



Method protocol October 2021

Eclipse Expert Working Group on the Mitigation hierarchy

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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; and, when impacts occur, rehabilitate or restore; and where significant residual impacts remain, off-set	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)	<p><i>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);</i></p> <p><i>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 ».</i></p> <p>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);</p>	<i>French law on the reconquest of biodiversity (n° 2016-1087 of 8 August 2016)</i>



	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	The benefits people obtain from nature	MEA, 2005
Exposure	A proposed management regime, policy, action or environmental variable to which the subject populations are exposed.	Collaboration for Environmental Evidence, 2018
Impact Avoidance	<p>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.</p> <p>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).</p>	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).	Eclipse, 2021



1 INTRODUCTION

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

11 **However, our aim is to find out the extent in which the implementation of the hierarchy is**
12 **correctly applied and ecosystems services are considered and well documented.** The
13 activities should focus on the “avoid” stage whenever possible, but it is also important to
14 consider ecosystem services throughout the process.

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

17 *“How can ecosystem services be considered in plans, projects, programmes, policies*
18 *and associated impact assessments with a particular focus on the avoid stage of the*
19 *mitigation hierarchy (avoid-reduce-restore-compensate)?”*

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

28 OBJECTIVES

29 The research has three main objectives:

- 30 1. To gather knowledge on how ecosystem services/natural capital as concepts foster
31 the conservation and enhancement of biodiversity;
- 32 2. To identify EU-wide cases and practices that actively consider and address the aspect
33 of ecosystem services in the mitigation hierarchy; for example in natural capital



34 assessments, impact assessments of projects, plans, programmes, policies or similar
35 processes;

- 36 3. If time allows, to develop guidance on best practices and information on:
- 37 a. If and how the consideration and operationalisation of ecosystem services
 - 38 can be integrated into natural capital assessments, impact assessments, and
 - 39 policy making processes to enhance biodiversity conservation as well as to
 - 40 understand the risks and potential ecosystem service trade-offs involved.
 - 41 b. What kind of outcomes, impacts, challenges, solutions, etc., may occur when
 - 42 the ecosystem services concept is used in the natural capital assessments,
 - 43 impact assessments, mitigation hierarchy and similar processes?
 - 44 c. The level of replicability/transferability of suggested/known
 - 45 tools/guidance/processes in other countries or regions that have been used
 - 46 successfully in the avoid stage.
 - 47

48 This research aims to unveil whether the early stages of project development in the EU is in
49 line with the state of the art on biodiversity conservation and ecosystem services.

