stakeholders

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

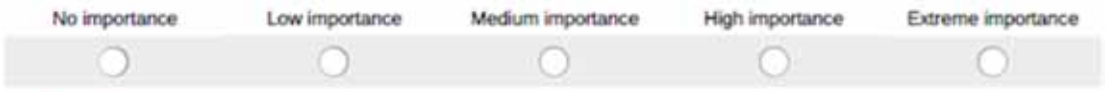
Explanation

*21. Lack of collaboration between different stakeholders



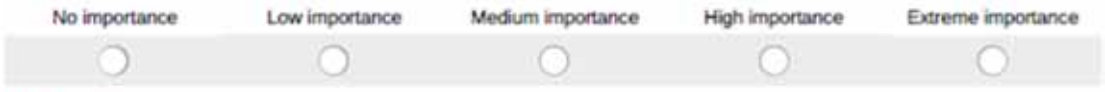
Explanation

*22. Conflicts between restoration goals, e.g. biodiversity, climate change mitigation, nutrient retention



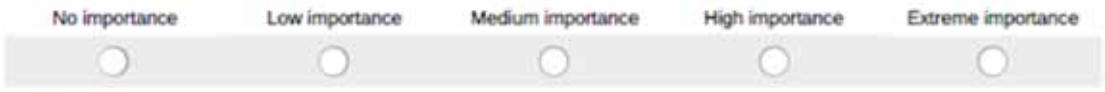
Explanation

*23. Constraints due to abiotic characteristics of the area, e.g. climate, topography, water availability



Explanation

*24. Constraints due to biotic challenges e.g. concerning species dispersal rates, inter-specific interactions, etc.



Explanation

*25. Difficulty in obtaining legal or property rights over the area to implement restoration

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*26. Harmful subsidies favouring degradation

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*27. High level and rate of degradation

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*28. Inadequate implementation of current policies

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*29. Insufficient funding

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*30. Lack of coordination between decision-makers in different domains and administrative departments.

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*31. Lack of effective knowledge exchange

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*32. Lack of evaluation, monitoring and documentation

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*33. Lack of skilled professionals to * perform restoration

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*34. Lack of integrated land use planning

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*35. Lack of involvement of the private sector

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*36. Lack of motivation in decision-makers to incorporate innovation

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*37. Lack of prior evaluation, assessment and design

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*38. Lack of quality plant material (including lack of suitable species and genotypes)

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*39. Lack of relevant ecological knowledge and experience

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*40. Lack of sense of identity, attachment to the landscape

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*41. Lack of societal awareness and engagement

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*42. Lack of standards against which progress can be measured

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*43. Lack of suitable technology

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*44. Lack of understanding and collaboration across different aspects of restoration, e.g. ecology, engineering, social sciences, etc.

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*45. Low political priority for restoration

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*46. Perceived complexity of implementing restoration

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*47. Lack of appropriate compensation and financial returns on restoration

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

Explanation

*48. The timing of restoration projects does not correspond to ecological and social timescales

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

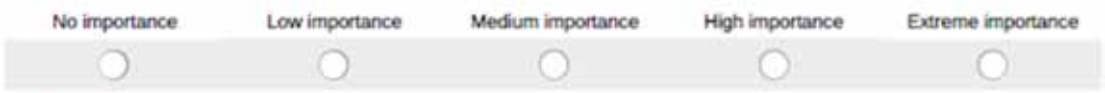
Explanation

*49. Unrealistic or unclear project goals

No importance	Low importance	Medium importance	High importance	Extreme importance
○	○	○	○	○

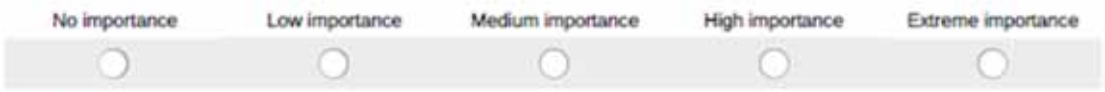
Explanation

*50. Unsuitable policies and lack of enabling policy instruments



Explanation

*51. Lack of knowledge about soils



Explanation

*52. For your most important barriers, please provide possible solutions. The text box will expand as you type.

Appendix 8: Delphi Survey template of round 3

EKLIPSE Restoration - Delphi Process Round 3: Second Rating of Barriers

In the framework of the EKLIPSE request "What is hampering the effectiveness of existing approaches that aim to restore biodiversity and ecosystem function and services", we are interested in your views as an expert, practitioner or other.

This is the third round of a three-stage Delphi process in which you have the opportunity to see the barriers identified by all respondents, revise your ranking and suggest solutions. If you did not participate in the previous round, you can still suggest solutions, and you will be redirected to the right part of the survey.

* 1. EKLIPSE requests relevant personal data in order to assess questionnaires appropriately. EKLIPSE is a science research project in the public interest and the lawful basis for processing your personal data under the EU's General Data Protection Regulation (GDPR) will be a public task. Our privacy policy (www.ceh.ac.uk/privacy-policy) contains further information on the purpose and lawful basis for processing your personal data.

By participating in this study, you agree that EKLIPSE will collect data on your background in restoration and views on barriers limiting the effectiveness of restoration. No personally identifying information will be recorded.

☐ I agree to take part

☐ I do not agree to take part

Current Role

In this section we ask you some questions on your experience of restoration. Even if you provided this information during the previous rounds of the survey, you must complete it again as every round is independent and completely anonymous, and this information is crucial for interpretation.

*2. What is the main focus of your work?

*3. Which country are you based in?

*4. Which country or region do you focus on, if different from above?

*5. Please identify your main employer:

☐ Academic institution, e.g. university

☐ Other research institution

☐ Non-governmental organization or charity

☐ Government

☐ Private company

☐ Government-associated agency or public body

☐ Government-associated company

* 6. Please choose which systems you focus on. You may select several options.

☐ Agricultural, including arable land, permanent crops and heterogeneous agricultural areas

☐ Arctic or alpine

☐ Coastal or marine

□ Forest or scrub, including natural ungrazed grassland, sand dunes, areas with scarce woody vegetation

□ Mining or industrial areas, including surrounding affected areas

□ Rivers or wetlands, including inland water bodies and banks, coastal wetlands, estuaries, tidal plains

□ Urban or peri urban areas, including brownfields, land strips along transport and energy infrastructure

□ Pasture or rangelands, with frequent livestock grazing

□ No specific system

□ Other (please specify)

*7. Please select the approaches that best fit your work. You may select several options.

□ Policy or governance

□ Science or education

□ Technical practice, implementation of restoration through dealing with biotic and/or abiotic elements but not focused on people

□ Participatory practice, including environmental education, volunteer coordination and training, facilitating participatory processes, etc.

□ Other concerned user, such as a member of a nature leisure organization, hunters' association, etc.

□ Other (please specify)

*8. How many years have you been involved in activities related to restoration? Please select

from the dropdown menu.

□ 0-5

□ 6-10

□ 11-20

□ 21-30

□ 31 or more

*9. Please choose whether or not you participated in the previous round of the Delphi process (where you ranked the components and the barriers for effective ecological restoration). If you did not, you will be directed to the solutions section.

□ Participated

□ Did not participate

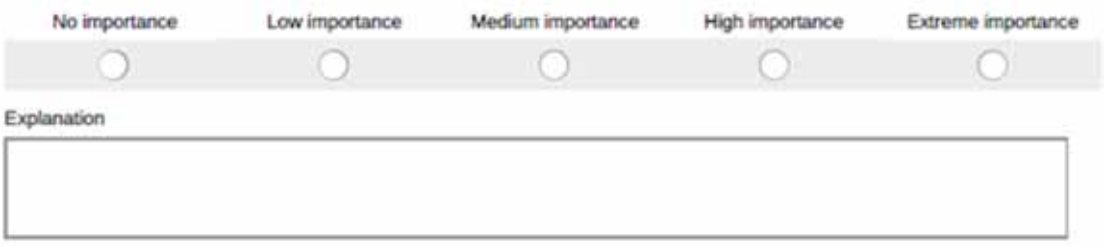
Now, please consider **the barriers to ecological restoration, and their importance ratings** combined across all participants in Round 2. You will be able to see the results of the collective weighting for each question, as **bar plots and participant comments**. In this light, **please rate the importance of the barriers** once more. You may also suggest **possible solutions** for the remaining key barriers.

Here we use "important" to indicate the degree to which the barrier impedes effective restoration, in your experience. At the end of each question, you will have the opportunity to be more specific about the barrier and your rating.

Q10: Complexity of the legal framework

Round 2 participant ratings of importance

*10. Second rating: Complexity of the legal framework



Round 2 participant comments

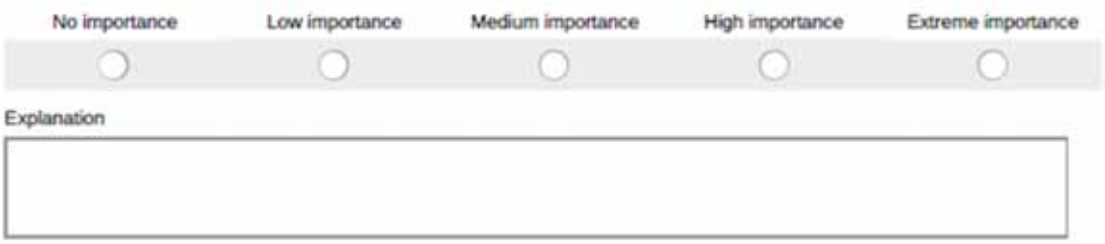
1. For example, on coastal areas there is a complex legal framework often with conflicting administrations
2. EU CAP and other regulatory frameworks and subsidies strongly influence the regional and countrywide laws and regulations, which in turn affect even what is considered restoration or success in restoration or conservation.
3. I think this is not a major barrier, but instead not complying with legislation for economic reasons
4. In our country there are many administrations involved for an specific project, and with different specifications
5. Legal frameworks are imagined realities based on vested interest and not always based on the reality of what needed to restore natural habitats. Lay people need to navigate the complex legal framework
6. Restoration can include permitting and taking account the possible effects to the neighbouring landowners, restrictions in the legislation of protected areas or species etc
7. Highly depends on the type and scale of restoration. The higher the scale, the more important it becomes.
8. "Legal" environment must be clear and to support the importance of (restored) ecosystems for the society. Quite often this environment is not clear since there are many interests from several legal bodies of society.

