KNOWLEDGE SYNTHESIS REPORT (DRAFT)

How could we improve adherence to the mitigation hierarchy using ecosystem services with a particular focus on the avoid state?

Requested by the French Biodiversity Agency (OFB)

December 2022

Eklipse Expert Working

Knowledge Synthesis Report
Draft version December 2022

Eklipse Expert Working Group on the Mitigation hierarchy

Members of the Expert Working Group:

Sini Savilaakso - University of Helsinki, Finland *(Co-chair)*

Joanna Storie - Estonian University of Life Sciences *(Co-chair)*

Daniel Depellegrin - Department of Geography, University of Girona, Spain

Sylvie Campagne - Station Biologique de Roscoff, CNRS and the Sorbonne University, Paris, France

Beatriz Caitana Da Silva - Centre for Social Studies – CES, Portugal

Davide Geneletti - University of Trento, Italy

Ifigeneia Kagkalou - Democritus University of Thrace, Greece

Francesca Leucci - Bologna/Rotterdam/Hanburg Universities)

Sandra Luque - INRAE - Institut national de recherche pour l'agriculture, l'alimentation et l'environnement, France

Danica Lacarac - The National Green Roof Association, Serbia

Members of the Eklipse Methods Expert Working Group:

Alister Scott - University of Northumbria, UK.

Lyudmyla Zahvoyska - Ukrainian National Forestry University, Ukraine.

Nils Bunnefeld – University of Stirling, UK.

Version	prepared by	Data	Status
1.	Expert Working Group (EWG)	15/12/2022	For public review

INDEX

Glossary 0
Summary and recommendations 1
Summary 1
Recommendations for researchers and educational institutions 7
Background and objectives 9
Methodological framework 11
Systematic mapping approach 13
Question components 13
Searches 14
Search terms and languages 14
Bibliographic searches 15
Search engines 15
Organisational websites 15
Supplementary searches 16
Search record database 17
Article screening 17
Eligibility criteria 17
Data extraction 18
Data synthesis 19
Applied policy Delphi 19
Results 24
Systematic mapping 24
Overview of the evidence base 24
Mitigation hierarchy as a concept 29
Avoidance as a concept 30
Ecosystem services as a concept to foster the conservation of biodiversity within decision making 31
Trade-offs 31
Trust and place attachment. 32
Current use of mitigation hierarchy in decision making 33
Policies and regulations 33
Impact avoidance measures in EU policies and regulations related to biodiversity 33

Impact avoidance measures and land-use planning 35
Impact avoidance measures and marine spatial planning 36
Use of ecosystem services concept and mitigation hierarchy 37
Impacts 37
Risks and Challenges 38
Institutional capacity 38
Management complexity 39
Scale 40
Multi-stakeholder collaboration 41
Data Quality 41
Solutions 42
Applied Policy Delphi process 43
Mitigation hierarchy as a concept 43
Ecosystem services as a concept to foster the conservation of biodiversity within planning processes 44
Tools and practices that address the aspect of ecosystem services in the mitigation hierarchy 45
Current use of mitigation hierarchy in policies and regulations 47
Use of ecosystem services concept and mitigation hierarchy 48
Challenges 48
Opportunities 50
Future directions 51
Further insights from the Applied Policy Delphi panel and case studies found in the literature 52
Enhance stage in the mitigation hierarchy 52
Inclusion of ecosystem services and risk to biodiversity 53
Implementing effective avoidance 55
Improving the effectiveness of the decision-making process 56
Strengthening capacity to implement mitigation hierarchy 59
Regulatory approaches towards avoidance 60
Cost of compensation to incentivise impact avoidance 62
Discussion 63
Quality of evidence and knowledge gaps 63

Enhancing landscapes through the use of mitigation hierarchy 63
Need for a stronger regulation to strengthen enforcement of the mitigation hierarchy 65
Mainstreaming ecosystem services as part of the mitigation hierarchy 66
Effective avoidance 67
Effective avoidance from infrastructure projects 70
Stakeholder engagement in policy and decision-making processes 71
Capacity building 73
Conclusions 75
Acknowledgements 77
References 78
Annexes 89
Annexe 1: The performance of the search string. 90
Annexe 2: List of articles used to test the comprehensiveness of the search string 103
Annexe 3: Search strings 105
Annexe 4: Organisations with relevant literature on mitigation hierarchy (full list of organisations) 106
Annexe 5: Applied Policy Delphi Panel - Ethics 109

GLOSSARY

Term	Definition	Key References
Mitigation hierarchy	The sequence of actions to anticipate and avoid impacts on biodiversity and ecosystem services. Where avoidance is not possible, the aim is to minimise the impacts. When impacts occur, the preferred options are to rehabilitate or restore. In a case where significant residual impacts remain, off-setting is recommended.	Ekstrom et al., 2015
Avoidance	Avoidance: the first step of the mitigation hierarchy comprises measures taken to avoid creating impacts from the outset, such as careful spatial or temporal placement of infrastructure or disturbance. For example, the placement of roads outside of rare habitats or key species' breeding grounds, or by timing of seismic operations when aggregations of whales are not present	The Biodiversity Consultancy, 2021 Ekstrom et al., 2015

Avoidance measure (*French legislation*)	*Les articles 2 et 69 codifient des éléments de la doctrine nationale ERC dans le code de l'environnement et enrichissent les principes de la séquence ERC avec une définition de la séquence ERC qui hiérarchise les trois phases (L. 110-1);* *Les lignes directrices sur la séquence ERC définissent la mesure d'évitement comme étant une « mesure qui modifie un projet ou une action d'un document de planification afin de supprimer un impact négatif identifié que ce projet ou cette action engendrerait ».* Articles 2 and 69 codify elements of the national mitigation hierarchy (ERC in French for Eviter Réduire Compenser) doctrine in the French Environmental Code and augment the principles of the mitigation hierarchy with a definition of the mitigation hierarchy that prioritises the three phases (L. 110-1); The guidelines on the mitigation hierarchy define an avoidance measure as "a measure that modifies a project or action in a planning document in order to eliminate an identified negative impact that this project or action would cause".	*French law on the reconquest of biodiversity (n° 2016-1087 of 8 August 2016)*
Applied Policy Delphi	This method is a subset of expert consultation, representing the most rigorous approach to eliciting expert knowledge. It combines the knowledge of multiple, carefully selected experts into either quantitative or qualitative assessments, using formal consensus methods such as the Delphi process (described and reviewed by Mukherjee et al. 2016) or other elicitation techniques, including Cooke's method for weighting experts for their accuracy, described in Martin et al. (2012).	Eklipse, 2021

Ecosystem Services (ES)	Contributions that ecosystems make to human well-being that arise from living processes. These are distinct from the goods and benefits people subsequently derive from ecosystems. Ecosystem services can be categorised into provisioning, cultural, regulation and maintenance services.	Haines-Young, R. and M.B. Potschin (2018)
Exposure	A proposed management regime, policy, action or environmental variable to which the subject populations are exposed.	Collaboration for Environmental Evidence, 2018
Impact Avoidance	The first part of the mitigation hierarchy, avoidance or prevention, refers to the consideration of options in project location, siting, scale, layout, technology and phasing to avoid impacts on biodiversity, associated ecosystem services, and people. This is referred to as 'the best option', but it is acknowledged that avoidance or prevention is not always possible. Impact avoidance requires developers to 'anticipate and prevent adverse impacts on biodiversity before actions or decisions are taken that could lead to such impacts' (Ekstrom et al., 2015). Impact avoidance is typically identified as the most important stage of the mitigation hierarchy (McKenney & Kiesecker, 2010; Clare et al., 2011; Ekstrom et al., 2015).	Lukey and Paras, 2017; Phalan et al., 2018
Systematic mapping approach	Structured, stepwise methodology following an *a priori* protocol to comprehensively collate and describe existing research evidence (traditional academic and grey literature).	Eklipse, 2021
Nature's contributions to people	Nature's contributions to people (NCP) are all the contributions, both positive and negative, of living nature (i.e. diversity of organisms, ecosystems, and their associated ecological and evolutionary processes) to the quality of life for people.	IPBES Glossary (https://ipbes.net/glossary)

Natural capital	Natural capital can be defined as the world's stocks of natural assets, which include geology, soil, air, water and all living things. These assets are considered essential to the long-term sustainability of development for their provision of "functions" to the economy, as well as to mankind outside the economy and other living beings.	World Forum on Natural Capital (https://naturalcapitalforum.com/about/) and Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997.
Multiple stakeholder engagement	The participation of multiple stakeholders implies the active involvement of stakeholders at different stages of the decision-making process, in the strategies for capacity building, and the sharing knowledge environment. It is expected that the engagement is undertaken in a transparent way. This approach provides opportunities for co-production and co-governance to emerge and ensures stakeholder contributions for a just and inclusive transition.	EU Biodiversity Strategy 2030 European Green Deal
Vulnerable areas	Vulnerable areas in this report are those areas that are not part of a protected area but are still considered at risk of losing valuable biodiversity, habitat or ecosystem services.	Toivonen et al. (2021)

Impact assessment	Impact assessment (IA) is a structured process for considering the implications, for people and their environment, of **proposed actions** while there is still an opportunity to modify (or even, if appropriate, abandon) the proposals. It is applied at all levels of decision-making, from policies to specific projects.	International Association for Impact Assessment https://www.iaia.org/wiki-details.php?ID=4
Impact evaluation	An impact evaluation provides information about the observed changes or 'impacts' produced by an intervention. These observed changes can be positive and negative, intended and unintended, direct and indirect. An impact evaluation must establish the cause of the observed changes. Identifying the cause is known as 'causal attribution' or 'causal inference'.	Better Evaluation https://www.betterevaluation.org/methods-approaches/themes/impact-evaluation

SUMMARY AND RECOMMENDATIONS

SUMMARY

The **Mitigation Hierarchy** is the sequence of actions (avoid-mitigate-restore-compensate) to anticipate and avoid adverse impacts on **biodiversity and ecosystem services**. The avoid or prevent stage is the first and most important stage of the mitigation hierarchy in which developers anticipate adverse impacts on biodiversity before actions or decisions are taken. Action is then taken to prevent adverse impacts by considering different options in the project location, scale, layout, technology and phasing. Avoidance is often the easier, cheaper and more effective way than trying to restore a damaged habitat or offset elsewhere. The **Mitigation Hierarchy** application is mandatory in France, however, the French Biodiversity Agency put a request to Eklipse to find out to **what extent the adherence to and implementation of the hierarchy is correctly applied and ecosystem services are considered and well documented.**

To answer this request, an Expert Working Group on Mitigation hierarchy was established to answer three main questions:

1) If and how the consideration and operationalisation of ecosystem services can be integrated into natural capital assessments, impact assessments, and policymaking processes to enhance biodiversity conservation.

2) What kind of impacts and challenges may occur when the ecosystem services concept is used in the mitigation hierarchy and similar processes?

3) how replicable and transferable are tools and processes in countries or regions that have been used successfully at the avoid stage?

Three steps were implemented to answer the questions:

a) A systematic mapping approach was used to provide an overview of the available evidence and knowledge gaps.

b) An Applied Policy Delphi process for deliberative consultation, discussion, and feedback.

c) An analysis of results and conclusions based on the findings from the systematic mapping and the Applied Policy Delphi.

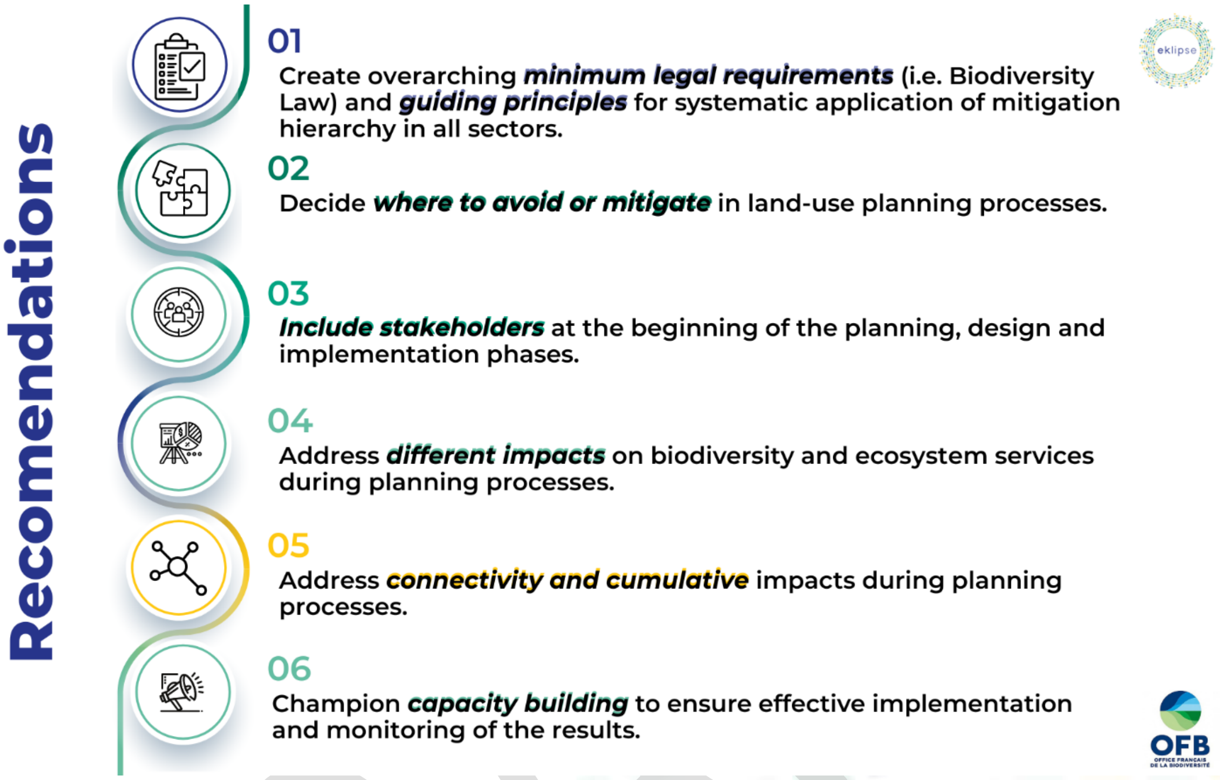
This research aimed to unveil whether land use planning and development in Europe is in line with the state of the art on biodiversity conservation and ecosystem services.

The aim of this report is also to provide evidence-based knowledge on if and how ecosystem services can be considered in projects, programmes, policies and associated impact assessments with a particular focus on the avoid stage of the mitigation hierarchy. In order to do this, the results of each step implemented are presented and discussed. We then provide recommendations based on the outcomes of this investigation.

We did not find much evidence of the use of the ecosystem services concept in the mitigation hierarchy. However, based on the Applied Delphi Process and the evidence we did find, ecosystem services can be mainstreamed into the mitigation hierarchy. Care will need to be taken to ensure that biodiversity and life-serving ecosystem services are prioritised and safeguarded over those ecosystem services that grant economic profits. When we look at the identified impacts on biodiversity, it is clear that impacts occur across different spatial and temporal scales and can be synergistic, antagonistic or dominant. In practice, a lack of resources is the biggest challenge to ensuring effective design, implementation, monitoring and evaluation practices. Other identified challenges were a lack of clear definitions and effective regulation, plus the need for capacity building and true stakeholder engagement and collaboration.

In this report, we provide examples of solutions and tools and practices that are transferable and replicable from one context to another. Within the upscaling process, we recommend that the information produced is made accessible to a broad set of stakeholders and to adapt communication strategies to different target audiences to ensure a wide reach of knowledge.

Finally, we conclude that putting biodiversity first and avoiding further loss is both possible and needed for the benefit of society and the planet we live on. Moving towards sustainability requires fundamental transformations, including changes in how biodiversity is perceived and valued. Newly established relations between societal actors are also required. The recommendations in this report provide a roadmap on how to do this, but they are only effective if decision-makers, land use planners and practitioners commit to improving legislation and practices. Hence, we urge all those involved in land-use planning: it is time to act to get effective mitigation practices into place before it is too late.



1. Create overarching minimum legal requirements (i.e., Biodiversity Law) and guiding principles for the systematic application of mitigation hierarchy in all sectors.

- This should happen at all levels starting from the EU level.
- Policymakers at the EU level should:
  - Improve existing guidelines to strengthen the application of the mitigation hierarchy in protected areas.
  - Strengthen the application of the Precautionary Principle where a threat to biodiversity is foreseeable but scientific information is not available.
  - Ensure that the principles of EU environmental law (i.e., EU law primacy, effectiveness, integration, precautionary, polluter pays) are fully utilised in key regulatory and voluntary tools aimed at implementing the mitigation hierarchy in a harmonised way throughout the EU.
  - Ensure that national restoration plans developed to implement the recent proposal for a Nature Restoration Law at the EU level take into account the

recommendations listed below, especially when designing renewable energy go-to areas.[1]

- Legislation at national level in each country should include, at a minimum:
  - A clear and harmonised definition of the scope and the goal of the mitigation hierarchy.
  - A definition of relevant avoidance and minimisation measures.
  - Mandatory registers for monitoring and disclosure of the wider mitigation hierarchy processes (not just offsetting) to ensure implementation happens in practice.
  - Technical guidance for land use planners, project developers, etc., to help operationalise the legislation.
  - Regulatory commitment to finance sufficient resources for effective implementation and monitoring of the results.
- Support the uptake and effective implementation of the mitigation hierarchy by creating national supporting bodies and/or a Europe-wide community of practice to share experiences and best practices and help knowledge transfer.

2. Decide where to avoid or mitigate in land-use planning processes.

- Land-use planners:
  - Mapping of biodiversity and ecosystem services at the local and regional level, paying particular attention to irreplaceable and vulnerable areas in terms of both biodiversity and ecosystem services where impact avoidance needs to be enforced.
  - Provide measures and scenarios based on multiple habitats and multiple species to integrate spatial and temporal dynamics into a connectivity approach. This approach should aim to improve the overall ecological network and provide a set of ecosystem services.
  - Map ecosystem services by also taking into account the conditions of ecosystems, for example, through the methodologies and indicators proposed by the European Commission in the 2022 report "EU-wide methodology to map and assess ecosystem condition"[2].
  - Manage surrounding blue and green infrastructure networks more effectively and ensure multi-functionality. Aim to support and connect protected and vulnerable areas by using restorative processes, support traditional semi-

[1] The recent Proposal for a Regulation of the European Parliament and of the Council on nature restoration of 22 June 2022 provides at p. 30, par. 61: "In the designation of renewables go-to areas, Member States should **avoid** protected areas and consider their **national nature restoration plans**."

[2] https://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/index_en.htm

natural management techniques and introduce high-quality green areas using indigenous and sensitive planting.

- National, sub-national and local authorities:
    - ➢ Invest in mapping ecosystem services, especially in the marine space where data on biodiversity is missing. This will improve the data available on the benefits to society, leading to better evidence-based policymaking.
    - ➢ Employ a mix of mandatory and voluntary tools, ranging from taxation to payments for ecosystem services, in order to strengthen avoidance, thus protecting valuable habitats.

3. Include stakeholders at the beginning of the planning, design and implementation phases

- Engage and include stakeholders at the beginning of the planning and design phase by recognising the plurality of forms of knowledge and establishing dialogue, especially in areas where there are potentially conflicting perspectives. Planning authorities and practitioners should:
    - ➢ Ensure stakeholder involvement in a transparent, well-defined process with a common and agreed-upon language and terminology.
    - ➢ Ensure transparency and strengthen trust between different stakeholders engaged during the decision-making process and for knowledge exchange.
    - ➢ Use proactive participatory mapping involving multiple stakeholders by investing the time and resources required to build the knowledge for an effective mapping exercise.
    - ➢ Consider the diversity of understanding by using an adaptive and customised process in order to accommodate different perspectives, practices and interests.
    - ➢ Ensure a balance or take corrective measures to safeguard minority or less powerful stakeholders.
    - ➢ Ensure that the process takes account of the ecosystem services valued by the local stakeholders.

4. Address different impacts on biodiversity and ecosystem services during planning processes.

- National, sub-national and local authorities should:
    - ➢ Consider mitigation and avoidance measures based on multiple spatial and temporal scales. For example, considerations of ecosystem services that are locally more rare or important or where there is a possibility for seasonal avoidance.
    - ➢ Implement pressure and intensity-based avoidance buffers that are specific to the wildlife of the area, e.g., noise mitigation measures during different offshore

wind energy development stages (construction, operational and decommissioning stage).

- ➢ Promote an explicit analysis of the trade-offs (e.g., between biodiversity conservation and specific ecosystem services or among different categories of ecosystem services).
- ➢ Extend the transparency and replicability of environmental impact assessments and adoption of criteria and methods, and reduce the evaluation procedures based on subjective judgments.
- ➢ Ensure social equity of the impacts on ecosystem services and the associated mitigation measures (e.g., in terms of people's well-being and health) through the concept of no-worse-off.
- ➢ Incorporate synergies between biodiversity and ecosystem services within the mitigation hierarchy where they have complementary conservation targets.

5. Address connectivity and cumulative impacts during planning processes.

- Stakeholder representatives and researchers
  - ➢ Highlight connectivity hotspots based on different groups of species with varied dispersal capacities to provide an effective decision support tool for planning, including terrestrial, freshwater and marine realms that can be used to implement avoidance and mitigation measures.
- National authorities and land use planners should:
  - ➢ Define procedures to address the cumulative effects in the planning process using an impact chain rationale as follows:
    - ▪ Characterise the source(s) of pressure;
    - ▪ Address the single/ multiple pressures exerted by the source(s);
    - ▪ Address the impacts on biodiversity components (community, structure and function) and ecosystem services.
    - ▪ Apply mapping and expert knowledge to link the impact chain rationale to effective avoidance and mitigation measures.
  - ➢ Ensure that the current acceleration and simplification of administrative procedures to speed up renewable energy projects do not undermine a thorough assessment of cumulative effects.

6. Champion capacity building to ensure effective implementation and monitoring of the results.

- Planning authorities and institutions should invest time and resources to:
  - ➢ Incorporate capacity building into institutional operational structures, including improvement of knowledge and communication.

- Institutionalise citizens' engagement to strengthen local and more sustainable dynamics where knowledgeable communities can act in the interests of biodiversity.
- Share knowledge opportunities; for example, the European Environment Agency (EEA) should collect information on best practices around Europe at the EU and national level and make the knowledge and database available to all the stakeholders.

- Practitioners and authorities should:
  - Adopt more collaborative science practices with multiple stakeholders (e.g., citizen science).
  - Encourage and support citizen science programmes as a means to engage and educate citizens but also as a means of collecting extensive data for improved management and policymaking.
  - Disseminate the results of monitoring and evaluation activities to increase knowledge of what works and what does not.
  - Adopt a plurality of evaluation approaches in order to facilitate the understanding of assessment processes and results by different groups of stakeholders, including participatory assessment to build capacity, empower participants, sustain organisational learning, and improve the uptake of findings and understanding of data).
    - For example, the co-creation of scenarios, such as the deliberative democracy process (Fontaine et al., 2014), a companion modelling approach (Sahraoui et al., 2021), probabilistic graphical modelling (Gonzalez-Redin et al., 2016), and reflexive monitoring.

RECOMMENDATIONS FOR RESEARCHERS AND EDUCATIONAL INSTITUTIONS

- Develop methods and create maps of ecosystem services and areas with high biodiversity value in the marine space. Develop methods for ecosystem services assessment and areas with high biodiversity value that are biome-specific (terrestrial, freshwater, coastal-marine) in order to take into account the bio-physical processes and socio-ecological conditions that determine ecosystem services demand and supply.

- Conduct impact evaluations at different stages of the mitigation hierarchy (i.e., avoid, mitigate, restore, compensate) to increase the evidence base of what works in practice. Impact evaluations need to follow best practices (e.g., have a Before-After Control-Intervention design) to be able to address cause-effect relationships and the effectiveness of the intervention.

- Establish a common indicator framework for the evaluation of various Ecosystem Services, using appropriate approaches (e.g., a combination of biophysical, economic, and sociocultural indicators) and including also the assessment of ecosystem conditions

- Extend the traditional additive Cumulative Impact Assessment methods by including synergistic, antagonistic and dominant impact mechanisms that take account of the interactions from multiple pressures on biodiversity and ecosystem components.

- Ensure stakeholder involvement is equitable by including a wide range of stakeholders, especially minority and other often excluded groups, not just experts or easily reached groups. Adequate groups should also be provided for their participation during all project stages. Unfortunately, while we see many reports and articles that advocate for working with stakeholders, few achieve a satisfactory level of involvement, most merely rely on the expert representation. It is time that the scientific community puts the principles that many promote into action and achieves truly equitable collaboration.

- Develop capacity within educational/research institutions through, for example, adopting the service-learning approach and applying the existing expertise to enhance the good practice of mitigation hierarchy design and application.

- Disseminate best practices and case studies of mitigation hierarchy application through knowledge and databases to relevant organisations by creating alliances with stakeholders in a learning-in-action approach.

- Promote the uptake and effective implementation of the mitigation hierarchy by supporting the creation of a community of practice of researchers, planners and practitioners aimed at knowledge co-production and the sharing of best practices.

BACKGROUND AND OBJECTIVES

The Mitigation Hierarchy is the sequence of actions to anticipate and avoid adverse impacts on biodiversity and ecosystem services (see definitions above). The avoid or prevent stage is the first and most important stage of the mitigation hierarchy in which developers anticipate adverse impacts on biodiversity before actions or decisions are taken. Action is then taken to prevent adverse impacts by considering different options in the project location, scale, layout, technology and phasing. Avoidance is often the easier, cheaper and more effective way than trying to restore a damaged habitat or offset elsewhere. The cost-effectiveness of this can only be realised by understanding the value of biodiversity and thus should be considered in the early stages of a project (Ekstrom et al., 2015).

However, our aim is to find out the extent in which the adherence to and implementation of the hierarchy is correctly applied and ecosystem services are considered and well documented. The activities should focus on the avoid and mitigation stages of the mitigation hierarchy (avoid-mitigate-restore-compensate).

With this in mind, the French Biodiversity Agency put forward the following request to Eklipse (CfR.5/2020/2):

> "How can ecosystem services be considered in plans, projects, programmes, policies and associated impact assessments with a particular focus on the avoid stage of the mitigation hierarchy?"

To answer this request, an Expert Working Group (EWG) on Mitigation hierarchy request was established, composed of members from different backgrounds (country distribution and career level) and research expertise (EU environmental laws and policies; landscape ecology and spatial planning; ecosystem services; environmental governance; evidence synthesis; marine, freshwater and terrestrial ecology; participation and stakeholder engagement; nature-based solutions). The research had three main objectives:

1. To gather knowledge on how ecosystem services/natural capital as concepts foster the conservation and enhancement of biodiversity within planning processes in sectors that are likely to have a direct impact on biodiversity, e.g., infrastructure development, resource use and land use change.

2. To identify EU-wide cases and practices that actively consider and address the aspect of ecosystem services in the mitigation hierarchy; for example, in natural capital assessments, impact assessments of projects, plans, programmes, policies or similar processes.

3. To develop guidance on best practices and information on:

a. If and how the consideration and operationalisation of ecosystem services can be integrated into natural capital assessments, impact assessments, and policymaking processes to enhance biodiversity conservation as well as to understand the risks and potential ecosystem service trade-offs involved.

b. What kind of outcomes, impacts, challenges, solutions, etc., may occur when the ecosystem services concept is used in the natural capital assessments, impact assessments, mitigation hierarchy and similar processes?

c. The level of replicability/transferability of suggested/known tools/guidance/processes in other countries or regions that have been used successfully in the avoid stage.

This research aims to unveil whether land use planning and development in Europe is in line with the state of the art on biodiversity conservation and ecosystem services.

METHODOLOGICAL FRAMEWORK

In order to address the research objectives presented in the introduction the following steps were implemented:

a) A systematic mapping approach was used to provide an overview of the available evidence and knowledge gaps present;

b) An Applied Policy Delphi process for deliberative consultation, discussion, and feedback; and

c) An analysis of results and conclusions based on the findings from the systematic mapping and the Applied Policy Delphi.