50 METHODS

51 METHODOLOGICAL FRAMEWORK

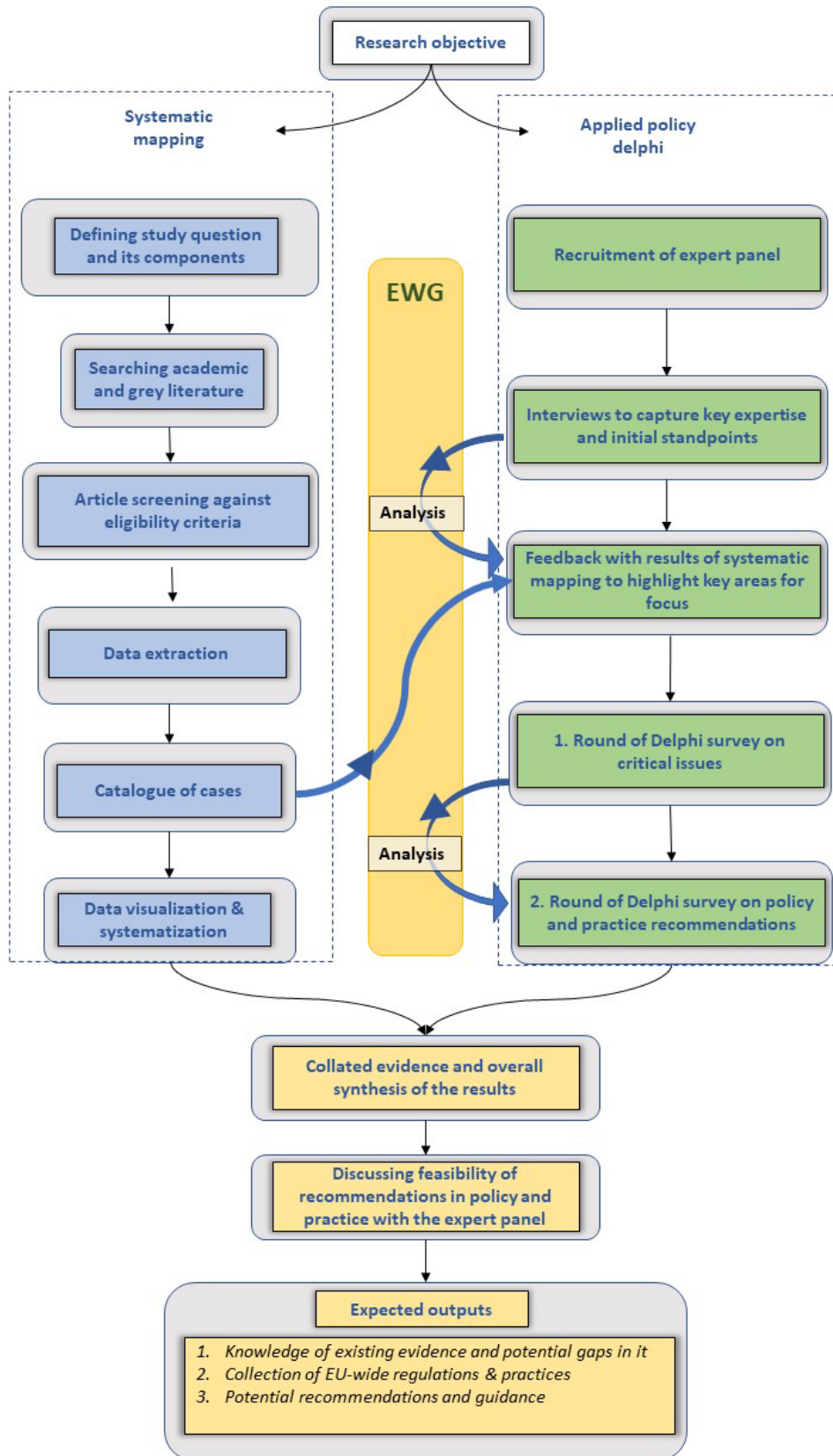
52 Figure 1 presents the methodological framework proposed by the Eklipse Expert Working
53 Group, which will be used to investigate how ecosystem services are incorporated into
54 mitigation hierarchy policy. In order to address the research objectives presented in the
55 introduction the following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

- 56 a) A systematic mapping approach will be used to provide an overview of the available
57 evidence and knowledge gaps present;
- 58 b) Applied policy Delphi for deliberative consultation, discussion, and feedback; and
- 59 c) Analysis of results and conclusions based on the findings from systematic mapping and the
60 applied policy Delphi.

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Figure 1. Methodological framework



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68 **SYSTEMATIC MAPPING APPROACH**

69 The systematic mapping will provide an overview of the distribution and amount of evidence
70 that exists related to the objectives of the request. It will help to identify knowledge gaps in
71 the literature for which further information can be sought from the expert consultation
72 process. The systematic mapping will be conducted according to CEE guidelines
73 (Collaboration for Environmental Evidence 2018).

74 **Question components**

75 A modified PerSPEcTiF framework (Booth *et al.* 2019) was used to outline the key question
76 elements.

77 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 operationalisation 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

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

80 **Searching**

81 **Search terms and languages**

82 A scoping exercise was conducted in the Web of Science Core Collection and Scopus (Annex
83 1). The search terms were defined in an iterative process to be as inclusive as possible. A list
84 of eight relevant articles was used to test the comprehensiveness of the search (Annex 2).
85 The test list was compiled based on the suggestions from the EWG. The final search string in
86 Web of Science format is:

87 #1 (avoid* OR prevent* OR mitigat* OR "land use planning" OR "management plan*" OR "urban
88 greening" OR "spatial planning" OR "marine planning" OR "impact assessment" OR "county plan*"
89 OR "municipal* plan*" OR "theme plan*" OR "environmental compensation" OR "green
90 corridors" OR "functional urban area*")



91 AND

92 #2 ("ecosystem service*" OR "ecosystem goods and services" OR "environmental service*"
93 OR "ecological service*" OR biodiversity OR "nature's contribution to people" OR "nature
94 value" OR "natural capital").

