

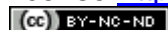
## Article (refereed) - postprint

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Jax, Kurt; Furman, Eeva; Saarikoski, Heli; Barton, David N.; Delbaere, Ben; Dick, Jan; Duke, Guy; Görg, Christoph; Gómez-Baggethun, Erik; Harrison, Paula A.; Maes, Joachim; Pérez-Soba, Marta; Saarela, Sanna-Riikka; Turkelboom, Francis; van Dijk, Jiska; Watt, Allan D. 2018. **Handling a messy world: lessons learned when trying to make the ecosystem services concept operational.**

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<https://doi.org/10.1016/j.ecoser.2017.08.001>

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1 Handling a messy world: Lessons learned when trying to make the ecosystem services  
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38 **Abstract**

39 The concept of ecosystem services is widely used in the scientific literature and increasingly also in  
40 policy and practice. Nevertheless, operationalising the concept, i.e. putting it into practice, is still a

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41 challenge. We describe the approach of the EU-project OpenNESS (Operationalisation of Ecosystem  
42 Services and Natural Capital), which was created in response to this challenge to critically evaluate  
43 the concept when applied to real world problems at different scales and in different policy sectors.  
44 General requirements for operationalization, the relevance of conceptual frameworks and lessons  
45 learnt from 27 case study applications are synthesized in a set of guiding principles. We also briefly  
46 describe some integrative tools as developed in OpenNESS which support the implementation of the  
47 principles. The guiding principles are grouped under three major headlines: “*Defining the problem*  
48 *and opening up the problem space*”, “*Considering ethical issues*” and “*Assessing alternative methods,*  
49 *tools and actions*”. Real world problems are often “wicked” problems, which at first are seldom clear-  
50 cut and well-defined, but often rather complex and subject to differing interpretations and interests.  
51 We take account of that complexity and emphasise that there is not one simple and straightforward  
52 way to approach real world problems involving ecosystem services. The principles and tools  
53 presented are meant to provide some guidance for tackling this complexity by means of a  
54 transdisciplinary methodology that facilitates the operationalisation of the ecosystem services  
55 concept.  
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## 58 **Highlights**

- 59 ○ A set of guiding principles for applying the ecosystem service concept is proposed
  - 60 ○ Tackling real world problems using the ecosystem services concept requires integrative tools
  - 61 ○ There is not only one approach or tool; guidance for choosing between alternatives is needed
  - 62 ○ Involving knowledge brokers which are already familiar with the concept is often desirable
- 63

64 **Keywords:** ecosystem services, conceptual frameworks, integrative tools, guiding principles,  
65 OpenNESS project  
66

## 68 **1. Introduction**

69 The concept of ecosystem services (ES) is widely used in the scientific literature and increasingly also  
70 in policy and practice documents (notably, MA 2005, TEEB 2010, European Commission 2006, 2011,  
71 UNEP 2015). While the general idea of ES as the contribution of nature to human well-being is  
72 intuitively appealing and easily understandable, putting the concept into practice is still a challenge  
73 (Daily et al. 2008, Primmer & Furman 2012, Bouma and Van Beukering 2015). In this paper, we  
74 provide an overview of an approach to the operationalisation of ecosystem services and natural  
75 capital taken in the EU-project OpenNESS (Operationalisation of Ecosystem Services and Natural  
76 Capital), which was created in response to this challenge. OpenNESS focused on testing how the ES  
77 concept could be operationalised and applied to real world problems at different scales and in  
78 different policy sectors, involving a wide range of stakeholders (see Furman et al. 2017a, Dick et al.  
79 2017a). We describe here some major lessons learned when trying to make the ES concept  
80 operational, expressed as ten guiding principles, and briefly sketch some integrative tools to  
81 implement these principles as developed in OpenNESS. Detailed descriptions of the principles and

82 methodologies introduced here are elaborated in other papers of this special issue (see overview in  
83 Furman et al. 2017a).

84 The goal of operationalisation is to put theoretical concepts into practice, by finding rules or guiding  
85 principles for their application. Rules of application are most often not included in definitions of  
86 concepts despite the argument that one basic requirement of sound and useful scientific concepts is  
87 what van der Steen (1990) calls the "principle of operationality", which "concerns our ability to  
88 decide whether some item does belong to the empirical reference of a concept" (van der Steen 1990,  
89 p. 385). In other words, which phenomena can be subsumed under a concept and which cannot. This  
90 is, however, only part of what "operationalisation" entails, as there is another, broader and more  
91 practical dimension to operationalisation of concepts than the one defined by van der Steen (1990).  
92 That is linking conceptual work with empirical work on *real world conditions and situations* in order  
93 to find ways to express and use concepts in practice.

94 Operationalisation in this sense includes conceptual, procedural, and methodological aspects. We  
95 therefore set out to consider relevant conceptual frameworks in relation to problems encountered in  
96 a series of 27 real-life case studies in a range of ecological and socio-economic contexts in Europe  
97 and worldwide (see Furman et al. 2017a, Dick et al. 2017a). A major purpose of conceptual  
98 frameworks for ES, such as in the Millennium Ecosystem Assessment (MA 2005) framework, the  
99 Cascade Model (Potschin and Haines-Young, 2011), the framework of the Inter-Governmental  
100 Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES; see UNEP 2015), or even the  
101 interlinkages of the SDGs (Agenda2030, 2015), is to visualise a particular set of complex relationships  
102 between humans and nature (namely those that contribute to human well-being) as an aid to  
103 understanding. These frameworks show how ES may relate to ecosystem structure processes and  
104 functions, and to the various benefits and values that promote human well-being. Such conceptual  
105 frameworks provide important support in operationalising the concept of ES (see e.g. Saarikoski et al.  
106 2015). Specifically, the usefulness of the Cascade Model as a framework was explored through a  
107 focus group discussion in the Cairngorms case study (Dick et al. 2017b) and by a number of  
108 questionnaires with all case studies (Potschin et al. 2017). Stakeholders highlighted three themes in  
109 particular in how the cascade model supported their work: (i) strengthening communication, (ii)  
110 developing understanding and (iii) coordinating actions. Conceptual frameworks allow for a general  
111 orientation and understanding of the ES idea and help to distinguish and delimit different  
112 phenomena, such as biodiversity, ecosystem functions, ES, and benefits that flow from ES. OpenNESS  
113 stakeholders also expressed their need for common understanding of terms used as part of the ES  
114 concept (Carmen et al. 2017). Clear definition of these related terms is a necessary but not sufficient  
115 step to be able to measure them, to compare results between different studies, and to derive  
116 generalisations from empirical data that should allow predictions such as what happens to ES and  
117 human well-being when there is a particular change in biodiversity? However, when terms such as  
118 "ecosystem services", "benefits", and "values" are applied in the field, and as a basis for action in  
119 real-world contexts, we need to make them operational. That is, we need rules (or guidelines) stating  
120 how they should be applied, including rules for measurement and implementation (Daily et al. 2008).

121 This does not mean that there must be one unique definition of each term for all purposes, but when  
122 it comes to applying the ES concept, their meaning must be clear. In the context of OpenNESS  
123 ‘measurement’ is understood in a wide sense of both biophysical and monetary metrics, as well as  
124 qualitative, but consistent descriptions of socio-cultural phenomena. Similarly, ‘implementation’ has  
125 a broad interpretation of application ‘beyond science’ in terms of both changing public perspectives,  
126 supporting action, and assessing outcomes (Ruckelshaus et al. 2015, and see below).