9. legal framework is slow to adapt to need and technical advances; UK process makes it hard to develop and implement landscape scale approaches to mining sites restoration that would generate far more benefits than current piecemeal process
10. In Spain legal framework is complex, among other factors, due to the ownership of land (more than 70% private), which supposes an important challenge for landscape-scale restoration
11. One of the most significant factors, as it is not clear how to go about it, what permits are needed, what steps to follow, who to involve etc.
12. The legal system is which planning law and contract law are implemented are key to the delivery of effective projects. Also the development of policy requires that a legal framework / (bureaucratic) exists to monitor and assist delivery of such policy. Ensuring clear guidance to the interpretation and assistance to 'navigating' legal and regulatory environments is also a necessity as many community and local based groups require technical (science and engineering) and also help with legal and administrative frameworks.
13. Further detail required to refine my answer.
14. Works with managers include several legal contexts at different scales, sometimes flowing in the same direction, sometimes not; In river restoration for ex., the responses to the EWFD became crucial for manager, when sometimes local contexts were inadapted to.

Q11: Conflicting interests of different stakeholders

Round 2 participant ratings of importance

*11. Second rating: Conflicting interests of different stakeholders



Round 2 participant comments

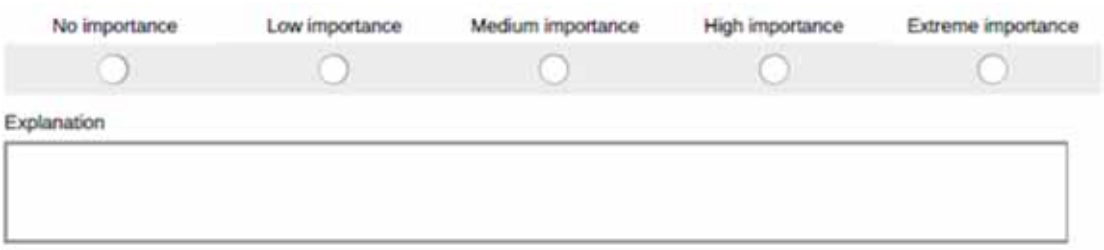
1. This is why there is a need of stakeholder mapping specially their dependence/power relationships but also their trust/mistrust ones. Power exercised on specific areas. And this works both for administrations and social ones.
2. Monetary/economic components still tend to easily override any other aspects, that are normally more longer term in scope, including provisioning of ecosystem services other than provisioning ones, and ecosystem functioning and high biodiversity as aims.
3. Think only at the big infrastructures or urban planning, that not always represent the common good
4. Unless stakeholders agree on what is common good or what is in the best interest of all, vested interests will be conflicting
5. Agriculture mainly, but also leisure activities such as hunting or fishing
6. Normally when you involve them at the initial part of the project they finally supporting it

7. There may be conflicts between the habitats and species targets, hunting, burning regulations and authorities etc.
8. restoration is to large degree about conflicting land-use
9. Different stakeholders have different interests (economic, social) often interact each other. However, such interest must be aligned to the premium interest for nature and society, i.e. the sustainability of natural resources.
10. In our experience these can often be managed through careful negotiation
11. what makes crucial real and effective participation processes to reconcile interests
12. Depends on the area/location of the restoration project. Usually though there are conflicting interests and positions. These, however, can be bridged through well-planned consultation and dialogue processes.
13. Stakeholder consultation and information is essential. Never underestimate their capacity to understand the science behind proposals. Frequent interaction also before implementation essential.
14. Is of high importance but with effective policy development and regulation, the 'common good' of ensuring BGI and NBS are delivered as the norm must be shown to be in the interests of all.....so it become medium importance.
15. The fish lobby in river ecological restoration could impact decisions, when it is not proven that it is the once way to restore biodiversity in rivers. Worth, the agro-industrial lobby could be so strong that the solutions in ER are useless.

Q12: Lack of collaboration between different stakeholders

Round 2 participant ratings of importance

*12. Second rating: Lack of collaboration between different stakeholders



Round 2 participant comments

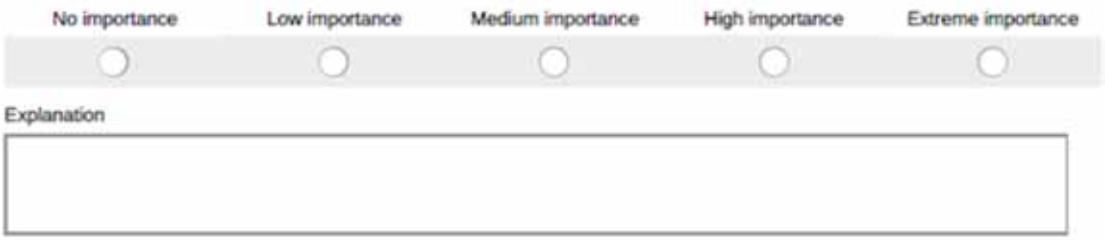
1. Surprisingly the whole system can work when conflict is contained inside limited areas of the project. For instance permit acquisition can be a very different cage and not linked with possible conflicts with neighbours.
2. People are regional government level tend to just follow the regulations, and not be as open for innovative measures to restore.
   Restoration in Germany is often hampered by the regulations and views of what is a good idea (e.g. being allowed to intervene and sow species in natural landscapes is generally not allowed under Germany's conservation law).
3. As a consequence of the above two points

4. Effective restoration requires multi-level, multi-disciplinary collaboration of all stakeholders for success
5. In large and multitargeting restoration projects many different aspects must be taken into account.
6. Clear communication pathways, collaboration schemes, and adjustment of stakeholder interest to the major society interest is highly important.
7. this is overcome by planned engagement to bring all to the table, but it is time expensive
8. While important, this particular barrier can be overcome through well-planned consultation and dialogue processes. It is quite often the case that stakeholders have never had the chance to meet and listen to one another, let alone collaborate.
9. At the outset of a collaboration, this is when facilitation is needed. Professional facilitators (conflict resolution .... Paolo Friere) should be used. It is not something designers can do...or contract /project managers. The societal framework is key to agreeing a 'way forward' and developing plans that are inclusive of all (in as much as that can be done !).
10. see above: lobby of fish ecology, stronger than the others; difficulty in rural agro-intensive landscapes to propose ER as a solution.
11. Better co-operation e.g. among landowners would lower the costs of restoration

Q13: Conflicts between restoration goals, e.g. biodiversity, climate change mitigation, nutrient retention

Round 2 participant ratings of importance

*13. Second rating: Conflicts between restoration goals, e.g. biodiversity, climate change mitigation, nutrient retention



Round 2 participant comments

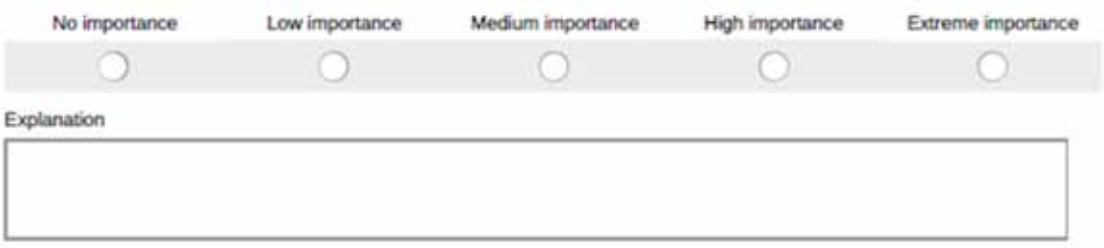
1. I have never encountered this situation. Trade-offs between ecosystem services but not restoration goals. Probably a sound problem understanding phase is enough to avoid this risk.
2. This is the key crux of what we now need to work on in a more concerted way. How do we reach multiple goals whilst still ensuring the biophysical basis of our existence and that of other organisms? I think we need strong research programmes on the extent to which biodiversity is not an equal bargaining chip with livelihoods and social components for large scale restoration. Or how much winwin and how much tradeoff do we need to take into account, needs proper assessment with multiple stakeholder research and projects. Until we have studied this in an integrated manner in different case study regions, we will not solve the debates about priorities.

3. The three examples given seem to go in the same direction. Yet, there is a conflict between productive vs. ecological approach
4. In my opinion, the effective restoration aims to solve this conflicts
5. Restoration goals should be complementary - one leads to the other
6. eg different types of mires produce different amount of emissions into the water and the air, so all effects must be evaluated and decisions made by the best expert knowledge
7. I think this can be prioritized.
8. Often such goals are mutually good for the whole set of ecological sustainability, and there is no apparent conflicts, i.e. the achievement of good nutrient status in the soil is often positively associated with high biodiversity.
9. in simple terms there is much work to be done to align these goals, and to do so needs development of process eg identifying ways to accurately value biodiversity in natural capital accounting etc
10. Effective restoration should be able to conciliate goals. Its design requires the participation of experts in all areas. It is an effort and a cost, but it is not an impossible barrier
11. Given the rising attention to nature-based solutions for climate change, this a matter of a silo scientific approach which does not see the multiple benefits of restoration. An area that can also benefit for greater cross-sectoral and interdisciplinary teams and approaches.
12. The project should be informed by a scientific and engineering approach... and so such conflicts are only a PR effect (I think). For instance all three of the examples could be reconciled into a project.....
13. Depending on individual cases.
14. ex, Nutrient retention in wetlands always conduct to banalisation of biodiversity
15. According to a recent LIFE project on peatlands the goals/positive outcomes may differ if we look at different time horizons. And the effects of restoration are strongly dependent on the conditions of the site.

Q14: Constraints due to abiotic characteristics of the area, e.g. climate, topography, water availability

Round 2 participant ratings of importance

*14. Second rating: Constraints due to abiotic characteristics of the area, e.g. climate, topography, water availability



Round 2 participant comments

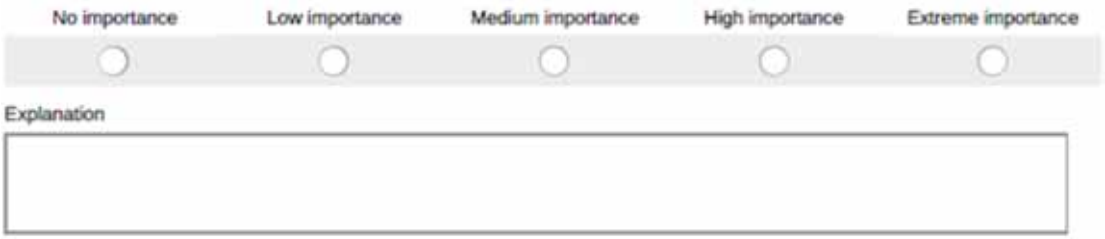
1. As previously stated, the "problem understanding" is a key issue. But usually of less relevance than cultural and administrative ones.