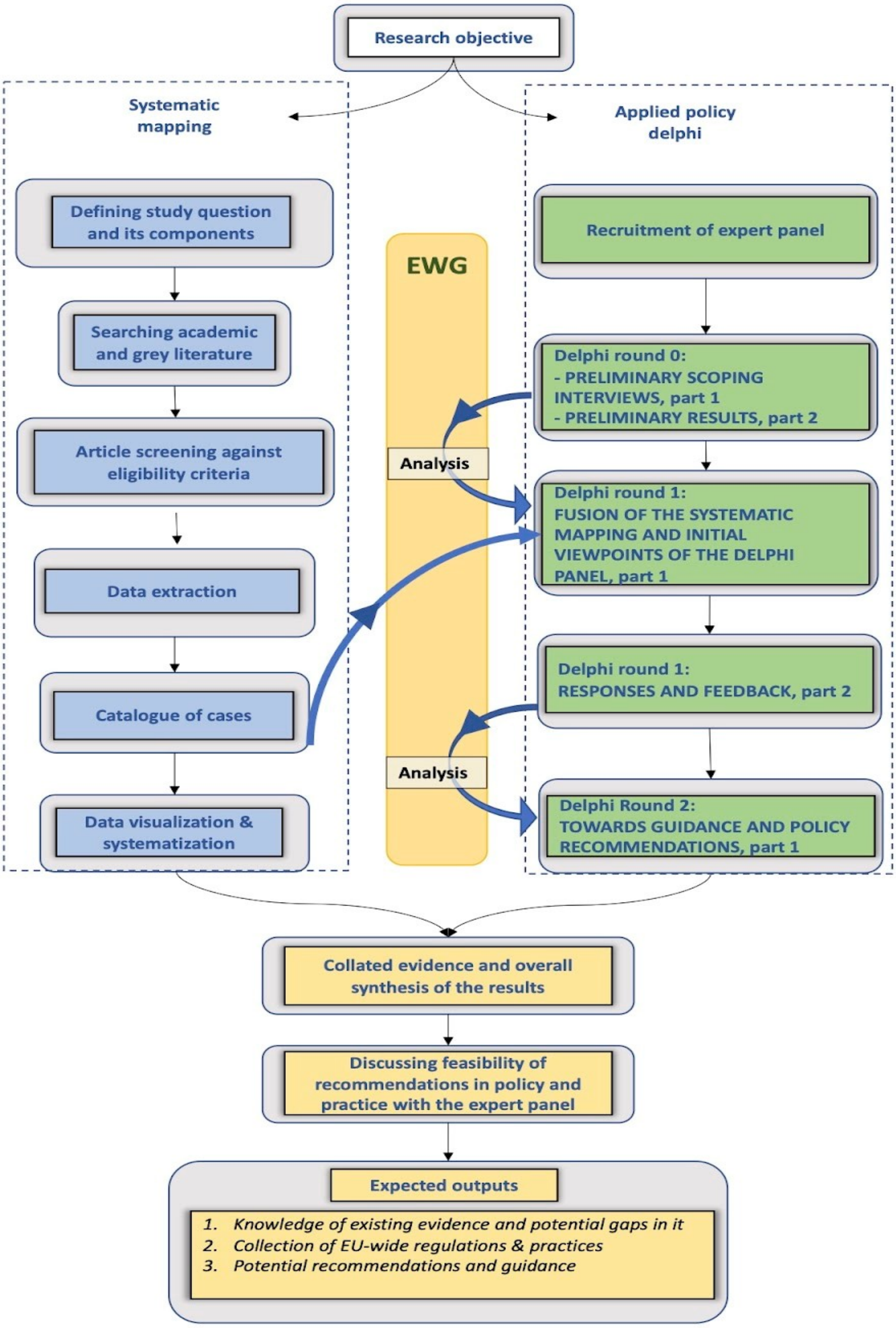


Figure 1. Presents the methodological framework by the Eklipse Expert Working Group to investigate how ecosystem services are incorporated into mitigation hierarchy policy.

SYSTEMATIC MAPPING APPROACH

The systematic mapping provided an overview of the distribution and amount of evidence that existed related to the objectives of the request. It helped to identify knowledge gaps in the literature for which further information was sought from the expert consultation process. The systematic mapping was conducted according to CEE guidelines (Collaboration for Environmental Evidence 2018).

Question components

A modified PerSPEcTiF framework (Booth et al. 2019) was used to outline the key question elements (Table 1). The question components were formulated based on the study questions and discussion with the requester about the details of the scope.

Table 1. Components of the study question

Perspective	Setting	Phenomenon of Interest	Environment	Exposure (*Pressure*)	Date Range	Findings
Global*	Impact assessments, natural capital assessments, and policymaking processes	Consideration and operalisation of the ecosystem services concept to mitigate and avoid impacts on ecosystem services and/ or biodiversity	Freshwater, marine and terrestrial ecosystems.	Infrastructure development, land use change and resource management	since 2000	Challenges and solutions for the use of ecosystem services concept, ecosystem services/biodiversity outcomes, trade-offs for people and between ecosystem services

*Although studies taking place anywhere in the world are included, the requester is especially interested in European cases and practices, reflected in the grey literature search.

Searches

Search terms and languages

A scoping exercise was conducted in the Web of Science Core Collection and Scopus. The search terms were defined in an iterative process of testing different terms and search strings (Annexe 1). The planning terms (#2) reflect the terms considered to have a potential impact on biodiversity. A list of relevant articles was used to test the comprehensiveness of the search (Annexe 2). The test list was compiled based on the suggestions from the EWG. The final search string (in Web of Science format) is:

> #1 (avoid* OR prevent* OR mitigat* OR reduce OR impact OR foster OR enhanc* OR integrat*)
>
> AND
>
> #2 ("mitigation hierarchy" OR "land use planning" OR "management plan*" OR "urban greening" OR "spatial planning" OR "marine planning" OR "county plan*" OR "municipal* plan*" OR "theme plan*" OR "green corridors" OR "functional urban area*" OR "impact assessment" OR "green infrastructure" OR "blue infrastructure")
>
> AND
>
> #3 ("ecosystem service*" OR "ecosystem goods and services" OR "environmental service*" OR "ecological service*" OR biodiversity OR "biological diversity" OR "natural diversity" OR "nature's contribution to people" OR "nature value" OR "natural capital").

The asterisk (*) at the end of a search term/word was used to accept any variant of a base term, whereas words or phrases within quotation marks were searched exactly as they appeared in the search string. Where the full search string could not be used because of limitations of the search interface (e.g., in organisational websites), a simplified search string was used. All search strings used were recorded (see Annexe 3).

Search languages were determined by mapping the language skills of the EWG and included English, French, German, Spanish, Portuguese, Italian, Croatian, Finnish, Greek, Serbian and Swedish. The EWG acknowledges that not all European languages were covered and hence, the comprehensiveness of the search, especially grey literature, was not exhaustive (Figure 2). Organisational websites were searched in the primary language of the website in which it was published. In case the website included a unique publication section in any of the other search languages (not simply translations from the original publications), those were searched as well.

Bibliographic searches

Searches in the following bibliographic databases were conducted on 16.12.2021, and search alerts were set for articles published after the search date. Search alerts were discontinued on 28.2.2022 when full-text screening started.

- Web of Science Core Collection (https://clarivate.com/); Topic search covering Science Citation Index Expanded (1945-present), Social Sciences Citation Index (1956-present), Arts & Humanities Citation Index (1975-present), Conference Proceedings Citation Index- Science (1990-present), Conference Proceedings Citation Index- Social Science & Humanities (1990-present), Emerging Sources Citation Index (2015-present).
- Scopus; Title, abstract, and keyword search.
- Lens (https://www.lens.org/); Title, abstract, keyword or field of study.

Search engines

Google was used for internet searches. The searches were conducted for each of the search languages in 'private mode' to avoid the influence of location and browsing history. The results were organised by relevance and checked until no more relevant results appeared (Livoreil et al., 2017). The cut-off was a hundred search records with no hits. Search dates, number of hits and records searched were recorded (Annexe 1). Grey literature searches took place between 24.2-19.4.2022.

Organisational websites

Websites of international and national organisations in Europe (see Figure 2) were searched. These included, for example, websites of research organisations, ministries and government agencies, and environmental organisations identified by EWG members as potential organisations to have relevant literature on mitigation hierarchy. A full list of organisations and the search results are included in Annexe 4.

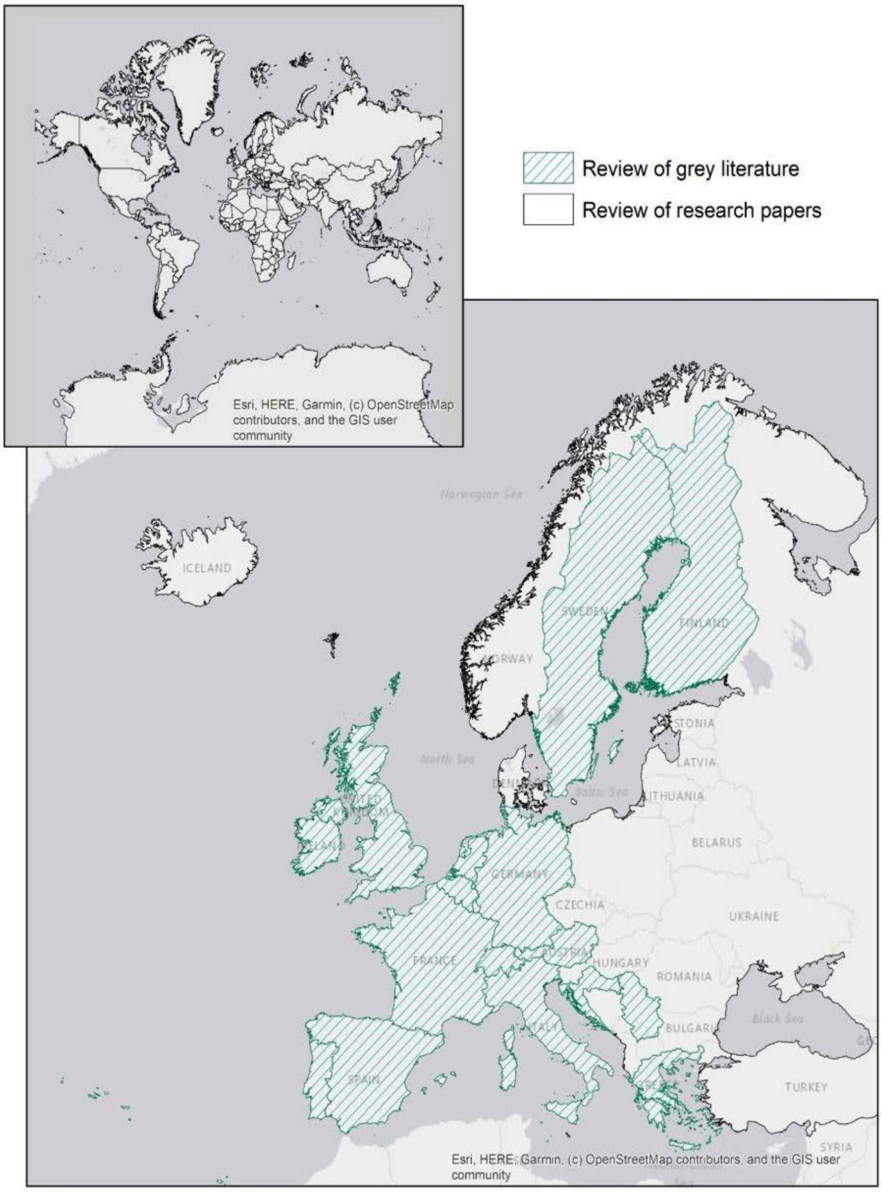


Figure 2. Map of the geographical areas covered by academic and grey literature searches.

Supplementary searches

A call for knowledge (Eklipse CfK.2/2020) was launched to compile and understand the type of knowledge available about the request, including case studies and practices on the use of the mitigation hierarchy. This call was published on the Eklipse website and widely distributed through networks and social media. Citation chasing was, in the end, not undertaken because of time constraints stemming from the relatively large number of articles screened.

Search record database

After the searches were completed, all references from academic databases were exported to Eppi Reviewer (Thomas et al. 2020), and duplicates were removed. An excel file was created for grey literature to record search results.

Article screening

Articles from the academic journals and grey literature were screened in two stages: 1) title and abstract and 2) full text. A single screening was conducted due to resource constraints. As screening involved multiple people, an alignment in screening decisions was established before screening at title and abstract commenced. A set of 20 articles were screened against inclusion criteria by all persons involved in the screening. Their inclusion/exclusion decisions were compared, and any discrepancies discussed. After the first round, the inclusion criteria were clarified and the process repeated with a new set of articles. Once the team was confident that their screening decisions were in agreement, the rest of the articles were divided among the screeners. If a screener was unsure during the screening whether to include or exclude an article, consultations were conducted with other team members and a joint decision was made. At the beginning of the full-text stage, five articles were screened together again to ensure alignment of screening decisions.

If articles shared the same study site (i.e., linked articles), they were screened together to avoid inclusion of duplicate data, as recommended by Frampton et al. (2017). True duplicate studies were removed, and the rest were screened as a single unit to consider all available data pertinent to the study when the eligibility decision was made.

Eligibility criteria

The eligibility criteria were based on the study question components. Studies that fulfilled the following criteria were included:

- Studies on freshwater, marine and terrestrial ecosystems anywhere in the world. This included studies on blue and green infrastructure as well.
- Studies addressing the use of biodiversity and/or ecosystem services concepts in the context of impact assessments, spatial planning, and policy processes.
- Studies addressing mitigation of impacts from grey infrastructure development, land use change and resource management on biodiversity and/or ecosystem services;
- Studies on mitigation hierarchy needed to be focused on the avoidance and minimisation stages as per the request.
- Both applied studies (i.e., real-world cases) and theoretical studies were included as well as studies addressing governance frameworks, challenges and solutions.

Exclusion criteria:

- Literature and systematic reviews were excluded.
- Studies on compensation and off-sets were excluded.
- Studies where impacts are minimised by restoring a habitat were also excluded.

Data extraction

At the beginning of data extraction, all persons involved in data extraction coded five articles together to ensure consistency and shared understanding. Any uncertainties during the data extraction phase were discussed among those involved in the systematic mapping, and a joint decision made. Data was extracted using the following framework:

Metadata (data on study characteristics)

- Source of the article.
- Information on publication details (title, authors, publication year, DOI).
- Type of publication (journal article, report, book, etc.).
- Language.

Study attribute data

- Ecosystem (Freshwater, marine and terrestrial).
- Geographical location.
- Scale of the study.
- Exposure type (i.e., details on infrastructure development, land use change or resource management).
- Applied or theoretical study.
- Biodiversity or ecosystem services or both studied.
- Studied ecosystem services.
  - provisioning
  - cultural
  - regulating and maintenance
  - ecosystem services disservice
- Studied level of biodiversity.
  - landscape
  - community
  - species
  - genes
- Use of mitigation hierarchy (yes/no).
- The stage of mitigation hierarchy (avoid or minimise).
- Governance.
  - legal framework for mitigation
  - relevant government policies
  - planning principles
- Outcomes of the study.

- direct and indirect ES and/or biodiversity impacts (inclusive of loss of and damage to ecosystem services and/or biodiversity)
- trade-offs
- risks
- challenges
- solutions

During data extraction, additional study attributes emerged that were not mentioned in the original list of data to be extracted as published in the protocol. They were identified and added to the framework. The Common International Classification of Ecosystem Services (CICecosystem services) V5.1 typology (Haines-Young and Potschin, 2018) was used to categorise the ecosystem services into provisioning, cultural, regulation and maintenance categories. Only the upper-level categories were used. Where the authors of the paper had not assigned a category for the ecosystem services in question, one was assigned based on EWG's expert judgement during data extraction. Similarly, the stage of the mitigation hierarchy (avoid or minimise) was assigned during data extraction if not explicitly mentioned in the paper.

Data synthesis

A narrative synthesis describing the evidence base was produced. A primary output was the collation of a catalogue of cases where mitigation hierarchy had been used in practice. Various data visualisations, such as bubble maps, were used to illustrate the extent of the evidence related to the study objectives and knowledge gaps that exist.

APPLIED POLICY DELPHI

The EWG conducted a deliberative email consultation involving an external expert panel using an Applied Policy Delphi technique to gain practical insights from experts involved in different aspects of the implementation of mitigation hierarchy or incorporating ecosystem services into land use planning. This was conducted in parallel to the systematic mapping process, where the result from the systematic mapping was used to help maximise the project outcomes, consequently:

- Further evidence and relevant case studies were identified;
- The process supported and built upon the EWG ideas and recommendations
- Critical issues were discussed with the panellists that emerged from the systematic mapping, and differences in opinions were noted.
- Feedback from the Applied Policy Delphi panel on the EWG synthesis of results was utilised to refine the draft recommendations for future policy and practice.

A panel of 11 experts from 9 countries was selected based on suggestions made by the EWG members via their networks and from further discussion within the group (Figure 3). The aim was to ensure appropriate representation of different types of experts (namely, practitioners, policymakers and researchers) and, as far as possible, different EU contexts and expertise, i.e., marine and terrestrial focus, based in different countries or with an international perspective and so on. We defined "experts" as people with on-the-ground experience in avoiding or mitigating biodiversity and/or ecosystem services impacts, e.g., consultants, resource managers, researchers, and policymakers, among others. A key goal was to ensure that all panellists have had some direct involvement in using the mitigation hierarchy or a related field, e.g., land use or marine spatial planning.

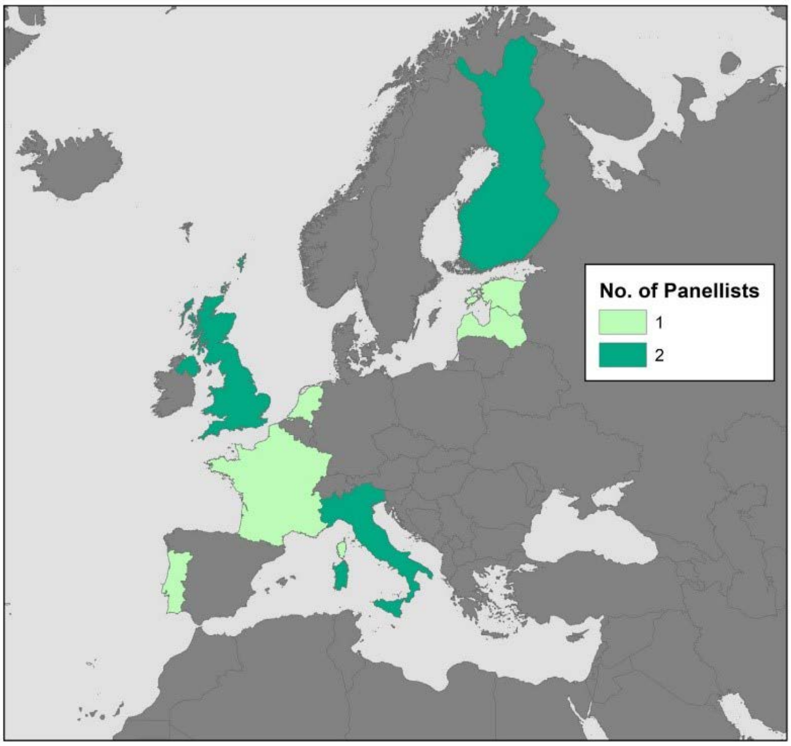


Figure 3. Geographical representation of the Applied Policy Delphi panel.

Operationally, the expert consultation in the Applied Policy Delphi process included the following steps, which were all conducted remotely through confidential email communication apart from the initial interviews and are summarised in figure 4:

Applied Policy Delphi round 0 PRELIMINARY SCOPING INTERVIEWS, part 1:

Preliminary individual interviews with experts were held remotely to explain the activities in detail, engage them in the process and engage key expertise for successive rounds. The central aim was to capture their initial standpoints with justification on the mitigation hierarchy and use of the avoid/minimise stage, highlighting barriers and opportunities.

Applied Policy Delphi round 0, PRELIMINARY RESULTS, part 2:

The preliminary results of the scoping interviews were analysed using thematic analysis between January and March 2022. The interviews were transcribed and coded inductively with the support of a research assistant using NVivo software. The themes emerging from the interviews were identified by the EWG and systematised in the:

- Theme 1: Understanding of the mitigation hierarchy,
- Theme 2. Ecosystem services,
- Theme 3. Practical experience- delivery and lessons learned,
- Theme 4. Strengths and Opportunities:
- Theme 5. Weaknesses and Challenges,
- Theme 6. Links with other policies and legal tools,
- Theme 7. Links with tools and practices,
- Theme 8. Future directions of the mitigation hierarchy.

These themes were used as headings for the outcomes of the Applied Policy Delphi process and combined with the outcomes from the systematic mapping process. The results are presented in the following section of this report. The results were compiled with initial systematic mapping results and presented to the experts. Areas of consensus and difference were highlighted in the research, and expert feedback was used to develop the priorities for questions for the first round;

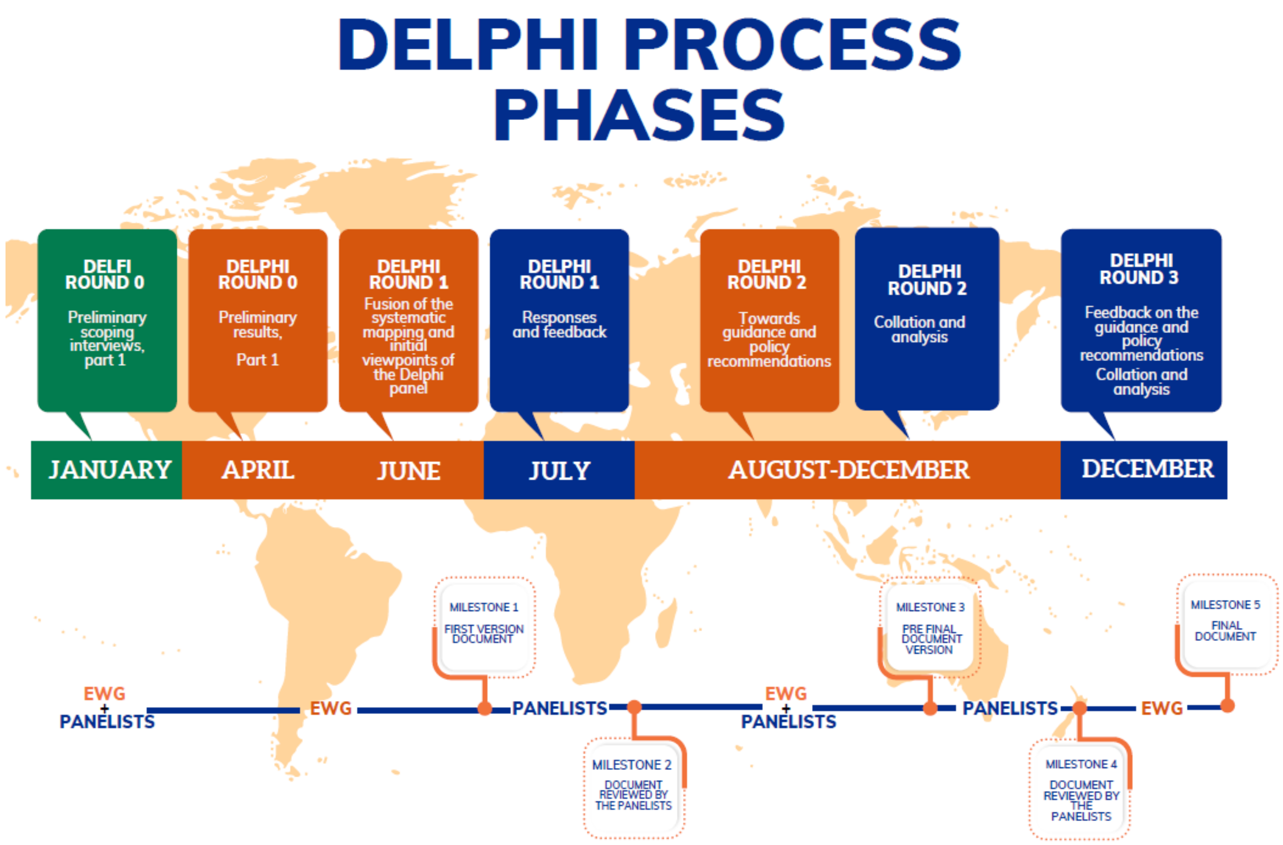


Figure 4. Applied Policy Delphi process phases.

Applied Policy Delphi round 1: FUSION OF THE SYSTEMATIC MAPPING AND INITIAL VIEWPOINTS OF THE Applied Policy DELPHI PANEL, part 1:

Here the Applied Policy Delphi process was used to complement and add value to the key findings from the systematic mapping and to identify the areas within which future guidance and recommendations were needed. For example, the key tools, governance frameworks and other drivers influencing success. A narrative was produced with questions to express these outcomes. The first questionnaire included mostly open-ended questions aimed at capturing and discussing key critical issues associated with the conceptualisation and application of the mitigation hierarchy (avoid and minimise stages) as revealed through the systematic mapping and initial Applied Policy Delphi responses.

Applied Policy Delphi round 1: RESPONSES AND FEEDBACK, part 2:

The responses to the questions were analysed and shared with the EWG. The comments of the EWG were then integrated and fed back to the Applied Policy Delphi Panel.

Applied Policy Delphi Round 2: TOWARDS GUIDANCE AND POLICY RECOMMENDATIONS, part 1:

Building on the work of the EWG, the draft final report, including the policy recommendations and guidance, was sent out for comment and feedback. The EWG used the feedback from the systematic mapping and previous Applied Policy Delphi rounds to set the recommendations.

Applied Policy Delphi Round 2: COLLATION AND ANALYSIS, part 2:

The EWG then collated and analysed the responses to produce the final report.

Applied Policy Delphi round 3: FINAL FEEDBACK ON THE RECOMMENDATIONS AND GUIDANCE:

This final round involved feeding back the changes made by the EWG in response to the Applied Policy Delphi panel with a chance for a final set of responses. Focus was placed on the interplay between the Applied Policy Delphi panel and the EWG to maximise the expertise across the groups.

Throughout the process, compliance with ethical issues was ensured following the procedures designed and agreed upon during the planning phases (Annexe 5).

RESULTS

In this section, we present the findings from the systematic mapping process followed by the outputs from the Applied Policy Delphi Process.

SYSTEMATIC MAPPING

Overview of the evidence base

Figure 5 shows the number of articles included and/or excluded through the process. It resulted in 18 164 hits, of which 6356 were duplicates. After screening, a total of 215 articles (peer-review and grey literature) were included in the narrative synthesis.

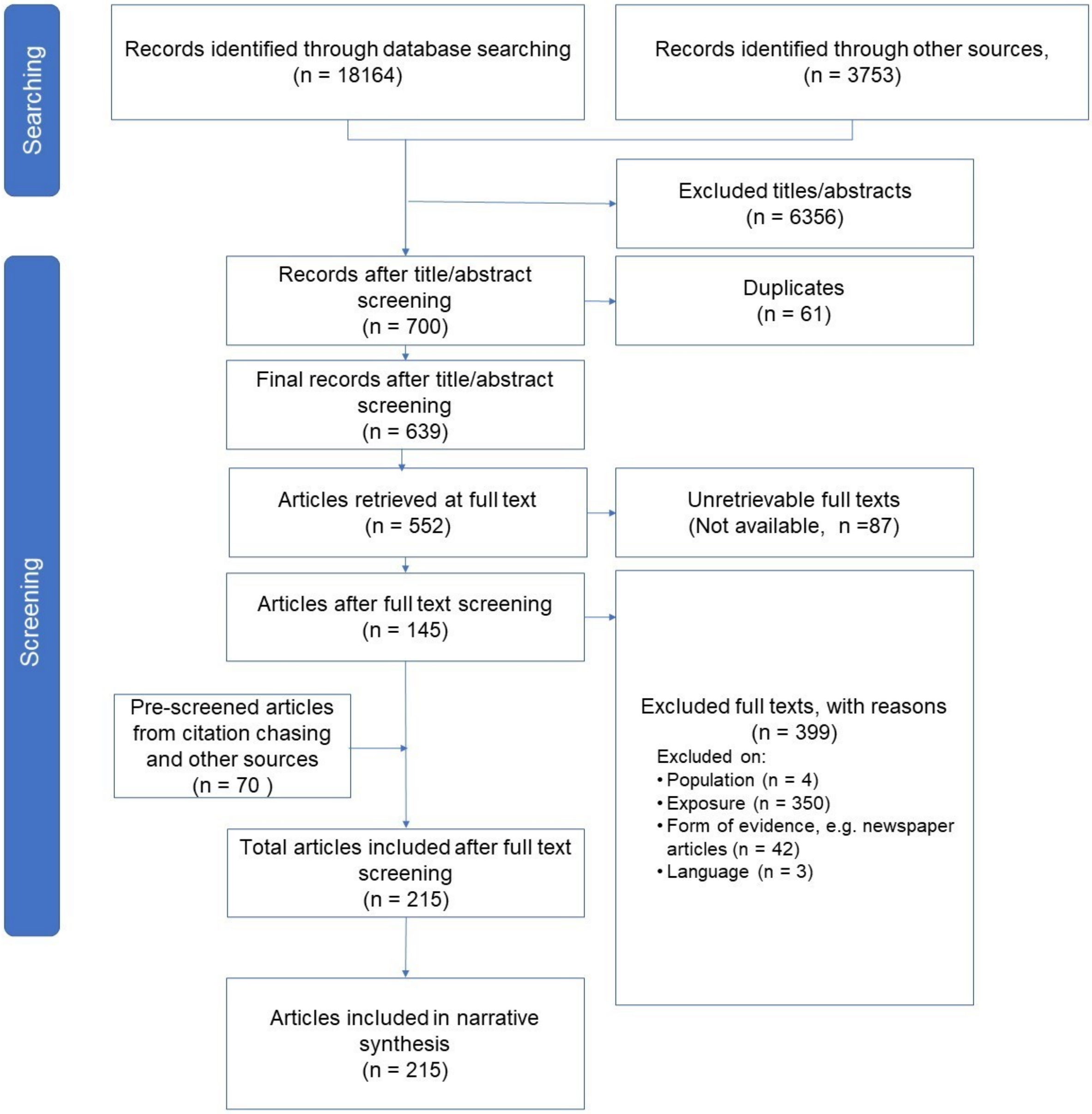


Figure 5. Overview of the articles included and excluded as part of the systematic mapping following the ROSES form.