95 The asterisk (*) at the end of a search term/word is used to accept any variant of a base term,
96 whereas words or phrases within quotation marks will be searched exactly as they appear in
97 the search string.

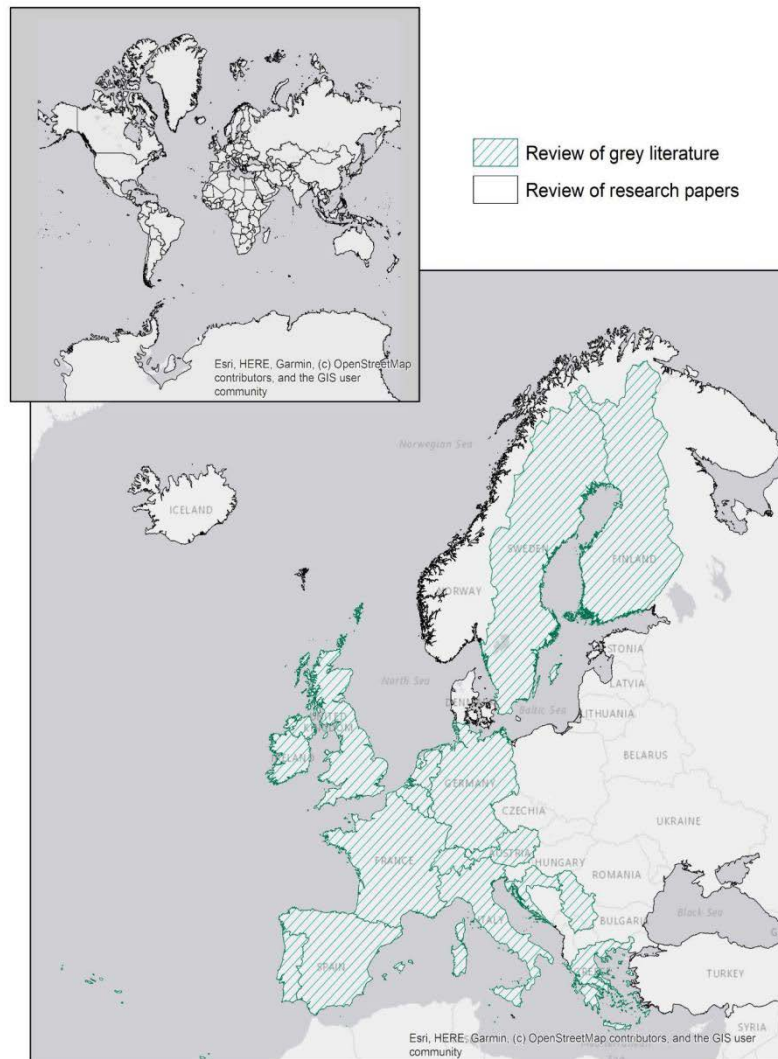
98 Where the full search string cannot be used because of limitations of the search interface
99 (e.g. in organisational websites), a simplified search string will be used. All search strings used
100 will be recorded and published alongside the final report.

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

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

Croatian	English	Finnish	French	German	Greek
Italian	Portuguese	Spanish	Swedish	Serbian	

108



109

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

111 **Bibliographic searches**

112 The following bibliographic databases will be searched:

- 113 - Web of Science Core Collection (<https://clarivate.com/>); Topic search covering
- 114 Science Citation Index Expanded (1945-present), Social Sciences Citation Index (1956-
- 115 present), Arts & Humanities Citation Index (1975-present), Conference Proceedings
- 116 Citation Index- Science (1990-present), Conference Proceedings Citation Index-
- 117 Social Science & Humanities (1990-present), Emerging Sources Citation Index (2015-
- 118 present).
- 119 - Scopus; Title, abstract, and keyword search.
- 120 - Lens (<https://www.lens.org/>); Title, abstract, keyword or field of study.
- 121