2. Excess N is a key issues in many parts of the world, a slow driver of change that sometimes prohibits effective biodiversity restoration. Climate change is a factor we need to increasingly plan in to our restoration.
3. It depends on the relation of the resilience threshold and how the abiotic characteristics affects. It contributes also to the biotic relations
4. Abiotic areas most probably would also restrict exploitation in the first place and thus less restoration required
5. We have practices to tackle these. It is more important if the system is sustainable on the long-term with no or minimum further intervention.
6. Ecological restoration must take place even if abiotic characteristics of the area are not in good status.
7. yes but by factoring them in at the start of the design planning you fit the restoration to the abiotic conditions and find a habitat that suits the conditions
8. The abiotic characteristics consideration is critical for an effective restoration. Abiotic characteristics are not a barrier, the goals for an effective restoration should be design considering this abiotic characteristics
9. Restoration is about restoring the ecosystems to what existed before degradation, loss, pollution etc, given the abiotic characteristics of the area. One would not try to restore a Mediterranean ecosystem in an alpine region, nor a continental forest along the coast of the Mediterranean. There may be physical constraints because of human interventions that have altered the landscape so significantly that restoration is made technically very difficult or costly.
10. The context within which the projects / environments exist is the key constraint to ensure minimal inputs and a sustainable / resilient outcome. Resource planning is thus a key task throughout any process such as ecosystem restoration.
11. Good knowledge of the ecosystem functioning, multidisciplinary approaches essential to understand potential to restore specific habitats.
12. difficulty to take in account all the scales that drive ecological restoration successes in the same project/action

Q15: Constraints due to biotic challenges e.g. concerning species dispersal rates, inter-specific interactions, etc.

Round 2 participant ratings of importance

*15. Second rating: Constraints due to biotic challenges e.g. concerning species dispersal rates, inter-specific interactions, etc.



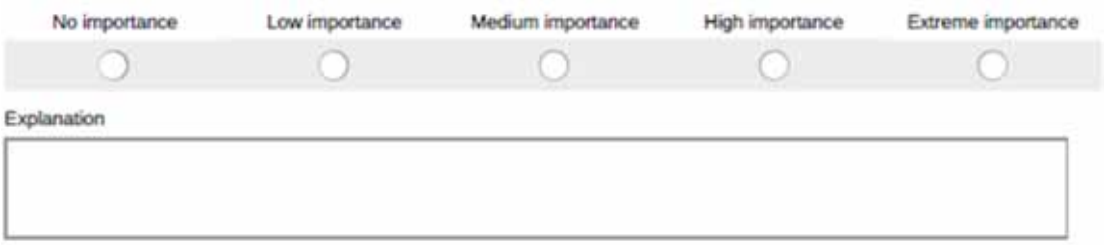
Round 2 participant comments

1. For example the negative feed-back of Ammophila arenaria with vegetation cover increase in dune ecosystems. Again system (problem) understanding plays a key role.
2. Interaction effects between abiotic drivers (N deposition) and biotic drivers (e.g. nitrophile grass species outcompeting Calluna vulgaris heather in the heathlands when there is more N available.). This means that socioeconomic and governance/political aspects including our behaviour need to be co-addressed if we want real change.
3. I think we know less about this subject or we study it less than the abiotic elements
4. Only in the situation where habitats are fragmented and not connecting green corridors exist
5. Invasion is still a huge problem with little success.
6. Ecological restoration is highly constrained by biotic challenges, especially for plants.
7. ensure landscape context is considered and avoid setting too specific species goals
8. Idem than before
9. This is an important barrier but restoration should take into account of time-scale and give time also for nature to return, without rushing it.
10. Further detail required to refine my answer. Relevance depending on cases.
11. As we develop more knowledge on this aspect and so 'assist' nature by collecting 'her' seeds and dispersing as we do, then this is of importance for our research objectives and developing practices so medium (not critical)
12. spatial analyses in RE is crucial, but rarely done

Q16: Difficulty in obtaining legal or property rights over the area to implement restoration

Round 2 participant ratings of importance

*16. Second rating: Difficulty in obtaining legal or property rights over the area to implement restoration



Round 2 participant comments

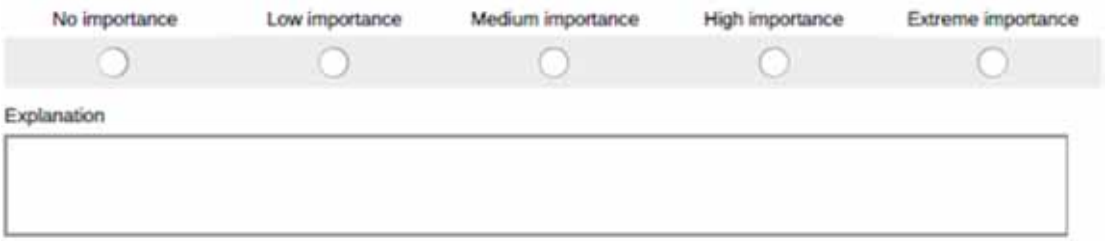
1. Not only permit acquisition, but also new conceptual grounds as the capacity to manage/restore abandoned (novel) ecosystems beyond property limits as a compensation strategy to manage trade-offs on housing/camping/economic activity projects that involve some level of urbanisation. There is an urgent need to implement the legal environment.
2. If we had different land ownership scenarios we would be able to mitigate biodiversity loss in a much stronger way. The fact that large bird conservation NGOs buy a lot of land to create the necessary habitat is a strong pointer for this.

3. In Portugal, most of the rural or "natural area" is private. So, this is a serious limitation
4. Specially in the rivers
5. Governments have legal instruments to overcome same
6. long-term problems
7. Quite often, especially in Mediterranean area, the property rights are not so well documented and several problems for effective ecological restoration are created.
8. UK land rights mean that unless the project has over-riding national importance you cannot force the owner to give up their rights. also, voluntary incentives eg compensation rates are insufficient
9. Particularly true in cases of privately owned property. Restoration should qualify for compensation to property owners, even if in the past they may have caused the degradation, based on previously applied legislation or common approaches. This would not apply if degradation was in fact illegal.
10. to ensure the effort results in long term results and a truly resilient landscape (urban and rural and .....peri-urban?), then the issue of property must be resolved at an early stage. Land ceded to the state and run by local NGOs appears to be a good model.

Q17: Harmful subsidies favouring degradation

Round 2 participant ratings of importance

*17. Second rating: Harmful subsidies favouring degradation



Round 2 participant comments

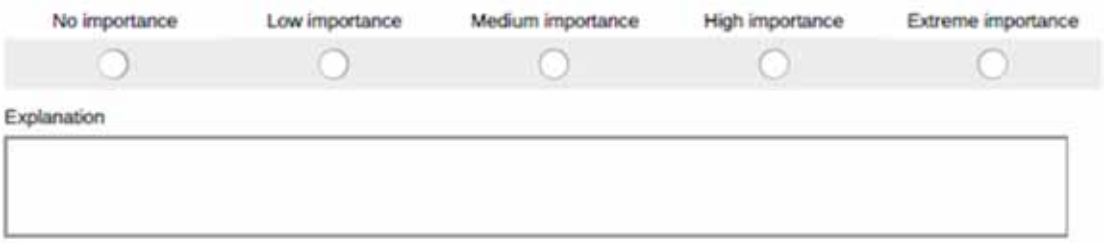
1. Peatlands are still being exploited and harvested in Ireland for horticultural peat and for power station generation and other peat products.
2. Mainly agricultural/farming ones. But I have never met one on my projects.
3. See CAP agrienvironment schemes that fail to deliver.
4. In intensive agriculture practices, for instance
5. In agriculture for example is high . In other situations i think is less
6. in particular related to forestry and agriculture
7. Subsidies in the agriculture sector could favour degradation since farmers expands their activities in natural areas, or use agrochemicals to increase crop production. This could be reversed if subsidies were given for restoration purposes as well.
8. in the UK this is largely in the past, but did much of the damage that ecosystem restoration now needs to redress.
9. Harmful subsidies that make it impossible to eliminate the degradation causes

10. Very high importance, because the incentive to support the restoration is minimal. Reforming subsidies schemes is of critical importance.
11. Not familiar with these cases. But I do not rule it out.
12. Can be eliminated by education of the industrialists....perhaps ? but is a very difficult message 'to save the environment now' for future 'business'.....The argument of 'self interest' in that it is not in their interest to destroy the planet ecosystem... a long term argument ...this requires both policy and an industrial agenda that is in line with 17 UNSDGs ?.
13. This does not actually prevent restoration per se, but the balance between funding for restoration and subsidies favouring degradation is so badly off that restoration outcomes are never sufficient. Moreover, it would always be cheaper to prevent the original damage than restore after the damage.

Q18: High level and rate of degradation

Round 2 participant ratings of importance

*18. Second rating: High level and rate of degradation



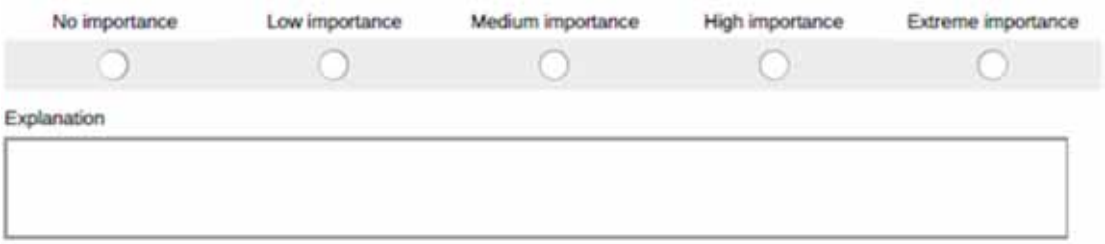
Round 2 participant comments

1. Of course this is not a linear process. There can be different tipping points. But this only adds complexity, and time and economic costs. But rarely constraining or making impossible the restoration goals.
2. More degradation , more difficult is to recover
3. Cost of restoration goes up exponentially, but it depends whether it is rehabilitation or restoration and to what level of restoration
4. In my opinion it is not a direct barrier to restoration, but can have indirect effect, like the lack of species pools, degradation of restored areas.
5. The highest level of and rate of degradation the hardest will be ecological restoration. It is important to retard these high rates.
6. not sure I understand how this is meant
7. Long-term process. It is a barrier in the short term
8. loss of species and niches is accelerating e.g recent UN Biodiversity report (May 2019)
9. This should determine the resources required and the importance of level of degradation will depend on resources available.