After that, and using an automatic document clustering (Figure 6), the included articles were divided into seven categories: land use planning, green infrastructure, marine spatial planning, water, environmental impact assessment, decision making, protected areas, and other categories. The environmental impact assessment was the largest category, followed by land-use planning.

Figure 6. Overview of the scientific articles included in the systematic mapping clustered by categories.

The coverage of the literature database per type of biome is shown in Figure 7. The database has a good representation at the European level, with fewer studies in Eastern Europe. The largest number of terrestrial studies were conducted in France at the country level, whereas Spain had the largest number of freshwater-related studies. The largest number of coastal and marine studies identified covered the coastal areas of the United Kingdom, Denmark and Spain.

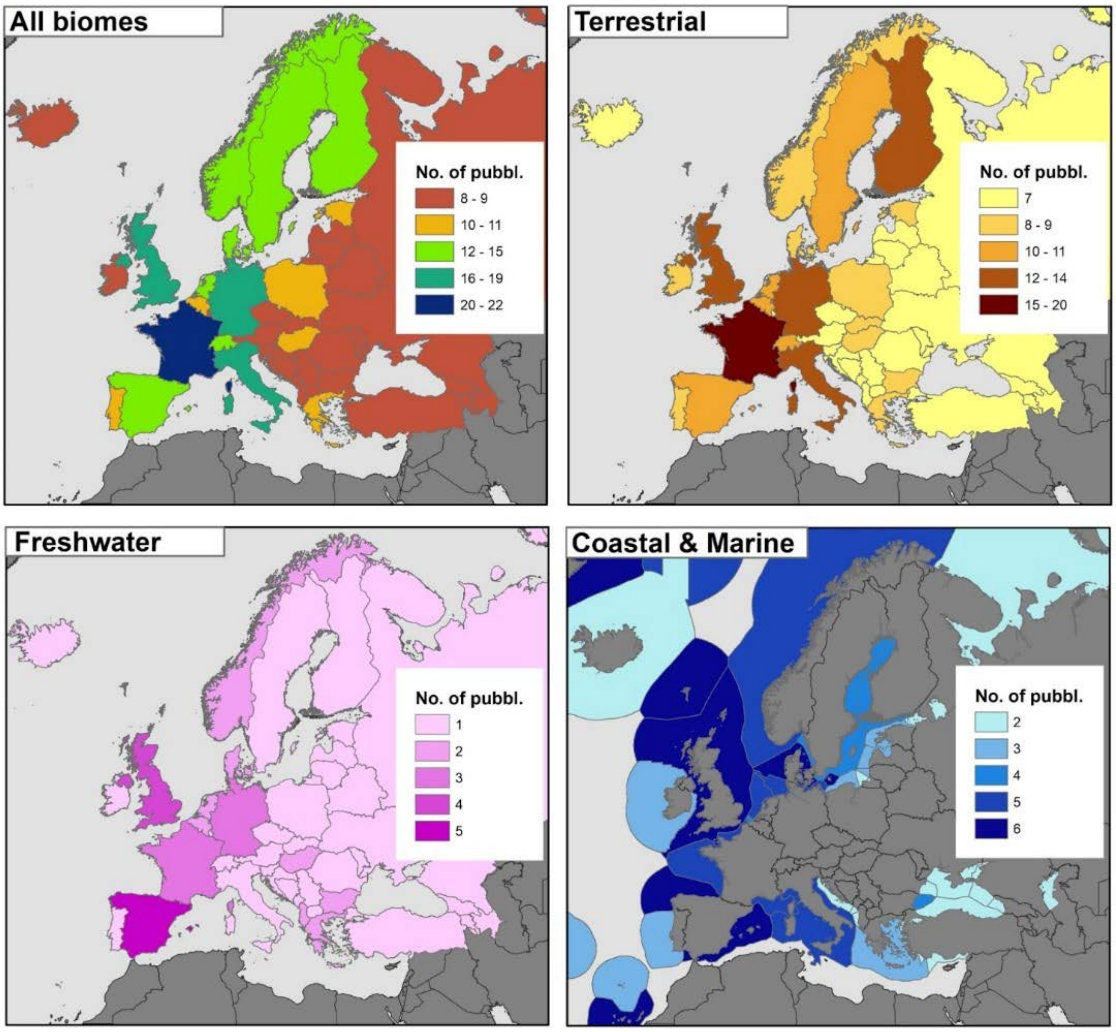


Figure 7. Overview of the coverage of the literature database included in the systematic mapping.

The literature database of terrestrial studies was classified into eight categories according to their ecosystem type: farmland, forest, grassland, mountain/alpine region, riparian landscapes, urban park, wetlands/peatlands, and multiple. Figure 8 shows the distribution of the literature on the different types of ecosystem categories per country. Farmland, forest and grasslands were the most studied categories compared to riparian landscapes and urban parks, which were the least researched.

Figure 8. Overview of the terrestrial literature database included in the systematic mapping by country.

Mitigation hierarchy as a concept

There were 45 papers that explicitly mentioned the mitigation hierarchy. The review demonstrates the **mitigation hierarchy concept is relatively well-known** in the literature. Several papers referred to existing guidance documents (e.g., in Environmental Impact Assessments and Strategic Environmental Assessments) that clearly describe the different steps of the hierarchy and their application (Cullen 2006; Hayes 2015). Even though there is an overall agreement about the usefulness of applying the mitigation hierarchy in relevant decision-making processes (Claireau et al., 2019; Jagerbrand and Bouroussis, 2021), the review of Environmental Impact Assessments conducted by Bigard et al. (2017) highlights the **avoidance stage is often disregarded**, and measures "to avoid" are often actually measures "to reduce". Furthermore, Barbe and Frascaria-Lacoste (2021) take a critical view of the mitigation hierarchy and question whether the policy goal of 'No Net Loss of biodiversity' should be based on a tool (i.e., mitigation hierarchy) that, at its core, is meant for, and largely used, only to reduce the harm caused by economic development, mainly from new projects.

The papers included both theoretical and applied studies as well as covered different outcomes (Figure 9). The majority of papers were on biodiversity, but ecosystem services were also included.

Figure 9. Papers on mitigation hierarchy. The bubble size denotes the number of papers. The green colour is for biodiversity, and the violet is for ecosystem services. An interactive form of this figure with links to the information on individual papers can be found [here.]

Avoidance as a concept

The concept of avoidance requires *"measures [are] taken to anticipate and prevent adverse impacts on biodiversity before actions or decisions are taken that could lead to such impacts"* (CSBI 2015 in Hayes et al. 2015, p2).

Following Bull (2022), avoidance can be defined as **action-based** (actions were taken to avoid impacts) or **outcome-based** (did the actions taken the lead to avoided impacts). Mostly the focus is on direct impacts, but indirect impacts should also be kept in mind, especially leakage (impacts taking place elsewhere). As Bull et al. (2022, p374) point out, "*it can never be assumed that avoiding environmental impacts within a certain jurisdiction will lead to their universal avoidance, in space and over time*". Also, avoidance is often associated with a change in land use, but cumulative impacts from ongoing land use, such as agriculture or forestry, may be large despite their typically small local footprint (Pappila, 2018). Furthermore, the way we define and consider 'adverse impacts' and 'significance' can greatly influence the implementation of the mitigation hierarchy (Barbe and Frascaria-Lacoste 2021)

Barbe and Frascaria-Lacoste (2021, p4) argue that "*the avoidance step does not always receive sufficient attention and leeway and does not always—as it should—raise the necessary questions about the choices (political, economic, etc.) that lead to new project development*". They further argue that "*the mitigation hierarchy is insufficiently effective or relevant from the ecological perspective*" (p4), a sentiment echoed by other authors. For example, Bigard (2017) maintains there is often no search for truly alternative options for avoidance in the early phases of development projects (which would allow an impact to be avoided), and there is an over-reliance on smaller revisions to reduce impacts.

A key issue is how impacts are avoided. In their earlier review, Phalan (2018) identified **four types of avoidance** measures: **project cancellation, spatial avoidance** (changing the location of a specific action), **temporal avoidance** (anticipating/differing that actions, activities do not take place during key seasons, e.g., breeding season), **and planning within site, i.e., design-based impact avoidance** (changing technology, operational methods, etc.). Furthermore, Tarabon et al. (2019a) highlight the importance of landscape-level land-use planning to ensure functional connectivity within the landscape. There is some evidence spatial avoidance and technical measures are most commonly used to avoid impacts, whereas total avoidance of impacts, e.g., project cancellations, are less common (Hayes et al., 2015; Gelot and Bigard, 2021). This may be because *"Often the ESIA is undertaken when project feasibility and design plans are already advanced, and therefore the opportunity to intervene early to address avoidance strategies, including the identification of alternative site selection, is missed"* (Hayes et al. 2015, p11). Enforcing this point, Bigard et al. (2020) recommend landscape scale as the appropriate scale for impact anticipation because it provides information on sites with high biodiversity values within that landscape that can be avoided before projects are approved.

Ecosystem services as a concept to foster the conservation of biodiversity within decision making

Considering ecosystem services under the mitigation hierarchy may further complicate the situation. For example, Ramel et al. (2020) asks if "the areas contributing most to preserve both biodiversity and ecosystem services coincide spatially, as suggested from work at the European scale?" as their results suggest that **prioritising ecosystem services may "be disadvantageous to biodiversity"**. Hence, while nature-based solutions may protect or enhance ecosystem services, they may not protect biodiversity (Seddon et al., 2020). This points to the importance of determining whether biodiversity impacts can be avoided Préau et al. 2022), where biodiversity loss should be avoided, and then mapping the highest priority areas for protection at the landscape scale, as suggested by Bigard et al. (2020).

Trade-offs

A trade-off is *'a situation where the use of one ecosystem services affects another ecosystem services and the benefits they supply',* but there are also situations where choices have not only to be made between ecosystem services but also between ecosystem services and non-ecosystem services. In general, **trade-offs are related to impacts that can be observed** (Gret-Regamey et al., 2008; Turkelboom et al., 2018), where choices may have real societal implications for stakeholders (Hayes et al., 2015).

Spatial planning deals with trade-offs between various stakeholders' wishes and needs as part of planning, development and management of particular sites, landscapes, natural resources and/or biodiversity. To make ecosystem services trade-off research more relevant to spatial planning, the literature proposes different frameworks, which **put stakeholders, their land-use/management choices, their impact on ecosystem services and responses at the centre of decision-making** (Turkelboom et al. 2018). In some cases, the analysis of ecosystem services trade-offs supports management choices that increase the delivery of other ecosystem services (Turkelboom et al., 2018; Di Marino et al., 2019). Within this framework, trade-off analysis supports sustainable urban planning (Di Marino et al., 2019), coastal benefits (Fontaine et al., 2014), and forest biodiversity (Gonzalez-Redin et al., 2016), among other applications.

It was pointed out in the literature that integrating **valuation approaches for ecosystem services helped to raise awareness of the societal benefits of green spaces** whilst also recognising the trade-offs between conflicting perspectives of stakeholders. Therefore, this aids the prioritisation of ecosystem services (Gonzalez-Redin et al., 2016; Kovacs et al., 2016; Langemeyer et al., 2016a). Further, Fontaine et al. (2014) argue preferences for iconic species present significant issues in constructing social values. It was also recognised that planners still struggle to incorporate green infrastructure and ecosystem services into land-use policy and planning practices due to the complex contexts - environmental, professional, cultural and political - aiming to maintain the status quo (Di Marino et al. 2019).

The literature shows that **provisioning ecosystem services were the most targeted trade-off, but regulating ecosystem services were the most impacted**. In addition, **cultural ecosystem services are underrepresented** because it is difficult to provide value for cultural ecosystem services that can be traded off against other ecosystem services, such as provisioning ecosystem services (Langemeyer et al. 2016). Ecosystem services are also often considered an aesthetic rather than a technical requirement (Khoshkar et al., 2020). Stakeholder characteristics, such as the degree of influence they have, the impacts they face, and their concerns, can partially explain their position and response in relation to trade-offs.

Trust and place attachment.

Trust is a major factor mentioned by Karrasch et al. (2014), where stakeholders were concerned about the impacts on their land use or possibly losing land. **Trust is necessary for implementing biodiversity strategies** that do not alienate people, for resolving conservation conflict (Kovacs et al., 2016), for decision-making processes and knowledge exchange between different stakeholders engaged. As Karrasch et al. (2014, p257) argue, place attachment needs to be considered, especially when stakeholders "were born and raised in the community and therefore had a strong sense of regional belonging and community cohesion".

Cerreta et al. (2021) also mentioned that trust was an important missing component in cultural ecosystem services evaluations.

Literature suggests it is important to **involve stakeholders in the process of evaluating ecosystem services to develop trust** so results are not seen as "a black box" exercise. This would also help people to understand the value that nature provides them. It was stressed that this process had to be transparent enough for decision-makers without jeopardising scientific rigour, thus requiring time (Fontaine et al., 2014; Gonzalez-Redin et al., 2016; Simeonova and van der Valk, 2016; Albert et al., 2021; Sahraoui et al., 2021).

Current use of mitigation hierarchy in decision making

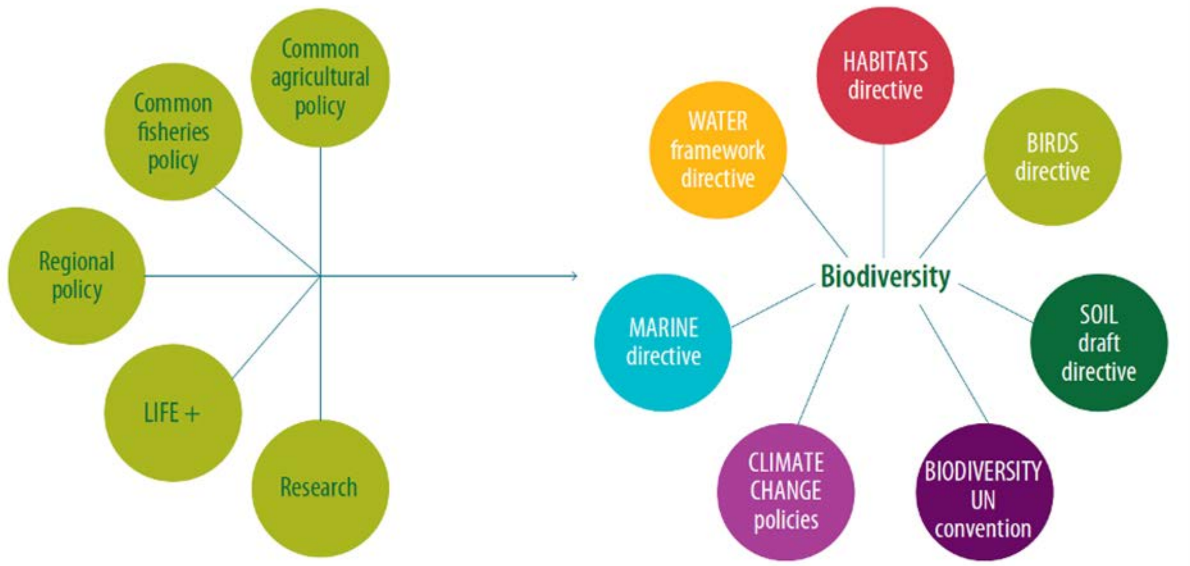
Policies and regulations

Impact avoidance measures stem from both public and private sector governance instruments. Regulatory tools form the backbone of development and application of impact avoidance measures, e.g., protected areas or Environmental Impact Assessment, but as Hayes et al. (2015) note, **there is no standardised framework for avoidance, and it varies considerably between countries**. In addition to regulations, there are voluntary instruments, such as third-party certification standards, financial loan requirements and corporate policies with requirements for avoidance, e.g., related to high biodiversity value habitats.

In the majority of European countries, the European Union (EU) plays an important role in setting policy and regulatory frameworks. General EU policies linked to impact avoidance measures include: the EU Green Deal, the CAP (Common Agricultural Policy), the EU Soil Strategy 2030, the EU taxonomy, the EU Adaptation Strategy, the EU Action Plan for disaster risk reduction, and the EU biodiversity strategy.

Impact avoidance measures in EU policies and regulations related to biodiversity

Several EU policies and regulations have an impact on biodiversity (Figure 10). The EU biodiversity strategy for 2030, adopted in 2020 (EU, 2020), is a long-term plan to protect nature and reverse ecosystem degradation by prioritising biodiversity throughout the other EU policies. It represents a core part of the EU Green Deal and will also support green recovery after the pandemic. It distinguishes itself from the previous Communication of 2011 by establishing a Trans-European Nature Network of protected areas covering 30% of EU land and seas, an EU Nature Restoration Plan with binding targets and a set of measures enabling a 'transformative change' including better tracking, knowledge base and financing.



Source: European Commission.

Figure 10. EU policies and legislation have an impact on biodiversity. The Marine Directive includes both the Marine Strategy Framework Directive (MSFD) and Marine Spatial Planning Directive (MSPD)

At the regulation level, **avoidance is strongly embedded in the Birds and Habitats Directives** (EU-DG Environment, 2014) that focus on species and habitats in need of protection. The two directives require the Member States to do more to prevent further deterioration of these species and habitat types. They must also undertake positive management measures to ensure populations are maintained or restored. According to Article 6, par. 2 of the Habitats Directive: *"Member States shall take appropriate steps to avoid, in the special areas of conservation, the deterioration of natural habitats and the habitats of species as well as disturbance of the species for which the areas have been designated, in so far as such disturbance could be significant in relation to the objectives of this Directive."*

To help the application of Article 6, the Commission issued various methodological guidance documents, such as 'Managing Natura 2000 sites' (EU-DG Environment, 2021). The guidance explicitly states the term 'avoid' refers to "*the **anticipatory nature of the measures** to be taken. It is not acceptable to wait until deterioration or disturbances occur before taking measures"* (p. 25). Furthermore, Article 6(2) specifies that appropriate avoidance steps must be taken *'in so far as such disturbance could be significant in relation to the objectives of this Directive'*. Therefore, the disturbance in question has to be relevant to (i.e., have an impact on) the conservation status of the species in relation to the objectives of the Directive.

Similarly, in 2020, the EU Commission issued guidance on wind energy developments and EU nature legislation (EU-DG Environment, 2020) that explicitly addressed the implementation of the mitigation hierarchy and, namely, the avoidance stage: *"A spatial plan should ideally identify categories of locations suitable for wind energy development, listed in order of priority ranging from locations of low-ecological-risk deployment (in terms of the objectives of the Nature Directives) to locations of high-ecological-risk deployment. In sites with exceptionally high biodiversity values, this could even lead to defining exclusion zones"* (p.44).

The guidance further states: *"The 'mitigation hierarchy' applies, which means that measures to avoid negative effects in the first place must be considered and implemented before measures to reduce negative effects. It is also **good practice to apply these measures at the source before considering measures for the receptor**. The best way to minimise negative effects on EU-protected habitats and species is to locate projects away from vulnerable habitats and species (a practice known as 'macro-siting'). This can best be achieved through **strategic planning at the administrative, regional, national or even international level**, in particular through the maritime spatial plans drawn up under the Maritime Spatial Planning Directive. Cooperation between the Member States and with countries outside the EU is also required when developing maritime spatial plans."*

Impact avoidance measures and land-use planning

In 2011, the European Parliament stressed the **need to strengthen the Environmental Impact Assessment Directive**, for a more rigorous interpretation of its objectives. The aim was to achieve No Net Loss and, where possible, biodiversity gains. In addition, it was stressed that specific requirements were needed for the ongoing monitoring of biodiversity impacts of projects and the effectiveness of mitigation measures, including appropriate provisions to access information for enforcement.

Concerning the latter point, an example from Bulgaria highlights that despite a legal requirement for stakeholder consultation in land use design and environmental impact assessments, there were still implementation problems. While public hearings are commonly used to hear stakeholder opinions, in practice, it is often merely a formality (Simeonova and van der Valk, 2016). This is in line with the findings of Tillemann et al. (2021) in Estonia, who conclude that **it is not only legislative requirements that determine the efficiency of ecological network planning and implementation but a rather effective implementation**. Other examples from practice, such as the bottom-up initiative for the development of the disused Airport Tempelhof, Germany, confirm that local stakeholders' values' are not always properly accounted for in planning processes (Langemeyer et al., 2016a).

It must be pointed out that the implementation of the mitigation hierarchy through planning laws relies on **consistent decision-making between various governance levels**. This is hard to achieve, considering that land use planning is a separate process from planning and conserving natural areas (Toivonen et al., 2021) and the most significant policy gaps notably concern the treatment of unavoidable residual impacts on biodiversity outside Natura 2000 sites (Pilgrim, 2013; van Teeffelen, 2014; Quétier, 2015; Schulp et al., 2016). Finland provides a good example of a collaborative process involving different levels. It has 18 Regional Councils with the remit to guide municipal planning processes by reconciling international, national, and regional rules and regulations with local interests (Toivonen et al., 2021). Conversely, in Sweden, municipalities have the main responsibility for spatial planning, thus, decisions taking into account ecosystem services and biodiversity can be taken at the local level generating multiple-level benefits (Khoshkar et al. 2020).

Establishing **a sufficient scientific base for avoiding the negative impacts of projects is often not ensured under the current legal framework**. Yet, the practice shows this does not hamper project approval, in spite of the precautionary principle. Indeed: "In most cases, the evidence base was sufficient to enable developers and decision-makers to comply with the Nature Directives, but there were knowledge gaps, which posed a challenge for developers and decision-makers when evaluating the impact of energy projects" (Moreira, 2019, p136). A clear obstacle to achieving an accurate basis for decision-making is the long administrative procedures required, which increases developers' administrative costs (Kyriazi et al., 2016).

Impact avoidance measures and marine spatial planning

In the most important EU-level Directives for marine biomes (EU, 2008), **the concept of mitigation hierarchy is not explicitly mentioned.** Instead, it refers to mitigation or mitigation measures of certain phenomena to be tackled through marine spatial planning by the Member States. In particular, the Marine Spatial Planning Directive (MSP) 2014 (2014/89/EU) defines in Article 13 that "…*healthy marine ecosystems and their multiple services, if integrated in planning decisions, can deliver substantial benefits in terms of food production, recreation and tourism,* ***climate change mitigation*** *and adaptation, shoreline dynamics control and disaster prevention."* Article 14 of the Directive specifies that Member States should use an ecosystem-based approach (EBA) to promote sustainable use of marine resources and *…"that the collective pressure of all activities is kept within levels compatible with the achievement of good environmental status (GES)*"…, as described within the Marine Strategy Framework Directive (MSFD; 2008/56/EC). Article 14 of the MSP Directive identifies …" *Member States should take into account the* ***precautionary principle and the principle that preventive action*** *should be taken*". Article 30 defines that the "*Member State…should take appropriate ad-hoc measures with the aim of continuing to pursue the environmental targets, preventing further deterioration in the status of the marine waters affected and mitigating the adverse impact within the marine region or subregion concerned."*

Use of ecosystem services concept and mitigation hierarchy

Impacts

The systematic mapping showed the **diversity of frameworks for impact assessment**; for example: the shellfish reef-based management framework focused on marine spatial planning (Cobacho et al., 2020), conservation priority networks for vulnerable marine ecosystems and the systematic conservation plan (Combes et al., 2021), biodiversity impact assessments (Geneletti, 2003), the Strategic Environmental Assessment and Environmental Impact Assessment (Honrado et al., 2013). Furthermore, there is the administrative and financial incentive scheme, the high nature value area, which proved an important factor for mitigating conflict (Kovacs et al., 2016). Similar results were obtained in the analysis of the effectiveness of the Cumulative Effects Assessment carried out by Farella et al. (2021)

However, ecosystem services benefits are often overlooked due to a lack of integration of local stakeholders into ecosystem services valuation processes (Fontaine et al., 2014; Karrasch, 2014; Kovacs, 2016) and an underestimation by businesses of the value of natural capital, especially of intangible benefits (Cambridge Conservation Initiative 2020; Gontier, 2007; Iberdrola, 2019). Ecosystem services benefits are also overlooked by landowners due to a lack of incentives when benefits accrue to others (Eyvindson, 2018; Iberdrola, 2019; Salata, 2020). Honrado et al. (2013), in an analysis of Strategic Environmental Assessments and Environmental Impact Assessment practices, underline the fact **ecosystem services benefits are being overlooked** in both instruments, and they are often not explicitly considered. Honrado et al. (2013) propose testing the ecosystem services-based framework for environmental assessment to remedy the situation.

Three types of approaches are put forward characterising the inclusion of biodiversity in Environmental Impact Assessments (Gontier et al., 2006): (a) an approach focused on **single sites or a single biodiversity element** with no general overview, (b) a functional and dynamic **ecosystem approach** and (c) a **habitat suitability approach** based on processes.

In relation to the first approach, there are different single-site impacts. Gontier et al. (2006) used modelling methods for the prediction of habitat suitability for the lesser spotted woodpecker. These authors demonstrate that the analysis of the habitat suitability, impact analysis, or potential distribution of one species is *"not an assessment of biodiversity, but it can still provide valuable information on potential impacts on the ecological value of an area"* (Gontier et al., 2006, p455).

For the second - a functional and dynamic ecosystem approach - several studies reinforce ecological importance by identifying and mapping high-priority areas for protection and superimposing them onto an urban development plan, thereby indicating avoidance in terms of landscape, e.g. (Geneletti, 2003; Azzellino et al., 2013; Coppola et al., 2019; Bigard et al., 2020).

The third approach takes participatory processes into consideration. Potential benefits of the impact assessment process include tools to generate new ideas, new forms of knowledge co-production and self-reflexivity, and mutual learning about the values and interests of other stakeholders anchored in a learning-by-doing process (Kovacs et al., 2016).

The application of the mitigation hierarchy and ecosystem services within impacts assessment provides an **opportunity to identify conflicts and synergies** between human actions and ecosystems, to establish dialogue and negotiation processes, to enhance gains for beneficiaries and avoid losers, as well as to explore long term benefits for which the strategic level of discussion is appropriate (Hornado et al. 2013). Although in many papers, the avoidance stage is not mentioned explicitly, the evaluation process infers it. The use of evidence within the impact framework can either indicate solutions for the avoidance step or assess whether this step has been adequately achieved.

Risks and Challenges

There are many risks and challenges to implementing biodiversity protection measures highlighted by the systematic mapping analysis. These range from a lack of institutional capacity to the complexity of managing landscapes for biodiversity. The notion of risk and challenges within the mitigation hierarchy has several dimensions relating to **how the mitigation hierarchy can contribute to the reduction of adverse environmental effects** on biodiversity/ecosystem services; and **how adaptations of the mitigation hierarchy framework across scales, methods and stakeholder groups have been misused**. In the following sections, the most important risks and challenges are addressed.

Institutional capacity

There are a **number of constraints on the institutional capacity of authorities and local organisations**, particularly in resource-constrained municipalities, which are unable to hire personnel with the necessary knowledge (Gonzalez-Redin et al., 2016; Di Marino et al., 2019; Khoshkar, 2020). Thus, understanding of Green Infrastructure and ecosystem services for implementation in planning at the local level is variable (Hayes et al., 2015; Langemeyer et al., 2016b; Di Marino et al., 2019). Even at the governmental level, there is a lack of knowledge, for example, of the marine environments required for projects, such as wildlife protection, offshore renewable energies or fracking (Moreira, 2019).

Loss of highly motivated personnel further compromises capacity (Madsen et al., 2017). Significant capacity building is therefore needed, including an increase in organisations' social and collective capacity (Simeonova and van der Valk, 2016; Madsen et al., 2017; Mazziotta et al., 2017). These issues are particularly acute in post-socialist countries, where unpredictable, hierarchical and fragmented structures are key concerns (Simeonova and van der Valk, 2016; Logmani et al., 2017; Simeonova et al., 2019). **Capacity building, though, requires significant investments of time** and can be technically demanding (Heinonen, 2019; Albert et al., 2021), which is often lacking in busy planning departments (Madsen et al., 2017; Di Marino et al., 2019).

Capacity issues in the private sector may also exist. Some lack the relevant knowledge of how their activities impact the environment, especially on the ecosystem services and biodiversity impacts that local communities depend on. Consequently, their perception of risks to environmental resources may differ, leading to uncertain costs and benefits to business and society, as well as the potential for conflicts (Mazziotta et al., 2017; Cambridge Conservation Initiative, 2020; Markantonatou et al., 2021).

