METHOD PROTOCOL

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 2021

Eklipse Expert Working

Method protocol
Reviewed version December 2021

Eklipse Expert Working Group on the Mitigation hierarchy

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1.	Expert Working Group (EWG)	11/10/2021	For public review
2.	Expert Working Group (EWG)	1/12/2021	Final version

INDEX

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, 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	*French law on the reconquest of biodiversity (n° 2016-1087 of 8 August 2016)*

	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".	
Ecosystem Services	Contributions that ecosystems make to human well-being that arise from living processes. These are distinct from the goods and benefits that 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	Eklipse, 2021

	academic and grey literature).	
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.

INTRODUCTION

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 **preventive 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. 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 implementation of the hierarchy is correctly applied and ecosystems services are considered and well documented. The activities should focus on the "avoid" stage whenever possible, but it is also important to consider ecosystem services throughout the process.

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 (avoid-reduce-restore-compensate)?"*

To answer these primary questions, the Expert Working Group (EWG) on Mitigation hierarchy request was established. The group has been meeting remotely every week since 21.06.2021. It first received an introduction to the Eklipse call, a presentation on the request and the needs of the requester. The initial stages undertaken by Eklipse were also presented in the accompanying Document of Work, and a summary of the recommended methods prepared by the Methods Expert Group (MEG). The EWG then selected four co-chairs to lead the subsequent meetings. After several discussions with the MEG, the EWG agreed on the research objectives and methods to be used.

OBJECTIVES

The research has 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 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 policy making 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 the early stages of project development in the EU is in line with the state of the art on biodiversity conservation and ecosystem services.

METHODS

METHODOLOGICAL FRAMEWORK

Figure 1 presents the methodological framework proposed by the Eklipse Expert Working Group, which will be used to investigate how ecosystem services are incorporated into mitigation hierarchy policy. In order to address the research objectives presented in the introduction the following steps will be implemented:

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

b) Applied policy Delphi for deliberative consultation, discussion, and feedback; and

c) Analysis of results and conclusions based on the findings from systematic mapping and the applied policy Delphi.