Q19: Inadequate implementation of current policies

Round 2 participant ratings of importance

*19. Second rating: Inadequate implementation of current policies



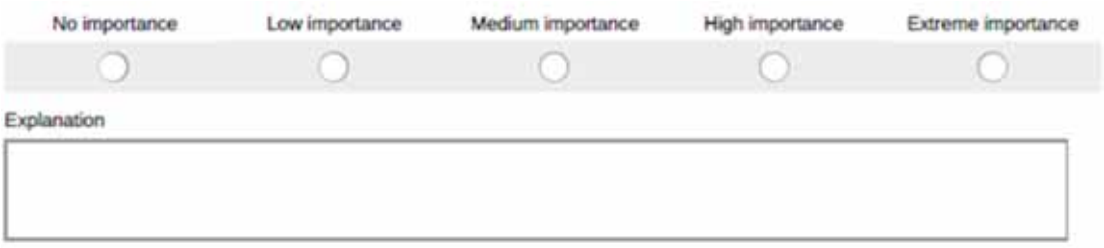
Round 2 participant comments

1. For instance the shocking legal environment on rain-water and regenerated water use.
2. As example the Water Framework Directive, a good legislation that have a poor implementation at the moment in Europe
3. In Ireland specifically, this is a factor depending on which political party is in government
4. Current policies that try to halt degradation and foreseen restoration or aim at ecological restoration are not successful in many cases. There are several interest that conflict. An integrated approach is needed.
5. a bigger issue might be that the current policies are not strong enough so main need is to strengthen them!
6. A qualifier is needed here. Under current policies we understand to mean "current environmental/ nature / restoration policies". If other policies were inadequately implemented in favor of the environment then the ranking could and probably would be different.
7. One of the most important impediments to nature conservation. Obviously depending on the geographic location (e.g. country, governments).
8. Implementation and monitoring is a key component .... responses to climatic and ecosystem 'crises' result in policy but then takes much time..... policy developed from the 'grassroots' such as Burrenbeo.... has positive impact due to the structure and approach..... https://burrenbeo.com/
9. green & blue ways restoration sometimes are going the the opposite way of ER
10. Or lack of proper implementation of e.g. CBD and other international agreements/policies.

Q20: Insufficient funding

Round 2 participant ratings of importance

*20. Second rating: Insufficient funding



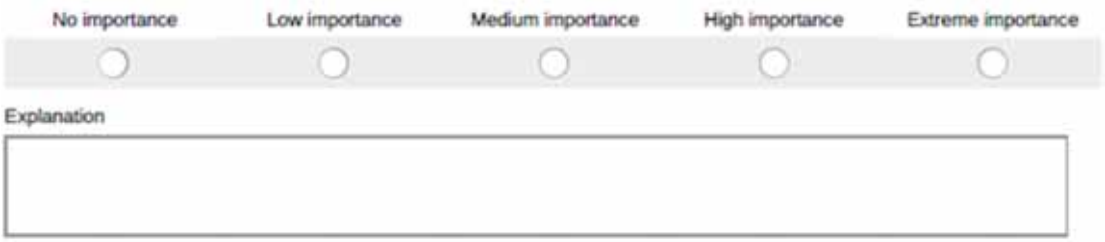
Round 2 participant comments

1. Probably the order of importance is legal/stakeholder/agility and on time response/funding/uncertainties and risks like flash floods, hurricanes, fires,...
2. If one compares the budget of the ministry of agriculture or health with that of the ministry of the environment then one gets a strong message about where our priorities as a species lie. Focussed on ourselves. This is probably the biggest leverage point potential for change, but very wicked as a problem.
3. Is important specially in when you work in a long term restoration
4. Restoration and rehabilitation is not a high priority, not a vote catcher and especially the Irish Government will only act or allocate funding when compelled to do so by EU legislators
5. It is extremely important to apply sufficient funding. The most of the ecological restoration works demands high rates of funding, depending on the time distance from the start of degradation and the economic interest behind.
6. In many cases yes, but increasingly a) low intensity low cost restoration choices eg natural succession b) new innovative restoration techniques c) working with business partners etc can overcome this and achieve good ecological outcomes
7. Most environmental / nature funding to date has been towards protection rather than towards restoration. This is gradually changing in the EU funds but still ways to go. Also, any environment/nature funding is only very small compared to the size of destructive funds in terms of subsidies (e.g. agriculture) or development plans (e.g. large infrastructure).
8. Funding is available but the layers of bureaucracy must be somehow be simplified..... and funding opportunities perhaps combined within zones or areas .... multiagency / multi departmental budgets..... for local government and for national and regional ....to include the European Commission....inter Directorates General.
9. Along with implementation of policies.
10. impossibility to follow long-term patterns, crucial in ER
11. From the list, this is the number 1!

Q21: Lack of coordination between decision-makers in different domains and administrative departments

Round 2 participant ratings of importance

*21. Second rating: Lack of coordination between decision-makers in different domains and administrative departments.



Round 2 participant comments

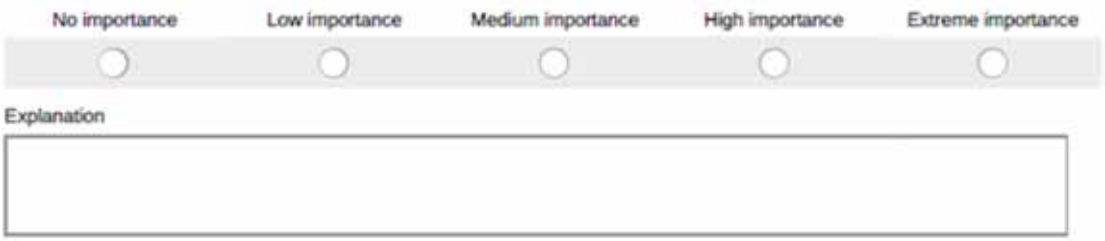
1. Relevant. But as stated before, the administrative environment can work if each administration keeps its own conflicting power behind prescribed mutually excluding limits.
2. Silo thinking in ministries and at political level is a key hampering factor.
3. Is important but not decisive
4. Not so much the lack of coordination as the fact that decision-makers don't have common goals or objectives, i.e. silo effect of implementing actions
5. No communication channels and no networking activities raise barriers to effective ecological restoration
6. reasonable alignment in most situations in the UK - much work has been needed to achieve it!
7. Silo approaches are truly detrimental.
8. as per previous point.
9. Further detail required to refine my answer. Also lack of coordination/interaction between policy makers and scientific community

   (e.g. academic community).
10. Especially important if trying to restore larger landscapes with different habitat types.

Q22: Lack of effective knowledge exchange

Round 2 participant ratings of importance

*22. Second rating: Lack of effective knowledge exchange



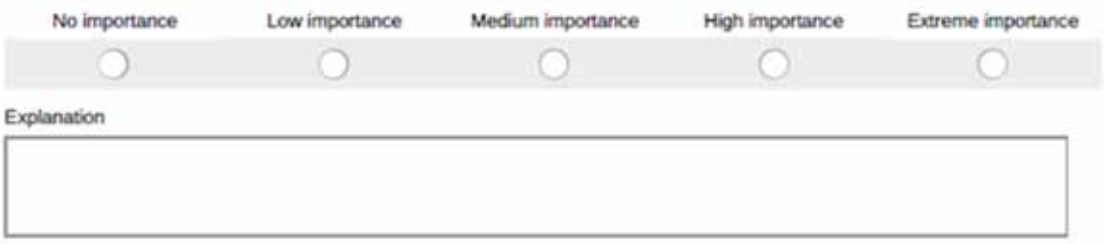
Round 2 participant comments

1. Mostly there is a need on new areas as governance system analysis. For example there is a frequent statement that the lack of capacity of administrations to adapt themselves to the pace imposed by climate change is a major issue. But there is a clear lack of "blueprint protocols" and metrics on this ground.
2. There is a lack of real case studies
3. Again more a lack of misalignment of objectives or goals
4. in particular between practitioners and scientists
5. Knowledge exchange is important to take place in effective ecological restoration. There is plenty of information provided by many sources, but given time constraints we lack of qualitative assessment of it.
6. this is a key delivery area for us; advising on restoration best practice is essential to success, however in the UK there is not enough capacity to provide the advice at the right level
7. The exchange of knowledge both on the scientific /engineering practices / methodologies (and their adaption locally) but also on the social and human land use / integration aspects must somehow be facilitated.
8. Publication of Best Practice Guidelines essential.
9. gap between managers, researchers, policy makers, progress in education
10. More so in the decision making of the landowners - they do not always have information on all their options.

Q23: Lack of evaluation, monitoring and documentation

Round 2 participant ratings of importance

*23. Second rating: Lack of evaluation, monitoring and documentation



Round 2 participant comments

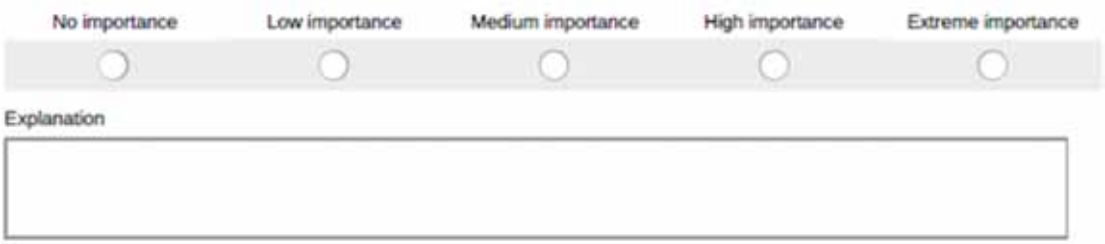
1. poor previous record keeping and archiving (pre-digital age) a big problem
2. Probably most on south European countries where environmental issues are treated as social reputation instruments. The need of adaptive management systems is high; and can only work with the input of evaluation, monitoring and documentation.
3. So many projects do not really get monitored. Programmes outside of academia in regional politics fund just enough to make some reports and brochures but not enough money to pay someone a salary to manage a reserve extensively so we can restore biodiversity to cultural landscapes, let alone to monitor the success adequately.
4. Specially in the evaluation and monitoring in a long term

5. Enough evaluation, monitoring and subsequent reports exist. The lack of political will to act on actions, or implementation of recommendations
6. Adaptive management is important, and the lack of evaluation, monitoring and documentation are issues of high importance in this respect.
7. cost and lack of time!
8. In addition, there is a need for the research to be linked to policy needs.
9. Plan, Act, Evaluate ..... we must know what we are doing to improve what we do next !
10. Essential to assess effectiveness and value for money.
11. job is done, but is it easily accessible?
12. Long-term monitoring and funding for it!