Management complexity

Literature suggests two of the most widely used decision-support tools to inform urban land-use planning are **Environmental Impact Assessment and Cost-Benefit Analysis (CBA)**. These have played an important role in the practical integration of environmental concerns into urban land-use planning. However, the Environmental Impact Assessment has faced much criticism due to a weak structure, built upon economic and legal values, far removed from ecology (Bigard et al., 2017; Barbe & Frascaria-Lacoste, 2021). Concerns that **economic interests were prioritised over conservation** measures were raised in the agricultural sectors (Kovacs et al., 2016; Lakner et al., 2020), Blue Growth in the marine sectors (Markantonatou et al., 2021) and the timber sector (Mazziotta et al., 2017). Combes et al. (2021), however, state that socioeconomic costs are essential to be considered and minimised, especially where they overlap with conservation areas.

Management choices must take into account different scenarios. Scenario-based frameworks, though, face a limited capacity in integrating ecosystem services and associated values, particularly with unmeasurable, non-market services, which can be highly site-specific and may change over time (Gret-Regamey et al., 2008; Fontaine et al., 2014; Langemeyer et al., 2016b; Leone and Zoppi, 2019; Cambridge Conservation Initiative, 2020; Cobacho et al., 2020). They also often make strong assumptions of stable human preferences for a specific ecosystem service at stake, therefore, this adds a degree of uncertainty to the scenario (Fontaine 2014). Temporality is also a particular issue for the long-term management of areas where avoidance has been applied and is dependent on the tenure of the system put in place, especially since post-monitoring is rarely well-supervised, resulting in depreciating biodiversity values (Barbe & Frascaria-Lacoste 2021; Hayes 2015).

Lack of transparency and replicability of environmental impact assessments is an additional common shortcoming causing inconsistencies across countries and evaluation procedures largely based on subjective judgments (Põder, 2006). The methodological framework set by standards ISO 14001 and ISO 14004 gives only general principles for environmental impact assessments. Moreover, even in countries where the environmental impact assessment is quite advanced, there are still unanswered questions, especially concerning cumulative effects and the monitoring of environmental effects (Weiland, 2010).

Cumulative impact assessments, therefore, are useful instruments that can help address and locate mitigation and avoidance measures, but they need to be provided at an adequate landscape scale. This is because apparent small-scale impacts or losses may result in significant impacts at the national scale (Hayes 2015). Before and after analyses in Environmental Impact Assessment studies are also essential at a systematic level (Claireau et al., 2019).

Scale

Ecosystems are not static systems, nor are they bounded by administrative boundaries posing problems for their management when broader-scale decisions are needed (Kurttila et al., 2002; Gontier, 2007; Gret-Regamey et al., 2008; Fichera et al., 2015; Gonzalez-Redin et al., 2016; Langemeyer et al., 2016b; Di Marino et al., 2019; Barbe & Frascaria-Lacoste, 2021). For example, basin-scale marine spatial planning is needed to mitigate against increasing impacts from the fishing and mining sectors (Azzellino 2013; Combes 2021).

Landscape effects impact biodiversity where species dispersal characteristics are influenced by a particular landscape matrix (Muratet et al., 2007; Tarabon et al., 2019b; Sahraoui et al., 2021). For example, lighting, provided for safety reasons, impacts light-sensitive species affecting circadian rhythms, predation, feeding and reproduction (Voigt et al., 2018; Jagerbrand and Bouroussis, 2021). Some studies found that the **current mitigation measures at the species level are inadequately implemented or have never been proven to be effective** (Delbaere et al., 2009; Claireau et al., 2019; Tarabon et al., 2019a). An example is the potential biodiversity loss in the time taken to construct wildlife corridors or overpasses (Tarabon 2019a).

Mejía et al. (2015) and Markantonatou et al. (2021) highlight the **need for an ecosystem-based approach in resource management** to improve the decision-making process. In addition, Toivonen et al. (2021) argues for increasing the size of nature protection areas as 70% of biodiversity currently lies outside of these areas. However, as Markantonataou (2021) points out, stakeholders prefer smaller protection zones, even though decision-makers prefer larger areas for administrative reasons.

Multi-stakeholder collaboration

Policies can add to the uncertainty and environmental risks to society. The absence of any social dimension that recognises the competing values of stakeholder groups creates a barrier to effectively avoiding impacts (Hayes 2015). However, **participation is sometimes limited to consultation and not collaboration**, which hampers stakeholder engagement (Simeonova & van der Valk 2016). The ecological network concept can be successfully implemented into planning documents only with an effective stakeholder network and an adequate basis for information across all levels of governance (Tillemann et al., 2021).

Formal and informal multi-layered governance structures of urban green spaces determine their management and the importance of ecosystem services in land-use planning and participatory decision-making. **Formal participatory measures in land-use governance tend to be ineffective** due to insufficient information flows within multi-level governance structures, lack of administrative coordination between upper governance levels and local and regional levels, insufficient administrative capacity and exclusion of certain stakeholders from the planning phase (e.g., NGOs, local association, social movements, citizens organised individually and collectively).

The **ecosystem services concept, therefore, is not fully acknowledged in spatial planning** (Lai et al., 2017; Di Marino et al., 2019) even though the socio-spatial context is essential for planning frameworks (Albert et al., 2021). The complexity inherent within ecosystems also presents a significant barrier to implementation in land-use planning, where **assessments tend to focus on the flow of benefits to people and so fail to recognise the current and future role of biodiversity** (Gonzalez-Redin et al., 2016; Cambridge Conservation Initiative, 2020). Limitations to the evaluation criteria chosen can occur as **citizens are usually concerned with short-term benefits, whereas the experts view the long-term ones (Langemeyer et al., 2016a)**. Therefore, new instruments and forms of science-practice collaboration in planning processes are needed (Gret-Regamey et al., 2008; Bigard et al., 2020; Sahraoui et al., 2021).

Data Quality

Spatial quality of the data, its comprehensiveness and costs are important in a given territory to ensure that local characteristics are taken into consideration (Borgstroäm and Kistenkas, 2014; Barbosa et al., 2019; Bigard et al., 2020). Failing to do so may lead to negative outcomes, particularly when a territory contains multiple landowners with varying interests (Kurttila et al., 2002; Albert et al., 2021). For example, forests may lose their functionality if they become reduced in size and become fragmented, but strategies need to also address the unequal impacts on landowners, ensuring equitable application (Kurttila et al., 2002; Tarabon et al., 2019a, b)

Data sets created from multiple classification systems, varying sources and resolutions never present an accurate picture at a point in time (Koschke et al., 2013). They may fail to account for the temporal nature of a territory, particularly for migratory species (Kovacs et al., 2016; Madsen et al., 2017; Bigard et al., 2020), and this is further compounded by low-resolution land maps reflecting unbalanced priorities that overlook the ecological complexity (Casalegno et al., 2014; Di Marino et al., 2019).

Solutions

It is argued in the literature that **scenarios, monitoring and evaluation are crucial** for exploring the impacts of time, future challenges, space and trends on current situations (Fontaine et al., 2014; Albert et al., 2021). Various methods were suggested for the co-creation of the scenarios, such as a deliberative democracy process (Fontaine et al., 2014), a companion modelling approach (Sahraoui et al., 2021), probabilistic graphical modelling (Gonzalez-Redin et al., 2016), and reflexive monitoring.

Involving stakeholders in a well-defined process to incorporate their views and perceptions is important in addressing conflicts related to conservation of protected species (Kovacs et al., 2016). However, different understandings between disciplines and sectors require an adaptive process, as effective avoidance strategies can only emerge through cross-sectoral and multi-stakeholder collaboration (Karrasch et al., 2014; Hayes et al., 2015; Madsen et al., 2017; Sahraoui et al., 2021) The environmental, social and economic issues intertwined in ecosystem services does not guarantee adequate inclusion of social impacts in evaluation schemes. Therefore, a common vocabulary between disciplines and stakeholders is needed as well as conflict resolution between productionist and conservation viewpoints (Sheate et al., 2008; Karrasch et al., 2014; Logmani et al., 2017; Brignon et al., 2022).

Long-term maintenance is needed in areas where avoidance has been applied and therefore requires national legislation to ensure its continuity. Since voluntary standards are insufficient to ensure future support and investments avoidance measures are usually put in place (Hayes et al., 2015).

Nature-based solutions emerged in the literature as an opportunity to address societal challenges using ecological processes. In most cases, nature-based solutions are applying new solutions to address existing problems, which helps protect existing ecosystem services and biodiversity (Albert et al., 2021).

Literature suggests that the inclusion of the **ecosystem services-based approach in coastal ecosystem** management has so far been largely absent (Karrasch et al., 2014), although it could be a potential solution for inclusive management. The Multi-Criteria Decision Analysis (MCDA) can bridge ecosystem services and policy processes. However, Langemeyer et al.

(2016a, p54) suggests it is not the "silver bullet" as there are limitations where there are multiple levels of ecosystem services supply and demand. For example, there are difficulties in defining problems and dealing with several issues and the potential risk of marginalisation of "*minority objectives*" (Langemeyer et al. 2016a, p55).

APPLIED POLICY DELPHI PROCESS

Mitigation hierarchy as a concept

Generally, there was **a range of different understandings of the concept** evident. For some, the mitigation hierarchy was seen as part of a process leading toward sustainability and biodiversity protection. However, only four panellists explicitly mentioned that the mitigation hierarchy is mainly focused on initiatives to protect ecosystems or measures linked to pressures (pollution, spatial planning, climate change), with panellist 7 stating, "*mitigation hierarchy is kind of connected, in my opinion with this DPSIR (Drivers, Pressures, States, Impacts, Responses) framework*". Most panellists agreed there are four aspects to the mitigation hierarchy, "*avoidance, minimisation, restoration and offsetting*", where the first two stages fall into preventative actions. They agreed that the avoidance stage is *"the very first phase that we should have, with the present ideas about transition"* [Panellist 1]. However, Panellist 1 also suggested that the mitigation hierarchy should have five stages, with "enhance" as the first stage.

All panellists had expertise in using the general principles of the mitigation hierarchy, however, **most use varying terms for mitigation measures in practice**. It was perceived that the mitigation hierarchy "*is implicit rather than explicit* "and focused on "*quantitative hierarchy (e.g., metrics, indicators for biodiversity), not a qualitative framework or a part of Environmental Impact Assessment"* [Panellist 3]. Despite the varying definitions of the mitigation hierarchy, panellists considered it a useful tool for practical issues or as part of a broader approach to environmental management, e.g., spatial planning or ecosystem-based management. It was stressed that the mitigation hierarchy is a valuable tool for biodiversity protection, among others, due to aspects of stakeholder involvement and transparency- which are embedded in the holistic approach and supported by the precautionary principle.

Ecosystem services as a concept to foster the conservation of biodiversity within planning processes

One of the tasks of this project is to see if the ecosystem services concept could be useful to the application of the mitigation hierarchy. During the interviews, a general consensus emerged that **including ecosystem services could indeed be beneficial,** although at least one panellist expressed strong disagreement with including ecosystem services into the mitigation hierarchy: "*having people external to the technical discussion, you want to make sure that incorporating ecosystem services into the mitigation hierarchy isn't in the end of shutting these people out - it's hard enough to train a judge on what a species is, what the habitat of that species is, and on what basis it was determined to be protected and therefore has this and that legal provision. But if you start mixing in much more fuzzy concepts, and the problem with ecosystem services is that it's much more fuzzy than 'is this a frog, not a frog'? You might be generating confusion and lots of obstacles for other people – non-technical people to be involved"* [Panellist 2].

Several panellists highlighted that the concept helps to translate the biophysical environment into the value they bring to people. This **process of translating the values** helps in understanding how the site is used by stakeholders. However, panellist 2 pointed out that *"you're assuming that some kind of expert is able to describe and document the ecosystem services, and in this way somehow speaks on behalf of the people who use or depend on those ecosystems and so you're creating a barrier in fact, rather than an enabling environment for people to voice their concerns - to make sure that you don't replace a much more effective system…with something that gives power to experts so that they tell the people what are ecosystem services".* It also allows the use of different types of methods and indicators (that may include, for example, the analysis of ecosystem conditions and ecosystem accounting). This **plurality of evaluation approaches offers a great advantage** "*because for some groups of people it's very good to see numbers, for other people it's very good to have data presented qualitatively in storylines*" [Panellist 6], and for some, it will be combining both together.

Another broadly agreed-upon advantage of using the ecosystem services concept is the generation of spatially-explicit analysis of the distribution of ecosystem services. **Ecosystem services maps are helpful to identify irreplaceable areas** where impact avoidance should be enforced but also to contribute to the identification of pragmatic solutions for developments that need to go somewhere, and for proposing suitable offsetting measures.

Some panellists, however, shared concerns about how the ecosystem services concept is applied in impact assessment and mitigation practices. The first concern relates to the **separation of ecosystem services and biodiversity conservation**, which is not consistent with the idea that biodiversity is essential to support all ecosystem services. In the words of Panellist 1, "*the ecosystem services component for me it's obviously an all-encompassing thing, not detaching conservation from sustainable use aspects. (…) You have to process this stuff from an integrated perspective. (…). Conservation and sustainable use of ecosystem services is something you have to address in one topic and not split up*". However, Panellist 8 highlighted that in Estonia, conservation issues are rooted in legislation, but ecosystem services only have implicit backing and not legal backing in decision-making.

A second concern, shared by two panellists, is the **excessive focus on the direct benefits** that people get from the natural environment and on associated cost-benefit analyses: "*Because a lot of people when they think ecosystem services, they think cost-benefit analysis and looking at the economic value from an ecosystem service and somehow thinking that decisions are made on a harmful project on the basis of rigorous cost-benefit analysis, which is not true*" [Panellist 2].

Individual panellists also identified a few critical points that need to be carefully addressed in future applications of the mitigation hierarchy to offset biodiversity and ecosystem services loss. These critical points include:

- The need to set up multi-scalar offsetting schemes that can consistently address biodiversity and ecosystem services issues at multiple levels (from the EU scale to the local scale).
- The problem of finding suitable spaces to implement compensation actions, especially in marine areas, where ecosystems do not have fixed boundaries.
- The inevitable uncertainty associated with how ecosystems actually evolve in offset sites (in terms of species composition, ecosystem structure and functioning, the evolution of the ecosystems over time due to external influences such as climate change, etc.).

Tools and practices that address the aspect of ecosystem services in the mitigation hierarchy

As the mitigation hierarchy is a framework, it has strong links with tools and practices that are used in making land- and resource-use decisions. Several panellists highlighted the **link between mitigation hierarchy and land-use planning** to incorporate ecosystem services and biodiversity knowledge into decision-making. "*Mitigation hierarchy avoiding or reducing the pressure must be going with a nice planning and really detailed planning, and MSP* [Marine spatial planning] *does it from the beginning stage*" [Panellist 7]. The EU has recognised the link between avoidance and MSP with the checklist toolbox, which proposes an ecosystem-based approach.

The link between mitigation hierarchy and land-use planning is especially important at the early stages of planning. Several panellists suggested that the avoid stage, in particular, is useful in emphasising where development should not occur. "*We have irreplaceable habitats, and they are truly irreplaceable, you can't do net gain if you lose them, they're just irreplaceable*" [Panellist 3]. However, panellists recognised that avoiding all impacts is impossible in practice, "*it's always an intervention in an area that results in positive and negative impacts (…) So simply avoiding everything is impossible because you'll be interfering in the environment….Avoidance and mitigations are very intricately interwoven very often*" [Panellist 1]. It was stressed though, that "*we have to keep on talking also about avoiding as we can still do things there*" [Panellist 4].

To avoid impacts, the panellists emphasised that it is key to know if there are any sensitive biodiversity spots, what ecosystem services are produced, what ecological condition the ecosystem under investigation is in, and what pressures biodiversity and ecosystem services face. In the avoidance stage, *"we can understand which areas potentially in the future will be under pressure, and specific recommendations or regulations can be defined for this kind of analysis"* [Panellist 7]. There was a general consensus in the panel that it is **important to work with spatial tools to identify conflict areas and pressures** to deal in planning to avoid future negative impacts. For this, modelling can help: "*we were checking using the Bayesian Belief Networks, trying to identify the best areas, the most suitable areas and most sustainable areas for offshore wind platforms in Basque country but at the same time in the Eastern Atlantic Coast,"* [Panellist 7]. However, *"There will always be an impact* [if we interfere in the environment]*, but it depends on the perception of the stakeholders and the experts involved, whether it's acceptable or not - whether you have more positive consequences, or you have negative"* [Panellist 1].

Furthermore, it's important to consider **cumulative impacts and risk-based assessments**; *panellist 9 explained that there is the potential to incorporate risk-based assessment into cumulative impact assessments, "For example, to better frame the cumulative effect assessment but also the MSP* [Marine Spatial Planning]*, to try to harmonise the concept provided by the mitigation hierarchy with the risk-based assessment could offer a better opportunity to the methodology to be directly used from the practitioners and the planners, and so on - a good next step for that can be implemented."*

It's worth noting that ecosystem and ecosystem services mapping can reveal that **impacts have already happened**, and the question then becomes **what is the baseline for mitigation hierarchy – to avoid or to restore**? Panellist 8 explained from their experience, "*After we had mapped this ecosystem condition and ecosystem services, we found out that it's not too good the condition of our natural ecosystems, especially in the forests and the fields in agriculture. But it's good that we have these maps at the moment, and we can use it* [for] *decision-makers. Also, this is how it is at the moment, we should do something, we should preserve something that we already have, at least. Very important is that we have this spatial data"*.

Current use of mitigation hierarchy in policies and regulations

Some countries have **incorporated mitigation hierarchy principles into their laws,** with some countries of Europe applying it *"more strategically in land use plans"* [Panellist 2]. Not all planning laws are helpful, though, for example, *"quite old regional rules and regional plans for land. Not so effective, not so good in avoiding the impact of the process"* [Panellist 5].

It has been reported that "*the mitigation hierarchy is not very consistently used*" [Panellist 4] in land-use laws except for coastal land use, where "*they want to avoid the most biodiverse rich areas. While in other laws, there is not usually the requirement to find the most unharmful spot for certain projects."* [Panellist 4]. Also, it is **difficult to assess the mitigation hierarchy use in land use plans**, as decisions taken to apply the avoidance stage of the mitigation hierarchy are not clearly stated [Panellist 2]. Some municipal land use plans state that they want to use the "no net loss approach", an aspect of the mitigation hierarchy, and there are examples of pilot projects applying the concept in practice [Panellist 4, e.g., Ekoteko project in Finland].

Building laws and the Environmental Impact Assessment are also relevant for applying the mitigation hierarchy. Some countries have introduced the concept of ecosystem services in their building laws, such as in Germany [Panellist 2]. However, the German tool seems more focused on offsetting, the last stage of the mitigation hierarchy, rather than avoidance. Panellists stressed that the avoidance stage in the Environmental Impact Assessment still plays a minor role due to unclear wording. In addition, project approvals are unbalanced since developers hold more power than other actors. Another problem highlighted is that: "*in environmental impact assessment, it says that you have to look for alternatives, but it does not always mean that you have to look for alternative locations*" [Panellist 4].

In some countries, there are specific regulations for how you **mitigate and compensate forest clearing (deforestation)**: "*the rationale for that is that those forests provide services, and so when you determine if and how you should give a permit for that clearing, then ecosystem service aspects (...) such as the leisure activity, green spaces, all of that is taken on board"* [Panellist 2]. Other regulations that might be linked are those related to **gas and oil extraction in the sea** [Panellist 9].

General **EU policies** mentioned by the panellists linked to the mitigation hierarchy avoidance stage include: the EU biodiversity strategy - i.e. the No-Net-Loss objective; the EU Green Deal; CAP; the EU Soil Strategy 2030; and the EU taxonomy.

Furthermore, it has been suggested that **international bodies' funding project policy tools** are successful examples of implementation. For example, "*the IFC [*International Finance Corporation] *criteria are still the strongest around the world, but I must say for example, that the EIB* [European Investment Bank] *has developed guidelines for hydropower which are revolutionary*" [Panellist 1]. Taxes are also potential policies to impact the avoidance stage: "*some municipality councils received (…) a proposal to increase the local taxes, local fees for new buildings in order to avoid the new land take and reuse of the already taken areas in the cities*" [Panellist 5].

To sum up, links to the policies that may be used to implement the mitigation hierarchy can be listed based on the following **multilevel approach**:

- International level: Guidelines on Environmental Impact Assessment/Strategic Environmental Assessments,
- EU level: policies on biodiversity.
- National level: policies on zoning.
- Local/municipal level: policies on zoning and taxation.

Use of ecosystem services concept and mitigation hierarchy

Challenges

Panellists highlighted various challenges with mitigation hierarchy definitions. *"There's so many different definitions of it and the ways to frame it - that doesn't help. Because when you get inconsistency, it undermines the concept of it"* [Panellist 3]. **Unclear definitions** often lead to unclear rules and a lack of consistent application of concepts, a concern of many panellists. *"It's too easy to jump this step, the mitigation and go directly to compensation… [and]* In some cases *municipalities that are not following these principles, guidelines at all" [Panellist 5].*

Furthermore, the mitigation hierarchy framework faces multiple issues at varying levels of **governance and implementation**. Global frameworks are being developed where discussions on biodiversity are *"not even bothering to put a quantitative assessment on the avoidance side of things because it's not clear how to do that"* [Panellist 10]. *As mentioned earlier, d*iscussions at all levels can be hampered by **power imbalances,** and as Panellist 2 notes: *"Mitigation and compensation are a tool to find a common ground. The problem with that is that the parties who are around the table to find this common ground are not equals" where those "working on endangered species hold much less power in that discussion than, you know, the multinational with deep pockets or that has managed to obtain strong support from government authorities etc.".*

It has also been argued that **policymakers are *"not passionate"* about biodiversity** and generally *"not so open to new policies"* [Panellist 6]. *"My concern is how we will keep this concept and that this is not just the 10 years' fashion"* [Panellist 6]. However, Panellist 11 suggested that *"politicians have been very welcoming to these new ideas"* to incorporate ecological thinking. Panellist 6 also pointed out how **many governments are not stable**, so politicians are reluctant to take action as they are focussed on short-term gains because, as Panellist 2 says, *"defining a target is difficult", and "not having a target is a good way for politicians to not take a stand and remain ambiguous and make everyone happy".*

Weaknesses at the national level of policymaking can pose a threat to local-level implementation. **Weak local-level capacity** can threaten national biodiversity strategies and so on. As Panellist 2 argues, *"it's going to be a multilevel governance system that you'd have to put in place (…). That's why some of the biodiversity issues, some of the ecosystem services issues are managed at the EU level and others are managed only locally (…) it's not, national versus local".* This can be further amplified by a **lack of knowledge and education**: *"We know how to do it because we have been trained on how to do it. But that's not always the case, to be very honest, we have lots of things to learn"* [Panellist 11]. They go on to argue that large multidisciplinary teams are needed. Panellist 2, however, highlighted that *"local governments don't necessarily have the capacity or the staff to guide them on the technical aspects.* This is exacerbated by problems with *"defining who have the main competences at the national level"* [Panellist 5].

A lack of resources, effective design, monitoring and application in practice were challenges highlighted by several panellists because *"in order to avoid the sensitive areas, you should know where the sensitive areas are, and lack of data is a really big important problem I see"* [Panellist 7]. In other words, it is important *"to have good data about where you can and cannot do a project"* [Panellist 2]. *"We need something to show that no, you can't go there - you can't waste all these remaining ecosystems in good condition, you have to choose between them, and then you may build into already disturbed areas."* [Panellist 8]. But *"We really need a lot of resources to carry out investigations in marine areas. I see a lot still needs to be investigated"* [Panellist 6]. And in the end, it **all comes down to money** and attitudes towards it *"when talking about benefits…. there might be still the economic valuation. I also know that there are different attitudes towards making a price tag or estimations in society and also among politicians"* [Panellist 6], and in practice, *"Money is a big issue to the cities that are now trying to apply it* [mitigation hierarchy] *to their land use planning. …. as always, it's [the] economy, at least short-term economy, that rules"* [Panellist 4]. The main threat is that developers *"want to build where it's the most cheap"* [Panellist 8], *"in practice compensation is never costly enough"* [Panellist 2].

Also, having tools, even those mandated in regulations, does not mean they are effective in avoiding impacts or mitigating them. As Panellist 10 highlights, "*I have plenty of concerns about whether it's done properly or not, whether it's effectively resourced, whether it's effectively designed (the kind of the offsets and avoidance measures), whether it's defective, where whether it's monitored, whether it's actually done in practice, whether people are transparent about the plans and then the outcomes of the biodiversity offsets they build*". In other words, the **link between mitigation hierarchy and the tool can be strong in theory but weak in practice**: "*Then the other examples I've run nowadays into very, very often because I'm now involved in a panel of experts for the European Commission for the international cooperation agenda, and we have to judge all the proposed projects, and we get a very, very short notice. We get a very short summary of any proposed project they want to fund, and then we usually have to ask for Environmental Impact Assessment, and then, in the end, they come up with an Environmental Impact Assessment - you see that it's a tick mark exercise. Their project has to do an Environmental Impact Assessment, you get the obvious preferred alternative and then usually they have a few other alternatives, which they made up and didn't assess very seriously, (...)The quality still is simply unacceptable in terms of trying to avoid negative impacts, let alone try to do good for the environment* [Panellist 1]". Thus, **assessment times are too short for meaningful evaluation** of the case. As Panellist 5 points out, authorities have a duty to carry out monitoring activities to control and guide the processes of development.

Finally, the **focus on the avoid stage was highlighted as a weakness** by two panellists arguing that a more pragmatic stance should be taken. Panellist 10 suggested that *"minimisation is also important"*. However, Panellist 1 argues *"that it* [mitigation hierarchy] *doesn't include the very first phase"*, that we should *"build back better"*, and *"the first step should be enhanced"*.

Opportunities

Several strengths and opportunities where the mitigation hierarchy could be used at different levels and in varying situations were suggested (Table 2). Three panellists agreed that the mitigation hierarchy is getting **increased attention and application** at local/municipality and regional levels. In contrast, Panellist 10 identified the opportunity to use the mitigation hierarchy at a national level as a "*kind of extension (....) towards the idea of a conservation hierarchy, where you're looking at national scale application in the mitigation hierarchy*". One panellist identified the use of the mitigation hierarchy within a No-Net-Loss approach, and another suggested that financial institutions also have an important role to play by "*not going to fund this project because this is a really critical habitat*" [Panellist 2].

Two panellists identified the **use of payment mechanisms** in the context of the mitigation hierarchy. This includes, for instance, local scale application by municipalities for land use planning payments for ecosystem services modification. This proposal would include increasing *"the local taxes local fees for new buildings, in order to avoid the new land take and reuse the already taken areas in the cities"* [Panellist 5]. Panellist 10 identified a mechanism for compensation from multinational corporations to *"evaluate their biodiversity impacts year on year and then use the mitigation hierarchy as a framework for how they minimise, mitigate and ultimately compensate for those [impacts on] the biodiversity of their activities*.

Panellist 3 sees the opportunity for the mitigation hierarchy to be used… *within a risk assessment framework – "this could better join this methodology with the MSP [*Marine Spatial Planning] *or other processes, it can provide a common background"*. **Risk-based analysis** can be particularly useful in territorial and Marine Spatial Planning processes and within Blue Growth strategies.

Future directions

A diversity of views emerged from the panellists concerning future directions, in particular concerning pressures. Three panellists explicitly stated that the ecosystem services concept may be a good instrument to deal with environmental challenging topics; Panellist 6 further suggested that it was *"important to keep the topic of ecosystem services alive"*. In the same vein, two panellists mention the Green Deal and one Blue Growth that provide a framework to support different perceptions that may influence national policy sectors. These concepts were highlighted for their potential to support the first stage of the mitigation hierarchy, avoidance. However, they are not without opposition, as exemplified by panellist 2: *"Currently, we are in favour (as environmentalists), we have a Green Deal policy,* [and] *biodiversity targets (are very strict now) on how to establish protected areas - land and marine areas. But … we also are creating very strong opposition from people who want to generate income or money, because they get restrictions or limitations, where to go and what to do.*

Panellist 1 suggested that **participation and early intervention** meant better outcomes, *"and that's the ideal situation that you try to avoid potential unacceptable negative impacts."* Panellist 8 suggested that people were developing **an awareness concerning the environment,** and **greater value was being put on nature**. For example, *"a very strong confrontation from ordinary people"* helped to ensure detrimental laws were not passed in one case. Production of ecosystem service maps of the country was also an asset for raising knowledge on the value of nature to people.