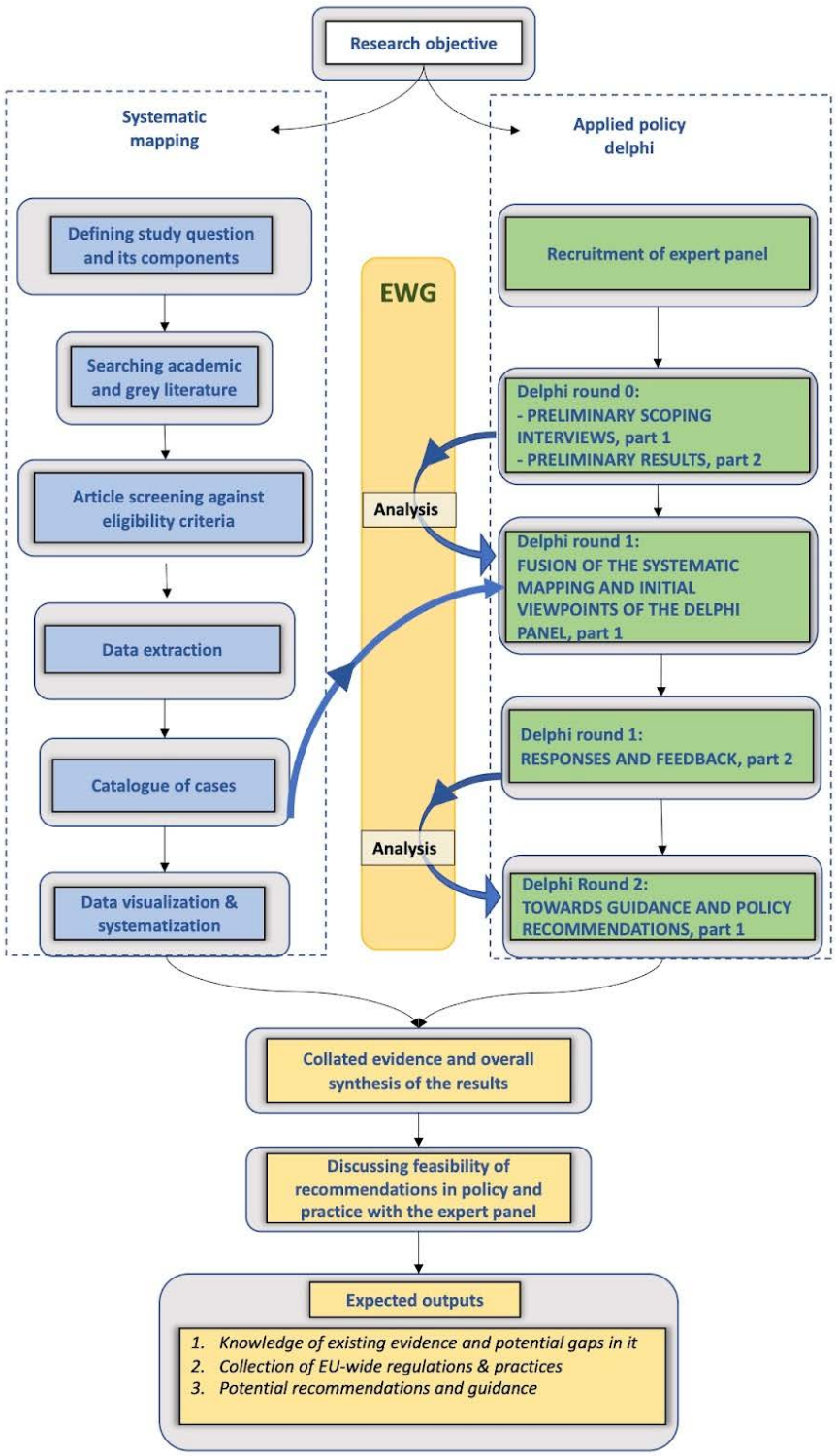

Figure 1. Methodological framework. EWG refers to the Expert Working Group.

SYSTEMATIC MAPPING APPROACH

The systematic mapping will provide an overview of the distribution and amount of evidence that exists related to the objectives of the request. It will help to identify knowledge gaps in the literature for which further information can be sought from the expert consultation process. The systematic mapping will be 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. Components of the study question

Perspective	Setting	Phenomenon of Interest	Environment	Exposure (*Pressure*)	Date range	Findings
Global*	Impact assessments, natural capital assessments, and policy making processes	Consideration and operalisation of the ES concept to mitigate and avoid impacts on ES 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 ES concept, ES/biodiversity outcomes, trade-offs for people and between ES

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

Searching

Search terms and languages

A scoping exercise was conducted in the Web of Science Core Collection and Scopus (Annex 1). The search terms were defined in an iterative process to be as inclusive as possible. The planning terms (#2) reflect the terms considered to have a potential impact on biodiversity.

A list of eight relevant articles was used to test the comprehensiveness of the search (Annex 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 is used to accept any variant of a base term, whereas words or phrases within quotation marks will be searched exactly as they appear in the search string.

Where the full search string cannot be used because of limitations of the search interface (e.g. in organisational websites), a simplified search string will be used. All search strings used will be recorded and published alongside the final report.

Search languages were determined by mapping the language skills of the EWG (Table 2). The EWG acknowledges that not all European languages are covered and hence, the comprehensiveness of the search, especially grey literature, will not be exhaustive (Figure 2). Organisational websites will be searched in the primary language the website is published. In case the website includes a unique publication section in any of the other search languages (not simply translations from the original publications), those will be searched as well.

Table 2. The languages that will be used in literature search.