127 Bringing a conceptual framework into the field takes us far from the ordered world represented in  
128 such frameworks, to a world where things are more complex and ‘messy’. Conceptual frameworks  
129 can, however, help to provide structure to this complex real-world, highlighting important inter-  
130 linkages and avenues for measurement and assessment (Jann et al. 2007).

131 In OpenNESS we aimed to provide systematic guidance for operationalising the ES concept. We also  
132 consider the concept of natural capital (NC)<sup>2</sup> to a more limited extent. When looking at the state-of-  
133 the-art in the literature on operationalisation of ES much has been written on concepts and methods  
134 (Potschin et al., 2016). Only recently, however, have scientists started to publish analyses that  
135 elaborate on practices in various contexts (e.g. Hauck et al. 2014, Primmer et al. 2015, Spangenberg  
136 et al. 2015, Grêt-Regamey et al., in press). The challenge with putting the concept of ES into practice  
137 is that real-world problems, as already mentioned above, are seldom clear-cut and well-defined, but  
138 often rather complex and ‘messy’, including both indirect and unexpected linkages, both ecologically  
139 and socially (Norton and Nooan 2007, Langemeyer et al. 2016). Furthermore, they involve multiple  
140 knowledge producers, interests and values, as well as shifting institutional, economic and political  
141 environments (Balint et al. 2011, Salomaa et al, 2016). Likewise, the ways to solve such problems and  
142 find the proper place for the application of the ES concept are not easy or straightforward, but may  
143 require iteration and take unexpected turns before they materialise. In fact, there may often be  
144 multiple paths and methodologies for tackling a problem, depending on their specific ecological,  
145 social and political contexts. This was a major assumption before starting the project, which was  
146 corroborated by the variety of case studies. Moreover, the ES concept may give rise to (alternative)  
147 solutions that may compete with more conventional ways of dealing with problems, such as  
148 engineered or technological solutions. Therefore, operationalising the concept of ES cannot be  
149 captured as a simple one-size-fits-all solution and one simple scheme of application but needs to  
150 take account of the variety of questions, contexts and purposes, both to avoid either overly  
151 complicating or simplifying the issues at hand. In addition, it is not only necessary to describe the  
152 potential of the ES concept but to be aware of the limitations of applying it. In fact, the concepts of  
153 ES and NC, with their economic connotations of ‘services’ and ‘capital’, will always be only two  
154 among many possible metaphors that capture the importance of nature to humans and cannot be  
155 taken as a panacea for solving environmental problems (Larson 2011, Raymond et al. 2013,  
156 Spangenberg et al. 2014).

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<sup>2</sup> See Furman et al. 2017a for a more detailed discussion of the natural capital concept.

157 OpenNESS allowed us, especially through its many case studies, to obtain insight into the multitude  
158 and complexity of real-world problems and solutions. In this paper we describe this complexity and  
159 elaborate a set of guiding principles and tools which may be appropriate for solving complex  
160 environmental or socio-ecological problems. By this we do not mean to cover all aspects of  
161 operationalisation in all steps of implementation, but to focus on procedural and methodological  
162 aspects which we see neglected in many studies and/or for which OpenNESS provided important  
163 ideas and tools. In spite of the complexity and even messiness of real world problems, which we take  
164 into account here, we acknowledge that some form of simplification is necessary in order to be able  
165 to consider the broad range of contexts where operationalisation takes place, including the  
166 limitations on time available, on personnel or institutional ambitions and skills, as well as on budgets  
167 available. The resulting guidance tries to balance these concerns by providing a means to synthesise,  
168 focus and make the procedural choices needed for the various settings in which people operate (see  
169 Potschin et al. 2017, Harrison et al. 2017, Pérez-Soba et al. 2017, Turkelboom et al. 2017).

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## 172 **2. Methodological approach: a procedure to link research, real-world problems and societal** 173 **challenges**

174 The process of the OpenNESS project proved to be valuable in itself. An anonymous survey with 246  
175 practitioners in OpenNESS case studies found out that "to a large extent the impact [of  
176 operationalising the ES concept in OpenNESS] was attributed to a well conducted science-practice  
177 interaction process (>70%)." (Dick et al. 2017a, p. xyz). In this section, we therefore briefly describe  
178 the crucial procedural features of the project, as a potential guide for future projects aiming at  
179 applying the ES concept.

180 In the project, we used a transdisciplinary approach to guide problem solving (Furman et al. 2017b).  
181 There was an inter-play between researchers from various disciplines including sociology, political  
182 sciences, environmental sciences, geography, economics, philosophy, biology and ecology, experts  
183 from communication, policy, and business, as well as various local and EU level stakeholders (Carmen  
184 et al. 2017; Dick et al. 2017a; Turkelboom et al. 2017).

185 The research design was based on an iterative application of ES assessment methods and tools in 27  
186 place-based case studies in thirteen European and four non-European countries (see Wijnia et al.  
187 2016). Out of the 27 case studies, 25 case study sites had local study teams which included both  
188 researchers and local, non-scientific experts in the implementation of the ES concept, as well as Case  
189 Study Advisory Boards (CABs) in which the various local stakeholder groups were represented (see  
190 Dick et al. 2017a). The case study teams not only provided local knowledge but also were often  
191 involved in refining the research questions to be explored and selecting the tools to be applied.  
192 Together with the CABs, these place-based research teams tested the conceptual, methodological  
193 and governance-oriented tools and approaches developed by the project. This included challenging  
194 the tools and approaches with respect to the needs and requirements of local practitioners in putting  
195 the ES concept into practice.

196 The case studies allowed us to test the applicability of our conceptual and methodological work on  
197 ES by identifying potential solutions to specific problems in the case studies, as well as at the EU and  
198 national levels. It also allowed us to further develop our conceptual and methodological  
199 understanding by generalising from specific case studies, thereby guiding future users of the ES  
200 concept. The interaction between those involved in conceptual and methodological development  
201 and those testing concepts and methods in the case studies promoted common interests and social  
202 learning through tackling problems from different angles in an open collaboration. Thus a  
203 continuous, iterative dialogue led to research outcomes that were tested in practice and suitable for  
204 implementation in the real world (Dick et al. 2017a).

205 The cases were also analysed according to the societal challenges where operationalisation of ES  
206 could play a role. We selected four major challenges: human wellbeing, sustainable ecosystem  
207 management, governance, and competitiveness. These are discussed in more detail in Potschin et al.  
208 (2017).

209 In the following section, we first elaborate ten guiding principles for operationalising the ES concept  
210 and then in section 4 provide examples of important tools that were produced in OpenNESS and  
211 which support the implementation of these principles.

### 212 213 **3. From problems to solutions: guiding principles for operationalising the ecosystem services** 214 **concept**

215 Sometimes it is assumed that solving an environmental problem should work as a simple linear or  
216 circular process roughly along the lines of the ideal policy cycle. Regarding ecosystem services, this  
217 process starts with defining the problem, defining the relevant ES, assessing and valuing the ES,  
218 suggesting solutions to decision makers, adopting and implementing the solution, monitoring and  
219 evaluating the effect of the solution, and then recommencing the cycle once again to assess whether  
220 any further adjustment is required. Such approaches are important and much progress has been  
221 made in elaborating them further and adapting them (e.g. Chan et al. 2012, Förster et al. 2015); we  
222 also make use of them as a simplified form of guidance to ecosystem service assessments (see  
223 section 4, ESAST). Experiences from OpenNESS suggest, however, that this may often be an  
224 oversimplification, which does not fit the way many real-world problems are tackled (see  
225 Langemeyer et al. 2016).