There is a perception that there is **more information on terrestrial systems**, *"where you have been studying a lot, so you know what impact will cost"* [Panellist 6] to deal with pressures and impacts. This contrasts with marine systems where there is *"bigger uncertainty. It's also much more difficult to justify why we need to avoid - might be we don't need it!"* [Panellist 6] In general, the lack of deep knowledge of different systems, pressures and impacts seems to be of critical importance to be able to plan for the future and deploy different mechanisms such as compensation to deal with trade-offs and decision-making to be able to plan for future directions. This is particularly important, as pointed out by Panellist 6, *"when (…) politicians are also asking concrete arguments or facts, and you are proposing to avoid some activities"*.

Another important consideration is the **spatial dimension to be able to know where to avoid or compensate** *"is an opportunity to protect the nature because if we have the maps and materials where we can show the most valuable ecosystems in good condition, then we can say where it should be preserved"* [Panellist 8], followed by *"In planning protected areas, (…). We need to prove more that these protected areas are necessary so that we need to preserve these communities and ecosystems in these specific areas (…) there are places where we have to avoid - in protected areas, the offsetting part is not even applicable at all"*; Other than the spatial dimension it is also important **the temporal dimension towards the future** to be considered in planning projects concerning protected areas *" You have to think more about the long term impacts on biodiversity, even though you don't go through a protected area, so that's a bit to mitigation hierarchy"* [Panellist 1].

FURTHER INSIGHTS FROM THE APPLIED POLICY DELPHI PANEL AND CASE STUDIES FOUND IN THE LITERATURE

After the first round of the Applied Policy Delphi process was completed and the results of the systematic mapping were shared with the panellists, further research was undertaken by the EWG on the points raised during the Applied Policy Delphi process. In this section, we present the results from the second round of the Applied Policy Delphi process combined with insights from the case studies found in the literature. We have included the questions that were posed to the Applied Policy Delphi panel members under each heading for clarity.

Enhance stage in the mitigation hierarchy

Q1. Should the mitigation hierarchy embrace the enhance stage, or will this complicate the concept unnecessarily? By enhance, we mean, for example, adding green spaces to developments.

Seven panellists were divided on whether an "enhance" stage should be included in the mitigation hierarchy. Three panellists felt it would complicate or muddle the hierarchy [Panellists 1, 2 & 8], especially since it is a recognised and well-established framework [Panellist 10]. Panellists 2 and 4 suggested that this would lead to a risk of developments with low-grade green spaces over-riding the correct application of mitigation hierarchy principles; for example, green areas added to housing developments. Panellist 8 pointed out that the application of an enhance stage implies that "*we assume that some impact has already happened/is going to be happen and then it would not be avoidance or first stage of the hierarchy anymore*". This, therefore, implies that enhance is essentially about the restoration of degraded environments. Panellist 4 added, *"enhancing implies that we can 'create better' than what existing nature already is. The term should rather be part of the mitigation hierarchy, but the government should make regulations that require avoiding and minimising first. Otherwise, it will be grass and tulips"*. Panellists 1, 3 and 5, however, felt this stage would improve the mitigation hierarchy application as *"it should specify the outcome for biodiversity to achieve by following the mitigation hierarchy, i.e., net gains"* [Panellist 3]. Panellist 6 suggested that if the enhance stage was added, then the mitigation hierarchy name should be changed to mitigation governance, as this would broaden the scope of the mitigation hierarchy to embrace the enhance stage.

There is no explicit evidence found in the literature reviewed in this study for the use of the enhance stage within the mitigation hierarchy. However, in our opinion, the enhance concept could be applied as an overarching theme to support biodiversity conservation and the health and well-being of society rather than in the hierarchy itself. Examples of how this could be applied is in the use of brownfield sites rather than new sites so that green belt land is protected from urban sprawl (Cullen, 2006) or in the provision of corridors to connect high-quality habitats (Tarabon, 2019a). Kowarik (2021) makes the distinction between "ancient wilderness", or remnants of nature in need of conservation or restoration and "novel wilderness" arising from degraded urban-post-industrial sites. These novel wilderness areas reflect the enhance concept, where designers have incorporated them into green infrastructure, thus supporting biodiversity and providing additional ecosystem services to society.

Schulp et al. (2016) argue that spatial flexibility potentially brings higher gains for biodiversity and ecosystem services, as does the provision of corridors to connect high-quality habitats in Tarabon (2019a). Therefore, we suggest embracing the concept of enhancement as an umbrella term to frame a biodiverse future that brings multiple benefits to society, i.e., is net positive for nature and people. It can help to set a more positive tone in the land-use debate that recognises the important role that biodiversity plays. In conclusion, the term enhance is not a useful term within the mitigation hierarchy itself but may prove useful in framing a more positive debate around land use for the benefit of biodiversity and society.

Inclusion of ecosystem services and risk to biodiversity

Q2. Does including ecosystem services in the mitigation hierarchy pose a risk for biodiversity conservation because provisioning ecosystem services might take preference over biodiversity? If ecosystem services are included, how do we ensure biodiversity conservation?

Out of the six panellists who answered the question, three panellists [2, 3 and 8] expressed concern with including ecosystem services in the mitigation hierarchy due to the potential risks it poses in biodiversity conservation. This is because provisioning ecosystem services are “easy to assess” [Panellist 8] and because “biodiversity might be downplayed against much more vocal and organised interest groups that will favour intensive agriculture, forestry, fisheries (a.k.a. provisioning ecosystem services)” [Panellist 2]. However, Panellist 2 does suggest that there are opportunities to connect biodiversity to social challenges though “in the context of an Environmental and Social Impact Assessment (ESIA)… as long as the biodiversity issues remain under their own standard (e.g., ″net gain″)”.

In contrast, panellists 4, 5, 6 and 10 see the potential to incorporate ecosystem services into the mitigation hierarchy, for example, by including “conservation” as an ecosystem service, where conservation may consist of a mix of regulations applied to more than one ecosystem service [Panellist 1]. However, Panellist 5 suggests that biodiversity and ecosystem services should be kept separated in the evaluation in order to better protect irreplaceable areas.

In addition, Panellist 10 suggested defining an “accounting for the social impacts of No Net Loss type policies”. This would allow the social dimension values and non-values associated with biodiversity loss to be accounted for in projects. The panellist also suggests introducing the concept of no-worse off (Griffiths et al., 2017). No-worse-off does not substitute the No-Net-Loss of biodiversity but works in parallel to ensure social equity of the process and people’s well-being and health. Panellist 8 added it was necessary to assess and map regulating and cultural ecosystem services to create a “stronger case” for the implications of biodiversity loss and conservation. Panellist 4 suggested It would be good to integrate ecosystem services into the mitigation hierarchy, but it should not be made too complicated since mitigation hierarchy, especially the aspects of ecological compensations, are complicated enough alone. Also, they argue that there should be a hierarchy of ecosystem services; for example, life-serving ecosystem services should be prioritised and safeguarded before those ecosystem services that grant economic profits.

The literature showed that although there is increasing support for the use of ecosystem services in planning, there is little evidence in the mitigation hierarchy literature that the use of ecosystem services poses a threat to biodiversity. A wider search of the literature is needed to bring these elements together as the expert working group is aware of the literature that suggests the use of ecosystem services does potentially impact biodiversity. In the marine environment, according to (Azzellino et al., 2013; Farella et al., 2021), there is no evidence of ecosystem services being used in marine assessment and mapping procedures. However, Farella et al. (2021) use regulatory measures and zoning principles to mitigate impacts on marine biodiversity (habitats, seabirds, mammals, fish) from human activities. According to Kyriazi et al. (2016), the governance of marine natural resources means trade-offs between multiple biotic ecosystem services conserved through a Marine Protected Area

(MPA) and the enabling of abiotic ecosystem services (wind, wave of tidal energy) in its spatial proximity as a societal demand for energy. However, the preference for biodiversity conservation over abiotic energy provision and vice versa does not always occur as they may co-exist in marine realms.

In terrestrial environments, Eyvindson et al. (2018) demonstrate that combining different forest management regimes reduces the negative effects of increasing harvest levels to biodiversity and non-wood ecosystem services. Good landscape-level forest management planning is crucial to minimise ecological costs by prioritising biodiversity values that need to be safeguarded. Biodiversity and ecosystem processes, however, are not evenly distributed over time and space, and that may result in a mismatch of priorities between biodiversity and ecosystem services. Using a landscape-level assessment (Hayes et al., 2015) demonstrates that key biodiversity and ecological processes that characterise a landscape can also support a wide range of ecosystem services in an equitable manner.

Lerouge et al. (2017) state that buffer zones provide spatial resilience to biological functions and services to protect against internal and external shocks. Spatial resilience, however, is a socio-ecological system term. Schulp et al. (2016) identifies the effectiveness of policy options in a mitigation hierarchy context by distinguishing biodiversity and ecosystem services. However, it remains challenging to achieve No Net Loss for biodiversity and ecosystem services at a large spatial scale.

The Mapping and Assessment of Ecosystem Services (MAES) process in Europe proved to be a very constructive and successful way to engage stakeholders from the member states, test methods and deliver relevant outcomes. Some successful examples from Bulgaria (Nedkov et al., 2018), Latvia (Ruskule et al., 2018), among others (Santos-Martin et al., 2018), provided good insights in terms of the advantage of mapping ecosystem services to improve assessments. However, it was difficult to downscale the process from the national level to the territorial planning level in order to reach practical outputs to target the needs of avoiding or/mitigating biodiversity loss. Still, the integration of ecosystem services supported knowledge development and cooperation to improve biodiversity conservation (Maes et al., 2012, 2018).

Implementing effective avoidance

Q3: What does effective avoidance look like, at what level should it happen, e.g., landscape, species, ecosystems, and how do you measure it?

All panellists who responded to the question agreed that *"avoidance should happen at all scales, from policies, (programmes), plans to projects"* [Panellist 2] and from species to ecosystems. *"The level depends on the intended scale of activities"* [Panellist 6], and determining the *"appropriate level should be project-specific"* [Panellist 5]. Moving from species to landscape and ecosystem level makes avoidance more complicated as ecological corridors, and other essential elements of ecological networks are often not under protection. Hence, early stages of development were emphasised, as this is when decisions to use or not to use untouched sites can be taken. Four panellists highlighted the importance that *"development is planned based on spatial / mapped conservation priorities with zones of development and zones of no-development based on conservation priorities"* [Panellist 3]. This makes avoidance effective and *"makes business sense as it is a much more cost-effective way to plan [compared to the current system]"* [Panellist 3]. Of course, *"to choose, which areas have to be untouched, a good input spatial data of the ecosystems, their ecological connectivity and other aspects characterising their condition and ecological value is needed"* as Panellist 8 put it.

Only three panellists commented on how effective avoidance should be measured, but those that did highlight measuring both actions (what actions are taken) and outcomes (are decisions adhered to) [Panellist 3] and the cost aspects "*It should be measurable in the same units as offsets to allow a loss gain balance"* [Panellist 10].

Evidence from case studies and policy documents is aligned with the panellists' views. Case studies support early analysis of potential direct and cumulative impacts as a means for effective avoidance (Bigard et al., 2017, 2020), as well as avoidance measures targeting all levels from landscape to species that take into account connectivity (Bigard et al., 2020; Pontoppidan MB & Nachman G, 2013; Sahraoui et al., 2021; Tarabonet al., 2019b). The importance of landscape scale is emphasised, especially in places undergoing rapid landscape changes (Tarabon et al., 2019a). Based on their analysis of several Environmental Impact Assessments over a decade, Bigard et al. (2017) conclude that: *"The development of a territorial strategy that shifts from an approach based on treating "symptoms" at the scale of individual projects to a more preventive approach focused on the avoidance of biodiversity loss and mitigation of cumulative impacts is now necessary".* Similarly to the panellists' views, mapping and good input spatial data is highlighted in several of the case studies (e.g., Bennett, 2018; Pontoppidan & Nachman, 2013; Tarabon et al., 2019a; Tarabon et al., 2019b;) and incorporating biodiversity into natural capital assessments is recommended (Cambridge Conservation Initiative, 2020).

Improving the effectiveness of the decision-making process

Q4. Stakeholders have different degrees of power to influence decisions under the mitigation hierarchy. How can the decision-making process that supports the delivery of mitigation hierarchy be made more effective?

Of the six panellists who answered this question, each interpreted it in a different way. They all agreed that the mitigation hierarchy should be incorporated into the initial stages of decision-making, policy design and planning. Panellist 2 also suggests that consideration of ecosystem services is also one way of incorporating stakeholders into the process. Panellist 3 argues that the most effective application of the mitigation hierarchy is *"at the earliest possible stage"* of policymaking, for example, locally when development plans are made. Panellist 4 also stated that research in Finland concluded that citizens should be involved as early as possible and kept involved during the land use planning process (or the Environmental Impact Assessment process). However, the process of applying the mitigation hierarchy should be made more clearly a part of these processes. As panellist 4 explains, it is especially difficult in land use planning to get all segments of society to participate in public hearings etc.

While the answers provided by the six panellists were not explicit regarding the effectiveness of citizens' engagement in mitigation hierarchy decision-making processes, they all agreed that support mechanisms were important, such as legislation and regulation. Panellists 2 and 6 highlighted the challenges of implementation and enforcement of the European legislative framework. This is due to the discrepancies in incorporating EU law and policy into national regulations and in the capacity and political will of those involved in enforcing it [Panellist 2 & 6]. Panellist 10 highlights that it is a challenging problem, as the proper application of the mitigation hierarchy requires consideration of avoidance measures very early on in the project concept design and planning stages. Whilst they would advocate for including community stakeholders at that stage, they highlight that the input needs to be treated meaningfully, and such input could substantially alter the direction of the entire project; they are, therefore, "sceptical about the degree to which project proponents would accept that! So, this is a tricky one".

With regard to the dynamic of the decision-making process, Panellist 10 argues that there is a difference between equity, which refers to a power imbalance in the decision-making process, where stakeholders have different levels of recognition, reputation and influence, and efficacy, where the power dynamics results in good decision-making. Panellist 8 suggested a practical measure to encourage social participation was to raise the awareness of *"the value of other valuable ecosystems and their processes*" and to integrate them "*into spatial plans and in the decision-making process as a whole*". Panellist 5 added that an *"explicit definition of impacts"* will help to increase public awareness. Panellist 11 added from their experience that in "*any participatory process, there is a need to explain and educate people on the qualities of the ecosystem services. If properly done, the communities will not just support an ecosystem service approach; they will embrace it*". Panellist 1 also suggests that people can easily understand the role nature plays in providing water to drink, air to breathe, food to eat and a place to live safely. So in this respect, it is not a difficult topic to comprehend at this level.

The scientific evidence underlines the need to consider the environment in strategic decision-making across various sectors and activities, as the panellists suggested. The need for the engagement of stakeholders is one of the governance aspects mentioned in the literature. Several studies reported the engagement of stakeholders, namely (Fontaine et al., 2014; Ottersen et al., 2011; Sahraoui et al., 2021; Schulp et al., 2016). The engagement of stakeholders, who were experts in the field, included ranking co-existence challenges and opportunities (Farella et al., 2021; Kyriazi et al., 2016). In addition, the conservation NGOs are engaged in working with companies to develop conservation strategies (CEMEX UK & RSPB, 2020), and the stakeholder consultation and involvement throughout the entire design process is reported in Iberdrola (2019). In Sahraoui (2021), co-creation brings various actors together, but it was perceived that there was a lack of participation by the public authorities. The community-based research is mentioned explicitly in only two articles that refer to meetings with local fishermen (Aunins et al., 2018) and local forest managers' participation (Fontaine et al., 2014).

The literature showed that most studies dedicated to the mitigation hierarchy do not include community-based stakeholders. The usual suspects continue to be the target audience, and when they participate, their engagement occurs during the co-design or co-implementation phases, in some instances as consultants. This lack of diversity of stakeholders makes us question whether there is a lack of recognition of non-technical and non-academic knowledge or the influence of socio-political dimensions within the mitigation hierarchy agenda. In addition, it is unclear whether the opportunities for participation include stakeholders at all stages of the decision-making process and at which level of intensity (consultation, information, collaboration, co-production, empowerment).

Significant values agreed on by stakeholders' active involvement are highlighted in Fontaine et al. (2014) as a way to improve the appreciation of ecosystem services concept by citizens to decision-makers and to identify the owners and beneficiaries of ecological functions. For instance, the VOTE (Fontaine et al., 2014) as a framework solution focused on ecosystem services participatory valuation to achieve sustainable ecosystem services management. Despite some authors highlighting the risks of ignoring customers' or citizens' values (Cambridge Conservation Initiative, 2020; Cullen, 2006), there is no active involvement of stakeholders mentioned in their literature.

Generally speaking, there is consensus in the literature regarding the importance of citizen engagement, but, hitherto, the roles, the tools, the responsiveness, and the degrees are still unspecified. The lack of literature that scrutinises what really happens in the application of the mitigation hierarchy decision-making process is an obstacle to understanding the power imbalance and dynamics, as mentioned by the Applied Policy Delphi panel.

Strengthening capacity to implement mitigation hierarchy

Q5. Education and capacity are clearly weaknesses at various levels/settings. In your opinion, at which level/setting is the need to strengthen the capacity the greatest? How would this influence discourse on trade-offs?

Out of the five panellists who answered this question, four stressed the influence of power on education and capacity as a weakness, and two stressed the need for better education to improve the capacity to make better decisions.

The capacity is related to "power imbalances among stakeholders" [Panellist 6]. Panellist 2 argues that "The current pressure to expedite environmental permitting (e.g., for renewable energy) is likely to make power imbalances worse" and suggests strategy games as an approach to improve environmental decision-making. They also emphasised it is "important to give the less powerful time to organise, fund-raise, etc." and that transparency is crucial. However, Panellist 6 stated that "even if the process is transparent with public participation, still the politicians will take decisions according to their political priorities, considering trade-offs. Mitigation hierarchy can only support wiser, smarter decisions, but still, the decisions cannot be in favour of biodiversity conservation but for socio-economic benefits".

Regarding the need for building capacity, panellist 8 suggested that "raising awareness, giving solid facts and scenarios ("what happens if") and explanations of the benefits that protection of nature entails might help". For this, we need "better background information (consistent data collection about nature, not only species but the overall state of the ecosystems, etc.), better tools for communication, visualisation, etc.". Indeed, to educate, knowledge is needed, followed by effective communication.

Panellist 10 suggested that "the greatest need for capacity [building] surely has to be in validation, enforcement, and monitoring – at the scale of local/regional public decision-makers". They also suggested that those enforcing policies should be able to "enforce penalties for non-compliance". Panellist 3, however, pointed out that even if capacity building and education is needed at all levels, "the senior leadership who have the biggest influence on decision-making, be this in Government and industry, and the financial sector," must be considered as a priority.

Within the literature that applies the mitigation hierarchy in case studies, there is little information on the limiting factors of education and capacity. This may reflect the use of experts in the field as stakeholders, as detailed in the previous section. Hayes et al. (2015), however, highlight the "lack of the capacity and resources for enforcement in many developing nations". They also say that there is a "lack of capacity within both governments and companies themselves and a lack of data with which to assess impacts". Also, "insufficient funding for education and awareness rising" is also highlighted (Aunins et al., 2018).

The lack of knowledge and sufficient expertise in relevant government departments and agencies has been confirmed by Moreira (2019). Whilst the issue of weak enforcement and poor long-term monitoring is supported by evidence in national case studies, the lack of knowledge is a barrier to effective enforcement and monitoring (Moreira, 2019). This has been seen, for example, when valuing the impact of energy projects in the marine environment (Kyriazi et al., 2016).

Regulatory approaches towards avoidance

Q6. Is there a need for a stronger regulatory approach towards avoidance of impacts and inclusion of mitigation hierarchy in general? I.e., How can EU/national/regional laws improve the implementation of the mitigation hierarchy, or what alternatives are there to the regulatory approach?

Among the various tools that can support a shift towards the avoidance stage of the mitigation hierarchy or its valorisation, regulation has been mentioned by most of the seven panellists who answered this question (five panellists). Three panellists [Panellists 10, 5 and 3] support a stronger regulatory approach, and three [Panellists 10, 8 and 6] point out possible reasons why regulations fail to achieve their goals, such as how the mitigation hierarchy is only vaguely embedded in land-use planning. However, panellist 2 suggests that it does depend on the country and the regulatory framework already in place. Among those suggesting a stronger regulatory approach, Panellist 10 reports that there is evidence that stronger regulation ensures more widespread and effective implementation of the mitigation hierarchy. Likewise, Panellist 3, drawing on the UK as an example, supports a stronger regulatory approach to strengthen avoidance in land planning in high biodiversity areas where the development is extremely time-consuming and costly. Panellist 5 suggests a "national-level adoption of the hierarchy as the 'normal principle' of planning" with an explicit monitoring strategy.

Notwithstanding the advantages of regulations, the experts recognised the following obstacles that are likely to hinder the regulatory approach:

1. Lack of a clear **definition** and framing of avoidance in regulations [Panellist 10];

2. **Weak enforcement and monitoring** of the outcomes of the avoidance stage, e.g., a public register on the model of offsetting public registers [Panellist 10];

3. Insufficient **technical capacity** of regulators, especially of local government officials and those not working in the environmental sector but still involved in development projects, e.g., finance officials [Panellist 8]. Panellist 6 adds that education and capacity are needed at all levels since "staff are frequently changing".

The evidence primarily supports the current role of regulations when it comes to mitigation hierarchy. Indeed, most countries require impact avoidance to be considered as part of the Environmental and Social Impact Assessment process (Pope et al., 2013). However, other studies point out various hindering factors, which include those mentioned by the panellists but are not limited to them. The **lack of a clear definition** is supported by various case studies. Bigard et al. (2017) provided evidence from the introduction of a new policy in France in 2010 to integrate the Environmental Impact Assessment legislation (law n 2010-788)[3]. Likewise, the definition of "environmental objective" in the National Planning Policy Framework of England (Cullen, 2006) is too vague. To overcome this, these scholars propose consulting agencies provide clearer explanations or standardised methods. Likewise, the case study by Bigard et al. (2017) shows that avoidance should take place in the early stage of project development. For Gelot and Bigard (2021), a clear definition of the stakeholders' roles and responsibilities is also needed to enter the correct information into datasets and allow effective long-term monitoring of the mitigation hierarchy at the national scale (see below).

Generally, **weak enforcement and insufficient technical expertise** hamper the application of the hierarchy, but a joint report by CEMEX UK & RSPB (2020) on the biodiversity management of quarry sites and the impact of extractive manufacturing industries in the UK highlights that good results can be achieved through the collaboration of local conservation officials and business. The lack of knowledge and sufficient expertise in relevant government departments and agencies has been confirmed by Moreira (2019). Gelot and Bigard (2021) show that the mitigation hierarchy in France has been poorly implemented and primarily focused on reduction/offset measures based on technical solutions rather than geographical or temporal solutions. They recommend nationwide, up-to-date datasets to improve enforcement. The lack of knowledge is a barrier to effective enforcement and monitoring (Moreira, 2019), especially in the marine environment (Kyriazi et al., 2016). In addition to the above, the evidence supports other issues equally likely to hinder the achievement of avoidance in regulations, e.g., the lack of **landscape-scale planning** (Bigard et al., 2020; Tarabon et al., 2019).

Lastly, the evidence shows the role of voluntary tools (third-party certification standards and financial loan requirements) are equally needed to create incentives and requirements for impact avoidance. Sustainability standards include those set by financial institutions, such as the Performance Standard of the International Finance Corporation, as well as **sector-specific standards,** such as those of the Roundtable on Sustainable Palm Oil. Increasingly, however, companies are adopting commitments to No Net Loss or Net Positive Impact to reduce

[3] Loi n° 2010-788 du 12 juillet 2010 portant engagement national pour l'environnement

negative impacts on biodiversity and ecosystem services (Gardner et al., 2013; Rainey et al., 2015). Biodiversity impact indicators and target setting for the analysis of **supply chains** have the potential of avoiding biodiversity impacts during business operations by first anticipating the potential impacts of business activity and then putting in place measures to prevent these adverse impacts (Cambridge Conservation Initiative, 2020). According to a recent report (TBC, 2012), 38 companies (15 of which were extractives companies) have now set ambitious biodiversity commitments towards No Net Loss or Net Positive Impact that will require significant avoidance of biodiversity impacts (see also Rainey et al., 2015). Two examples include ASN Bank, a finance organisation committed to sustainable and socially responsible investment and Kering S.A, Supply chain to the fashion industry. Greater uptake of these internal policies will be needed for the widespread application of impact avoidance. A number of challenges remain with regard to effective avoidance. For example, the speed by which corporate decisions need to be made may preclude effective analysis of the avoidance options/need to avoid (Hayes et al., 2015).

Cost of compensation to incentivise impact avoidance

Q7. One panellist suggested that "in practice, compensation is never costly enough". Do you have any thoughts or comments on this quote?

Five panellists who replied to the question agreed with the fact that compensation needs to be costly in order to properly account for everything that is lost (from carbon sequestration to people's wellbeing), as well as to incentivise impact avoidance. However, the implementation of effective compensation measures requires transparency (i.e., the costs should be clearly disclosed) and a guarantee of enforcement by permitting authorities.

DISCUSSION

QUALITY OF EVIDENCE AND KNOWLEDGE GAPS

During the research, we identified several knowledge gaps. There is a lack of studies on marine and freshwater environments. Terrestrial environments are more widely studied, but there were only a few studies on riparian landscapes and wetlands/peatlands. Geographically, studies from Eastern Europe are lacking.

Although the concept of mitigation hierarchy is relatively well known in the literature, when we look at avoid and mitigation stages of the mitigation hierarchy, the body of literature where the application of mitigation hierarchy in practice has been studied is small. This is especially true when we look at different topics linked with the application of the mitigation hierarchy. There is a lack of studies on risks, trade-offs and impacts. Also, the role of ecosystem services under the mitigation hierarchy has rarely been studied. We found hardly any literature that scrutinises what happens in the application of the mitigation hierarchy decision-making process in practice and the role and contributions of community-based stakeholders in that process.

Similarly, there was little information on the limiting factors of education and capacity. Overall, ecological aspects of avoid and mitigation stages have been studied more than social or governance aspects. However, to succeed in using mitigation hierarchy to its full potential in practice, we need an understanding of all three aspects.

We used the Applied Policy Delphi to supplement the literature and address knowledge gaps. Hence, the results and recommendations presented in this report are based on the best available evidence. Of course, there is an element of subjectiveness in the Applied Policy Delphi process, and the panel composition may have influenced the results. However, the results from the Applied Policy Delphi aligned with the literature and within the panel, indicating agreement on the topics. Where panel members had differing views, we have noted those in the text to give an unbiased perspective.

ENHANCING LANDSCAPES THROUGH THE USE OF MITIGATION HIERARCHY

Based on our results, it is clear that there is room for improvement in understanding and implementing the concept of mitigation hierarchy in practice. There is a need to ensure the strengthening of the implementation of the mitigation hierarchy, especially the avoid stage, to protect remaining natural ecosystems as they are irreplaceable habitats. There is also a need to enhance managed landscapes to achieve overall net biodiversity gains. Therefore, we suggest embracing the positive concept of landscape-level enhancement as an umbrella term to frame a biodiverse future that brings multiple benefits to society. We do not mean enhancement of natural areas in the sense of restoration but rather assessing our landscapes and thinking proactively about where to avoid, mitigate or restore and how to ensure nature-positive developments to achieve landscapes that ensure net gains for biodiversity and human wellbeing. This also includes management practices required to ensure the biodiversity of the particularly biodiverse vulnerable landscapes, for example, management required of semi-natural grasslands and the wildlife management of expansive/invasive species (e.g., Rūsiņa et al. 2017). Support for these managed landscapes is needed but outside of the scope of this report. The landscape-level enhancement framing can also help to set a more positive tone in the land-use debate that recognises the important role that biodiversity plays.

In the rest of the section, we will focus on how the conservation of biodiversity can be improved through the better application of mitigation hierarchy. A recent conceptual framework on avoidance by Bull et al. (2022), suggested by two panellists, highlights different categories of environmental avoidance and serves as a starting point for our discussion (Figure 11). We will recommend actions that strengthen the implementation of the mitigation hierarchy in relation to each of these categories. We will also discuss how to integrate ecosystem services into the mitigation hierarchy to make the social benefits of avoidance more visible and strengthen biodiversity conservation through synergies with ecosystem services.