Q24: Lack of skilled professionals to perform restoration

Round 2 participant ratings of importance

*24. Second rating: Lack of skilled professionals to perform restoration



Round 2 participant comments

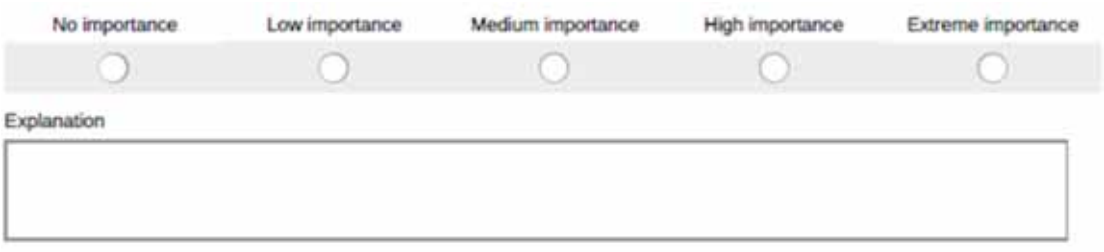
1. Most professionals are staff of administrations. And very few administrations keep interested on adaptive management. Most of them keep the previously stated methods without any analysis on effectiveness and efficiency.
2. There is a lack of specific training in restoration
3. Enough expertise exist in Ireland due to the extent of research grants and knowledge obtained through practical fieldwork. Lack of streaming funds to actually implement restoration more so
4. In some fields. Connection between research and implementation is not good enough in France
5. There are several good technical equipment and practices to do the restoration. The problem is whether decision makers hire a specialist or simply the price
6. if project is well planned and monitoring/evaluation is working well it is not necessary to have expert doing the work (but it is of course useful if available)
7. Ecological restoration demands skilled professionals in less-studied topics, like the below ground sciences, or systematics.
8. this is improving in the UK through training and skills sharing
9. training of locals to carry this out..... they build it and maintain it under instruction....to start with....and then teach us !

10. ecological restoration is very often used in place of classical management: some manager do not know what RE is.
11. Not a major issue in Finland with the current rate of restoration, but may become a bottleneck if more funding is directed to restoration.

Q25: Lack of integrated land use planning

Round 2 participant ratings of importance

*25. Second rating: Lack of integrated land use planning



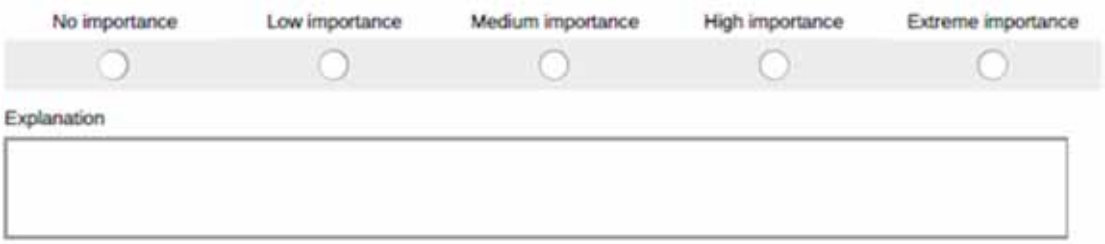
Round 2 participant comments

1. Probably this is one of the major issues making the ecosystem services concept a needed explicit management tool. Most of tradeoff analysis is about this. The need to integrate human and economic activity and find new revenue resources.
2. We need a regional landscape scale approach such as the Land Degradation Neutrality framework of the UNCCD.
3. The planification is the first step
4. Other land-use options, like intensive farming, economic activities, and the like are preferred land-use above green infrastructure or ecosystem service considerations
5. Integration of planning of land formation and management is extremely important, since all management efforts must be tuned and coordinated for the major goods for the society.
6. many opportunities to realise restoration at scale are missed.
7. Related to the need for inter agency / inter department thinking ... avoidance of 'silo' thinking.....
8. Further detail required to refine my answer.
9. scales in RE are crucial
10. With the lack of funding, number one reason! With better land use planning (directed more according to ecological values and sustainability rather than just economical aspects) we could avoid degradation better in the first place. Hard to perform in a country where major part of the land is owned by hundreds of thousands private land owners...

Q26: Lack of involvement of the private sector

Round 2 participant ratings of importance

*26. Second rating: Lack of involvement of the private sector



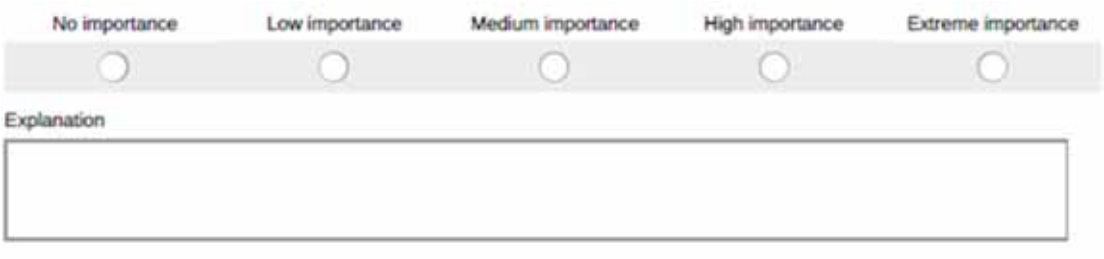
Round 2 participant comments

1. When the goal is going beyond a critical threshold and get a major impact, we need private sector involvement and nearly always public-private collaboration.
2. Companies still consider the environment a luxury product not an inherent component of their success. Free ecosystem services provisioning does not help this.
3. Private sector would only get involved if there is a direct economic benefit in it. That in itself could skew the quality of restoration
4. in some cases the private sector are more involved that the public sector
5. Private sector can support towards the effective ecological restoration but is the public sector who can do it more effectively, since the goods of restoration go to the society and not only to a company.
6. private sector are a significant actor in the UK. the reverse might be true; the state / municipal actors are often not active
7. Depending on the ecosystem & species. Essential to a) improve operation licencing restoration requirements (EPA licences), b) Publication of requirement standards and best practice guidelines and c) funding in some other cases.
8. BGI and NBS must be developed as part of the fabric of all development. The private sector responds to requirements / regulation but also opportunities and collaboration on issues leading both to good urban / rural outcomes but also integrated manufacturing and innovation in design. The model may involve community companies in tandem with larger to moderate use of resources .....to avoid consumerism for its own sake etc.
9. if they enter, we will have only E services...public engagement needed!
10. More funding to restoration through ecological compensation!

Q27: Lack of motivation in decision-makers to incorporate innovation

Round 2 participant ratings of importance

*27. Second rating: Lack of motivation in decision-makers to incorporate innovation



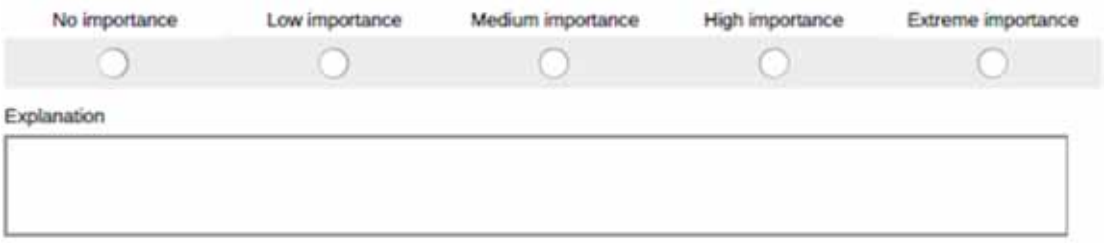
Round 2 participant comments

1. But not as a technophobic symptom. It is a collateral effect of using environmental issues as social reputation instruments. Innovation is a natural consequence of ecosystem governance with the attributes of trust, responsiveness and legitimacy.
2. Many politicians are currently less brave than in previous decades in terms of daring to speak the truth and instigate big change. This is the opposite of what we need locally and globally.
3. Decision makers have to consider carefully innovative approaches and techniques in ecological restoration.
4. still an issue but feel a strong increase in motivation to innovate
5. It is still not clear how restoration could be a profit-making activity.
6. Decision makers respond to need and so a convincing argument must be made to incorporate BGI / NBS in our policies and projects.
7. globally they are motivated

Q28: Lack of prior evaluation, assessment and design

Round 2 participant ratings of importance

*28. Second rating: Lack of prior evaluation, assessment and design



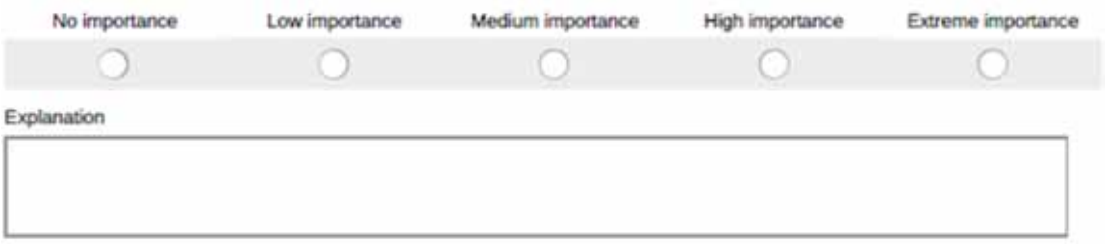
Round 2 participant comments

1. Depending on the project complexity. Some projects can work with very few problem understanding and just reproducing a previously stated method. But, for example, dune ecosystems work in a very different way than common knowledge.
2. A good project and evaluation is necessary to do a good restoration.
3. Is important but most of the projects already have it
4. Effective ecological restoration extremely needs good preparation phase.
5. reducing as ecological assessment requirements are improved
6. Failure to plan is..... to plan to fail etc.....
7. always in management, engineering works are too early; .. but also ER in already degraded systems do not need prior evaluation, they need a good design,.. objectives
8. The level of knowledge could always be better, but in Finland it is rather good

Q29: Lack of quality plant material (including lack of suitable species and genotypes)

Round 2 participant ratings of importance

*29. Second rating: Lack of quality plant material (including lack of suitable species and genotypes)



Round 2 participant comments

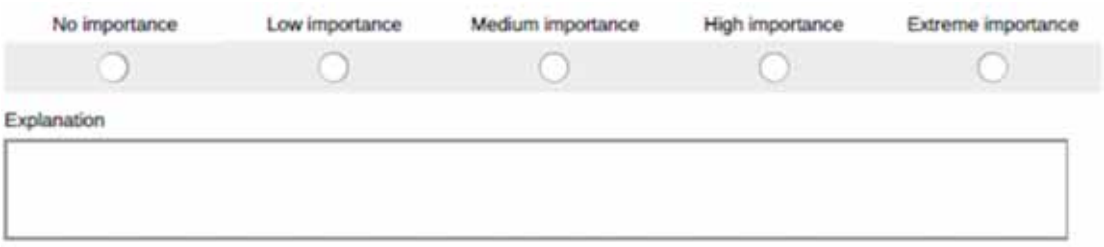
1. The extent of this issue probably linked to a time/space scale related to climate change. Not very evident but probably of very high relevance.
2. This will become more important as more projects and legal framings change so that one can use regional seeds to restore e.g. roadsides (as the env law regarding this is going to change in 2020). There will probably not be enough capacity to provide the necessary plant cuttings or seeds for large scale restoration. Large commercial seed companies, I have heard, are not adapting and entering the regional natural seed market but instead hoping environmental laws will change in favour of such seed sources. This seems absurd to me. Like the German car industry hoping that the electrical car will disappear, or not need research and people will continue to want large numbers of large luxury cars.
3. Specially in the seeds
4. Now there are some good nurseries managing it. Very little control in herbaceous.
5. Probably it depends on the country and system, but i our experience is often the case.
6. It is importance in case of plant introduction to use species and genotypes from the local flora.

