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Handling a messy world: Lessons learned when trying to make the ecosystem services concept operational

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Abstract

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

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

Highlights

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

Keywords: ecosystem services, conceptual frameworks, integrative tools, guiding principles, OpenNESS project

1. Introduction

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

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

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

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

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

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

[2] See Furman et al. 2017a for a more detailed discussion of the natural capital concept.

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

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

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

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

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

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

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

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

3. From problems to solutions: guiding principles for operationalising the ecosystem services concept

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

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

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

3.1. Defining a problem and opening up the problem space

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

A) 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.

Stakeholders in our context are any individual or group of people who can affect the use, or is affected by the use, of ecosystem services (Hauck et al. 2013). Relevant stakeholders can be defined by answering questions, such as: Who is affected? Who derives benefits? Who manages the delivery of ES? Who decides? Who can influence the policy or management rules (Lovens et al. 2015)? It is important to identify together with stakeholders the relevant ES and the potential benefits that different groups of people derive from these services (see also Potschin and Haines-Young 2011). Other objects of value (e.g. built infrastructure, culture etc.), which may be linked to the problem, should also be identified and included at the same time (see also principle F). While often done alone by scientists providing a list of ES, it is often better to adopt a transdisciplinary approach (Cash et al. 2003), involving stakeholders with their specific local knowledge and interests in the selection of relevant ES. Involving stakeholders in this way can also prevent potential biases from pre-elaborated ES classifications that may be at odds with stakeholders' ways of perceiving these services. For example, Chan et al. (2012) illustrate the importance of this in the context of salmon fishing in British Columbia. “Wild salmon fishing” would be perceived by most scientists normally as a provisioning service, however it also has a crucial cultural value for the local people, related to their cultural identity. (Fishing of) wild salmon thus was not replaceable by farmed salmon, as it would have been if salmon had been considered only as a provisioning service.

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

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

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

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

In OpenNESS the main interaction with stakeholders was provided by creating CABs. Most cases studies were initiated by researchers, identifying potential problems and being partly based on previous research in the area (e.g. for landscape-ecological planning in urban and peri-urban areas in Slovakia, Bezák et al. 2017), or for farmland management in Kiskunság in Hungary, Kelemen et al. 2015a). However, as a spin-off, e.g., of the Belgian case studies, researchers were contacted by the city of Genk and the Provincial administration of Oost-Vlaanderen to start similar research with their case studies (i.e. Stiemerbeek and Maarkebeek) to support solving already identified problems. More than 80% of OpenNESS stakeholders responding to a questionnaire stated that the people involved were trusted and that the researchers provided good facilitation (Dick et al., 2017a).

C) 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.

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

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

García-Llorente et al. (2016) described this complexity for two protected areas which were also OpenNESS case study sites (Doñana and Sierra Nevada), emphasising the differing perceptions and priorities of environmental managers and researchers compared to that of users of ES. To account for the multiple complex problem constellations experienced in OpenNESS case studies and elsewhere, we developed and tested the so called OpenNESS Conceptual Nexus (ONEX), in order to tailor the different entry points according to the specific situation. It is designed to find the most appropriate pathway for approaching the problem at hand (see Potschin et al. 2017, Haines-Young et al. 2017, and below). ONEX was tested in the case study in the Kiskunság region (Hungary) and according to the key informant from that case study "enabled a ‘comprehensive picture’ of the case study to be built up.” Also, “the experience was found to ‘shed light on non-trivial relationships’ between different aspects of the problems and issues that were the focus of the case study, that were previously not so well articulated." (Haines-Young et al. 2017, p. 81)

D) 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.

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

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

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

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

The required precision of concepts depends on the specific problem and situation. Vague concepts may be sufficient or even better at some stages in the research process (theory formation) and also for some application purposes (general communication about the value of nature for humans, "didactic purpose", see e.g. Jax & Heink 2015). Vague concepts are also important in bringing people into the process, as no interpretation has yet been left out or closed and they feel that they still have a say in what the discussion is about (boundary concepts; see Abson et al. 2014), as also expressed by some OpenNESS stakeholders (Carmen et al. 2017). Vagueness, however, can become problematic when decision-support is required, as argued above (section 1). It can impede operationalisation of the ES concept in real world situations and implementation of results. The ES terminology is replete with concepts that are either vague or for which multiple definitions exist (see e.g. Jax 2016).