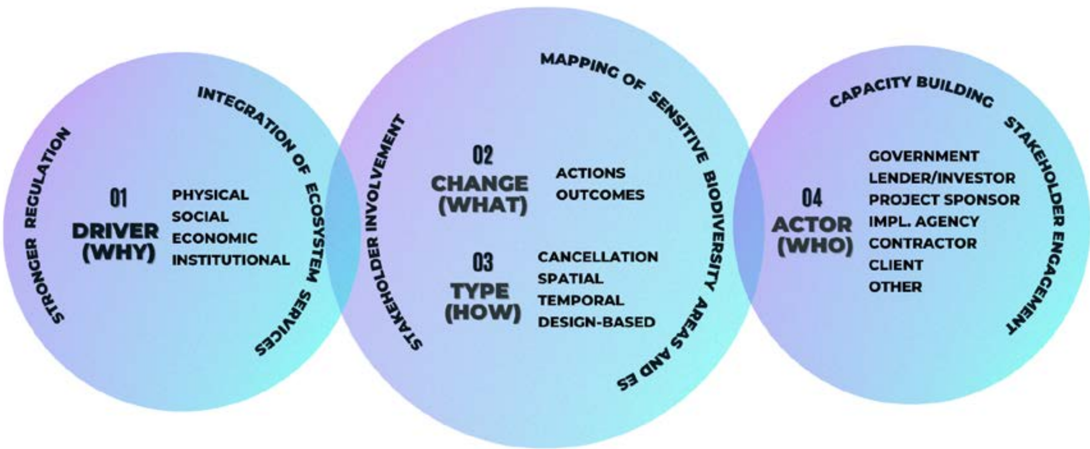


Figure 11. A conceptual framework of different categories of environmental avoidance and issues linked with them; adapted from Bull et al. 2022.

NEED FOR A STRONGER REGULATION TO STRENGTHEN ENFORCEMENT OF THE MITIGATION HIERARCHY

Our results support a stronger regulatory approach to mitigation hierarchy from the EU to national levels. Although mitigation hierarchy exists in various regulations and guidance documents, it is not consistently and systematically applied across European countries and within different planning levels. As land-use planning is often a separate process from planning and conserving natural areas, effective application of mitigation hierarchy would require that it is systematically considered at all planning levels, from local to national, as an overarching principle of planning. The evidence indicates that existing systems do not guarantee effective implementation of the existing approaches, e.g., Environmental Impact Assessments, and hence, strengthening both regulations and their governance is recommended. Voluntary standards can support and provide guidance on impact avoidance but cannot be relied upon alone.

There was consensus that a stronger focus should be put on avoidance and minimisation rather than offsetting. Based on our results and feedback from the panellists, we have made recommendations on a regulatory approach to ensure mitigation hierarchy is firmly established in law in all EU countries following the example of France (Box 1).

Box 1. France – leading the way in including mitigation hierarchy into legislation

The first reference to the definition of the mitigation hierarchy in France dates back to 1976 with the approval of the law on nature protection that stated this procedure was to be followed when assessing projects, plans and programmes *(Loi relative à la protection de la nature nº76-629 du 10 Juillet 1976 and article l.122-3 du code de l'environnement).* In 2004, the adoption of the Charte de l'environnement with constitutional relevance marked a crucial step forwards towards the recognition of a new human right related to the environment *(art. 1, Droit de vicre dans un environnement équilibré et repectueux de la santé)*, as well as towards the obligation of public authorities to implement the preucationary principle *(art.5, principe de précaution)* to reduce the risk of environmental damages. In 2012, the development of a national doctrine on the mitigation hierarchy (Doctrine nationale relative à la séquenece ERC) brought to the adoption in 2013 of Guidelines on the mitigation hierarchy aimed at harmonizing definitions of basic concepts. Lastly, in 2016 the law on recovering biodiversity, nature and landscape (Loi de reconquête de la biodiversité, de la nature et des paysages nº 2016-1087 du 8 août 2016) added two crucial result obligations to the National Doctrine of 2012:1. The respect of the sequence order (and not only the mitigation hierarchy). 2. The non-realisation of the project if the impacts on biodiversity cannot be avoided, reduced and compensated for in a satisfactory and appropriate way. Moreover, the 2016 Biodiversity Law improved the definition of the principle of preventive action with regard to the mitigation hierarchy by adding a reference to the No-Net-Loss principle.

MAINSTREAMING ECOSYSTEM SERVICES AS PART OF THE MITIGATION HIERARCHY

The advisability of including ecosystem services in the mitigation hierarchy has been deeply debated by the panel and in the literature. The general conclusion is that ecosystem services should be mainstreamed into the mitigation hierarchy in an attempt to address biodiversity values from a broader perspective, raising awareness of the societal benefits of nature conservation and highlighting the dependency on nature for the livelihoods of different stakeholder groups. The integration of ecosystem services provides the opportunity to better connect biodiversity issues with social challenges in the context of specific decision-making processes, allowing the meaning and implications of concepts to be expanded, such as impact "mitigation" and "No Net Loss", and to use different types of valuation approaches, methods and indicators (see Box 2). In addition, the separation of ecosystem services and biodiversity conservation would not be consistent with the idea that biodiversity is essential to support all ecosystem services and that conservation and sustainable use of ecosystems and their services are part of the same issue. However, concerns emerged related to the risk that the inclusion of ecosystem services could be disadvantageous to biodiversity (e.g., in cases where the conservation or enhancement of specific ecosystem services will be considered an acceptable substitute for biodiversity loss). Concerns related particularly to the fact that biodiversity might be downplayed against more vocal and organised interest groups that might favour, for example, provisioning services or, more generally, services that can be easily measured and quantified.

Box 2. Integration of ecosystem services to design more equitable mitigation strategies.

Mandle et al. (2015) developed an approach to mitigate the negative impacts from development that tracks how people are affected by environmental degradation. The approach combines an ecosystem services modeling framework with data on where people live an how they rely on benefits from ecosystems, and use the information to design more equitable mitigation strategies than would be created by simply focusing on biodiversity or ecosystem services. The approach is illustrated for a case study in road development, focusing on four ecosystem services (sediment retention, nitrogen regulation, phosphorus regulation and carbon storage), which are likely to be unaccounted for in classic impact assessment. They have a clear importance to local stakeholders and are likely to be affected by the proposed road. The concept of "serviceshed" (i.e., the area that provides a particular ecosystem service to a particular beneficiary, Tallis et al. 2016) is applied to determine the location and degree of mitigation needed to offset the impact on ecosystem services to those people who would be negatively affected by the road construction. This approach allows to transparently assess the equity of the positive and negative environmental impacts resulting from de development and mitigation actions. It also makes apparent how these impacts are distributed across the landscape and different segments of the society.

Source: Mandle et al. 2015. Who loses? Tracking ecosystem services redistribution from road development and mitigation in the Peruvian Amazon.

Tallis, H., Kennedy, C.M., Ruckelshaus, M., Goldstein, J., Kiesecker, J.M. 2016. Mitigation for the people: an ecosystem services framework. In: Geneletti, D (Ed). Handbook on biodiversity and ecosystem services in impact assessment, Edward Elgar Publishing, 41-61.

EFFECTIVE AVOIDANCE

It is clear from the results (see the section on "Avoidance as a concept") that there is a need for a proactive approach to ensure effective avoidance. One approach that came up in the research process is landscape-scale mapping of biodiversity and sensitive ecosystems along with their relevant ecosystem services. It was emphasised that there is a need to bring scientists and stakeholders together in a mutual learning process, linking expert and local knowledge(s). The aim of this process would be to implement meaningful territorial strategies and build local capacity to understand and implement the strategies in an inclusive process.

As one of the panellists pointed out, mapping cultural ecosystem services can be difficult. Still, the expert working group is aware of methodologies that could be helpful here, for example, Bachi et al. (2020), Crossman et al. (2013) and Ribeiro and Ribeiro (2016).

A multi-species approach is also important at the landscape scale, which takes into account their varying vulnerabilities, such as the mobility of the species and their sensitivity to habitat fragmentation. Trade-offs are inevitable in such approaches, but it is our opinion from the sum of the evidence that at the landscape scale, it is easier to minimise these trade-offs to ensure the maximum ecological benefit for a greater number of species by ensuring functional connectivity. As the literature states, however, these trade-offs do need to be identified and managed in a transparent manner. This is particularly important in cases where species have large spatial requirements. Thus, landscape mapping of the functional ecological units can highlight where further fragmentation of the landscape can be avoided and draw attention to the potential threats from multiple sources and their cumulative impacts.

Buffer zones can also be identified around sensitive habitats in need of protection, and habitats can be connected to ensure the long-term sustainability of biodiversity. Development of this blue and green infrastructure has the potential to support not just biodiversity but also a range of ecosystem services, such as food provisioning; improving water quality from agricultural agrochemicals and urban runoff; and biomass production for novel products and energy as part of the bioeconomy initiatives within the EU. It is therefore important not just to map biodiversity but also ecosystem services that people rely on to ensure a holistic overview of dynamic landscapes and the underlying processes to be able to minimise the trade-offs incurred.

Furthermore, landscape connectivity frameworks based on single or multi-species, including habitat networks, are popular approaches within the mitigation hierarchy (Berges et al. 2020; Préau et al. 2022). A connectivity approach based on species observations provides good insights not only to tackle avoidance, reduction but also to develop scenarios of compensation oriented towards planning. A habitat connectivity framework for the mitigation hierarchy provides direct benefits providing practical recommendations to be implemented at the local to the regional level (e.g., Préau et al. 2022a; Préau et al. 2022b). In addition, a well-conducted connectivity analysis for target species shows the multifunctionality and gain for certain species when mitigation measures are in place. Providing measures and scenarios based on connectivity approaches would improve the overall ecological network (Clauzel and Godet 2020) and thus provide a set of ecosystem services (Keesstra et al. 2018, Liquette et al. 2016), as well as increasing the potential for species to adapt to climate change (Chausson et al. 2020).

Box 3. French example avoidance for territorial planning

For connectivity assessments, context prioritisation is likely to differ depending on the species considered. These decisions are key for territorial planning. Here, we provide an example of areas identified in six urban sprawl projects inside a local management scheme (SCOT) in the South of France in the territory of the Thau Lagoon, to demonstrate the methodological approach. The objective was to assess the relevance of identifying priority areas for connectivity of groups of species based on common dispersal abilities. We aimed to address avoidance by assessing the impact of target groups' choices on predicted priority areas. The choice of species was made in agreement with stakeholders in accordance with their interest in biodiversity conservation measures and the knowledge base to be implemented. Ecological niche modelling was used to quantify species resistance and to identify suitable habitat patches and connectivity (see Preau et al. 2022). We found important differences in identified priority areas between groups with dissimilar dispersal abilities, with little overlap between highly connected areas. We identified a gap between the level of protection of low dispersal species and highly connected areas. We found mismatches between existing corridors and connectivity in low dispersal species and a greater impact in areas of expected urban sprawl projects on favourably connected areas for species with high dispersal capabilities.

This study demonstrates the importance of selecting a diversity of species with different dispersal capacity ranges to identify ecological corridors in programmes that aim to restore habitat connectivity at territorial levels. These findings are oriented to support decisions of planning initiatives at both local and regional scales working in tandem with local knowledge and stakeholders.

For more details: Préau C, Dubos N, Lenormand M, Denelle P, Le Louarn M, Alleaume S & Luque S (2022) Dispersal-based species pools as sources of connectivity area mismatches. *Landscape Ecology* 37, 729-743. [arXiv][pdf][code] https://doi.org/10.1007/s10980-021-01371-y(0123456789).

Box 4. Estonian example of ecosystem services mapping.

Estonian has been actively mapping ecosystem services with the view of integrating the values into the planning processes of the country. The ELME project is a nationwide project to map terrestrial ecosystems and their services, and LIFE IP CleanEst deals with aquatic ecosystems. The results from both projects are meant to be used in practice.

Mapping of the biophysical ecosystem services and the condition of the ecosystems are finished, and mapping of the monetary values of ecosystem services is currently ongoing. The mapping has involved some very emotional discussions, such as in the siting of wind arms with obvious divergent views of stakeholders. However, mapping is viewed as an important step in protecting nature as it is possible to see where the most valuable ecosystems in good condition are located and make it easier to implement nature protection in practice. It also helps planners to be aware of the ecosystem services provided by nature to stakeholders.

Estonian website for the public: https://loodusveeb.ee/en

Effective avoidance from infrastructure projects

The effective avoidance of impacts from infrastructure projects may be addressed in certain circumstances by addressing spatio-temporal dimensions of the impacts that affect the biodiversity or local communities. It was documented by a panellist in the Applied Policy Delphi process that conservation should be considered as an ecosystem service per-se. Conservation may consist of a mix of regulations and spatial-temporal measures that can be applied to multiple ecosystem goods and services, and sectors. While the application of cumulative effects assessments is seeing increased momentum in Maritime Spatial Planning, their application in territorial planning still needs further work. Overall, the cumulative effects exerted by a development project need to be determined by identifying the physical (e.g., soil sealing), ecological (e.g., chemical pollutants, nutrients), and energy-related (e.g., electromagnetic field, light or noise pollution) pressures. In addition, there is a need to examine how the impacts affect biodiversity and societal dimensions in terms of the sectors that depend on the impacted ecosystem. An operational framework for identifying pressures is provided for aquatic environments: Annexe III of the Marine Strategy Framework Directive (MSFD), which identifies the pressures exerted by anthropogenic coastal and marine activities. The advantage of the pressure framework is that it is 1) possible to formalise avoidance measures in spatio-temporal terms (pressure and intensity-based avoidance buffers, wildlife-specific avoidance buffers, and seasonal avoidance buffers); 2) pressure propagation patterns (e.g., buffers of influence) can be defined and 3) the sensitivity of biodiversity components to the pressures addressed. Other examples of the categorisation of threats and pressures are provided by Art.17 of the Habitat Directive and Art. 12 of the Birds Directive (EIONET, 2015). This is used to report species and conservation status and address particular threats and pressures in protected sites.

Technological innovations and design can, in some cases, further alleviate the impacts of infrastructure projects on biodiversity. However, they may bring with them uncertainty with new and diversified pressures and pressure mechanisms on biodiversity. The cancellation of infrastructure projects should be considered if technology and design lead to high uncertainty of impacts on biodiversity and society. To increase the effectiveness of avoidance mechanisms of the infrastructure project, it should be identified how the social dimension could be included in the avoidance measures.

STAKEHOLDER ENGAGEMENT IN POLICY AND DECISION-MAKING PROCESSES

The need to strengthen the active involvement of different stakeholders is one of the governance aspects which can be concluded from the results. The literature showed that in nearly all case studies dedicated to the mitigation hierarchy, community-based stakeholders were not included, apart from cases reported, which included the engagement of local fishermen (Farella et al. 2021; ICES 2016). Thus, it is crucial to challenge the viewpoints of scientific and non-scientific players when assessing the sustainability of local ecosystems through the services they can provide to the local community. Although it is documented that a sustainable development scenario is developed with the contribution of stakeholders (Sahraoui et al., 2016), a number of studies dedicated to the mitigation hierarchy only included the usual suspects as a target audience, and their engagement occurred during the co-design or co-implementation phases, in some instances as consultants.

Fontaine et al. (2014) highlighted that significant values agreed on by stakeholders' active involvement are a way to improve the appreciation of the ecosystem services concept by citizens to decision-makers and to identify the owners and beneficiaries of ecological functions. The objective to achieve consensus building implies that there are possibilities to influence, negotiate and deliberate on decisions by all stakeholders. Conflicts are a part of this kind of process, as well as the resources required for this implementation. The engagement of stakeholders not usually reached in engagement processes depends on explicit inclusion into the political agenda and the definition of clear strategies. The mapping of local participatory culture can support the identification of the stakeholder groups, their level of influence, the activities that already exist and, more importantly, how to engage them. Attention to inclusiveness ensures that priority groups who are sub-represented, such as women, elderly people, children, immigrants, and traditional communities, are recognised. The institutionalisation of citizens' engagement is a solution to the difficulties of upscaling and replicability by strengthening local and more sustainable dynamics.

Several opportunities arise from the prioritisation of this type of collaboration, also recognised as co-production, e.g. to inform the decision-making process better (Farella et al., 2016; Fontaine et al., 2014;) to include a diversity of knowledge, to better evaluate the process, to include socio-cultural values and needs from a heterogeneous group of stakeholders (Barbe 2021, Sahraoui et al., 2021). The core leverage and enabling factors for the success of citizens' engagement are the transparency of the co-governance structure, the trust in the relational dynamic, the communication and interaction among all participants, the inclusion of different groups, the quality of deliberation and the co-production opportunities (see Box 5 for a possible method). Despite the numerous benefits, possible challenges, such as delays and problems getting the stakeholders to respond, need to be considered as potential problems.

Box 5. Strategy games – one way for a meaningful stakeholder engagement

One way to explore trade-offs and consequences of different land-use scenarios are strategy games (Garcia et al 2022). Strategy games provide an opportunity to test probable impacts of different land-use scenarios and policies and find solutions that are acceptable to different stakeholders. The way the games are designed makes it possible for stakeholders to experience the consequences of decisions from the perspective of other stakeholders and engage in collaborative learning. Through the collective, explicit, and transparent problem exploration and solution identification processes, power imbalances can be revealed and addressed, and mental models updated to better correspond with realities of different stakeholders. This form of decision-making counterbalances hidden, unformulated and/or opaque decision-making processes and should lead to improved outcomes in land-use decisions because stakeholders jointly agree on the future they want to see.

Source: Garcia, C. A., Savilaakso, S., Verburg, R. W., Stoudmann, N., Fernbach, P., Sloman, S. A., Peterson, G. D., Araújo, M. B., Bastin, J.-F., Blaser, J., Boutinot, L., Crowther, T. W., Dessard, H., Dray, A., Francisco, S., Ghazoul, J., Feintrenie, L., Hainzelin, E., Kleinschroth, F., ... Waeber, P. O. (2022). Strategy games to improve environmental policymaking. Nature Sustainability, 5(6), 464–471. https://doi.org/10.1038/s41893-022-00881-0

CAPACITY BUILDING

The scientific evidence underlines the complexity and dynamic nature of the issues involved and the necessity to clarify definitions and terminology to ensure common understanding. However, it is also important to construct narrative accounts that are specific to a place, as each landscape unit presents unique challenges to biodiversity and the people who live and work in that landscape. Building the capacity to understand this natural capital across sectors is critical.

There are several challenges regarding stakeholder engagement and capacity building. These include, for example, the limited knowledge of the participants, the loss of motivation of the public authorities and organisations, and insufficient funding for implementation. These all pose a risk for conflicts, lead to response delays and affect institutional capacity.

According to the results from the Applied Policy Delphi process, greater transparency generates numerous positive effects on decision-making processes. The transparency is underlined as crucial for education and capacity, both associated with the validation, enforcement and monitoring process. Moreover, the degrees of power to influence decisions were pointed out through two approaches suggested for further exploration, the power imbalances associated with equity distribution and power dynamics related to the efficacy of the decision-making process.

It is recommended from the results that active participation should be encouraged by raising awareness through better, solid background information about the ecological status of the ecosystems (or the site-specific ecosystem). In this sense, specific language, tailored formats and appropriate communication channels to engage the different stakeholder groups and to ensure the "translation" of technical information into language easily understood is also recommended. These strategies can improve the transparency process, at the same time that it educates individuals and institutions to enhance the mitigation hierarchy impacts.

Box 6. Multi-stakeholder collaboration to create an operational model for municipalities to implement mitigation hierarchy

A multi-stakeholder process was used in the No Net Loss City project in Finland to develop an operational model for municipalities to effectively use mitigation hierarchy in their land-use planning, and where needed, implement biodiversity offsets (Hohti et al. 2022). The development process was built on collaboration between researchers and practitioners and combined researchers' scientific knowledge on ecological compensation with practitioners' knowledge about land-use planning processes.

At the beginning, objectives for the work were jointly defined. Based on these objectives, the development for practical solutions took place in four workshops, which had different themes. The first workshop focused on knowledge needs and challenges of biodiversity offsets, in the second workshop a preliminary operational model was introduced and discussed, and compensation was looked at more in detail (e.g. ecological values to be compensated, data availability). The third workshop focused on land-use planning and decision making in municipalities, the processes, and responsibilities. In the fourth workshop the operational model was finalised. Overall, 40 people participated in the process. Of those, 13 were experts on land-use planning at municipality level, 18 were researchers, and 9 people represented other stakeholders. Two of the workshops were held virtually and two in person. The whole process took around 9 months to complete. The operational model is being piloted in Jyväskylä, a mid-sized city in Finland. More information can be found here: https://boostbiodiversityoffsets.fi/en/.

Source: Hohti, J., Nieminen, E., Jalkanen, J., Oinonen, I., Huttunen, S., Pappila, M., Halme, P., Salokannel, V., Pietilä, K., Kujala, H. (2022). Kunnat hidastamaan luontokatoa – Suosituksia luontohaittojen välttämiseksi, lieventämiseksi ja kompensoimiseksi kuntien maankäytössä. *Wisdom Letters.*

CONCLUSIONS

The aim of this report was to provide evidence-based knowledge on if and how ecosystem services can be considered in projects, programmes, policies and associated impact assessments with a particular focus on the avoid stage of the mitigation hierarchy. The focus was particularly on three questions 1) If and how the consideration and operationalisation of ecosystem services can be integrated into natural capital assessments, impact assessments, and policymaking processes to enhance biodiversity conservation; 2) What kind of impacts and challenges may occur when the ecosystem services concept is used in the mitigation hierarchy and similar processes?; and 3) how replicable and transferable are tools and processes in countries or regions have been used successfully in the avoid stage?

We conclude that ecosystem services can be mainstreamed into the mitigation hierarchy, but care will need to be taken to ensure that biodiversity and life-serving ecosystem services are prioritised and safeguarded over those ecosystem services that grant economic profits. Integrating ecosystem services into mitigation hierarchy and land-use planning processes is also an opportunity for improved stakeholder engagement. By engaging with local stakeholders in an area from the very early stages, land-use planners and decision-makers can integrate stakeholder values and perspectives into planning and ensure land-use planning is driven by local experience and knowledge, together with the best available scientific evidence.

We did not find much evidence of the use of the ecosystem services concept in the mitigation hierarchy. Therefore, we cannot give an evidence-based answer to the question of what impacts may occur when the ecosystem concept is used in the mitigation hierarchy. When we look at the identified impacts on biodiversity, it is clear that impacts occur across different spatial and temporal scales and can be synergistic, antagonistic or dominant. In practice, a lack of resources is the biggest challenge to ensuring effective design, implementation, monitoring and evaluation practices. Other identified challenges were a lack of clear definitions, effective regulation, capacity building and true stakeholder engagement and collaboration.

None of the challenges identified are insurmountable nor novel in environmental governance and land-use planning. Nor are we lacking solutions to address them. In this report, we provide examples of solutions and tools and practices that are transferable and replicable from one context to another.

Within the upscaling process, we recommend that the information produced is made accessible to a broad set of stakeholders and to adapt communication strategies to different target audiences to ensure a wide reach of knowledge.

Finally, we conclude that putting biodiversity first and avoiding further loss is both possible and needed for the benefit of society and the planet we live on. Moving towards sustainability requires fundamental transformations, including changes in how biodiversity is perceived and valued. Newly established relations between societal actors are also required. This demands a holistic vision for the maintenance of biodiversity that balances conservation and mitigation processes and the sustainable provision of ecosystem services. The mitigation hierarchy and its effective implementation are central to fulfilling this vision. The recommendations in this report provide a roadmap on how to do this, but they are only effective if decision-makers, land use planners and practitioners commit to improving legislation and practices. Hence, we end our report with a call for action to all those involved in land-use planning: it is time to act to get effective mitigation practices put into place before it is too late.

ACKNOWLEDGEMENTS

First and foremost, we thank our panellists for their commitment to participating and sharing their knowledge. It's been a pleasure working with you, and your knowledge has been of enormous value for the compilation of this report. To our research assistants, Karoliina Haikoski and Fiona Nevzati: not only do you work hard, but you are wonderful people. Thank you for everything. We also thank Alister Scott, Lyudmyla Zahvoyska, and Nils Bunnefeld for their input as members of Eklipse's Methods Expert Group. Alister deserves a special mention for his active participation and the valuable support he provided for the Applied Policy Delphi process. We thank Onno Knol and Agnes Zolyomi from the Eklipse Knowledge Coordination Body for being critical friends throughout the process and making the final report all the better for it. Finally, Karla Locher-Krause, thank you for steering us through the Eklipse process and taking care of all the practicalities and logistics. Without you, this report would not be here, so a big thank you from all of us.

REFERENCES

Albert, C., M. Brillinger, P. Guerrero, S. Gottwald, J. Henze, S. Schmidt, E. Ott, and B. Schroter. 2021. Planning nature-based solutions: Principles, steps, and insights. AMBIO 50(8):1446-1461. doi: 10.1007/s13280-020-01365-1

Aunins, A., Lappalainen, A., Fleet, D. M., Stienen, E., Haas, F., Simian, G., Glemarec, G., Mitchell, I., Petersen, I. K., & Luigujoe, L. 2018. Report of the Joint OSPAR/HELCOM/ICES Working Group on Marine Birds (JWGBIRD). *Joint OSPAR/HELCOM/ICES Working Group on Marine Birds*.

Azzellino, A., J. P. Kofoed, C. Lanfredi, L. Margheritini, and M. L. Pedersen. 2013. A Marine Spatial Planning framework for the optimal siting of Marine Renewable Energy Installations: two Danish case studies. JOURNAL OF COASTAL RESEARCH (12th International Coastal Symposium (ICS)):1623-1628. doi: 10.2112/SI65-274.1

Bachi, L., Ribeiro, S. C., Hermes, J., & Saadi, A. 2020. Cultural Ecosystem Services (CES) in landscapes with a tourist vocation: Mapping and modelling the physical landscape components that bring benefits to people in a mountain tourist destination in southeastern Brazil. *Tourism Management*, *77*, 104017. https://doi.org/10.1016/j.tourman.2019.104017

Barbe, H., and N. Frascaria-Lacoste. 2021. Integrating Ecology into Land Planning and Development: Between Disillusionment and Hope, Questioning the Relevance and Implementation of the Mitigation Hierarchy. SUSTAINABILITY 13(22)doi: 10.3390/su132212726

Barbosa, A., B. Martin, V. Hermoso, J. Arevalo-Torres, J. Barbiere, J. Martinez-Lopez, S. Domisch, S. D. Langhans, S. Balbi, F. Villa, G. Delacamara, H. Teixeira, A. J. A. Nogueira, A. I. Lillebo, Y. Gil-Jimenez, H. McDonald, and A. Iglesias-Campos. 2019. Cost-effective restoration and conservation planning in Green and Blue Infrastructure designs. A case study on the Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain) - Morocco. SCIENCE OF THE TOTAL ENVIRONMENT 652:1463-1473. doi: 10.1016/j.scitotenv.2018.10.416

Bennett, R. 2018. No Net Loss of Biodiversity and Ecosystem Services: Applying the Mitigation Hierarchy and Biodiversity Offsets as tools to achieve sustainable development in the WIO. In *Nairobi Convention Science to Policy Meeting* (pp. 1–7). Wildlife Conservation Society. https://wedocs.unep.org/bitstream/handle/20.500.11822/25931/Mitigation_offsets_WCS.pdf?sequence=1

Bigard, C., S. Pioch, and J. D. Thompson. 2017. The inclusion of biodiversity in environmental impact assessment: Policy-related progress limited by gaps and semantic confusion. JOURNAL OF ENVIRONMENTAL MANAGEMENT 200:35-45. Doi: 10.1016/j.jenvman.2017.05.057

Bigard, C., P. Thiriet, S. Pioch, and J. D. Thompson. 2020. Strategic landscape-scale planning to improve mitigation hierarchy implementation: An empirical case study in Mediterranean France. LAND USE POLICY 90doi: 10.1016/j.landusepol.2019.104286

Booth, A.; Noyes, J.; Flemming, K.; Moore, G.; Tunçalp, Özge; Shakibazadeh, E. (2019) Formulating questions to explore complex interventions within qualitative evidence synthesis. BMJ Glob. Heal. 4, e001107, doi:10.1136/bmjgh-2018-001107.

Borgstroäm, S., and F. H. Kistenkas. 2014. The compatibility of the habitats directive with the novel EU green infrastructure policy. European Energy and Environmental Law Review 23(2):36-44.

Brignon, J. M., M. Lejart, M. Nexer, S. Michel, A. Quentric, and L. Thiebaud. 2022. A risk-based method to prioritize cumulative impacts assessment on marine biodiversity and research policy for offshore wind farms in France. Environmental Science and Policy 128:264-276. doi: 10.1016/j.envsci.2021.12.003

Bull, J., Sonter, LJ, Gordon, A, Maron, M, Narain, D, Reside, AE, Sánchez, LE, Shumway, N, von Hase, A, Quétier, F. 2022. Quantifying the "avoided" biodiversity impacts associated with economic development. Front Ecol Environ doi: doi:10.1002/fee.2496

Cambridge Conservation, I. 2020. Framing Guidance. March.

Casalegno, S., J. J. Bennie, R. Inger, and K. J. Gaston. 2014. Regional Scale Prioritisation for Key Ecosystem Services, Renewable Energy Production and Urban Development. PLOS ONE 9(9)doi: 10.1371/journal.pone.0107822

Cemex UK & RSPB. 2020. *Building Biodiversity*. https://www.rspb.org.uk/globalassets/downloads/join-and-donate/cemex-uk-and-rspb-biodiversity-strategy.pdf

Cerreta, M., G. Poli, and M. Somma. 2021. Assessing Infrastructures Alternatives: The Implementation of a Fuzzy Analytic Hierarchy Process (F-AHP). In: COMPUTATIONAL SCIENCE AND ITS APPLICATIONS, ICCSA 2021, PT VII. p 504-516.