7. bigger problem is actors not knowing where to access them and how to inoculate the restoration sites
8. we must spread whatever seed we have thinly.... this would require an industrial scale horticultural effort. Citizen Science could help in gathering seed (by parents, schoolkids and walkers generally.....)
9. Relevance depending on cases.
10. I work (a lot) in passive ecological restoration, so..
11. Not in Finland

Q30: Lack of relevant ecological knowledge and experience

Round 2 participant ratings of importance

*30. Second rating: Lack of relevant ecological knowledge and experience



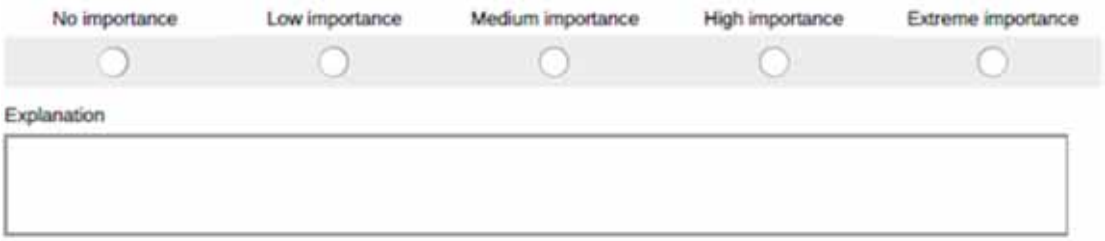
Round 2 participant comments

1. Some social groups of expertise tend to construct conceptual echo chambers that can limit the interest for critical analysis and innovation.
2. we actually generally know enough about this.
3. Always is good to have more information about the plants.
4. typically not the limiting factor
5. We most have the knowledge.
6. Adequate knowledge and experience are needed for ecological restoration. However, the most of the time the conditions are sitespecific and thus unique.
7. some very good, some not so. a problem can be that consultant ecologists can propose less ambitious schemes thinking they satisfy the client
8. To 'restore' or 'recreate' if that is possible, we must know what it is that we are aiming to achieve... especially given the need to plan interventions..... but with a learn as we go approach and using local knowledge, this may stimulate efforts at a local level. It is of high importance but can be overcome....
9. adding the adjective "ecological" to the word "restoration" imply that ecological knowledge are there: not always the case..
10. See above, long-term effects could still be better known but this does not hinder the action in Finland

Q31: Lack of sense of identity, attachment to the landscape

Round 2 participant ratings of importance

*31. Second rating: Lack of sense of identity, attachment to the landscape



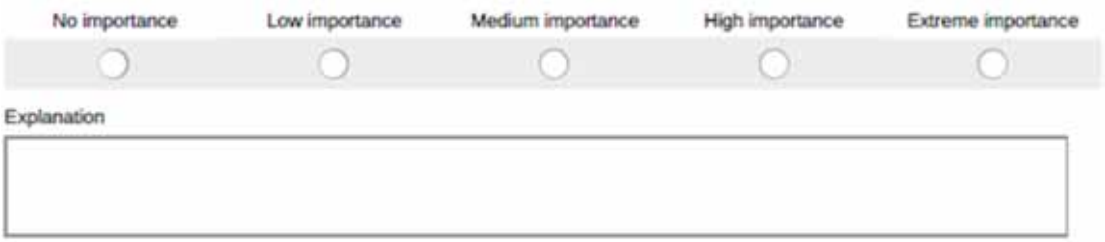
Round 2 participant comments

1. Emotional and nearly religious narratives are frequent, but with low capacity to affect restoration projects. Much more relevant is the lack of system understanding (i.e. the new and extremely harmful trend of pet accumulation on sensible areas).
2. I think this is getting worse for many people, not better. I heard last week that the farmers in the Luneburger Heathland now even consider wonderful old oak trees on their farms as a pain. They just want to remove them.
3. Most of the people lack of the sense of identity, and consider natural environment as belonging to others (state, society).
4. this is an important issue, but feel that many schemes now starting to take account of landscape context
5. probably the opposite in some cases and attachment is what drives the effort. Protecting our landscape is important to much of humanity..... maybe the word landscape might be explained to mean 'sense of place' or 'place we live'...
6. managers need standardised tools, but does it match in every landscape? how to adapt them if no sensibility to the considered landscape?

Q32: Lack of societal awareness and engagement

Round 2 participant ratings of importance

*32. Second rating: Lack of societal awareness and engagement



Round 2 participant comments

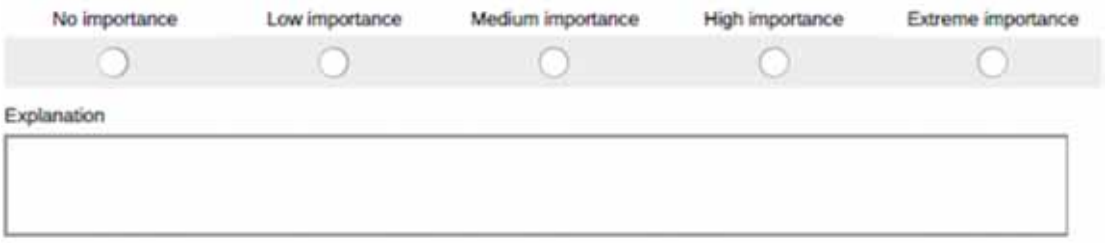
1. Irrelevant in a moral quasi hysterical society. The power of political correctness. But people asking for healing narratives instead of practical and accountable projects.

2. recent developments thanks to the media coverage of the insect declines is showing that the general public is pretty interested in species loss.
3. Without social engagement, there are not politic engagement
4. Society is more aware of the importance of natural habitats than given credit for. It is more a case that most conservation and restoration is a top-down approach and society are not incentivized or enabled to participate or not regarded as an equal partner
5. In the stakeholders (agriculture)
6. again, a question of scale.
7. Societal awareness and engagement form the basis for all stages of implementation of ecological restoration.
8. important in UK where local views are important in determining plan approval
9. education can fix that..... we must make more efforts on that 'front'.....
10. no success without local engagement

Q33: Lack of standards against which progress can be measured

Round 2 participant ratings of importance

*33. Second rating: Lack of standards against which progress can be measured



Round 2 participant comments

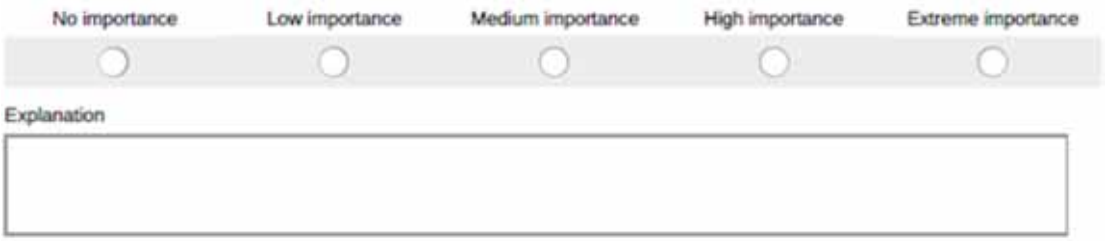
1. As previously stated. there is a need of standardised metrics on efficiency and effectiveness.
2. See LDN again.
3. This point is in relation with the need of monitoring
4. Unfortunately there is lack of optimal standards, although the set of them is extremely important.
5. improving
6. Standards are being developed but needs to be an 'organised effort' to ensure BGI / NBS standards are compiled to be transparent.

   Currently standards are piecemeal or difficult to find. .... A central repository of 'what standards exists and how are they applied?' would be useful !
7. standardisation is homogenisation in ER, is it what we want?

Q34: Lack of suitable technology

Round 2 participant ratings of importance

*34. Second rating: Lack of suitable technology



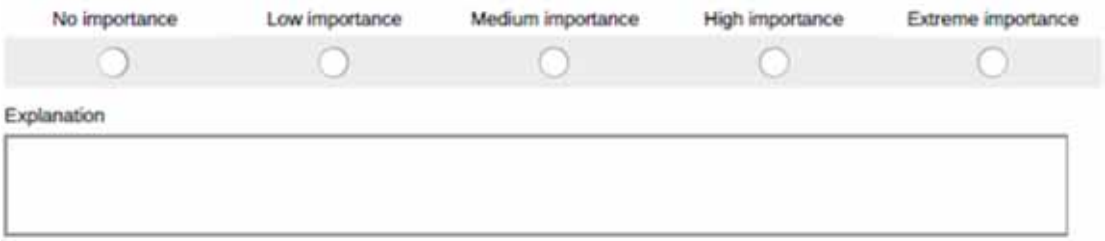
Round 2 participant comments

1. We already have a lot of available technology. Probably beyond our ability to interpret resulting data
2. We always should learn but we know what to do
3. Though the engagement of technology is necessary, the lack of it must not halt the ecological restoration, especially when it has sitespecific characteristics.
4. rapid developments in eg remote sensing etc mean this is a smaller issue than previously
5. Plenty of technology. It is about how we use it !

Q35: Lack of understanding and collaboration across different aspects of restoration, e.g. ecology, engineering, social sciences, etc

Round 2 participant ratings of importance

*35. Second rating: Lack of understanding and collaboration across different aspects of restoration, e.g. ecology, engineering, social sciences, etc.