226 In this section, we describe ten guiding principles which we deem are necessary to apply the ES  
227 concept to a variety of problems. These principles were developed on the basis of several sources. In  
228 part they are based on empirical experiences drawn from the case studies in OpenNESS, in part they  
229 are reflections taken from the literature and/or from our previous work and then “tested” in the case  
230 studies. We describe the principles as propositions and characterise the potential or actual problems  
231 or obstacles to which they respond as well as the evidence that support them, both from the  
232 literature, from the OpenNESS case studies and from other conceptual and methodological work  
233 undertaken in the project.

234 The order of the principles we describe here does not imply a fixed sequence of the pathway from  
235 problems to solutions, neither their importance; specific problems and situations require different  
236 entry points and sometimes quite convoluted pathways, and perhaps also with iteration (already  
237 emphasised by Chan et al. 2012, and see Mouchet et al. 2014, Langemeyer et al. 2016; also Potschin  
238 et al. 2017). This is why we deliberately use the term "principles" instead of "steps". Depending on  
239 the specific problem, some principles may not be pertinent at all. For instance, it is not always  
240 necessary to make a complex choice of methods, in order to map, quantitatively assess, or formally  
241 value ES. Sometimes ES may simply be used as metaphors or heuristics for explaining and/or  
242 structuring a problem, without any need for quantification. In the following, we list and briefly  
243 characterise the principles we consider as crucial for operationalising the ES concept in various  
244 problem contexts. We do not claim, however, that this is all that can be said about operationalisation  
245 of ES, especially concerning methodological approaches; instead we focus on some *fundamental*  
246 *issues*, which are often underestimated when applying ES approaches to real-world problems. In the  
247 following section, we then briefly sketch some selected tools that OpenNESS assessed for supporting  
248 the implementation of these principles.

249

### 250 **3.1. Defining a problem and opening up the problem space**

251 A problem space consists of all the different aspects or components of a problem as well as the  
252 (often various) possible pathways to its solution. Not all these components are evident to everyone  
253 from the outset. Defining and framing (Bardwell 1991, Hajer 2006) the problem is easily  
254 underestimated, but crucial to an effective and efficient way of applying the ES concept in a useful  
255 way (Wittmer & Gundimedia 2012). Therefore, adequate time should be devoted to it. It comprises  
256 five of our guiding principles, which we now describe (see table 1 for summary).

257 *A) As real-world problems involve and affect people, it will in most cases be necessary to involve*  
258 *stakeholders from the very beginning, when the problem is defined and the entire problem space*  
259 *is laid out.*

260 Stakeholders in our context are any individual or group of people who can affect the use, or is  
261 affected by the use, of ecosystem services (Hauck et al. 2013). Relevant stakeholders can be defined  
262 by answering questions, such as: Who is affected? Who derives benefits? Who manages the delivery  
263 of ES? Who decides? Who can influence the policy or management rules (Lovens et al. 2015)? It is  
264 important to identify together with stakeholders the relevant ES and the potential benefits that  
265 different groups of people derive from these services (see also Potschin and Haines-Young 2011).  
266 Other objects of value (e.g. built infrastructure, culture etc.), which may be linked to the problem,  
267 should also be identified and included at the same time (see also principle F). While often done alone  
268 by scientists providing a list of ES, it is often better to adopt a transdisciplinary approach (Cash et al.  
269 2003), involving stakeholders with their specific local knowledge and interests in the selection of  
270 relevant ES. Involving stakeholders in this way can also prevent potential biases from pre-elaborated  
271 ES classifications that may be at odds with stakeholders' ways of perceiving these services. For



272 example, Chan et al. (2012) illustrate the importance of this in the context of salmon fishing in British  
273 Columbia. “Wild salmon fishing” would be perceived by most scientists normally as a provisioning  
274 service, however it also has a crucial cultural value for the local people, related to their cultural  
275 identity. (Fishing of) wild salmon thus was not replaceable by farmed salmon, as it would have been  
276 if salmon had been considered only as a provisioning service.

277 Missing or unsatisfactory stakeholder involvement can be a major impediment to using the ES  
278 concept in real-world situations, both in terms of legitimacy, as well as in terms of missing crucial  
279 information on the respective social and ecological context (thus saliency) (Cash et al. 2003). On the  
280 other hand, haphazard participation can be costly and ineffective in representing social interests  
281 (Paloniemi et al. 2015).

282 Stakeholder involvement was a crucial element in the OpenNESS case studies, most of which  
283 involved a Case Study Advisory Board (CAB) consisting of practitioners, policy-makers and place-  
284 based experts (Dick et al. 2017a; Saarikoski et al. 2017). Dick et al. (2017a) found that stakeholder  
285 perspectives were involved in framing the issue in 40% of the OpenNESS case studies. Saarikoski et al  
286 (2017) also found that a transdisciplinary research approach increased mutual understanding  
287 between planners and researchers in several OpenNESS case studies, especially in cases where  
288 stakeholders were involved in joint problem formulation. For example, in one Belgian case study (De  
289 Cirkel), the research topics were defined based on strategic knowledge gaps of the project managers  
290 and on expertise available within the research team. This resulted in a research focus on the  
291 landscape needs of local inhabitants and their perception of the functions of traditional orchards.  
292 This approach enabled a direct uptake of some of the findings of the case study.

293

#### 294 *B) The role of scientists in approaching the problem should be clarified*

295 Scientists can have various tasks and roles in contributing to solving real-world problems, from “pure  
296 scientist” to issues advocate, but also as an “honest broker” towards finding (policy) alternatives  
297 (Pielke 2007). The more deeply they are involved, the more important it will be for them to gain trust  
298 and acceptance to be involved within the discourse (Chan et al. 2012). To increase legitimacy and  
299 effectiveness (Cash et al. 2003, Heink et al. 2015), scientists should see themselves as having a  
300 designated, but not dominant, role in a group of people who are collectively identifying and solving  
301 the problems at stake. Too close a relationship may lead to a dependence on the researcher which  
302 was not planned beforehand and which is out of scope of his or her project (Stone 2006).

303 In OpenNESS the main interaction with stakeholders was provided by creating CABs. Most cases  
304 studies were initiated by researchers, identifying potential problems and being partly based on  
305 previous research in the area (e.g. for landscape-ecological planning in urban and peri-urban areas in  
306 Slovakia, Bezák et al. 2017), or for farmland management in Kiskunság in Hungary, Kelemen et al.  
307 2015a). However, as a spin-off, e.g., of the Belgian case studies, researchers were contacted by the  
308 city of Genk and the Provincial administration of Oost-Vlaanderen to start similar research with their

309 case studies (i.e. Stiemerbeek and Maarkebeek) to support solving already identified problems. More  
310 than 80% of OpenNESS stakeholders responding to a questionnaire stated that the people involved  
311 were trusted and that the researchers provided good facilitation (Dick et al., 2017a).