Claireau, F., Y. Bas, S. J. Puechmaille, J. F. Julien, B. Allegrini, and C. Kerbiriou. 2019. Bat overpasses: An insufficient solution to restore habitat connectivity across roads. JOURNAL OF APPLIED ECOLOGY 56(3):573-584. doi: 10.1111/1365-2664.13288

Clare EL, Lim BK, Fenton MB, Hebert PDN (2011) Neotropical Bats: Estimating Species Diversity with DNA Barcodes. PLOS ONE 6(7): e22648. https://doi.org/10.1371/journal.pone.0022648

Clauzel and Godet 2020 Cybergeo: European Journal of Geography,Environnement, Nature, Paysage 2019, 900. Apports de la modélisation spatiale pour la gestion de la trame verte et bleue Spatial Modeling for the management of green and blue infrastructure. https://doi.org/10.4000/cybergeo.32333

Cobacho, S. P., S. Wanke, Z. Konstantinou, and G. El Serafy. 2020. Impacts of shellfish reef management on the provision of ecosystem services resulting from climate change in the Dutch Wadden Sea. MARINE POLICY 119doi: 10.1016/j.marpol.2020.104058

Collaboration for Environmental Evidence. (2018). Guidelines and Standards for Evidence synthesis in Environmental Management. Version 5.0 (AS Pullin, GK Frampton, B Livoreil & G Petrokofsky, Eds) www.environmentalevidence.org/information-for-authors. [Accessed 21.9.2021]

Combes, M., S. Vaz, A. Grehan, T. Morato, S. Arnaud-Haond, C. Dominguez-Carrio, A. Fox, J. M. Gonzalez-Irusta, D. Johnson, O. Callery, A. Davies, L. Fauconnet, E. Kenchington, C. Orejas, J. M. Roberts, G. Taranto, and L. Menot. 2021. Systematic Conservation Planning at an Ocean Basin Scale: Identifying a Viable Network of Deep-Sea Protected Areas in the North Atlantic and the Mediterranean. FRONTIERS IN MARINE SCIENCE 8doi: 10.3389/fmars.2021.611358

Coppola, E., Y. Rouphael, S. De Pascale, F. D. Moccia, and C. Cirillo. 2019. Ameliorating a Complex Urban Ecosystem Through Instrumental Use of Softscape Buffers: Proposal for a Green Infrastructure Network in the Metropolitan Area of Naples. FRONTIERS IN PLANT SCIENCE 10doi: 10.3389/fpls.2019.00410

Crossman, N. D., Burkhard, B., Nedkov, S., Willemen, L., Petz, K., Palomo, I., Drakou, E. G., Martín-Lopez, B., McPhearson, T., Boyanova, K., Alkemade, R., Egoh, B., Dunbar, M. B., & Maes, J. (2013). A blueprint for mapping and modelling ecosystem services. *Ecosystem Services*, *4*, 4–14. https://doi.org/10.1016/j.ecoser.2013.02.001

Cullen, F. 2006. *National Planning Policy Framework* (pp. 1–65). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf

Delbaere, B., A. N. Serradilla, M. Snethlage, R. Alkemade, L. Boitani, J. Eggers, A. Falcucci, E. Framstad, M. de Heer, S. M. Hennekens, D. Kemitzoglou, B. de Knegt, G. de Knijf, G. Louette, D. Maes, L. Maiorano, S. Nagy, W. A. Ozinga, H. J. Schaminée Joop, S. van Tol, and K. Tröltzsch. 2009. BioScore: A tool to assess the impacts of European Community policies on Europe's biodiversity.

Di Marino, M., M. Tiitu, K. Lapintie, A. Viinikka, and L. Kopperoinen. 2019. Integrating green infrastructure and ecosystem services in land use planning. Results from two Finnish case studies. LAND USE POLICY 82:643-656. doi: 10.1016/j.landusepol.2019.01.007

EIONET (European Environment Information and Observation Network), 2015. Checklists for Habitats Directive Article 17 reporting. Web: https://www.eionet.europa.eu/etcs/etc-bd/activities/reporting/article-17/reference-material-for-reporting-period-2007-2012-art-17

Eklipse Methodological Protocol, S., S; Depellegrin, D; Sorie, J; Larac, D; Campagne, S; Caitana Da Silva, B; Geneletti, D; Kagkalou, I; Leucci, F; Luque, S. 2021. Method Protocol, How could we improve adherence to the Mitigation hierarchy using ecosystem services with a particular focus on the avoid state?, Eklipse website. Web: https://eklipse.eu/wp-content/uploads/website_db/Methods/Method19_Systematic_map-1.pdf, accessed 25/08/2021.

Ekstrom, J., Bennun, L., Mitchell, R., (2015). A cross-sector guide for implementing the Mitigation Hierarchy. Cross-Sector Biodiversity Initiative. Executive Summary and Overview. Web:

http://www.csbi.org.uk/wp-content/uploads/2017/10/Mitigation-Hierarchy-Executive-summary-and-Overview.pdf, accessed 03/08/2021.

EU, 2008. Directive of the European Parliament and the Council Establishing a Framework for Community Action in the Field of Marine Environmental Policy (Marine Strategy Framework Directive).

European Commission. Directorate-General for the Environment. 2014. The EU Birds and Habitats Directives: For Nature and People in Europe. Publications Office of the European Union, 2014. ISBN: 9279405853, 9789279405853.

European Commission. 2020. EU Biodiversity Strategy for 2030. Bringing nature back into our lives. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

European Commission, Directorate-General for Environment, *Managing Natura 2000 sites: the provisions of Article 6 of the 'Habitats' Directive 92/43/EEC*, 2001.

European Commission, Directorate-General for Environment, a *Guidance document on wind energy developments and EU nature legislation*, Publications Office, 2000. https://ec.europa.eu/environment/nature/natura2000/management/docs/wind_farms_en.pdf

Eyvindson K, Repo A, & Monkkonen M. 2018. Mitigating forest biodiversity and ecosystem service losses in the era of bio-based economy. *Forest Policy and Economics*, *92*, 119–127. https://doi.org/10.1016/j.forpol.2018.04.009

Farella, G., A. N. Tassetti, S. Menegon, M. Bocci, C. Ferra, F. Grati, A. Fadini, O. Giovanardi, G. Fabi, S. Raicevich, and A. Barbanti. 2021. Ecosystem-Based MSP for Enhanced Fisheries Sustainability: An Example from the Northern Adriatic (Chioggia-Venice and Rovigo, Italy). SUSTAINABILITY 13(3)doi: 10.3390/su13031211.

Fichera, C. R., L. Laudari, and G. Modica. 2015. Application, validation and comparison in different geographical contexts of an integrated model for the design of ecological networks. Journal of Agricultural Engineering 46(2):52-61. doi: 10.4081/jae.2015.459

Fontaine, C. M., N. Dendoncker, R. De Vreese, I. Jacquemin, A. Marek, A. Van Herzele, G. Devillet, D. Mortelmans, and L. François. 2014. Towards participatory integrated valuation and modelling of ecosystem services under land-use change. Journal of Land Use Science 9(3):278-303. doi: 10.1080/1747423X.2013.786150

Frampton GK, Livoreil B, Petrokofsky G. (2017) Eligibility screening in evidence synthesis of environmental management topics. Environ Evid. BioMed Central; 6(1):27.

French law on the reconquest of biodiversity (n° 2016-1087 of 8 August 2016) Web: https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000033016237 accessed 25/08/2021

Gardner, T. A., Von Hase, A., Brownlie, S., Ekstrom, J. M. M., Pilgrim, J. D., Savy, C. E., Stephens, R. T. T., Treweek, J., Ussher, G. T., Ward, G., & Ten Kate, K. 2013. Biodiversity Offsets and the Challenge of Achieving No Net Loss. *Conservation Biology*, *27*(6), 1254–1264. https://doi.org/10.1111/cobi.12118

Gelot, S., and C. Bigard. 2021. Challenges to developing mitigation hierarchy policy: findings from a nationwide database analysis in France. BIOLOGICAL CONSERVATION 263doi: 10.1016/j.biocon.2021.109343

Geneletti, D. 2003. Biodiversity Impact Assessment of roads: an approach based on ecosystem rarity. Environmental Impact Assessment Review 23(3):343-365. doi: https://doi.org/10.1016/S0195-9255(02)00099-9

Gontier, M. 2007. Scale issues in the assessment of ecological impacts using a GIS-based habitat model - A case study for the Stockholm region. ENVIRONMENTAL IMPACT ASSESSMENT REVIEW 27(5):440-459. doi: 10.1016/j.eiar.2007.02.003

Gontier, M., Balfors, B., & Mörtberg, U. 2006. Biodiversity in environmental assessment—current practice and tools for prediction. Environmental impact assessment review 26(3):268-286.

Gonzalez-Redin, J., S. Luque, L. Poggio, R. Smith, and A. Gimona. 2016. Spatial Bayesian belief networks as a planning decision tool for mapping ecosystem services trade-offs on forested landscapes. ENVIRONMENTAL RESEARCH 144:15-26. doi: 10.1016/j.envres.2015.11.009

Gret-Regamey, A., A. Walz, and P. Bebi. 2008. Valuing ecosystem services for sustainable landscape planning in Alpine regions. Mountain Research and Development 28(2):156-165. doi: 10.1659/mrd.0951

Haines-Young, R. and M.B. Potschin (2018): Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Available from www.cices.eu

Hayes, G., S. Whitaker, S., Brooks, D., Marsh, A. Kowalska, B. Costelloe, P. Howard, B. Phalan, and B. Vira. 2015. Strengthening implementation of the mitigation hierarchy: managing biodiversity risk for conservation gains, The Cambridge Conservation Initiative Collaborative Fund.

Heinonen, T. 2019. Developing landscape connectivity in commercial boreal forests using minimum spanning tree and spatial optimization. CANADIAN JOURNAL OF FOREST RESEARCH 49(10):1198-1206. doi: 10.1139/cjfr-2018-0480

Honrado, J. P., C. Vieira, C. Soares, M. B. Monteiro, B. Marcos, H. M. Pereira, and M. R. Partidario. 2013. Can we infer about ecosystem services from EIA and SEA practice? A framework for analysis and examples from Portugal. ENVIRONMENTAL IMPACT ASSESSMENT REVIEW 40:14-24. doi: 10.1016/j.eiar.2012.12.002

Iberdrola. 2019. *We protect biodiversity*. Iberdrola. https://www.iberdrola.com/sustainability/environment/iberdrola-biodiversity

ICES. (2016). *Report of the OSPAR/HELCOM/ICES Working Group on Marine Birds (JWGBIRD). October* 10–14.

Jagerbrand, A. K., and C. A. Bouroussis. 2021. Ecological Impact of Artificial Light at Night: Effective Strategies and Measures to Deal with Protected Species and Habitats. SUSTAINABILITY 13(11)doi: 10.3390/su13115991

Karrasch, L., T. Klenke, and J. Woltjer. 2014. Linking the ecosystem services approach to social preferences and needs in integrated coastal land use management - A planning approach. LAND USE POLICY 38:522-532. doi: 10.1016/j.landusepol.2013.12.010

Khoshkar, S., Hammer, M., Borgström, S., Dinnétz, P., & Balfors, B. 2020. Moving from vision to action-integrating ecosystem services in the Swedish local planning context. Land use policy 97:104791.

Koschke, L., C. Furst, M. Lorenz, A. Witt, S. Frank, and F. Makeschin. 2013. The integration of crop rotation and tillage practices in the assessment of ecosystem services provision at the regional scale. ECOLOGICAL INDICATORS 32:157-171. doi: 10.1016/j.ecolind.2013.03.008

Kovacs, E., V. Fabok, A. Kaloczkai, and H. P. Hansen. 2016. Towards understanding and resolving the conflict related to the Eastern Imperial Eagle (Aquila heliaca) conservation with participatory management planning. LAND USE POLICY 54:158-168. doi: 10.1016/j.landusepol.2016.02.011

Kowarik, I. 2021. Working With Wilderness: A Promising Direction for Urban Green Spaces. *Landscape Architecture Frontiers*, *9*(1), 92–104.

Kurttila, M., J. Uuttera, S. Mykra, S. Kurki, and T. Pukkala. 2002. Decreasing the fragmentation of old forests in landscapes involving multiple ownership in Finland: economic, social and ecological consequences. FOREST ECOLOGY AND MANAGEMENT 166(1-3):69-84. doi: 10.1016/S0378-1127(01)00663-6

Kyriazi, Z., F. Maes, and S. Degraer. 2016. Coexistence dilemmas in European marine spatial planning practices. The case of marine renewables and marine protected areas. ENERGY POLICY 97:391-399. doi: 10.1016/j.enpol.2016.07.018

Lai, S., F. Leone, and C. Zoppi. 2017. Strategic environmental assessment and enhancement of ecosystem services: A study concerning spatial planning in Sardinia (Italy), Urban Planning and Renewal. Nova Science Publishers, Inc. p. 61-84.

Lakner, S., Y. Zinngrebe, and D. Koemle. 2020. Combining management plans and payment schemes for targeted grassland conservation within the Habitats Directive in Saxony, Eastern Germany. LAND USE POLICY 97doi: 10.1016/j.landusepol.2020.104642

Langemeyer, J., E. Gomez-Baggethun, D. Haase, S. Scheuer, and T. Elmqvist. 2016a. Bridging the gap between ecosystem service assessments and land-use planning through Multi-Criteria Decision Analysis (MCDA). ENVIRONMENTAL SCIENCE & POLICY 62:45-56. doi: 10.1016/j.envsci.2016.02.013

Langemeyer, J., E. Gómez-Baggethun, D. Haase, S. Scheuer, and T. Elmqvist. 2016b. Bridging the gap between ecosystem service assessments and land-use planning through Multi-Criteria Decision Analysis (MCDA). Environmental Science & Policy 62:45-56. doi: 10.1016/j.envsci.2016.02.013

Leone, F., and C. Zoppi. 2019. Local Development and Protection of Nature in Coastal Zones: A Planning Study for the Sulcis Area (Sardinia, Italy). SUSTAINABILITY 11(18)doi: 10.3390/su11185095

Lerouge F, Gulinck H, & Vranken L. 2017. Valuing ecosystem services to explore scenarios for adaptive spatial planning. *Ecological Indicators*, *81*, 30–40. https://doi.org/10.1016/j.ecolind.2017.05.018

Liquete, C., Kleeschulte, S., Dige, G., Maes, J., Grizzetti, B., Olah, B., & Zulian, G. 2015. Mapping green infrastructure based on ecosystem services and ecological networks: A Pan-European case study. *Environmental Science and Policy*, *54*, 268–280. https://doi.org/10.1016/j.envsci.2015.07.009

Livoreil B, Glanville J, Haddaway NR, Bayliss H, Bethel A, de Lachapelle FF, et al. (2017) Systematic searching for environmental evidence using multiple tools and sources. Environ Evid. BioMed Central; 6(1):23.

Logmani, J., M. Krott, M. T. Lecyk, and L. Giessen. 2017. Customizing elements of the International Forest Regime Complex in Poland? Non-implementation of a National Forest Programme and redefined transposition of NATURA 2000 in Bialowieza Forest. FOREST POLICY AND ECONOMICS 74:81-90. doi: 10.1016/j.forpol.2016.11.004

Lukey, P., Paras, S., (2017). The Environmental Impact Mitigation Hierarchy as a Hierarchy of Risk. J Biodivers Biopros Dev 04. https://doi.org/10.4172/2376-0214.1000166.

Madsen, J., J. H. Williams, F. A. Johnson, I. M. Tombre, S. Dereliev, and E. Kuijken. 2017. Implementation of the first adaptive management plan for a European migratory waterbird population: The case of the Svalbard pink-footed goose Anser brachyrhynchus. AMBIO 46:275-289. doi: 10.1007/s13280-016-0888-0

Maes, J., Egoh, B., Willemen, L., Liquete, C., Vihervaara, P., Schägner, J. P., Grizzetti, B., Drakou, E. G., Notte, A. L., Zulian, G., Bouraoui, F., Luisa Paracchini, M., Braat, L., & Bidoglio, G. 2012. Mapping ecosystem services for policy support and decision-making in the European Union. *Ecosystem Services*, *1*(1), 31–39. https://doi.org/10.1016/j.ecoser.2012.06.004

Maes, J., Liekens, I., & Brown, C. 2018. Which questions drive the Mapping and Assessment of Ecosystems and their Services under Action 5 of the EU Biodiversity Strategy? *One Ecosystem*, *3*, e25309. https://doi.org/10.3897/oneeco.3.e25309

Markantonatou, V., S. Giakoumi, N. Koukourouvli, I. Maina, G. Gonzalez-Mirelis, M. Sini, K. Maistrelis, M. Stithou, E. Gadolou, D. Petza, S. Kavadas, V. Vassilopoulou, L. Buhl-Mortensen, and S. Katsanevakis. 2021. Marine spatial plans focusing on biodiversity conservation: The case of the Aegean Sea. AQUATIC CONSERVATION-MARINE AND FRESHWATER ECOSYSTEMS 31(8):2278-2292. doi: 10.1002/aqc.3610

Mazziotta, A., D. Podkopaev, M. Trivino, K. Miettinen, T. Pohjanmies, and M. Monkkonen. 2017. Quantifying and resolving conservation conflicts in forest landscapes via multiobjective optimization. SILVA FENNICA 51(1)doi: 10.14214/sf.1778

Mejía, C. V., L. Shirotova, and I. F. M. De Almeida. 2015. Green infrastructure and German landscape planning: A comparison of approaches. Urbani Izziv 26:S25-S37. doi: 10.5379/urbani-izziv-en-2015-26-supplement-002.

McKenney, B.A., Kiesecker, J.M. (2010) Policy Development for Biodiversity Offsets: A Review of Off-set Frameworks. Environmental Management 45, 165–176. https://doi.org/10.1007/s00267-009-9396-3.

Millennium Ecosystem Assessment (Program) (ed). (2005) Ecosystems and human well-being: synthesis. Washington, DC: Island Press, 2005.

Moreira, F. 2019. Love me, love me not: Perceptions on the links between the energy sector and biodiversity conservation. ENERGY RESEARCH & SOCIAL SCIENCE 51:134-137. doi: 10.1016/j.erss.2019.01.002

Muratet, A., N. Machon, F. Jiguet, J. Moret, and E. Porcher. 2007. The role of urban structures in the distribution of wasteland flora in the greater Paris area, France. ECOSYSTEMS 10(4):661-671. doi: 10.1007/s10021-007-9047-6

Nedkov, S., Borisova, B., Koulov, B., Zhiyanski, M., Bratanova-Doncheva, S., Nikolova, M., & Kroumova, J. 2018. Towards integrated mapping and assessment of ecosystems and their services in Bulgaria: The Central Balkan case study. *One Ecosystem*, *3*, e25428. https://doi.org/10.3897/oneeco.3.e25428

Ottersen, G., Olsen, E., van der Meeren, G., Dommasnes, A., & Loeng, H. 2011. The Norwegian plan for integrated ecosystem-based management of the marine environment in the Norwegian Sea. *MARINE POLICY*, *35*(3), 389–398. https://doi.org/10.1016/j.marpol.2010.10.017

Pappila, M. 2018. Forestry and no net loss principle. The possibilities and need to implement NNL in forest management in Finland. Nordic Environmental Law Journal: 55–79.

Phalan, B., Hayes, G., Brooks, S., Marsh, D., Howard, P., Costelloe, B. Whitaker, S. (2018). Avoiding impacts on biodiversity through strengthening the first stage of the mitigation hierarchy. Oryx, 52(2), 316-324. doi:10.1017/S0030605316001034.

Pilgrim, J. B., Susie & Ekstrom, Jonathan & Gardner, Toby & Hase, Amrei & Ten Kate, Kerry & Savy, Conrad & Stephens, R. & Temple, Helen & Treweek, Jo & Ussher, Graham & Ward, Gerri. 2013. A process for assessing the offset ability of biodiversity impacts. Conservation Letters 6.

Préau, C., Bertrand, R., Sellier, Y., Grandjean, F. and Isselin-Nondedeu, F., 2022. Climate change would prevail over land use change in shaping the future distribution of Triturus marmoratus in France. Animal Conservation, 25(2), pp.221-232.

Põder, T. 2006. Evaluation of environmental aspects significance in ISO 14001. Environmental Management 37(5):732-743. doi: 10.1007/s00267-004-0190-y

Pontoppidan MB & Nachman G. 2013. Spatial Amphibian Impact Assessment—A management tool for assessment of road effects on regional populations of Moor frogs (Rana arvalis). *Nature Conservation-Bulgaria*, *5*, 29–52. https://doi.org/10.3897/natureconservation.5.4612

Pope, J., Bond, A., Morrison-Saunders, A., & Retief, F. 2013. Advancing the theory and practice of impact assessment: Setting the research agenda. *Environmental Impact Assessment Review*, *41*, 1–9. https://doi.org/10.1016/j.eiar.2013.01.008

Ribeiro, F. P., & Ribeiro, K. T. 2016. Participative mapping of cultural ecosystem services in Pedra Branca State Park, Brazil. *Natureza & Conservação*, *14*(2), 120–127. https://doi.org/10.1016/j.ncon.2016.09.004

Quétier, F., Regnery, B., & Levrel, H. (2014). No net loss of biodiversity or paper offsets? A critical review of the French no net loss policy. Environmental Science & Policy, 38, 120-131.

Quétier, F., Moura, C., Menut, T., Boulnois, R., & Rufray, X. 2015. La compensation écologique fonctionnelle: innover pour mieux traiter les impacts résiduels des projets d'aménagements sur la biodiversité. Sciences Eaux Territoires 2:24-29.

Rainey, H. J., Pollard, E. H. B., Dutson, G., Ekstrom, J. M. M., Livingstone, S. R., Temple, H. J., & Pilgrim, J. D. 2015. A review of corporate goals of No Net Loss and Net Positive Impact on biodiversity. *Oryx*, *49*(2), 232–238. https://doi.org/10.1017/S0030605313001476

Ramel, C., P. L. Rey, R. Fernandes, C. Vincent, A. R. Cardoso, O. Broennimann, L. Pellissier, J. N. Pradervand, S. Ursenbacher, B. R. Schmidt, and A. Guisan. 2020. Integrating ecosystem services within spatial biodiversity conservation prioritization in the Alps. ECOSYSTEM SERVICES 45doi: 10.1016/j.ecoser.2020.101186

Ruskule, A., Klepers, A., & Veidemane, K. 2018. Mapping and assessment of cultural ecosystem services of Latvian coastal areas. *One Ecosystem*, *3*, e25499. https://doi.org/10.3897/oneeco.3.e25499

Sahraoui, Y., C. D. Leski, M. L. Benot, F. Revers, D. Salles, I. van Halder, M. Barneix, and L. Carassou. 2021. Integrating ecological networks modelling in a participatory approach for assessing impacts of planning scenarios on landscape connectivity. LANDSCAPE AND URBAN PLANNING 209doi: 10.1016/j.landurbplan.2021.104039

Santos-Martin, F., Viinikka, A., Mononen, L., Brander, L., Vihervaara, P., Liekens, I., & Potschin-Young, M. 2018. Creating an operational database for Ecosystems Services Mapping and Assessment Methods. *One Ecosystem*, *3*, e26719. https://doi.org/10.3897/oneeco.3.e26719

Seddon, N., Chausson, A., Berry, P., Girardin, C.A., Smith, A. and Turner, B., 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society B, 375(1794), p.20190120.

Schulp, C. J. E., A. J. A. Van Teeffelen, G. Tucker, and P. H. Verburg. 2016. A quantitative assessment of policy options for no net loss of biodiversity and ecosystem services in the European Union. LAND USE POLICY 57:151-163. doi: 10.1016/j.landusepol.2016.05.018

Sheate, W. R., M. R. D. Partidário, H. Byron, O. Bina, and S. Dagg. 2008. Sustainability assessment of future scenarios: Methodology and application to mountain areas of Europe. Environmental Management 41(2):282-299. doi: 10.1007/s00267-007-9051-9

Simeonova, V., E. Achterberg, and E. A. van der Grift. 2019. Implementing ecological networks through the Red for Green approach in a densely populated country: Does it work? ENVIRONMENT DEVELOPMENT AND SUSTAINABILITY 21(1):115-143. doi: 10.1007/s10668-017-0026-6

Simeonova, V., and A. van der Valk. 2016. Environmental policy integration: Towards a communicative approach in integrating nature conservation and urban planning in Bulgaria. LAND USE POLICY 57:80-93. doi: 10.1016/j.landusepol.2016.05.017

Tallis, H., Kennedy, C.M., Ruckelshaus, M., Goldstein, J., Kiesecker, J.M. (2016). Mitigation for the people: an ecosystem services framework. In: Geneletti, D (Ed). Handbook on biodiversity and ecosystem services in impact assessment, Edward Elgar Publishing, 41-61.

Tarabon, S., L. Berges, T. Dutoit, and F. Isselin-Nondedeu. 2019a. Environmental impact assessment of development projects improved by merging species distribution and habitat connectivity modelling. JOURNAL OF ENVIRONMENTAL MANAGEMENT 241:439-449. doi: 10.1016/j.jenvman.2019.02.031

Tarabon, S., L. Berges, T. Dutoit, and F. Isselin-Nondedeu. 2019b. Maximizing habitat connectivity in the mitigation hierarchy. A case study on three terrestrial mammals in an urban environment. JOURNAL OF ENVIRONMENTAL MANAGEMENT 243:340-349. doi: 10.1016/j.jenvman.2019.04.121

Tillemann, K., M. Suškevičs, and M. Külvik. 2021. Ecological network as a multi-level spatial planning too for biodiversity conservation: Analysis of an Estonian case study. Tiltai 70(1):83-98. doi: 10.15181/tbb.v69i1.1052

The Biodiversity Consultancy, (2021). Net Positive and the Mitigation Hierarchy. https://www.thebiodiversityconsultancy.com/approaches/mitigation-hierarchy/, accessed 03/08/2021.

Thomas, J.; Graziosi, S.; Brunton, J.; Ghouze, Z.; O'Driscoll, P.; Bond, M. EPPI-Reviewer: (2020) Advanced Software for Systematic Reviews, Maps and Evidence Synthesis; EPPI-Centre Software; UCL Social Research Institute: London, UK, 2020.

Toivonen, T., J. Kuustera, J. Jalkanen, A. S. Kukkala, J. Lehtomäki, S. Aalto, and A. Moilanen. 2021. Spatial Conservation Prioritisation as Part of a General Land Use Planning Process. doi: 10.21203/rs.3.rs-182680/v1

Turkelboom, F., M. Leone, S. Jacobs, E. Kelemen, M. García-Llorente, F. Baró, M. Termansen, D. N. Barton, P. Berry, E. Stange, M. Thoonen, Á. Kalóczkai, A. Vadineanu, A. J. Castro, B. Czúcz, C. Röckmann, D. Wurbs, D. Odee, E. Preda, E. Gómez-Baggethun, G. M. Rusch, G. M. Pastur, I. Palomo, J. Dick, J. Casaer,

J. van Dijk, J. A. Priess, J. Langemeyer, J. Mustajoki, L. Kopperoinen, M. J. Baptist, P. L. Peri, R. Mukhopadhyay, R. Aszalós, S. B. Roy, S. Luque, and V. Rusch. 2018. When we cannot have it all: Ecosystem services trade-offs in the context of spatial planning. Ecosystem Services 29:566-578. doi: 10.1016/j.ecoser.2017.10.011

van Teeffelen, A. J., Opdam, P., Wätzold, F., Hartig, F., Johst, K., Drechsler, M., ... & Quétier, F. 2014. Ecological and economic conditions and associated institutional challenges for conservation banking in dynamic landscapes. Landscape and Urban Planning 130:64-72.

Voigt, C. C., C. Azam, J. J. A. Dekker, J. Ferguson, M. Fritze, S. Gazaryan, F. Hölker, G. Jones, N. Leader, D. Lewanzik, H. Limpens, F. Mathews, J. Rydell, H. Schofield, K. Spoelstra, and M. Zagmajster. 2018. Guidelines for consideration of bats in lighting projects.

Weiland, U. 2010. Strategic Environmental Assessment in Germany - Practice and open questions. Environmental Impact Assessment Review 30(3):211-217. doi: 10.1016/j.eiar.2009.08.010

ANNEXES

ANNEXE 1: THE PERFORMANCE OF THE SEARCH STRING.