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

125 Search engines

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

131 Organisational websites

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

- 134 - EU Law - Regulations, Directives, and other acts ([https://europa.eu/european-](https://europa.eu/european-union/law/legal-acts_en)
135 [union/law/legal-acts_en](https://europa.eu/european-union/law/legal-acts_en))
- 136 - IUCN (<https://www.iucn.org/>)
- 137 - Finnish Environment Institute (<https://www.syke.fi/en-US>)
- 138 - HELCOM (<https://helcom.fi>)
- 139 - Latvian Institute for Environmental Solutions (<http://www.videsinstituts.lv/en>)
- 140 - Stockholm Environment Institute (<https://www.sei.org/>)
- 141 - Swedish environmental protection agency (<http://www.naturvardsverket.se/>)
- 142 - Connecting Nature (<https://connectingnature.eu>)
- 143 - Nature Conservancy (<https://www.nature.org/en-us/>)
- 144 - Network Nature (<https://networknature.eu>)
- 145 - Office Francais de la Biodiversité (<https://ofb.gouv.fr/documentation>)
- 146 - Fondation pour la Recherche sur la Biodiversité
147 (<https://www.fondationbiodiversite.fr/publications/>)
- 148 - CEREMA (<https://www.cerema.fr/fr/centre-ressources/boutique/general>)
- 149 - Partnership for European Environmental Research (<https://www.peer.eu>)

150
151 A full list of organisations and the search results will be published in the final report.

152 Supplementary searches

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

156 Search record database

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

159



160 Article screening

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

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

176 Eligibility criteria

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

- 179 - Studies on freshwater, marine and terrestrial ecosystems anywhere in the world. This
180 includes studies on blue and green infrastructure as well.
- 181 - Studies addressing the use of biodiversity and/or ES concept in the context of impact
182 assessments, spatial planning, and policy processes.
- 183 - Studies addressing mitigation of impacts from grey infrastructure development, land
184 use change and resource management on biodiversity and/or ecosystem services;
- 185 - Studies on mitigation hierarchy need to be focused on the avoidance and minimisation
186 stages.
- 187 - Both applied studies (i.e. real-world cases) and theoretical studies will be included as
188 well as studies addressing governance frameworks, challenges and solutions.
- 189

190 Exclusion criteria

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

194 Data extraction

195 At the beginning of data extraction, all persons involved in data extraction will code five
196 articles together to ensure consistency and shared understanding. If time allows, coding will
197 be cross-checked. Any uncertainties during the data extraction phase will be discussed



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

200 Metadata (data on study characteristics)

- 201 • Source of article
- 202 • Information on publication details (title, authors, publication year, DOI)
- 203 • Type of publication (journal article, report, book, etc.)
- 204 • Language
- 205

206 Study attribute data

- 207 • Ecosystem (Freshwater, marine and terrestrial)
- 208 • Geographical location
- 209 • Scale of the study
- 210 • Exposure type (i.e. details on infrastructure development, land use change or resource
211 management)
- 212 • Applied or theoretical study
- 213 • Biodiversity or ecosystem services or both studied
- 214 • Studied ecosystem services
 - 215 ○ provisioning
 - 216 ○ cultural
 - 217 ○ regulating and maintenance
- 218 • Studied level of biodiversity
 - 219 ○ Landscape
 - 220 ○ Community
 - 221 ○ Species
 - 222 ○ Genes
- 223 • Use of mitigation hierarchy (yes/no)
- 224 • The stage of mitigation hierarchy (avoid or minimise)
- 225 • Governance
 - 226 ○ Legal framework for mitigation
 - 227 ○ Relevant government policies
- 228 • Outcomes of the study
 - 229 ○ direct and indirect ES and/or biodiversity impacts (inclusive of loss of and
230 damage to ES and/or biodiversity)
 - 231 ○ trade-offs
 - 232 ○ risks
 - 233 ○ challenges
 - 234 ○ solutions
 - 235

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



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

244 Data synthesis

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

249 APPLIED POLICY DELPHI

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

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

260
261 Operationally, the expert consultation will include the following steps (all to be conducted
262 remotely through confidential email communication):