Croatian	English	Finnish	French	German	Greek
Italian	Portuguese	Spanish	Swedish	Serbian	

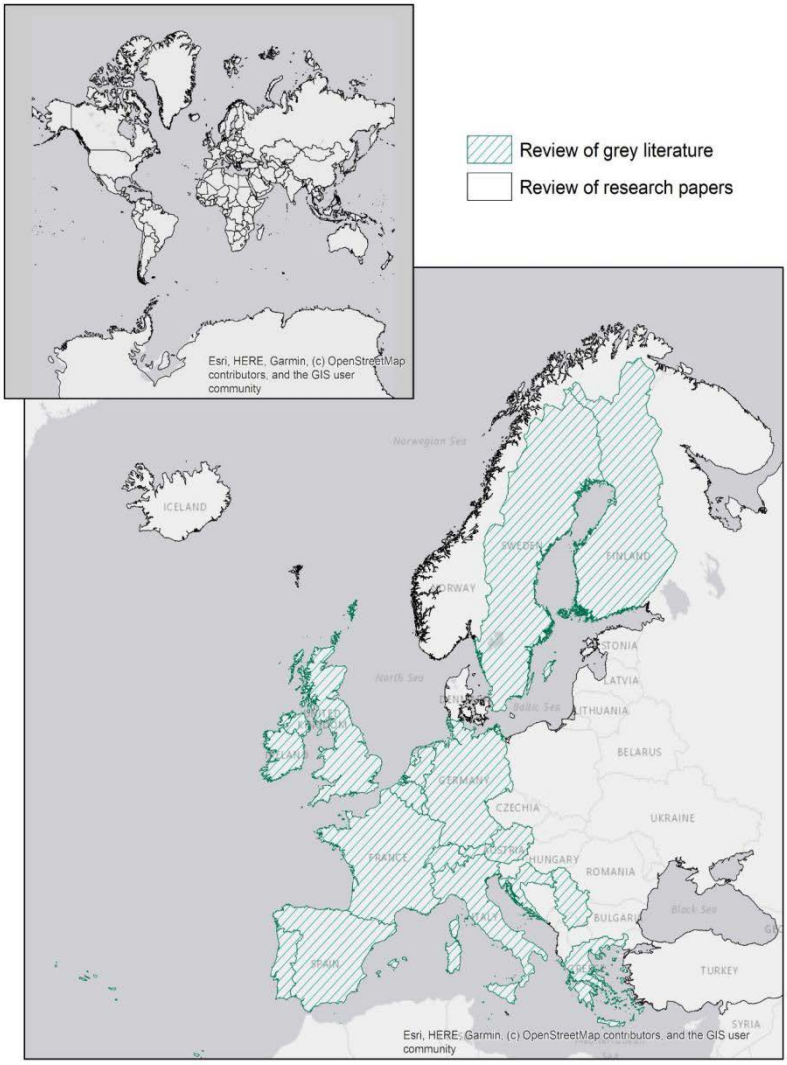

Figure 2. Map of the geographical areas covered by academic and grey literature searches.

Bibliographic searches

The following bibliographic databases will be searched:

- 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.

A search alert will be set in bibliographic databases to include articles that are published before the data synthesis commences. The number of articles retrieved through search alerts will be reported together with the other literature in the final report.

Search engines

Google will be used for internet searches. The searches will be conducted for each of the search languages in a 'private mode' to avoid the influence of location and browsing history. The results will be organised by relevance and checked until no more relevant results appear (Livoreil *et al.,* 2017). The cut-off will be a hundred search records with no hits. Search dates, number of hits and records searched will be recorded and reported in the final report.

Organisational websites

Websites of international and national organisations in Europe (see Figure 2) will be searched. These include but are not limited to the following:

- EU Law - Regulations, Directives, and other acts https://europa.eu/european-union/law/legal-acts_en
- IUCN (https://www.iucn.org/)
- Finnish Environment Institute (https://www.syke.fi/en-US)
- HELCOM (https://helcom.fi)
- Latvian Institute for Environmental Solutions (http://www.videsinstituts.lv/en)
- Stockholm Environment Institute (https://www.sei.org/)
- Swedish environmental protection agency (http://www.naturvardsverket.se/)
- Connecting Nature (https://connectingnature.eu)
- Nature Conservancy (https://www.nature.org/en-us/)
- Network Nature (https://networknature.eu)
- Office Francais de la Biodiversité (https://ofb.gouv.fr/documentation)
- Fondation pour la Recheche sur la Biodiversité (https://www.fondationbiodiversite.fr/publications/)
- CEREMA (https://www.cerema.fr/fr/centre-ressources/boutique/general)
- Partnership for European Environmental Research (https://www.peer.eu)
- British Ecological Society - Applied Ecological Resources (https://www.britishecologicalsociety.org/applied-ecology-resources/)

A full list of organisations and the search results will be published in the final report.