312

313 *C) The complexity and often "wickedness" of the problem should be acknowledged and the nature of*  
314 *the problem, including its social, ecological, administrative and economic spheres, should be*  
315 *charted. Simplistic understandings of problems should be avoided to ensure that the problem and*  
316 *how an ES approach might contribute to its solution is clearly expressed. Hidden links between*  
317 *the different spheres need to be exposed.*

318 Scientists as well as decision makers strive for clear-cut questions and problem descriptions. Many  
319 real-world problems, especially those involving social-ecological systems with multiple stakeholders  
320 and interests, are by their very nature "messy", often only vaguely captured; they are also complex,  
321 uncertain and urgent (Funtowicz and Ravetz, 1994). Norton and Noonan (2007) call environmental  
322 problems "wicked problems", by which they mean, following Rittel and Webber (1973), that "they do  
323 not emerge as well-defined problems that are formulated similarly by different participants in the  
324 discussion. There will be, on the contrary, varied complaints and varied explanations of what the  
325 problem is, often associated with varied value positions and perspectives of the participants."  
326 (Norton and Noonan 2007, p. 672). Defining the problem itself is a result of a social process (an  
327 interaction of actors allowed to take part in problem definition). How a problem is defined (whether  
328 structured, moderately structured or unstructured) affects significantly how it is handled (Hoppe  
329 2011).

330 The variety of case studies in OpenNESS showed how different the entry points to a complex  
331 problem can be. It may be, e.g., a social conflict (such as in the Cairngorms case study on woodland  
332 creation, Dick et al 2017b) or the demand deriving from some formal regulatory requirement (such  
333 as in the Loch Leven case study, where the overarching aim was assessing the consequences of the  
334 EU Water Framework-Directive for the delivery of ES). Nevertheless, the social, ecological and  
335 political aspects will generally be linked in a complex manner.

336 García-Llorente et al. (2016) described this complexity for two protected areas which were also  
337 OpenNESS case study sites (Doñana and Sierra Nevada), emphasising the differing perceptions and  
338 priorities of environmental managers and researchers compared to that of users of ES. To account  
339 for the multiple complex problem constellations experienced in OpenNESS case studies and  
340 elsewhere, we developed and tested the so called OpenNESS Conceptual Nexus (ONEX), in order to  
341 tailor the different entry points according to the specific situation. It is designed to find the most  
342 appropriate pathway for approaching the problem at hand (see Potschin et al. 2017, Haines-Young et  
343 al. 2017, and below). ONEX was tested in the case study in the Kiskunság region (Hungary) and  
344 according to the key informant from that case study "enabled a 'comprehensive picture' of the case  
345 study to be built up." Also, "the experience was found to 'shed light on non-trivial relationships'

346 between different aspects of the problems and issues that were the focus of the case study, that  
347 were previously not so well articulated.” (Haines-Young et al. 2017, p. 81)

348

349 *D) Political space and influence spheres should be defined. The manoeuvring space (what is possible*  
350 *within the boundaries of e.g. a legal or societal situation) should be defined.*

351 Defining political space and manoeuvring space is a matter of clarifying governance conditions as  
352 well as power relations (Gómez-Baggethun et al. 2013, Berbés-Blázquez et al. 2016), for finding  
353 consent between different stakeholders for potential solutions and an appropriate problem  
354 delimitation and simplification. Manoeuvring space refers also to the space of possible solutions, as  
355 they may be restricted by e.g. property rights, budgetary restrictions, or policy regulations (e.g. the  
356 EU Water Framework Directive or the EU Habitats Directive). Being clear and transparent about such  
357 limitations is important both to focus research as well as avoid unrealistic expectations among  
358 stakeholders in terms of implementation (Reed et al. 2014, Spangenberg et al. 2015, Görg et al.  
359 2014), which may undermine trust between researchers and stakeholders (Cash et al. 2003).

360 In their analysis on the possibilities of mainstreaming the ES concept in EU policy making, conducted  
361 as part of the OpenNESS project, Schleyer et al. (2015) warn of raising wrong and unfulfillable  
362 expectations. According to their study, the ES concept is only partly incorporated in EU policy making  
363 and currently restricted to the environmental sector. Thus, its potential to address trade-offs with  
364 other policy sectors (such as agriculture or regional development) and to identify possible synergies  
365 is still limited due to the silo mentality of policy-making and other administrative challenges  
366 (including power imbalances across sectors). To move forward, a deeper understanding of the  
367 factors affecting the uptake is required, including communication barriers, stakeholder attitudes to  
368 the ES concept, and tensions between policy sectors.

369 At a national to local scale, Bezak et al. (2017) in their OpenNESS case study in Slovakia identified,  
370 e.g., the existence of partly contradictory legislation and regulations for spatial land use planning and  
371 assessment. At a local scale, they found perceived obstacles for ES-based management in the  
372 “complex land ownership structures in Slovakia where many owners are unknown and some private  
373 properties have many owners” (p. 129) and also in the resistance of many politicians on the local  
374 level, who perceived environmental legislation as an obstacle to rural development. To avoid  
375 frustration of local stakeholders and to aid discussion of synergies and trade-offs, local networks  
376 could play an important role, and ‘local ownership’ of these ‘integration’ frameworks should be  
377 encouraged.

378

379 *E) Concepts and language should be adapted to the specific situations and stakeholders.*

380 The required precision of concepts depends on the specific problem and situation. Vague concepts  
381 may be sufficient or even better at some stages in the research process (theory formation) and also  
382 for some application purposes (general communication about the value of nature for humans,

383 "didactic purpose", see e.g. Jax & Heink 2015). Vague concepts are also important in bringing people  
384 into the process, as no interpretation has yet been left out or closed and they feel that they still have  
385 a say in what the discussion is about (boundary concepts; see Abson et al. 2014), as also expressed  
386 by some OpenNESS stakeholders (Carmen et al. 2017). Vagueness, however, can become  
387 problematic when decision-support is required, as argued above (section 1). It can impede  
388 operationalisation of the ES concept in real world situations and implementation of results. The ES  
389 terminology is replete with concepts that are either vague or for which multiple definitions exist (see  
390 e.g. Jax 2016).

391 This also relates to the language used (Carmen et al. 2017). It is important to use terms and words  
392 that are understood well by all in the process. Opening up the meaning of technical words is  
393 essential for transferring the ES concept into practice. With its economic connotations, the language  
394 used may not be familiar for many stakeholders and decision makers (e.g. Lamarque et al. 2011, Böck  
395 et al. 2015), or it may appear to be less suitable to a stakeholders way of approaching their relations  
396 with nature (e.g. Turnhout et al. 2013, see also the recent discussion on the IPBES framework, e.g.  
397 Borie & Hulme 2015). ES language may thus often require "translation" when communicating it  
398 (Gómez-Baggethun and de Groot 2010). In many previous studies, the questions put to elicit relevant  
399 ES from stakeholders were (at least initially) not phrased in the ES terminology, especially at a local  
400 or regional scale (e.g. Chan et al. 2012, Koschke et al. 2014).

401 Metaphors to describe nature should be tailored to specific audiences and decision-making contexts.  
402 For example, the term 'natural capital' works well in economic discussions on environmental  
403 accounting, 'green infrastructure' can work well in discussions with urban planners, 'ecosystems' fits  
404 discussions with ecologists, 'Mother Earth' is suitable in discussions with indigenous peoples on  
405 nature's sacredness, whereas 'nature' may still be the best term to communicate with general  
406 audiences (Gómez-Baggethun and de Groot 2010). We should, however, also be aware that the  
407 different metaphors are not simple translations, but often also carry decisive differences ("framings")  
408 in terms of the values connected to them (Bardwell 1991, Larson 2011, Raymond et al. 2013), which  
409 must be considered in their own right (see Section 3.2). Discussions about the exact framing are  
410 always boundary negotiations, shaped by power relations, that define the precise meaning and  
411 relevance of a problem across a variety of stakeholder perceptions and scientific disciplines and thus  
412 require a truly inter- and transdisciplinary approach (Schleyer et al. 2017).