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

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

In some OpenNESS case studies, the appropriate terms were discussed with the stakeholders. It was attempted to find 'context-relevant' and 'self-explanatory' terms in an interactive process (Ulenaers et al. 2014). In some case studies the ES terminology was simplified as a response to interactions with the stakeholders. In the case study in Sibbesborg, Finland, for example, the five steps of the cascade model were pooled and reduced to three because some distinctions (in this case between structure and function, and between service and benefit, respectively) were not clear to the planners and eventually not required for the purpose, namely to "structure thinking and communicate with planners and residents" (Jari Niemelä, personal communication, June 2016). Likewise, interviews on important ES used in the Hungarian case study did not use the ES terminology since “previous experience had shown that locals were not familiar with the term and had difficulties relating to the scientific categories” (Kovács et al. 2015, p. 121).

3.2. Considering ethical issues

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

F) 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.

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

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

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

[3] Of course, also less obvious relationships in the biophysical system (e.g. groundwater recharge) must be visualised.

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

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

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

G) *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.*

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

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

In OpenNESS we addressed this issue by developing participatory scenarios (Priess et al. 2017) and an integrative valuation tool able to include biophysical, monetary and non-monetary valuation methods and thus, in principle, to respect different cultural perceptions (Jacobs et al. 2016, Martín Lopez et al. 2017 and see below).

3.3 Assessing alternative methods, tools and actions

H) ES tools and methods may not always be the only or even the best choice. 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.

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

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

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

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.*

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

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

J) *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.*

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

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

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

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

[Insert table 1 here]

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

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

Ecosystem Service Assessment Support Tool (ESAST)

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

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

[Insert figure 1 here]

Tool for problem specification: OpenNESS Conceptual Nexus (ONEX)

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

The application of the ES concept generally has to be approached iteratively because it usually involves diverse groups of stakeholders (principle A), who need to develop a shared understanding of issues and potential solutions. To support this deliberative approach, we have explored how guidelines can be created to help people understand, discuss and apply key ideas in ways that are relevant to their situation (principle E). These guidelines take the form of a 'conceptual nexus', or network of concepts, termed ONEX (Potschin et al. 2017). The ONEX tool, starting from the general question "what is the issue at hand", guides people via different potential entry points, namely the types of ecosystems being considered, the stakeholders involved and the dominant social and political processes within the study area (principle D). Via a number of questions, it enables people to look at the relationships between ideas and gives them access to resources that allow them to build deeper insights into issues (principle C, also supporting principle G). ONEX is implemented using the freely available internet tool, Trello, which is widely used for project management. In an operational context, researchers often have to work as 'knowledge brokers' (Pielke 2007, Reed et al. 2014) with diverse groups of people. ONEX can help them by facilitating deliberative work involving ES, which requires the co-production of knowledge and social learning. The focus is on how it can be used by case studies to build a richer picture of their problem situation (principle C) by looking at, e.g., the four OpenNESS Challenges of human well-being, sustainable ecosystem management, governance, and competitiveness (Potschin et al. 2017). The ONEX tool can be downloaded and used via https://trello.com/b/sm1lX0S0/the-onex-lab.

Toolbox for Integrated Assessment and Valuation

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

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

Scenarios for regulatory frameworks

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

[4] http://openness.hugin.com/oppla/ValuationSelection

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

Digital interaction via Oppla

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

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

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

[5] 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.

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

5. Conclusions and outlook

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

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

A) *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.*
B) *The role of scientists in approaching the problem should be clarified.*
C) *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.*
D) *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.*
E) *Concepts and language should be adapted to the specific situations and stakeholders.*
F) *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.*
G) *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.*
H) *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) *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.*
J) *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.*

Fig. 1 The ESAST scheme. See text for explanation.