Supplementary searches

A call for case studies and practices on the use of the mitigation hierarchy will be published on the Eklipse website and distributed by the EWG members. Citation chasing will be undertaken using the citation chaser (https://estech.shinyapps.io/citationchaser/).

Search record database

After the searches are complete, all references will be exported into Eppi Reviewer (Thomas *et al.* 2020) and duplicates removed.

Article screening

Articles will be screened in two stages: 1) title and abstract and 2) full text. A single screening is expected due to resource constraints. As screening involves multiple people, an alignment in screening decisions will be established before screening at title and abstract commences. A set of 20 articles will be screened against inclusion criteria by all persons involved in the screening. Their inclusion/exclusion decisions will be compared and any discrepancies discussed. Where needed, inclusion criteria will be clarified and the process repeated with a new set of articles. Once the team is confident that their screening decisions are in agreement, the rest of the articles will be divided among the screeners. If a screener is unsure during the screening whether to include or exclude an article, they will consult other team members and a joint decision will be made. At the beginning of the full-text stage, five articles will be screened together again to ensure alignment of screening decisions.

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

Eligibility criteria

The eligibility criteria are based on the study question components. We will include studies that fulfil the following criteria:

- Studies on freshwater, marine and terrestrial ecosystems anywhere in the world. This includes studies on blue and green infrastructure as well.
- Studies addressing the use of biodiversity and/or ES concept 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 need to be focused on the avoidance and minimisation stages.
- Both applied studies (i.e. real-world cases) and theoretical studies will be included as well as studies addressing governance frameworks, challenges and solutions.

Exclusion criteria

- Literature reviews will be excluded.
- Studies on off-sets will be excluded.
- Studies where impacts are minimised by restoring a habitat will also be excluded.

Data extraction

At the beginning of data extraction, all persons involved in data extraction will code five articles together to ensure consistency and shared understanding. Coding will be cross-checked within resources available. Any uncertainties during the data extraction phase will

be discussed among those involved in the systematic mapping and joint decision made. We will extract data using the following framework:

Metadata (data on study characteristics)

- Source of 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
- 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
- Outcomes of the study
    - direct and indirect ES and/or biodiversity impacts (inclusive of loss of and damage to ES and/or biodiversity)
    - trade-offs
    - risks
    - challenges
    - solutions

We will use the Common International Classification of Ecosystem Services (CICES) V5.1 typology (Haines-Young and Potschin, 2018) to categorise ecosystem services into provisioning, cultural, regulation and maintenance categories. Only the upper-level categories will be used. Where the authors of the paper have not assigned a category for the ES in question, one will be assigned during data extraction. Similarly, the stage of the mitigation

hierarchy (avoid or minimise) will be assigned during data extraction if not explicitly mentioned in the paper. If during data extraction, any additional valuable factors not mentioned in the list above are identified, these will be added to the framework.

Data synthesis

A narrative synthesis describing the evidence base will be produced. A primary output will be a catalogue of cases where mitigation hierarchy has been used in practice. We will use various data visualisations, such as bubble maps, to illustrate the extent of evidence related to the study objectives and knowledge gaps that exist.

APPLIED POLICY DELPHI

The EWG will conduct a deliberative email consultation involving an external expert panel using an applied policy Delphi technique. This will be conducted in parallel to the systematic mapping process, where the result from the systematic mapping will be used to help maximise project outcomes (Figure 1) to:

- Identify further evidence and relevant case studies;
- Support and build upon the EWG ideas and recommendations
- Discuss critical issues emerging from the mapping and, when applicable, achieve consensus;
- Receive feedback from the Delphi panel on the EWG synthesis of results and using these to draft recommendations for future policy and practice.

Operationally, the expert consultation will include the following steps (all to be conducted remotely through confidential email communication):

- Selecting a panel of 8-10 experts. The selection of experts will be based on suggestions made by the EWG members via their networks and further discussion within the group to ensure appropriate representation of different expertise (namely, practitioners, policy-makers and researchers) and, as far as possible, different EU contexts. We define practitioners as people who have on the ground experience in avoiding or mitigating biodiversity and/or ES impacts, e.g. consultants, resource managers, etc. A key goal will be to ensure that all panellists have had some direct involvement in using the mitigation hierarchy.