413 In some OpenNESS case studies, the appropriate terms were discussed with the stakeholders. It was  
414 attempted to find 'context-relevant' and 'self-explanatory' terms in an interactive process (Ulenaers  
415 et al. 2014). In some case studies the ES terminology was simplified as a response to interactions  
416 with the stakeholders. In the case study in Sibbesborg, Finland, for example, the five steps of the  
417 cascade model were pooled and reduced to three because some distinctions (in this case between  
418 structure and function, and between service and benefit, respectively) were not clear to the planners  
419 and eventually not required for the purpose, namely to "structure thinking and communicate with  
420 planners and residents" (Jari Niemelä, personal communication, June 2016). Likewise, interviews on

421 important ES used in the Hungarian case study did not use the ES terminology since “previous  
422 experience had shown that locals were not familiar with the term and had difficulties relating to the  
423 scientific categories” (Kovács et al. 2015, p. 121).

424

### 425 **3.2. Considering ethical issues**

426 Ethical issues in the use of the ES concept arise in various ways and are often unrecognized. Making  
427 them visible and considering them in research and application is necessary.

428 *F) When applying the ES concept in a specific situation, hidden and neglected issues, hidden values,  
429 and hidden links between issues should be revealed and made transparent. Hidden and  
430 suppressed issues and values may be the most important in terms of conflicts and conflict  
431 resolution between stakeholders.*

432 Due to the complexity of real-world problems, researchers, decision makers and other stakeholders  
433 striving to apply the ES concept may easily overlook some issues, as well as underlying values or links  
434 between issues. Such things are often of ethical relevance (see Luck et al. 2012, Jax et al. 2013). They  
435 refer to questions of justice such as who benefits, who carries the burdens of ES production or  
436 impairment (Daw et al. 2011; 2015, Pascual et al. 2014; Phelps et al. 2015)? Thus, for example, after  
437 the occurrence of mad cow disease in the 1990s and the resulting strong restrictions for feeding  
438 meat and bone meal to cattle, Europe's import of soybeans from South America for feed strongly  
439 increased. Importing ES (feed for more healthy animals and food) from South America has further  
440 increased deforestation and the transformation of other natural ecosystems there and – via the use  
441 of high loads of pesticides – partly led to diseases among the local population (WWF 2014).

442 Relevant items and values may not be captured by the ES concept, e.g. items which have no obvious  
443 value to most people or which some people consider to have intrinsic value (Davidson 2013, Jax and  
444 Heink 2015). But there are also *links* between issues that are easily overlooked. These include links  
445 between different ES categories. Reyes García et al. (2015), for example, found that edible wild  
446 plants for many people are not primarily a provisioning service, but their use is mainly continued  
447 because they have a high cultural and recreational value and thus also represent cultural services  
448 (see also Schnegg et al. 2014, Chan et al. 2012, 2016). Also, there are often crucial and complex links  
449 between ecological, social and economic issues, which are decisive for understanding and solving a  
450 problem, but may be missed if only one type of expertise is available (Abson et al. 2014).<sup>3</sup> These can  
451 be severe problems for operationalising the ES concept in a way that is appropriate for the problem  
452 at hand, not the least in the sense of reaching compromise solutions that are comprehensive and  
453 acceptable to all or most stakeholder groups.

454 In one OpenNESS case study, for example, García-Llorente et al. (2016) found that priorities given to  
455 specific ES in two Spanish protected areas (Sierra Nevada and Doñana Natural and National Parks)

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<sup>3</sup> Of course, also less obvious relationships in the biophysical system (e.g. groundwater recharge) must be visualised.

456 were different between managers and researchers on the one hand and ES users on the other; in  
457 consequence only some of the ES considered as vulnerable and important by stakeholders were part  
458 of the management plan of the protected areas, providing potential for conflict and loss of valued ES.

459 In the Hungarian case study, winners and losers from conservation-related land use changes became  
460 apparent through application of the ES concept and trade-off-analysis for different stakeholders. This  
461 then provided a clearer view on the specific potentials for conflict (Kovacs et al. 2015).

462 Tools developed in OpenNESS (such as The ONEX; see below) also provide support in identifying  
463 hidden values through raising questions and opening up the problem space to raise awareness of  
464 issues (such as justice and value plurality) that otherwise might easily be overlooked. We also have  
465 promoted methodologies for an integrated valuation of ES that is designed to cover a plurality of  
466 values embraced by people (see Jacobs et al. 2016, and below). For example, one of the Scottish case  
467 studies, showed that established methods such as QUICKscan can support elicitation of different  
468 values and viewpoints, and aid communication (Dick et al. 2017).

469

470 *G) To avoid socially unacceptable results or decisions arising from application of the ES concept the*  
471 *social and political compatibility of outcomes should be assessed and potential winners and losers*  
472 *identified during the implementation process.*

473 The outcomes of applying the ES concept may not always be welcomed by every stakeholder.  
474 Unexpected issues (materially, economically or socially) may also arise which may compromise  
475 particular interests and the desired problem solution. Payments for ES schemes may, for example,  
476 lead to locally undesirable injustices (e.g. Muradian et al. 2013) or to a loss of previous intrinsic  
477 motivation to protect nature without any further payments (“crowding out”, see. Rode et al. 2015).  
478 In some cases, monetary valuation may even violate stakeholder perceptions as they feel alienated  
479 and consider their cultural, social and other non-monetary values as being ignored (Spangenberg et  
480 al. 2015). This principle thus includes visualising implications of potential and alternative actions on  
481 ES and biodiversity. It also calls for considering issues of justice and environmental values (Daw et al.  
482 2011, Sikor et al. 2013).

483 In one of our Belgian case studies (De Cerkel), we observed the negative and initially “unexpected”  
484 side-effects of promoting rural tourism: garbage, apple theft along paths, parking problems, and  
485 damage to erosion grass strips. Thus one solution brought about unexpected problems. In another  
486 case study (Cairngorms, Scotland), participatory recreational mapping was used to determine where  
487 woodland could be located. The map showed roads as non-use areas as the survey focused on  
488 recreational use. However, one stakeholder commented she really valued the ‘view while driving to  
489 work on a daily basis’ along the roads and ‘would not like the view blocked by trees’ (Jan Dick,  
490 personal communication, June 2017).

491 In OpenNESS we addressed this issue by developing participatory scenarios (Priess et al. 2017) and an  
492 integrative valuation tool able to include biophysical, monetary and non-monetary valuation

493 methods and thus, in principle, to respect different cultural perceptions (Jacobs et al. 2016, Martín  
494 Lopez et al. 2017 and see below).

495

### 496 **3.3 Assessing alternative methods, tools and actions**

497 *H) ES tools and methods may not always be the only or even the best choice. To determine what*  
498 *kind of assessment is needed for decision-making, deliberative tools for scoping the problem*  
499 *space and the most appropriate tools for problem solving can be useful.*

500 The ES concept may not be able to address all types of problems, maybe not even fundamentally  
501 environmental ones. This may be because the ES concept and its terminology is not accepted due to  
502 its specific framing, which some people think does not reflect their relationships with nature, e.g.  
503 because they feel that this relationship cannot be expressed as a “service” but more as a “gift” (Borie  
504 and Hulme 2015), or because they care about nature without having to receive a benefit from it  
505 (“benefits to nature”: Davidson 2013). Also, many types of problem have traditionally been dealt  
506 with using other tools (e.g. in forest and water management or in traditional landscape planning; see  
507 e.g. von Haaren & Albert 2011). Earlier experiences and ways of thinking may have led to a mindset  
508 which expects that it is easier and more appropriate to handle the problem using conventional tools,  
509 such as multifunctional landscapes, sustainable development, or identifying the need for a protected  
510 area (see Raymond et al. 2013, Rozzi 2015, Norton 2015 for alternative approaches).