(The final search string is in bold)

Search string	Hits (WoSCC)	Hits (Scopus)	Date	Who did the search	Which access	Comments	Test list articles found in WoSCC	Articles not found in testing
”Mitigation hierarchy” AND ”avoid$stage”	0		19.7. 2021	Sini Savilaakso	University of Helsinki			
”Mitigation hierarchy”	125		19.7. 2021	Sini Savilaakso	University of Helsinki			
”mitigation hierarchy” AND avoid*	58		19.7. 2021	Sini Savilaakso	University of Helsinki			
mitigation AND avoid AND biodiversity	317		19.7. 2021	Sini Savilaakso	University of Helsinki			
mitigat* AND avoid* AND biodiversity	516		19.7. 2021	Sini Savilaakso	University of Helsinki			

mitigat* AND (avoid* OR prevent*) AND biodiversity	966		19.7. 2021	Sini Savilaakso	University of Helsinki				
mitigat* AND (avoid* OR prevent*) AND biodiversity AND Europ*	219		19.7. 2021	Sini Savilaakso	University of Helsinki				
mitigat* AND (avoid* OR prevent*) AND "ecosystem service*"	452		19.7. 2021	Sini Savilaakso	University of Helsinki				
mitigat* AND (avoid* OR prevent*) AND (ecosystem service* OR biodiversity)	1230		19.7. 2021	Sini Savilaakso	University of Helsinki				
(biodiversity OR "ecosystem services") AND mitigat*	9328		19.7. 2021	Sini Savilaakso	University of Helsinki				
(avoid* OR prevent*) AND (ecosystem service* OR biodiversity)	11530		19.7. 2021	Sini Savilaakso	University of Helsinki				
"mitigation hierarchy" AND biodiversity	111		21.7. 2021	Sini Savilaakso	University of Helsinki				
mitigation AND hierarchy	894	988	25.8. 2021	Sylvie Campagne	CNRS, France				

mitigation AND hierarchy AND avoid	71	56	25.8. 2021	Sylvie Campagne	CNRS, France			
mitigation AND hierarchy AND "ecosystem services*"	48	35	25.8. 2021	Sylvie Campagne	CNRS, France			
mitigation AND hierarchy AND ("ecosystem services*" OR biodiversity)	143	160	25.8. 2021	Sylvie Campagne	CNRS, France			
mitigation hierarchy "ecosystem services*" biodiversity			25.8. 2021	Sylvie Campagne	CNRS, France			
avoid* AND "ecosystem services*"	1156							

(avoid* OR prevent* OR mitigat*) AND (ecosystem service* OR biodiversity OR "nature's contribution to people" OR aesthet* OR "air quality" OR aquacultur* OR art OR assimilat* OR attenuat* OR biodiversity OR biofilt* OR "biogeochemical services" OR biomass OR bioremediation OR biosecurity OR birdwatching OR buffer* OR catch OR "coastal protection" OR cognitive OR conservat* OR control OR cultur* OR denitrificat* OR deposit* OR detoxific* OR disease OR diversity OR "ecosystem services" OR ecosystem* OR ecotouris* OR filter* OR fish* OR habitat OR harvest* OR hunting OR identity OR improve* OR informat* OR inspirat* OR leisure OR minerali* OR mitigat* OR "non-consumptive use" OR nursery OR "nutrient cycl*" OR "nutrient recycl*" OR pest OR photosynthesis OR pollinat* OR prevention OR product* OR provision* OR purificat* OR "quality maint*" OR "raw materials" OR recreat* OR reduct* OR refug* OR regenerat* OR regulat* OR remov* OR research OR resources OR retent* OR sequestrat* OR stabilisation OR storage OR touris* OR treatment OR uptake OR "water quality" OR wildlife)	2248362		8.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat*) AND (ecosystem service* OR biodiversity OR "nature's contribution to people" OR aesthet* OR "air quality" OR aquacultur* OR biofilt* OR "biogeochemical services" OR bioremediation OR biosecurity OR birdwatching OR "coastal protection" OR denitrificat* OR deposit* OR detoxific* OR ecotouris* OR filter* OR hunting OR leisure OR minerali* OR "non-consumptive use" OR "nutrient cycl*" OR "nutrient recycl*" OR pest OR photosynthesis OR pollinat* OR prevention OR product* OR provision* OR purificat* OR "quality maint*" OR recreat* OR refug* OR regulat* OR resources OR retent* OR sequestrat* OR stabilisation OR storage OR touris* OR "water quality" OR wildlife)	1298326		8.9. 2021	Sini Savilaakso	University of Helsinki			

(avoid* OR prevent* OR mitigat*) AND (ecosystem service* OR biodiversity OR "nature's contribution to people")	17923		8.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat*) AND (ecosystem service* OR biodiversity OR "nature's contribution to people" OR aesthet*)	23003		8.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat* OR "land use planning") AND (ecosystem service* OR biodiversity OR "nature's contribution to people")	18758		8.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat* OR "land use planning" OR "impact assessment") AND (ecosystem service* OR biodiversity OR "nature's contribution to people")	19773		8.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat* OR "land use planning" OR "impact assessment" OR "environmental compensation") AND (ecosystem service* OR biodiversity OR "nature's contribution to people")	19787		8.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat* OR "land use planning" OR "impact assessment" OR "environmental compensation") AND (ecosystem service* OR biodiversity)	19786		8.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat* OR "land use planning" OR "impact assessment" OR "environmental compensation") AND (ecosystem service* OR biodiversity OR "blue infrastructure" OR "green infrastructure" OR "green space" OR "blue space")	20907		9.9. 2021	Sini Savilaakso	University of Helsinki			

(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″impact assessment″ OR ″environmental compensation″) AND (ecosystem service* OR biodiversity OR ″blue infrastructure″ OR ″green infrastructure″ OR ″green space″ OR ″blue space″ OR ″urban green*″)			9.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat* OR ″impact assessment″ OR ″environmental compensation″) AND ((ecosystem service* OR biodiversity) OR ((″ecosystem service*″ OR biodiversity) NEAR5 (″land use planning″ OR ″blue infrastructure″ OR ″green infrastructure″ OR ″green space″ OR ″blue space″)))	18982		9.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat* OR ″impact assessment″ OR ″environmental compensation″) AND ((ecosystem service* OR biodiversity) OR ((″ecosystem service*″ OR biodiversity) NEAR5 (″land use planning″ OR ″blue infrastructure″ OR ″green infrastructure″ OR ″green space″ OR ″blue space″ OR ″urban green*″)))	18982		9.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat* OR ″impact assessment″) AND ((ecosystem service* OR biodiversity) OR ((″ecosystem service*″ OR biodiversity) NEAR5 (″land use planning″ OR ″blue infrastructure″ OR ″green infrastructure″ OR ″green space″ OR ″blue space″)))	18968		9.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″impact assessment″ OR ″environmental compensation″) AND (ecosystem service* OR biodiversity OR ″nature′s contribution to people″)	13782		9.9. 2021	Sini Savilaakso	University of Helsinki	Title, abstract and author keywords only		

(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″impact assessment″ OR ″environmental compensation″) AND (ecosystem service* OR biodiversity OR ″nature′s contribution to people″)	13794		9.9. 2021	Sini Savilaakso	University of Helsinki			
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″impact assessment″ OR ″environmental compensation″) AND (ecosystem service* OR biodiversity OR ″nature′s contribution to people″)	14371		9.9. 2021	Sini Savilaakso	University of Helsinki	Title, abstract and author keywords only		
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″impact assessment″ OR ″environmental compensation″) AND (ecosystem service* OR biodiversity OR ″nature′s contribution to people″)	20832		9.9. 2021	Sini Savilaakso	University of Helsinki	Topic search		
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″impact assessment″ OR ″environmental compensation″) AND (ecosystem service* OR ″environmental services″ OR ″ecological services″ OR biodiversity OR ″nature′s contribution to people″)	21140		9.9. 2021	Sini Savilaakso	University of Helsinki	Topic search		
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″impact assessment″ OR ″environmental compensation″) AND (ecosystem service* OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″)	21176		9.9. 2021	Sini Savilaakso	University of Helsinki	Topic search		

(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″impact assessment″ OR ″environmental compensation″) AND (ecosystem service* OR ″ecosystem goods and services″ OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″)	21217	14964	14.9. 2021	Sini Savilaakso	University of Helsinki	Topic search	3/4	Almeida et al. 2018
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″impact assessment″ OR “county plan*” OR “municipal* plan*” OR “theme plan*”OR ″environmental compensation″) AND (ecosystem service* OR ″ecosystem goods and services″ OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″)	21252	14985	15.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC	4/4, 5/5	
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″impact assessment″ OR “county plan*” OR “municipal* plan*” OR “theme plan*”OR ″environmental compensation″) AND (ecosystem service* OR ″ecosystem goods and services″ OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″ OR ″nature value*″)	21326		21.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC		
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″impact assessment″ OR “county plan*” OR “municipal* plan*” OR “theme plan*”OR ″environmental compensation″) AND (ecosystem service* OR ″ecosystem goods and services″ OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″ OR ″natural capital″)	21404		21.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC	6/7	Almeida et al. 2018

(avoid* OR prevent* OR mitigat* OR "land use planning" OR "urban greening" OR "spatial planning" OR "impact assessment" OR "county plan*" OR "municipal* plan*" OR "theme plan*"OR "environmental compensation") AND (ecosystem service* OR "ecosystem goods and services" OR "environmental service*" OR "ecological service*" OR biodiversity OR "nature's contribution to people")	21301		21.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC	6/7	Almeida et al. 2018
(avoid* OR prevent* OR mitigat* OR "land use planning" OR "urban greening" OR "spatial planning" OR "impact assessment" OR "county plan*" OR "municipal* plan*" OR "theme plan*"OR "environmental compensation") AND (ecosystem service* OR "ecosystem goods and services" OR "environmental service*" OR "ecological service*" OR biodiversity OR "nature's contribution to people" OR "nature value" OR "natural capital")	21420		21.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC	6/7	Almeida et al. 2018
(avoid* OR prevent* OR mitigat* OR "land use planning" OR "urban greening" OR "spatial planning" OR "impact assessment" OR "county plan*" OR "municipal* plan*" OR "theme plan*"OR "environmental compensation" OR "marine spatial planning") AND (ecosystem service* OR "ecosystem goods and services" OR "environmental service*" OR "ecological service*" OR biodiversity OR "nature's contribution to people" OR "nature value" OR "natural capital")	21420		21.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC		

(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″impact assessment″ OR "county plan*" OR "municipal* plan*" OR "theme plan*"OR ″environmental compensation″ OR ″green corridors″) AND (ecosystem service* OR ″ecosystem goods and services″ OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″ OR ″nature value″ OR ″natural capital″)	21467		21.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC		
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″impact assessment″ OR "county plan*" OR "municipal* plan*" OR "theme plan*"OR ″environmental compensation″ OR ″green corridors″ OR ″functional urban area*″) AND (ecosystem service* OR ″ecosystem goods and services″ OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″ OR ″nature value″ OR ″natural capital″)	21473		21.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC		
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″marine planning″ OR ″impact assessment″ OR ″county plan*″ OR ″municipal* plan*″ OR ″theme plan*″ OR ″environmental compensation″ OR ″green corridors″ OR ″functional urban area*″) AND (ecosystem service* OR ″ecosystem goods and services″ OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″ OR ″nature value″ OR ″natural capital″)	21498		21.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC	6/7	Almeida et al. 2018

(avoid* OR prevent* OR mitigat* OR ˝land use planning˝ OR ˝urban greening˝ OR ˝spatial planning˝ OR ˝marine planning˝ OR ˝impact assessment˝ OR ˝county plan*˝ OR ˝municipal* plan*˝ OR ˝theme plan*˝ OR ˝environmental compensation˝ OR ˝green corridors˝ OR ˝functional urban area*˝) AND (˝ecosystem service*˝ OR ˝ecosystem goods and services˝ OR ˝environmental service*˝ OR ˝ecological service*˝ OR biodiversity OR ˝nature´s contribution to people˝ OR ˝nature value˝ OR ˝natural capital˝)	20512		23.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC	6/7	Almeida et al. 2018
(avoid* OR prevent* OR mitigat* OR ˝land use planning˝ OR ˝management plan*˝ OR ˝urban greening˝ OR ˝spatial planning˝ OR ˝marine planning˝ OR ˝impact assessment˝ OR ˝county plan*˝ OR ˝municipal* plan*˝ OR ˝theme plan*˝ OR ˝environmental compensation˝ OR ˝green corridors˝ OR ˝functional urban area*˝) AND (˝ecosystem service*˝ OR ˝ecosystem goods and services˝ OR ˝environmental service*˝ OR ˝ecological service*˝ OR biodiversity OR ˝nature´s contribution to people˝ OR ˝nature value˝ OR ˝natural capital˝)	22114	26,584	23.9. 2021	Sini Savilaakso (WoSCC) / Sylvie Campagne (Scopus)	University of Helsinki / CNRS, France	Topic search in WoSCC	7/8	Almeida et al. 2018
(avoid* OR prevent* OR mitigat* OR ˝land use planning˝ OR ˝urban greening˝ OR ˝spatial planning˝ OR ˝marine planning˝ OR ˝impact assessment˝ OR ˝county plan*˝ OR ˝municipal* plan*˝ OR ˝theme plan*˝ OR ˝environmental compensation˝ OR ˝green corridors˝ OR ˝functional urban area*˝) AND (˝ecosystem service*˝ OR ˝ecosystem goods and services˝ OR ˝environmental service*˝ OR ˝ecological service*˝ OR biodiversity OR ˝nature´s contribution to people˝ OR ˝nature value˝ OR ˝natural capital˝)	20512	24,817	23.9. 2021	Sini Savilaakso (WoSCC) / Sylvie Campagne (Scopus)	University of Helsinki / CNRS, France	Topic search in WoSCC		

(avoid* OR prevent* OR mitigat* OR ″impact assessment″ OR ″environmental compensation″) AND (″land use planning″ OR ″urban greening″ OR ″spatial planning″ OR ″marine planning″ OR ″county plan*″ OR ″municipal* plan*″ OR ″theme plan*″ OR ″green corridors″) AND (″ecosystem service*″ OR ″ecosystem goods and services″ OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″ OR ″nature value″ OR ″natural capital″)	406		23.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC		
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″management plan*″ OR ″urban greening″ OR ″spatial planning″ OR ″marine planning″ OR ″impact assessment″ OR ″county plan*″ OR ″municipal* plan*″ OR ″theme plan*″ OR ″environmental compensation″ OR ″green corridors″ OR ″functional urban area*″) AND (″ecosystem service*″ OR ″ecosystem goods and services″ OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″ OR ″nature value″ OR ″natural capital″)	22123	25959	23.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC; title, abstract, keywords in Scopus	8/8	
(avoid* OR prevent* OR mitigat* OR ″land use planning″ OR ″management plan*″ OR ″urban greening″ OR ″spatial planning″ OR ″marine planning″ OR ″impact assessment″ OR ″county plan*″ OR ″municipal* plan*″ OR ″theme plan*″ OR ″environmental compensation″ OR ″green corridors″) AND (″ecosystem service*″ OR ″ecosystem goods and services″ OR ″environmental service*″ OR ″ecological service*″ OR biodiversity OR ″nature′s contribution to people″ OR ″nature value″ OR ″natural capital″)	22117		23.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC	8/8	

(avoid* OR prevent* OR mitigat* OR "land use planning" OR "management plan*" OR "urban greening" OR "spatial planning" OR "marine planning" OR "impact assessment" OR "county plan*" OR "municipal* plan*" OR "theme plan*" OR "environmental compensation" OR "green corridors" OR "functional urban area*") AND ("ecosystem service*" OR "ecosystem goods and services" OR "ecosystem function and services" OR "environmental service*" OR "ecological service*" OR biodiversity OR "nature's contribution to people" OR "nature value" OR "natural capital")	22163		29.9. 2021	Sini Savilaakso	University of Helsinki	Topic search in WoSCC; title, abstract, keywords in Scopus	8/8	

ANNEXE 2: LIST OF ARTICLES USED TO TEST THE COMPREHENSIVENESS OF THE SEARCH STRING

1. Almeida, E. de L.; Nascimento, A.P.B. do; Gallardo, A.L.C.F.; Claudio, C.F.B.R. & Ruiz, M.S. (2018) Contribuições da avaliação de impacto ambiental à redução dos impactos dobre a biodiversidade em região de alto fluxo turístico em São Paulo, Brasil. Revista Rosa dos Ventos Turismo e Hospitalidade, 10(3),pp. 464-482, DOI: http://dx.doi.org/10.18226/21789061.v10i3p464.

2. [Contributions of Environmental Impact Assessment to Reduce Impacts on Biodiversity in a High Tourism Flow Region in São Paulo, Brazil]

3. Laurent Bergès, Catherine Avon, Lucie Bezombes, Céline Clauzel, Rémi Duflot, Jean-Christophe Foltête, Stéphanie Gaucherand, Xavier Girardet, Thomas Spiegelberger (2020) Environmental mitigation hierarchy and biodiversity offsets revisited through habitat connectivity modelling, Journal of Environmental Management, Volume 256, 109950, DOI: https://doi.org/10.1016/j.jenvman.2019.109950.

4. Hansen, K., Malmaeus, M., Hasselström, L., Lindblom, E., Norén, K., Olshammar, M., Söderqvist, T., & Soutukorva, Å. (2018). Integrating ecosystem services in Swedish environmental assessments: an empirical analysis. Impact Assessment and Project Appraisal, 36(3), 253–264. https://doi.org/10.1080/14615517.2018.1445178

5. Timo P. Karjalainen, Mika Marttunen, Simo Sarkki, Anne-Mari Rytkönen (2013) Integrating ecosystem services into environmental impact assessment: An analytic–deliberative approach. Environmental Impact Assessment Review, Volume 40, Pages 54-64, https://doi.org/10.1016/j.eiar.2012.12.001.

6. Phalan, B., Hayes, G., Brooks, S., Marsh, D., Howard, P., Costelloe, B., . . . Whitaker, S. (2018). Avoiding impacts on biodiversity through strengthening the first stage of the mitigation hierarchy. Oryx, 52(2), 316-324. doi:10.1017/S0030605316001034

7. Rozas-Vásquez, D., Fürst, C., & Geneletti, D. (2019). Integrating ecosystem services in spatial planning and strategic environmental assessment: The role of the cascade model. Environmental Impact Assessment Review, 78(February), 106291. https://doi.org/10.1016/j.eiar.2019.106291

8. Heather Tallis, Christina M. Kennedy, Mary Ruckelshaus, Joshua Goldstein, Joseph M. Kiesecker (2015) Mitigation for one & all: An integrated framework for mitigation

of development impacts on biodiversity and ecosystem services. Environmental Impact Assessment Review, Volume 55, Pages 21-34, DOI: https://doi.org/10.1016/j.eiar.2015.06.005.

9. Léa Tardieu, Sébastien Roussel, John D. Thompson, Dorothée Labarraque, Jean-Michel Salles (2015). Combining direct and indirect impacts to assess ecosystem service loss due to infrastructure construction, Journal of Environmental Management, Volume 152, Pages 145-157.

ANNEXE 3: SEARCH STRINGS

https://docs.google.com/spreadsheets/d/1OhVeTem51QkI2IgqA7eCQkzvP4OMn8rC/edit#gid=634614416

ANNEXE 4: ORGANISATIONS WITH RELEVANT LITERATURE ON MITIGATION HIERARCHY (FULL LIST OF ORGANISATIONS)

Organisation	Website
ACCOBAMS (The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area)	https://accobams.org/news-pubblications/outreach-materials/
Offshore Coalition for Energy and Nature	https://offshore-coalition.eu/publications
ICES (International Council of the Exploration of the Sea)/OSPAR	https://ices-library.figshare.com/search
HELCOM	https://helcom.fi/helcom-at-work/publications/
IUCN	https://portals.iucn.org/library/dir/publications-list
IUCN	https://portals.iucn.org/library/search
OFB	https://www.ofb.gouv.fr/documentation
FRB	https://www.fondationbiodiversite.fr/publications/
CEREMA	https://www.cerema.fr/fr/centre-ressources/boutique/general
these.fr	https://theses.fr/
IFREMER	https://archimer.ifremer.fr/search
Biodiversité outre-mer	https://biodiversite-outre-mer.fr/
PNDB	https://www.pndb.fr/
INPN	https://inpn.mnhn.fr/accueil/index
Latvian Institute for Environmental solutions	
SYKE - Finnish Environment Institute	https://www.syke.fi/
Tiede ja tutkimus - a website that collects and shares information on research conducted in Finland	https://tiedejatutkimus.fi/fi/

Tiede ja tutkimus - a website that collects and shares information on research conducted in Finland	https://tiedejatutkimus.fi/fi/
Luke - Natural Resources Institute Finland	https://www.luke.fi/
Luke - Natural Resources Institute Finland	https://www.luke.fi/
Ympäristöministeriö	https://ym.fi/etusivu
Ympäristöministeriö	https://ym.fi/etusivu
WWF Suomi	https://wwf.fi/
SLL	https://www.sll.fi/
Birdlife	https://www.birdlife.fi/
Birdlife	https://www.birdlife.fi/
Forestry Research Institute of Sweden	https://www.skogforsk.se/
Forestry Research Institute of Sweden	https://www.skogforsk.se/
Forestry Research Institute of Sweden	https://www.skogforsk.se/
Forestry Research Institute of Sweden	https://www.skogforsk.se/
Swedish Forest Society	https://www.skogssallskapet.se/
Swedish Forest Society	https://www.skogssallskapet.se/
Swedish Forest Society	https://www.skogssallskapet.se/
Swedish Forest Society	https://www.skogssallskapet.se/
Swedish Research Council Formas	http://www.formas.se/
Swedish Research Council Formas	http://www.formas.se/
Swedish Research Council Formas	http://www.formas.se/
Swedish Research Council Formas	http://www.formas.se/
https://www.naturvardsverket.se/	https://www.naturvardsverket.se/
Swedish environmental protection agency	https://www.naturvardsverket.se/
Swedish environmental protection agency	https://www.naturvardsverket.se/

Swedish environmental protection agency	https://www.naturvardsverket.se/
Istituto Superiore per la Protezione e la Ricerca Ambientale	www.isprambiente.it
Umweltbundesamt	https://www.umweltbundesamt.de/
Bundesamt fur Umwelt	https://www.bfn.de/
Bundesministerium fur Klimaschutz	https://www.bmk.gv.at/
Umweltdachverband	https://www.umweltdachverband.at/
EUROBATS	
DG - Territorio	https://www.dgterritorio.gov.pt
Instituto da Conservação da Natureza e das Florestas	https://www.icnf.pt
Environmental and Climate Action Ministry -	https://www.sgambiente.gov.pt
National System Geographical information	https://snig.dgterritorio.gov.pt
Ecodes	https://ecodes.org/quienes-somos

ANNEXE 5: APPLIED POLICY DELPHI PANEL - ETHICS

Briefing material

1. Introduction to the process

The Eklipse mechanism is an EU initiative established in 2016 to help governments, institutions, businesses, and NGOs make better-informed decisions when it comes to biodiversity in Europe (https://www.eklipse.eu/). It is set up to address specific requests made by policy-makers by gathering and synthesising existing evidence and knowledge.

This process is part of a request that the French Biodiversity Agency (OFB) made in 2020 to explore and map existing knowledge and identify knowledge gaps to improve adherence to the mitigation hierarchy using ecosystem services with a particular focus on the avoid stage (https://eklipse.eu/request-mitigation/).

To address this request, an Expert Working Group (EWG) was established in June 2021, which adopted a Method Protocol consisting of two main elements:

- A systematic mapping of the literature;
- A Delphi survey with about ten experts (from the scientific, policy, and academic sector).

The full Method Protocol is available here:

2. Overview of the Delphi survey

As you know, you are one of the experts selected for the Delphi survey. The survey is structured into a preliminary scoping interview to collect your initial view on the topic (about 45-60 min) and three rounds of an email survey, where we will ask you a few open and close-ended questions. After each round, you will be provided with a summary of the replies of the other experts. We expect each survey to require about 60-90 minutes to be completed, including the time needed to read the summary material. In the Method Protocol (pages 10-11), you can find more information about the expected content of the three rounds.

The outline of the preliminary interview includes:

- Introduction and Q&A about the process, as needed;
- Exploration of the perception of the panellist about the mitigation hierarchy and use of avoid stage;
- Exploration of the perception and expectation of the panellist about the outcomes of the process.

3. Research protocol

- **Informed consent:** according to the ethical guidelines within the EU's General Data Protection Regulation GDPR, during the data collection activities, the researchers applied two modalities of informed consent: verbal consent in the first part of the interview and written informed consent based on the models provided previously by Eklipse. During all interviews, participants were informed of its purpose, duration, recording authorisation and context of the research. Also, how the interview could be used and the institution responsible for data storage, treatment and analysis.

- Anonymity: following the European standards, data collected during the interviews will be audio-recorded, transcribed and anonymised, eliminating names and other identity markers and references that might identify the interviewee, except specific cases previously identified and with formal permission. The transcriptions will be kept separately from the codes that correspond to the real names of the respondents. Only the data protection officer and relevant team members will have access.
- Data storage: the semi-structured interviews will be stored for five years following the GDPR rules. The Eklipse Mechanism will be responsible for managing and storing all data collected. The participants will be able to request a withdrawal of their participation in the survey at any time. The Eklipse data protection officer will adopt the procedure needed. Data protection officer email: emb@eklipse.eu
- Data protection: Eklipse will keep on file the declarations on compliance and authorisations for collecting and processing personal data-informed consent. Detailed information on the informed consent procedures with regard to the collection, storage, and protection of personal data will also be kept on file, as well as templates of the informed consent forms and information sheets. The audio recorded files will be password-protected, and only team members will have access to them. The objective is to ensure compliance with the GDPR procedures and the rights and interests of the voluntary research participants.
- Data use: the data collected will be used within the EWG mitigation hierarchy, whose goal is to implement a research process to find out the extent to which the implementation of the hierarchy is correctly applied and ecosystem services are considered and well documented. The qualitative interviews will contribute to the Delphi Panel technique and the final report. Other uses of data collected will be exclusively for scientific purposes, with the adequate reference and citation of the source and primary research.

For further information on the purpose and lawful basis for processing your personal data, please check the Eklipse privacy policy publicly available on our website: http://eklipse.eu/privacy-policy/.

Declaration of consent under data protection law filled by the Expert panel.

1. Information:

The members of the Expert Working Group[4] on how to incorporate ecosystem services in mitigation hierarchy policy working under the frame of the Eklipse mechanism are conducting interviews. These interviews are in the context of the request put to Eklipse by the French Biodiversity Agency (OFB) about 'how can we improve adherence to the mitigation hierarchy using ecosystem services with particular focus on the avoid stage'. For reports and scientific publications, interviews will be conducted with experts from various organizations (civil society, politics, business, science).

The following personal data will be collected, processed and stored during the interviews:

- First name and surname
- Function
- Professional e-mail address

The interviews may be recorded on the platform zoom and then transcribed. For the further scientific evaluation of the interview texts, all information that could lead to an identification of the interviewed person is removed from the text. In the reports and scientific publications, interviews are quoted only in excerpts and without personal reference. This ensures that the interviewed person cannot be identified by third parties.

All personal data is administered solely by those responsible. Contact data and recording of the interview are stored separately from the transcript. The video/sound recording is only stored until a transcript is created and then deleted.

The aforementioned personal data will not be processed for purposes other than

---

[4] Members of the Experts working group on how to incorporate ecosystem services in mitigation hierarchy policy:
Sini Savilaakso (University of Helsinki, Finland) (Co-chair)
Daniel Depellegrin (Oceans and Human Health Chair, Institute of Aquatic Ecology, University of Girona, Spain) Co-
chair)
Joanna Storie (Estonian University of Life Sciences) (Co-chair)
Danica Lacarac (The National Green Roof Association, Serbia) (Co-chair)
Sylvie Campagne (Station Biologique de Roscoff, CNRS and the Sorbonne University, Paris, France)
Beatriz Caitana Da Silva (Centre for Social Studies – CES, Portugal)
Davide Geneletti (University of Trento, Italy)
Ifigeneia Kagkalou (Democritus University of Thrace, Greece)
Francesca Leucci (Bologna/Rotterdam/Hanburg Universities)
Sandra Luque (INRAE – Institut national de recherche pour l'agriculture, l'alimentation et l'environnement, France)

those described and will not be passed on to third parties.

Page 1 / 2

2. Consent:

☐ Yes, I consent to the processing of my personal data listed in section 1 above in the form of original sound recordings and transcripts of the interview for the stated purposes.

I am aware that these consents are voluntary and can be revoked at any time. A revocation, however, does not eliminate the legality of the processing retroactively, but only for the future. The revocation is to be addressed to Dr. Marie Vandewalle, Head of the Eklipse Management Body and Coordinator of Eklipse:

by e-mail:
marie.vandewalle@ufz.de
or by post:

Dr. Marie Vandewalle

Helmholtz Centre for Environmental Research – UFZ
Department of Conservation Biology & Social-Ecological Systems
Permoserstraße 15
04318 Leipzig, Germany

After receipt of the revocation, the relevant data will no longer be used and processed or immediately deleted.

____

Person interviewed (surname, first name in block letters; signature)

____Place, date