Round 2 participant comments

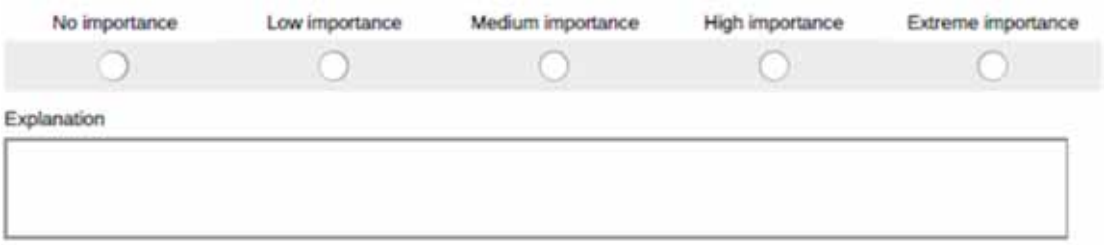
1. A central issue on ecosystem services concept. The need to go beyond multidisciplinarity and at least go to interdisciplinarity with integrated research and shared conceptual models.
2. Interdisciplinarity
3. Restoration is a complex process and requires multi-disciplinary collaboration
4. We always work with multidisciplinary teams, today this is generally assumed.
5. Ecological restoration is an interdisciplinary process.
6. one of the things I think we are getting a lot better at in the UK is bringing these skills together

7. There is a great need for cross-sectoral and inter-disciplinary approaches, consultations, dialogues, synergies.
8. the approach must be inter disciplinary and multi disciplinary .. a list of disciplines would include architects / landscape architects / landscape / natural / social scientists / civil and other engineering disciplines and others as needs be.. ?... and depending on the issue and context etc.

Q36: Low political priority for restoration

Round 2 participant ratings of importance

*36. Second rating: Low political priority for restoration



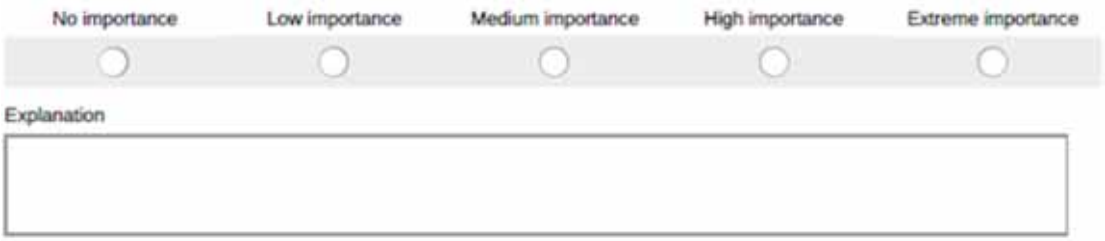
Round 2 participant comments

1. Everyone speaking about environment. But very low problem understanding and most difficult to explore new instruments to promote extensive management projects. Also the monopolistic structure (at least in Spain, with only one company making most of the projects) is a very limiting factor.
2. Even though we now have the decade of restoration, politically it is not as on the map as it should be.
3. Is related with the social engagement
4. Not a vote catcher
5. Institutional environment (and most the political part of it) must acknowledge the benefits from ecological restoration to the society, although political entities often neglect it.
6. rising up the political agenda quickly - still not fast enough to combat eg climate impacts on ecosystems and society
7. The concept of restoration is not clear, the ecological, economic and social benefits not well explained.
8. where there is a will, there is a way..... ? Political support is an absolute must !
9. we can not wait more, politicals must engage on the topic

Q37: Perceived complexity of implementing restoration

Round 2 participant ratings of importance

*37. Second rating: Perceived complexity of implementing restoration



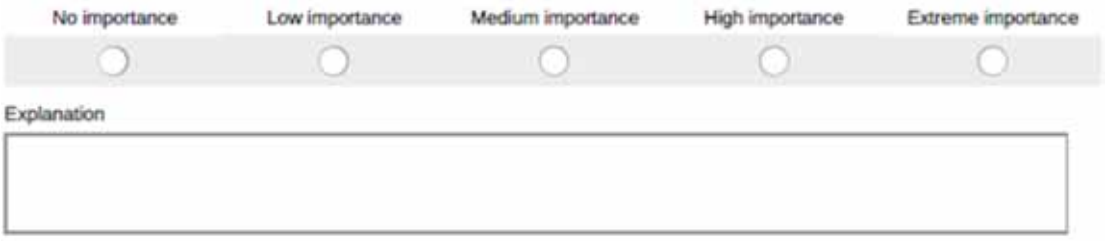
Round 2 participant comments

1. Mental laziness of public workers (or nearly public workers of companies like TRAGSA).
2. There is always a challenge ...
3. It is not an excuse for not doing it
4. Complexity is a characteristic from all ecological restoration works. However, complexity must not be considered as a real problem.
5. see need for training and education but showcasing best practice and solution finding is critical
6. Requirement for clear construction and maintenance guidance is clear. Most public and private works are done via contractual arrangements and thus the process must be facilitated with specifications and standards for BGI / NBS. This may assist in ensuring the incorporation of the principles and / or details in the works contracts
7. ER is complex, not so easy as restoration/management, mostly "tech"

Q38: Lack of appropriate compensation and financial returns on restoration

Round 2 participant ratings of importance

*38. Second rating: Lack of appropriate compensation and financial returns on restoration



Round 2 participant comments

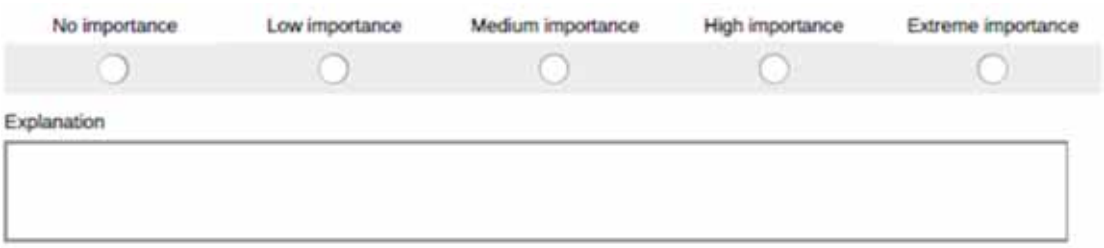
1. Again showing the need of ES concept. Usually stakeholders most of the economic benefit (i.e. housing close to a restored landscape) never pay for its costs. But probably would pay if they could promote further restorations.

2. It is hard to measure the returns but they are large and should be measured in terms of ecosystem services.
3. I think , the difficult to translate the benefits of the restoration in financial terms
4. That would be a perception only due to a lack of understanding of ecosystem services provided
5. It is a good way to persuade society to protect ecological restoration works.
6. depends on the land use. forest restoration is definitely affected by this. but UK moving towards state payments for public benefits
7. The business case needs to be improved. Perceived costs are high but delivery and maintenance may be lower depending on the mode of delivery.
8. Especially for the private landowners.

Q39: The timing of restoration projects does not correspond to ecological and social time-scales

Round 2 participant ratings of importance

*39. Second rating: The timing of restoration projects does not correspond to ecological and social timescales



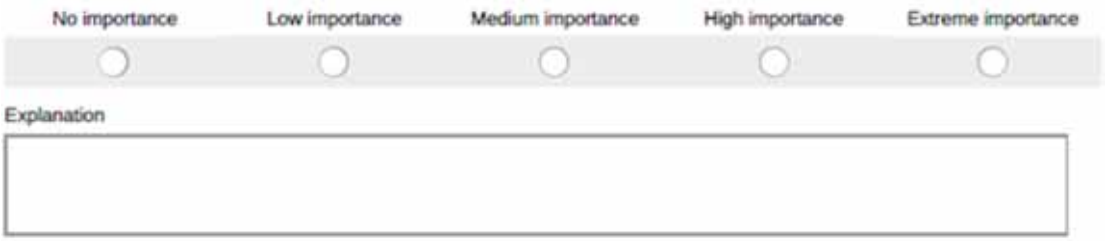
Round 2 participant comments

1. It can be determinant. So showing the need of pluriannual projects.
2. Political time-scales , more than ecological or social
3. It is a real problem for the major part of society who think in current people life-time horizons. However, restoration aims at broader time scales.
4. anytime is good to start surely? A good case being made at regional / national policy level may then 'inform' the social time scale.
5. Further detail required to refine my answer.
6. long term engagement needed!
7. Especially if the habitat needs regular nature management
8. Forest restoration is a slow process, long-term projects are rare

Q40: Unrealistic or unclear project goals

Round 2 participant ratings of importance

*40. Second rating: Unrealistic or unclear project goals



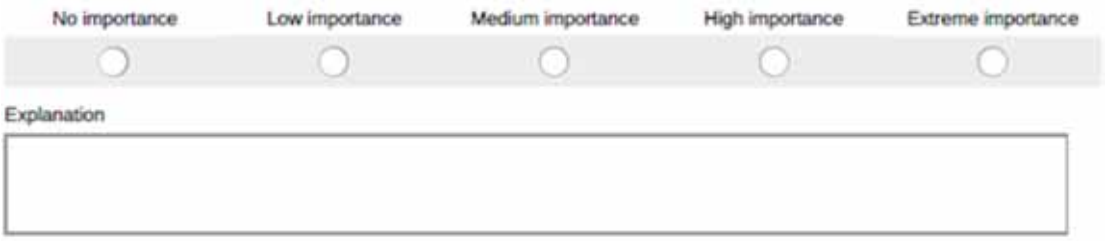
Round 2 participant comments

1. Or lack of system /problem understanding
2. If you have a good analysis and project, you have a realistic and clear goal..
3. That could be the case if project goals or plans were done unilaterally and not in collaboration with other stakeholders
4. Ecological restoration projects must have measurable goals and standards.
5. only where good advice is lacking
6. Good project management
7. Further detail required to refine my answer. Relevance depending on cases.
8. must be clear

Q41: Unsuitable policies and lack of enabling policy instruments

Round 2 participant ratings of importance

*41. Second rating: Unsuitable policies and lack of enabling policy instruments



Round 2 participant comments

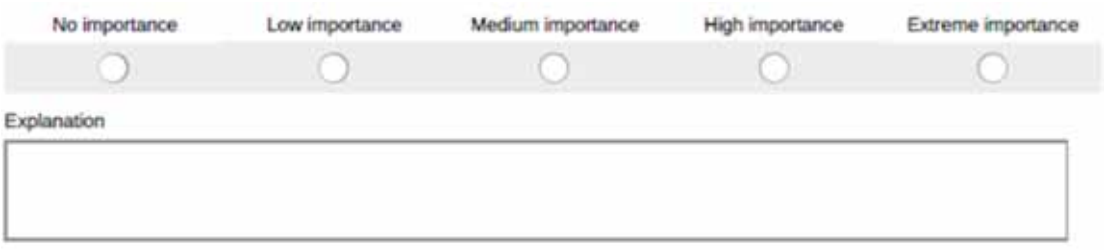
1. For example, at Catalonia more than 60% surface is somewhat abandoned land in need of restoration. To promote a sound ecosystem restoration and management plan of those lands we need a new legal framework based on the knowledge of trade-off analysis. Housing permits in exchange of extensive and permanent management projects.
2. Without policies, there are no funds
3. Enough aspirational policies but a lack of enabling policy instruments
4. Often there are good policies on ecological restoration, but it is necessary to be implemented by suitable policy instruments and structures.