511 The ES concept and deliberative methods which involve stakeholders may not be needed for many  
512 environmental issues. Existing environmental regulations have in most cases already been  
513 deliberated by a legislature, and often define the relevant scope of the problem. They may  
514 nevertheless be supported by an ES approach, which is discussed in several places for the WFD (see  
515 e.g. Vlachopoulou et al. 2014, Carvalho et al. 2017). At times, however, an ES approach may also be  
516 used to challenge shortcomings of existing regulations.

517 In OpenNESS we documented a situation, where regulating services (removal of air pollutants) were  
518 assessed to make a limited contribution to climate change mitigation and pollution removal in cities,  
519 thus concluding that for this specific situation it was more effective to limit pollution sources than  
520 using the assessed regulating services on green infrastructure sites as ecological sinks (Baró et al.  
521 2014). In the Finnish bioenergy case study, local stakeholders considered sustainability assessment  
522 criteria as performing better in describing and handling their situation than the ES approach. The  
523 latter was seen as being insufficient to express crucial aspects of human well-being related to the  
524 services (here: bioenergy and timber) like forest owner income, employment, and regional economy  
525 (Saarikoski et al. 2017).

526

527

528 I) *It is important to connect various data pools with each other. This requires including all relevant*  
529 *sectors (such as research disciplines, policy fields). However, not all ES need to be assessed, which*  
530 *leaves space to focus on the most relevant, assuming all relevant stakeholders are consulted.*

531 When ecosystem services are assessed, it often happens that the knowledge used leans on existing  
532 databases and institutions. However, the need is often beyond that. This requires modifications or  
533 total revision in data gathering, management and sharing on various levels and various institutions,  
534 both public and private. Given the costs involved in these data collection processes, it is also  
535 important to fit the scale of data resolution to the nature of the problem at hand. Hauck et al. (2013),  
536 for example, found in their study that synergies and trade-offs between different ES at a large scale  
537 did sometimes not match that at a regional or local scale. Different applications of the ES concept  
538 require different degrees of data accuracy, scale and reliability (Gómez-Baggethun and Barton 2013);  
539 sometimes collecting too much data may not be effective or even helpful ('optimal ignorance').

540 Assessments of ES may require diverse information. In the case of forest management, data is  
541 needed on timber, berries, their pricing etc., often in a form that allows integrated analyses between  
542 them, including traditional/local environmental data (Primmer & Furman 2012, Saarikoski et al.  
543 2015).

544

545 J) *Different methods, or combinations of methods, can be useful for answering different questions*  
546 *and therefore it is important to identify as precisely as possible what is wanted (in iterations with*  
547 *knowledge users) before starting to search for appropriate methods.*

548 In terms of methods selection, it is necessary to tailor the methodology to the specific problem at  
549 hand. This also should, wherever possible, be done in collaboration with knowledge users (Opdam et  
550 al. 2015, Rodela et al. 2017, Harrison et al., 2017). Not every application of the ES concept requires  
551 detailed mapping of ES, nor a formal valuation process. If – and at what stage of a process of  
552 problem description and solution – particular methods are needed again depends on the specific  
553 situation. This may not be clear at the outset as some methodological needs and the pertinence of  
554 some approaches may surface only in the course of the process. Alternatively, assessments which are  
555 too complex and detailed may lack focus and be ineffective. Very comprehensive methods may take  
556 too long to produce results relative to the often short windows of opportunity involved with both  
557 policy and practice. Flexibility is necessary here to adapt to the complexity and time-pressures  
558 involved in addressing real-world problems (Potschin et al., 2017).

559 There are several methods and tools available to identify, quantify, map and value ES (see e.g.  
560 contributions in Potschin et al. 2016). These include methods for quantifying and qualifying ES,  
561 valuing them, stakeholder analysis, conceptual analysis, and a variety of social science methods (see  
562 also section 4 below). As said above, which methods need to be used depend on the specific problem  
563 at hand, and even within a particular field (e.g. valuation) different methods may be possible.



564 For example, to assess and communicate the importance of urban gardens to policy makers in our  
565 Barcelona case study, it was not necessary to map each ES and value it on a monetary basis. Instead,  
566 social science methods, in particular interviews, were mainly used (Camps-Calvet et al. 2015).

567 In OpenNESS an iterative approach, determining needs, demands and feasibility was practiced. On  
568 that basis guidance was developed for selecting methods appropriate to the respective problem(s)  
569 and to the situation, e.g. decision-making context, expertise and data available, budgets of time and  
570 money (see below and Barton et al., 2017, Jacobs et al. 2017; Dunford et al. 2017; Harrison et al.  
571 2017; Perez-Soba et al. 2017, Turkelboom et al. 2017).

572

573 [Insert table 1 here]

574

#### 575 **4. Selected tools from OpenNESS for supporting the implementation of our guiding principles**

576 How can we implement the guiding principles described above? In this section we briefly introduce  
577 some integrative tools, as developed in OpenNESS, and describe how they can support the  
578 implementation of the principles presented above. More detailed accounts of the tools can be found  
579 in other papers of this special issue, as indicated below.  
580

#### 581 **Ecosystem Service Assessment Support Tool (ESAST)**

582 As an overarching guidance for ES assessments, the Ecosystem Service Assessment Support Tool  
583 (ESAST) was developed to involve a broad range of stakeholders from the beginning (principle A) (Fig.  
584 1). It is hosted in the web-platform Oppla ([www.oppla.eu](http://www.oppla.eu) and see below) and offers practical, step-  
585 by-step guidance on how to carry out an ES assessment process and to integrate the results into  
586 management and decision-making. The tool follows loosely the form of the classical “policy cycle”  
587 and links to other tools (such as those described below). It starts, following principle A, with an  
588 interactive problem formulation process to jointly with key stakeholders define the objectives as well  
589 as biophysical and socio-cultural dimensions that are relevant for the management or decision-  
590 making situation (step 1). The next step (step 2) in ESAST is the identification of the ES and the  
591 associated benefits and beneficiaries that are likely to be influenced by the management or policy  
592 decisions at hand (principles D and G) followed by an analysis of the ways in which direct and indirect  
593 drivers of change influence ecosystems and their capacity to provide services (step 3). To understand  
594 the values that people assign to ES and the benefits that they derive from them, ESAST then provides  
595 guidance for selecting biophysical assessment methods as well as monetary and non-monetary  
596 valuation methods that are fit for purpose (step 4, principle J). In the next step, it then uses the  
597 knowledge about ecosystem services to inform actual decision making (see Saarikoski et al. in this  
598 issue) through a multitude of decision support tools that are available (see Barton et al. 2017) (step

599 5). These tools structure information on management and policy options and their consequences,  
600 and highlight trade-offs between ES (see Turkelboom et al. 2017). Facilitation, mediation and dispute  
601 resolution methods are helpful in highly conflictual trade-off situations (supporting principles F and  
602 G). Overall, knowledge of ES is most effective when decision-makers and key stakeholders have been  
603 closely involved in the assessment process to ensure that they find the information relevant and  
604 reliable, and are ready act upon it.