- 263 - Selecting a panel of 8-10 experts. The selection of experts will be based on
264 suggestions made by the EWG members via their networks and further discussion
265 within the group to ensure appropriate representation of different expertise (namely,
266 practitioners, policy-makers and researchers) and, as far as possible, different EU
267 contexts. We define practitioners as people who have on the ground experience in
268 avoiding or mitigating biodiversity and/or ES impacts, e.g. consultants, resource
269 managers, etc. A key goal will be to ensure that all panellists have had some direct
270 involvement in using the mitigation hierarchy.
- 271
272 - **Delphi round 0 PRELIMINARY SCOPING INTERVIEWS, part 1:**
273 Preliminary individual interviews with experts to explain the activities in detail,
274 engage them in the process and capture key expertise for successive rounds. The
275 central aim will be to capture their initial standpoints with justification on the
276 mitigation hierarchy and use of the avoid/minimise stage, highlighting barriers and
277 opportunities.
- 278
279 - **Delphi round 0, PRELIMINARY RESULTS, part 2:**
280 Presenting to the experts the preliminary results of the scoping interviews and the
281 systematic mapping, in particular, highlighting areas of consensus and difference in



- 282 the research; and receive their feedback to develop the priorities for the first
283 round;
- 284
- 285 - **Delphi round 1: FUSION OF THE SYSTEMATIC MAPPING AND INITIAL VIEWPOINTS OF**
286 **THE DELPHI PANEL, part 1:**
- 287 Here the Delphi is used to complement and add value to the key findings from the
288 systematic mapping and to identify the areas within which future guidance and
289 recommendations are needed. For example, the key tools, governance frameworks
290 and other drivers influencing success. A narrative will be produced with questions
291 to capture these outcomes. The first questionnaire will include mostly open-ended
292 questions aimed at capturing and discussing key critical issues associated with the
293 conceptualisation and application of the mitigation hierarchy (avoid and minimise
294 stages) as revealed through the systematic mapping and initial Delphi responses
295
- 296 - **Delphi round 1: RESPONSES AND FEEDBACK, part 2:**
- 297 The responses to the questions will be analysed and shared with the EWG. The
298 comments of the EWG will then be integrated and fed back to the Delphi Panel.
299
- 300 - **Delphi Round 2: TOWARDS GUIDANCE AND POLICY RECOMMENDATIONS, part 1:**
- 301 Building on the work of the EWG, the draft policy recommendations and guidance
302 will be sent out for comment and feedback. The EWG will then use the feedback
303 from the systematic mapping and previous Delphi rounds to set out the desired
304 roadmap.
305
- 306 - **Delphi Round 2: COLLATION AND ANALYSIS, part 2:**
- 307 The EWG will then collate and analyse the responses to produce a revised policy
308 and recommendations, and guidance document.
309
- 310 - **Delphi round 3: FINAL FEEDBACK ON THE RECOMMENDATIONS AND GUIDANCE:**
- 311 This final round involves feeding back the changes that have been made by the
312 EWG in response to the Delhi panel with a chance for a final set of responses. Focus
313 will be placed on the interplay between the Delphi Panel and the EWG to maximise
314 the expertise across the groups.
315

316 LIMITATIONS

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

319 EXPECTED RESULTS

- 320 1. Collection of evidence about the contribution of natural capital/ecosystem services to
321 biodiversity conservation/elevated policy focus.
- 322 2. Collection/map of EU-wide regulations and practices (development plans and other
323 programmes/projects) talking about mitigation hierarchy (explicitly and implicitly) and/or

324 considering ecosystem services as biodiversity proxies in impact assessments, mitigation
325 hierarchies, spatial planning or similar processes focused on the “avoid” stage.

326 3. If time allows, recommendations for planners and other decision makers on how to translate
327 mitigation hierarchy, especially the avoid stage, into practice in projects/programmes.

328 VISUALISATION OF THE RESULTS

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

330 TIMELINE

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

332

333 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

334

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337 Helsinki, for their help regarding testing the comprehensiveness of the search string.



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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			



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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			



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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							



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<p>(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)</p>	2248362		8.9. 2021	Sini Savilaakso	University of Helsinki			
<p>(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)</p>	1298326		8.9. 2021	Sini Savilaakso	University of Helsinki			



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(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			

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(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		

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(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		

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(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

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(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		

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(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

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(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		

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(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 sobre 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>.

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

2. 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>.
3. 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>
4. Timo P. Karjalainen, Mika Marttunen, Simo Sarkki, Anne-Mari Rytönen (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>.
5. 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
6. 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>
7. 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>.

8. 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.