- Delphi round 0 PRELIMINARY SCOPING INTERVIEWS, part 1:
  Preliminary individual interviews with experts to explain the activities in detail, engage them in the process and capture key expertise for successive rounds. The central aim will be to capture their initial standpoints with justification on the mitigation hierarchy and use of the avoid/minimise stage, highlighting barriers and opportunities.

- Delphi round 0, PRELIMINARY RESULTS, part 2:
  Presenting to the experts the preliminary results of the scoping interviews and the systematic mapping, in particular, highlighting areas of consensus and difference in

the research; and receive their feedback to develop the priorities for the first round;

- Delphi round 1: FUSION OF THE SYSTEMATIC MAPPING AND INITIAL VIEWPOINTS OF THE DELPHI PANEL, part 1:
  Here the Delphi is 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 are needed. For example, the key tools, governance frameworks and other drivers influencing success. A narrative will be produced with questions to capture these outcomes. The first questionnaire will include 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 Delphi responses

- Delphi round 1: RESPONSES AND FEEDBACK, part 2:
  The responses to the questions will be analysed and shared with the EWG. The comments of the EWG will then be integrated and fed back to the Delphi Panel.

- Delphi Round 2: TOWARDS GUIDANCE AND POLICY RECOMMENDATIONS, part 1:
  Building on the work of the EWG, the draft policy recommendations and guidance will be sent out for comment and feedback. The EWG will then use the feedback from the systematic mapping and previous Delphi rounds to set out the desired roadmap.

- Delphi Round 2: COLLATION AND ANALYSIS, part 2:
  The EWG will then collate and analyse the responses to produce a revised policy and recommendations, and guidance document.

- Delphi round 3: FINAL FEEDBACK ON THE RECOMMENDATIONS AND GUIDANCE:
  This final round involves feeding back the changes that have been made by the EWG in response to the Delhi panel with a chance for a final set of responses. Focus will be placed on the interplay between the Delphi Panel and the EWG to maximise the expertise across the groups.

LIMITATIONS

Limitations of the results and synthesis produced will be analysed and discussed in the final report.

EXPECTED RESULTS

1. Collection of evidence about the contribution of natural capital/ecosystem services to biodiversity conservation/elevated policy within planning processes in sectors that are likely to have direct impact on biodiversity.

2. Collection/map of EU-wide regulations and practices (development plans and other programmes/projects) talking about mitigation hierarchy (explicitly and implicitly) and/or considering ecosystem services as biodiversity proxies in impact assessments, mitigation hierarchies, spatial planning or similar processes focused on the "avoid" stage.

3. Recommendations for planners and other decision makers on how to translate mitigation hierarchy, especially the avoid stage, into practice in projects/programmes.

VISUALISATION OF THE RESULTS

Different visualisation tools will be applied to find the best visual interpretation of results.

TIMELINE

The following key activities with milestones and proposed duration is described in table 4.

Table 3. Overview of the process indicates the different tasks, milestones and timelines.

	Description	**Duration/ T**
Task 1	**Method protocol**	**2.5 months**
Milestone 1	**Method protocol final version**	**11.10.2021**
	Method protocol peer-review finished (3 weeks allocated)	29.10.2021
	Reply comments peer review	9.11.2021
Task 2	**Systematic mapping**	**4 months**
Milestone 2	**Systematic mapping database**	**15.2.2022**
Task 3	**Possible systematic review**	**1.5 months**
Milestone 3	**Database with quantitative or qualitative results**	**31.3.2022**
Task 4	**Expert consultation**	**2.5 months** (1.2-15.4.2022)
Milestone 4	**Consultation finished - draft results?**	**15.4.2022**
Task 5	**Report writing**	**1 month**
Milestone 5.1	**Draft report ready for peer review**	**15.5.2022**
Milestone 5.2	**Report finished**	**30.6.2022**

ACKNOWLEDGEMENTS

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ANNEX 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	

ANNEX 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.