605

606 [Insert figure 1 here]

607

### 608 **Tool for problem specification: OpenNESS Conceptual Nexus (ONEX)**

609 To account for the messiness of real-world problems and the multitude of issues to which the ES  
610 approach may be applied, the OpenNESS Conceptual Nexus (ONEX) tool was developed. It supports  
611 the application of several of the above principles.

612 The application of the ES concept generally has to be approached iteratively because it usually  
613 involves diverse groups of stakeholders (principle A), who need to develop a shared understanding of  
614 issues and potential solutions. To support this deliberative approach, we have explored how  
615 guidelines can be created to help people understand, discuss and apply key ideas in ways that are  
616 relevant to their situation (principle E). These guidelines take the form of a ‘conceptual nexus’, or  
617 network of concepts, termed ONEX (Potschin et al. 2017). The ONEX tool, starting from the general  
618 question “what is the issue at hand”, guides people via different potential entry points, namely the  
619 types of ecosystems being considered, the stakeholders involved and the dominant social and  
620 political processes within the study area (principle D). Via a number of questions, it enables people to  
621 look at the relationships between ideas and gives them access to resources that allow them to build  
622 deeper insights into issues (principle C, also supporting principle G). ONEX is implemented using the  
623 freely available internet tool, Trello, which is widely used for project management. In an operational  
624 context, researchers often have to work as ‘knowledge brokers’ (Pielke 2007, Reed et al. 2014) with  
625 diverse groups of people. ONEX can help them by facilitating deliberative work involving ES, which  
626 requires the co-production of knowledge and social learning. The focus is on how it can be used by  
627 case studies to build a richer picture of their problem situation (principle C) by looking at, e.g., the  
628 four OpenNESS Challenges of human well-being, sustainable ecosystem management, governance,  
629 and competitiveness (Potschin et al. 2017). The ONEX tool can be downloaded and used via  
630 <https://trello.com/b/sm1IX0S0/the-onex-lab>.

631

### 632 **Toolbox for Integrated Assessment and Valuation**

633 In support of principle I and J, OpenNESS guidelines on method selection for conducting integrated  
634 assessment and valuation (Braat et al. 2014; Gómez-Baggethun et al. 2014; Kelemen et al. 2015b;  
635 Barton and Harrison 2017) have been developed. The toolbox featuring a range of new and existing  
636 methods for ES assessment includes different biophysical, socio-cultural and monetary techniques  
637 (Dunford et al 2017; Harrison et al. 2017; Jacobs et al. 2017; Smith et al. 2017, Zulian et al. 2017).  
638 Characteristics of each method in terms of their requirements (e.g. data, resources, expertise) and  
639 purpose (e.g. mapping, deliberation, valuation) are identified, recognising that several methods may  
640 suit a specific purpose or that combinations of methods may be useful for addressing certain  
641 problems (principle I and J). Documentation describing the steps required to implement each  
642 method is supplied. Several approaches which aim to provide guidance on selecting methods for  
643 biophysical, socio-cultural and monetary valuation, including a set of interlinked decision trees  
644 (Harrison et al. 2017), matrices of method considerations (Dunford et al. 2017), plural value  
645 dimensions covered by different methods (Jacobs et al. 2017), and an online method selection tool  
646 (Barton and Harrison 2017) are provided.

647 As an important lesson learned from the OpenNESS project we recommend that decision trees are  
648 not used literally to make decisions on method choice, but as an organised way of asking questions  
649 that aid method selection. Recognising that decision trees are limited by their fixed structures, they  
650 are supplemented by other approaches such as the online method selection tool<sup>4</sup>. The tool uses  
651 Bayesian Belief Network software to address method selection as a multi-criteria classification  
652 problem. In contrast to the decision trees which lead to single method recommendations through a  
653 series of binary choices, the method selection tool recommends portfolios of methods, which are a  
654 narrower set of options for further consideration 'off-line'.

655

## 656 **Scenarios for regulatory frameworks**

657 In order to provide better insights into the political and social manoeuvring space (principle D) and to  
658 elucidate the social and political compatibility of outcomes from decisions involving ES (principle G),  
659 we used a participatory scenario approach. One important aspect for the usefulness of the ES  
660 concept for policy making is its potential relevance as a cross-cutting issue that goes beyond  
661 biodiversity and nature conservation and integrates other dimensions of environmental policy (such  
662 as the WFD in Europe) and other societal sectors and the policy fields they regulate (such as  
663 agriculture and the Common Agricultural Policy or regional development and infrastructure policy).  
664 Even though the uptake of the ES concept in policy is currently limited (see above), scenario

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<sup>4</sup> <http://openness.hugin.com/oppla/ValuationSelection>

665 approaches are useful for capturing the interplay between different policies and other drivers of  
666 change (e.g. social, technological and environmental) and how this effects future changes in ES.  
667 Based on participatory scenario development at the European level and in the case studies, policy  
668 scenarios were developed to analyse policy options and their impact on future ecosystem change  
669 (García-Llorente et al. 2016, Priess et al. 2017). Policy analyses were combined with scenario  
670 approaches and modelling to better understand policy options (principle D) and their impacts on  
671 future changes in land use and ES (supporting principle G). Based on this analysis, we identify and  
672 explore alternative policy options that may have triggered (or at least fostered) certain changes  
673 (Hauck et al. 2017).

674

### 675 **Digital interaction via Oppla**

676 Oppla ([www.oppla.eu](http://www.oppla.eu)) is the web platform jointly developed by the OpenNESS and OPERAs projects,  
677 to facilitate knowledge exchange on ecosystem services, natural capital and nature-based solutions  
678 gathered from around Europe and beyond. It not only contains the main outcomes of both projects  
679 such as case studies, online tools and methods and guidance to select them, but it also supports  
680 communication and dissemination activities such as information on events, and organisation of  
681 consultancy and training (via webinars and MOOCS). Very importantly, it also hosts a community that  
682 will exchange and transfer the new knowledge acquired, developing individual capacities to address  
683 challenges associated with ecosystem services and natural capital (see Pérez-Soba et al. 2017). The  
684 content of Oppla initially came from OPERAs and OpenNESS, but other members of the community  
685 have contributed as well.<sup>5</sup>

686 The following key features describe Oppla's characteristics to make knowledge exchange  
687 operational. Oppla is open to a multidisciplinary and cross-sectoral Community of Practice, involving  
688 academic/research organisations, policy makers, NGOs, private companies, etc.

- 689 - In line with Principle A, from the very start Oppla was designed with the input of a range of  
690 potential users, and its development has been adjusted based on feedback on functionality, user  
691 friendliness and content, collected through several approaches including direct dialogue with  
692 representatives from the European Commission, European institutions, intergovernmental  
693 bodies, private sector and other target groups.

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<sup>5</sup> The Oppla ownership by the OpenNESS and OPERAs consortia was transferred in 2017 to a private company to ensure Oppla use and development beyond the lifetime of both projects.

694 - Supporting Principle J, Oppla is developed to facilitate the connection of various data sources.  
695 For example, over 40 case studies are currently described in the Case Study Finder, a tool that  
696 gathers and spatially displays all the case studies from both projects and some others. It covers a  
697 wide range of ecosystem services at multiple scales, areas and management schemes. These case  
698 studies provide fresh insights into the needs of those applying the ES concept in the field, as well  
699 as an empirical resource for testing ES instruments, tools and methods. Each case study refers to  
700 a contact person for further information and to a location. The Oppla community can hence learn  
701 from each other by this way of knowledge sharing.