5. agree for eg getting landscape scale projects approved
6. implementation bodies rolling a stone uphill. Policies must be one of the drivers and associated instruments / enabling / implementation bodies must be in place to provide the resources and impetus.
7. In Finland the funding for privately owned forest nature management follows the same funding law that gives out subsidies to harmful forest uses (in terms of biodiversity). And the balance is off, again.

Q42: Lack of knowledge about soils

Round 2 participant ratings of importance

*42. Second rating: Lack of knowledge about soils



Round 2 participant comments

1. Lack of knowledge is always a minor issue. First is to show the need of a sound problem understanding. And this always goes through soil system knowledge.
2. As lack of knowledge of other abiotic elements...
3. The importance of soil is well understood due to science, it is the vested interests that might prevent it more so
4. The knowledge on soil, and climate characteristics are basic in planning and implementing ecological restoration works.
5. that is where good advice is so important
6. Soil hasn't a role in my work, but geomorphology is really important
7. should not be the case....back to project scoping....
8. Relevance depending on cases.
9. Especially if thinking climate change mitigation.

We are also extremely interested in your suggested solutions to the barriers affecting restoration. For the 3 most important barriers, please provide possible solutions. Try to be as specific as possible. The text boxes will expand as you type.

*43. Insufficient funding

*44. Conflicting interests of different stakeholders

*45. Low political priority for restoration

You may also want to suggest specific solutions to other barriers that you find particularly relevant and solvable (please indicate the barrier and how it can be solved).

46. Any further solutions to barriers identified in Round 2:

47. Finally, what is a key ecological knowledge gap, which, if answered, could improve the effectiveness of restoration?

Appendix 9. Absolute and relative number of experts participating in rounds 1, 2 and 3 of the Delphi process that were specialized in the different sectors. Percentages refer to the total number of participants in each round, considering that experts may be specialized in various sectors.

Sector	Round 1: Number of participants	(%)	Round 2: Number of participants	(%)	Round 3: Number of participants	(%)
Rivers or wetlands, including inland water bodies and banks, coastal wetlands, estuaries, tidal plains	25	28	21	29	8	25
Forest and scrub, including natural ungrazed grassland, sand dunes, areas with scarce woody vegetation	17	19	23	32	7	22
Urban and peri- urban areas, including brownfields, land strips along transport and energy infrastructure	12	13	6	8	2	6

Pasture and rangelands, with frequent livestock grazing	12	13	7	10	6	19
Mining or industrial areas, including surrounding affected areas	11	12	6	8	2	6
Agricultural, including arable land, permanent crops & heterogeneous agricultural areas	8	9	8	11	4	13
Coastal and marine	2	2	1	1	1	3
No specific system	3	3	1	1	2	6

Appendix 10. Approaches to ecological restoration used by experts participating in round 1, 2 and 3 of the Delphi process. Percentages refer to the total number of participants in each round, considering that experts may use several approaches.

Approaches	Round 1: Number of participants	(%)	Round 2: Number of participants	(%)	Round 3: Number of participants	(%)
Technical practice, implementation of restoration through dealing with biotic and/or abiotic elements but not focussed on people	34	34.7	23	33.3	12	41.4
Science and education	27	27.6	20	29.0	8	27.6
Policy or governance	18	18.4	12	17.4	5	17.2
Participatory practice, including environmental education, volunteer coordination and training, facilitating participatory processes, etc.	14	14.3	9	13.0	4	13.8
Other concerned user, such as a member of a nature leisure organization, hunters' association, etc.	3	3.1	3	4.3	0	0.0
Other	2	1.9	2	2.9	0	0.0

Appendix 11. Years of experience in ecological restoration of experts completing rounds 1, 2 and 3 of the Delphi process.

Years	Round 1: Number of participants	(%)	Round 2: Number of participants	(%)	Round 3: Number of participants	(%)
0-5	4	8.3	1	3.1	1	6.7
6-10	7	14.6	5	15.6	3	20.0
11-20	18	37.5	10	31.3	4	26.7
21-30	18	37.5	16	50.0	7	46.7
31 or more	1	2.1	0	0.0	0	0.0

Appendix 12: Degree of agreement to questions concerning the importance of the different components of effective ecological restoration

Results are percentages of experts selecting a specific level of agreement for a specific question. The number of respondents to all questions was 32. Questions listed as in Table 15.

Table 15 Degree of agreement to questions concerning the importance of the different components of effective ecological restoration

	Strongly disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Strongly agree
Q9	0.0	0.0	0.0	0.0	0.0	12.5	87.5
Q10	0.0	0.0	0.0	0.0	3.1	40.6	56.2
Q11	0.0	3.1	3.1	3.1	3.1	25.0	62.5
Q12	0.0	0.0	3.1	0.0	6.3	25.0	65.6
Q13	3.1	0.0	0.0	3.1	6.3	46.9	40.6
Q14	0.0	0.0	0.0	0.0	21.9	56.2	21.9
Q15	0.0	0.0	0.0	3.1	12.5	31.3	53.1
Q16	0.0	3.1	3.1	18.8	18.8	31.3	25.0
Q17	0.0	3.1	0.0	3.1	12.5	28.1	53.1
Q18	0.0	3.1	0.0	6.3	15.6	28.1	46.9

Appendix 13: Degree of agreement to questions concerning the importance of the barriers for effective ecological restoration

Results are percentages of experts selecting a specific level of agreement for a specific question. The number of respondents to all questions was 32. Questions listed as in Table 16.

Table 16 Degree of agreement to questions concerning the importance of the barriers for effective ecological restoration

	No importance	Low importance	Medium importance	High importance	Extreme importance
Q19	0.0	0.0	25.0	68.8	6.3
Q20	0.0	0.0	15.6	43.8	40.6
Q21	0.0	0.0	15.6	71.9	12.5
Q22	0.0	21.9	46.9	25.0	6.3
Q23	0.0	18.8	37.5	31.3	12.5
Q24	0.0	9.4	31.3	50.0	9.4
Q25	0.0	3.1	12.5	56.3	28.1
Q26	0.0	0.0	25.0	50.0	25.0
Q27	3.1	6.3	21.9	46.9	21.9
Q28	0.0	3.1	37.5	37.5	21.9
Q29	3.1	0.0	9.4	40.6	46.9
Q30	3.1	0.0	28.1	46.9	21.9
Q31	3.1	0.0	37.5	53.1	6.3
Q32	3.1	3.1	15.6	50.0	28.1
Q33	3.1	21.9	28.1	40.6	6.3
Q34	0.0	6.3	9.4	50.0	34.4
Q35	3.1	9.4	31.3	46.9	9.4
Q36	3.1	9.4	34.4	31.3	21.9
Q37	3.1	9.4	31.3	43.8	12.5
Q38	9.4	6.3	43.8	25.0	15.6
Q39	0.0	25.0	25.0	34.4	15.6
Q40	3.1	21.9	46.9	21.9	6.3
Q41	3.1	3.1	43.8	37.5	12.5
Q42	3.1	15.6	31.3	43.8	6.3
Q43	6.3	31.3	46.9	12.5	3.1
Q44	3.1	3.1	31.3	50.0	12.5
Q45	3.1	6.3	9.4	25.0	56.3
Q46	0.0	15.6	40.6	31.3	12.5

	No importance	Low importance	Medium importance	High importance	Extreme importance
Q47	0.0	0.0	25.0	56.3	18.8
Q48	3.1	9.4	18.8	43.8	25.0
Q49	3.1	9.4	50.0	21.9	15.6
Q50	3.1	6.3	21.9	43.8	25.0
Q51	3.1	21.9	34.4	31.3	9.4

Appendix 14 List of abbreviations for barriers, used in statistical analysis of Delphi process results

Full barrier name	Abbreviation
Complexity of the legal framework	legal complexity
Conflicting interests of different stakeholders	conflicting interests
Lack of collaboration between different stakeholders	low collaboration
Conflicts between restoration goals, e.g. biodiversity, climate change mitigation, nutrient retention	goal conflicts
Constraints due to abiotic characteristics of the area, e.g. climate, topography, water availability	abiotic constraints
Constraints due to biotic challenges e.g. concerning species dispersal rates, inter-specific interactions, etc.	biotic constraints
Difficulty in obtaining legal or property rights over the area to implement restoration	area rights
Harmful subsidies favouring degradation	harmful subsidies
High level and rate of degradation	high degradation
Inadequate implementation of current policies	low implementation
Insufficient funding	low funding
Lack of coordination between decision-makers in different domains and administrative departments	low coordination
Lack of effective knowledge exchange	low exchange
Lack of evaluation, monitoring and documentation	low monitoring
Lack of skilled professionals to perform restoration	low skills
Lack of integrated land use planning	low planning
Lack of involvement of the private sector	low private
Lack of motivation in decision-makers to incorporate innovation	low innovation
Lack of prior evaluation, assessment and design	low assessment
Lack of quality plant material (including lack of suitable species and genotypes)	low plant material
Lack of relevant ecological knowledge and experience	low ecology KE
Lack of sense of identity, attachment to the landscape	low attachment
Lack of societal awareness and engagement	low engagement

Full barrier name	Abbreviation
Lack of standards against which progress can be measured	lacking standards
Lack of suitable technology	lacking technology
Lack of understanding and collaboration across different aspects of restoration, e.g. ecology, engineering, social sciences, etc	low interdisciplinarity
Low political priority for restoration	low priority
Perceived complexity of implementing restoration	implementation complexity
Lack of appropriate compensation and financial returns on restoration	low compensation
The timing of restoration projects does not correspond to ecological and social time-scales	poor timing
Unrealistic or unclear project goals	flawed goals
Unsuitable policies and lack of enabling policy instruments	poor policies
Lack of knowledge about soils	low soil knowledge

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