702

## 703 **5. Conclusions and outlook**

704 The approach towards operationalising the ES concept as developed in the OpenNESS project, whose  
705 process and outcomes are described in Furman et al. (2017 a and b) and in various articles in this  
706 special issue, was not constructed as a single formal framework or scheme. Rather it consists of a  
707 number of guiding principles and a set of integrative tools for operationalising the ES concept. We  
708 see the guiding principles as crucial to consider when applying the ES concept to real world  
709 situations. They were derived from an iterative interplay between experiences on the ground – from  
710 a broad array of case studies – and theoretical work. This procedure turned out to be extremely  
711 useful, as evidenced by the feedback given by stakeholders of the project (Dick et al. 2017a). The  
712 guiding principles also include a number of important caveats in order to avoid an over-simplistic and  
713 potentially counterproductive use of the concept, always a danger whenever a new concept starts to  
714 become “fashionable”. Based on the practical and theoretical work and the guiding principles, we  
715 developed integrative tools, in order to promote an inter- and transdisciplinary approach to  
716 operationalising the ES concept, making full use of the potential both of the concept (where it has  
717 often not been played out hitherto; Abson et al. 2014) and of a large-scale research project with (in  
718 our case) over 150 project participants. We did not develop tools for all of the guiding principles  
719 described, partly because such tools were already available in the rich literature on ES and beyond,  
720 and partly because the needs for additional tools surfaced only during the project and thus could not  
721 be implemented during the restricted duration of a project. Also, there is still room for integrating  
722 the different tools developed even further, e.g. more closely linking ONEX with the Toolbox for  
723 Integrated Assessment and Valuation. In any case we hope that our approach, presented in this  
724 paper and in more detail in the other papers in this Special Issue, will be of use to other projects on  
725 operationalising the ES concept, but even more for users on the ground. Concerning the latter, let us  
726 emphasise that, given the complexity of the ES concept, our approach (and the ES concept in  
727 general) should not be used by completely inexperienced non-scientific users. Instead, in most cases

728 it will require a “knowledge broker” (scientist or other experienced person) already familiar with the  
729 concept, to make the best use of it, for the benefit of all stakeholders – and of nature.

730  
731 **Acknowledgements**

732 This work was supported by the OpenNESS project (Operationalisation of Natural Capital and  
733 Ecosystem Services: From Concepts to Real-world Applications), funded from the European Union  
734 Seventh Framework Programme (FP7-ENV.2012.6.2-1) under grant agreement n1 308428. We also  
735 thank Leon Braat, Ulrich Heink, Marion Potschin-Young, Heidi Wittmer and an anonymous reviewer  
736 for their critical comments, as well as Suvi Vikström for kindly supporting our work on this paper.

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1063 Table 1: Ten Principles to consider when putting ecosystem services concepts into practice.

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| <p>A) <i>As real-world problems involve and affect people, it will in most cases be necessary to involve stakeholders from the very beginning, when the problem is defined and the entire problem space is laid out.</i></p> <p>B) <i>The role of scientists in approaching the problem should be clarified.</i></p> <p>C) <i>The complexity and often "wickedness" of the problem should be acknowledged and the nature of the problem, including its social, ecological, administrative and economic spheres should be charted. Simplistic understandings of problems should be avoided to ensure that the problem and how an ES approach might contribute to its solution is clearly expressed. Hidden links between the different spheres need to be exposed.</i></p> <p>D) <i>Political space and influence spheres should be defined. The manoeuvring space (what is possible within the boundaries of e.g. a legal or societal situation) should be defined.</i></p> <p>E) <i>Concepts and language should be adapted to the specific situations and stakeholders.</i></p> <p>F) <i>When applying the ES concept in a specific situation, hidden and neglected issues, hidden values, and hidden links between issues should be revealed and made transparent. Hidden and suppressed issues and values may be the most important in terms of conflicts and conflict resolution between stakeholders.</i></p> <p>G) <i>To avoid socially unacceptable results or decisions arising from application of the ES concept the social and political compatibility of outcomes should be assessed and potential winners and losers identified during the implementation process.</i></p> <p>H) <i>ES tools and methods may not always be the only or even the best tool. To determine what kind of assessment is needed for decision-making, deliberative tools for scoping the problem space and the most appropriate tools for problem solving can be useful.</i></p> <p>I) <i>It is important to connect various data pools with each other. This requires including all relevant sectors (such as research disciplines, policy fields). However, not all ES need to be assessed, which leaves space to focus on the most relevant, assuming all relevant stakeholders are consulted.</i></p> <p>J) <i>Different methods, or combinations of methods, can be useful for answering different questions, and therefore it is important to identify as precisely as possible what is wanted (in iterations with knowledge users) before starting to search for appropriate methods.</i></p> |  |
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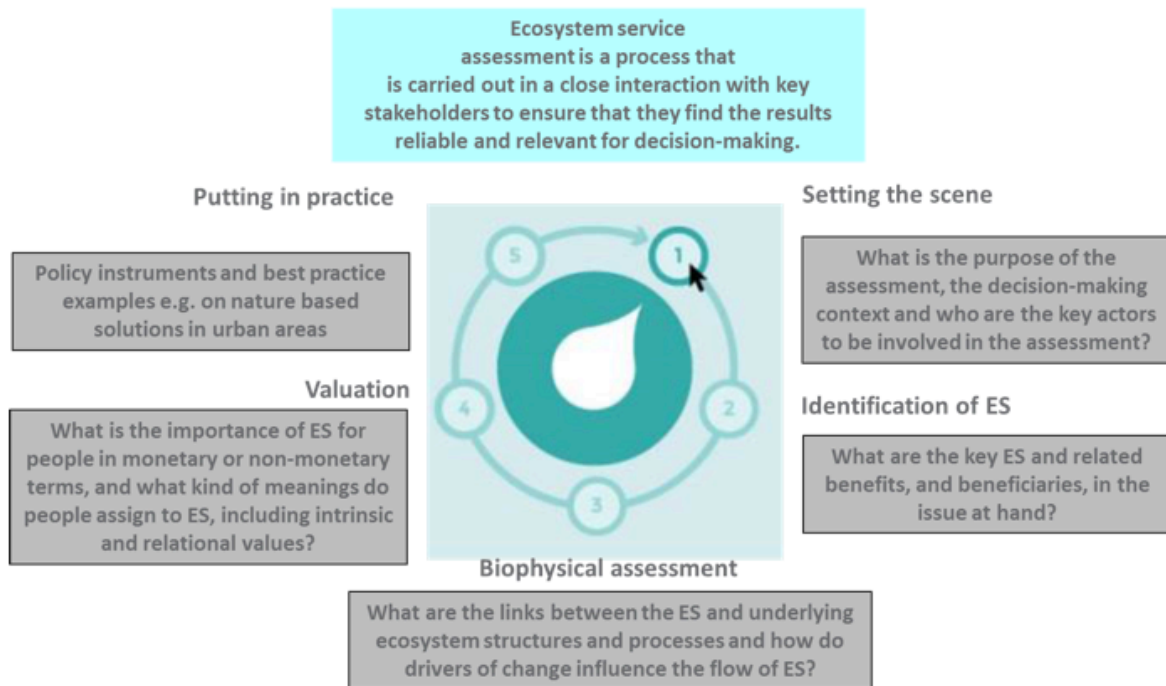
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1067 Fig. 1 The ESAST scheme. See text for explanation.

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