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Operationalising ecosystem service approaches for governance: Do measuring, mapping and valuing integrate sector-specific knowledge systems?

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ABSTRACT

The scientific community is working on ways to identify different ecosystem services and to bring them on par to allow tradeoff analysis and inform targeting of policies. However, those ultimately governing ecosystem services continue to base their decisions on traditional knowledge production segregated to specific habitats, ecosystems, geographical areas and sectors. The aim of our paper is to tackle the challenges of the transition from sector governance to a more integrated model of ecosystem service governance by building on existing governance arrangements geared towards sustainability. To examine the uptake of ecosystem service approaches, we review published material and conduct secondary analysis of how ecosystem services are identified, measured, mapped and valued in three Finnish real-world governance settings. The governance settings of voluntary biodiversity conservation, urban planning and natural resource strategies show that, at a qualitative level, identifying a broad range of ecosystem services is easy and appealing but cross-comparison and tradeoff analysis face challenges. The analysis demonstrates that measuring all services is impossible and faces difficulties where the services fall between traditional sectoral boundaries. Measuring and valuing services does not directly lead to increased use of this knowledge. We conclude that the mismatch between the governance needs and the ecosystem service paradigm can be closed only if the tools are developed so that they build on existing knowledge systems and governance arrangements but aim at communicating across ecosystem and sector boundaries.

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1. Introduction

Ecosystem services have been governed throughout the entire history of mankind. On the one hand, the exploitation of natural resources has been rationed to ensure the sufficiency of each of the resources, however often producing unsustainable outcomes (Norgaard, 1994). These management systems aiming at sustainability have been backed up with precautionary activities, such as establishment of gene reserves and restoration of degraded resources or sites (Convention on Biological Diversity, 1992). On the other hand, natural ecosystems have been appreciated for various reasons, ranging from aesthetic and experiential to the intrinsic value of pristine nature and rare species, which has led to the establishment of protected areas and national parks (IUCN, 1993). However, the awareness of those ecosystem processes and services whose use is less direct, such as climate, water or biological regulation, has been absent (Millenium Ecosystem Assessment, 2005; Wallace, 2007) and governance of these services is only emerging. Additionally, the interaction between the various uses of ecosystem services has been neglected in the existing governance models (Carpenter et al., (2009)), which has undermined sustainable use and safeguarding of ecosystem services. Governance, referring to all the institutional arrangements and processes aiming at identifying and enacting collectively acceptable principles (Ostrom, 1990; Paavola, 2007), would in the case of ecosystem services require integration of multiple knowledge sources and engaging those actors who understand, manage and benefit from the services.

The dichotomy in framing natural use and conservation has led to strong sectoral policies and practices, linked with institutions, including laws, administrative arrangements, professional practices and information management systems (Primmer, 2011). Behind the division cognitive framings reside about natural resource use as a source of income among natural resource extracting and managing sectors and as a target of protection by the environmental sector (Hukkinen et al., 1999). This has led to an abiding view of conservation as a constraint for the use of natural resources. In fact, nature conservation posing a constraint to economic activity has been shown to be a major obstacle for overcoming the stark segregation of administrative and governance arrangements (Rantala and Primmer, 2003; Rivera et al., 2009; Hiedanpää et al., 2011).

Instead of contrasting problems and possibilities, the ecosystem services approaches aim at integration by focusing on the spatial extent of ecosystem services as well as the underlying functions of ecosystems and the reliance of services on these functions, pointing to the added value that different ecosystem functions and services provide to the society (Daily, 1997; De Groot et al., 2010). Attention is drawn to those associated regulating and underlying supporting services that have not always been noticeably threatened or at least their governance has not been organised because they are public or collectively governed and difficult to delineate. These approaches recommend measuring, mapping and valuing ecosystem services as fundamental knowledge systems required for governing ecosystem services.

Although the ecosystem service approaches often pay attention to social–ecological systems and allow considering a range of issues simultaneously, they do not provide direct solutions to ecosystem service governance because they do not take existing administrative and governance structures and practices as a starting point. While the academia is working on the theoretical basis and developing knowledge systems for application, those designing policies and making operational decisions are struggling with integrating the vulnerability of regulating services and the underlying ecosystem functions into sustainable use and management. The developed measurement, mapping and valuation tools remain to be tested in practice. This endeavour requires attention to the knowledge systems and governance models that pre-exist the new tools. In other words, the way that existing policies and the institutional context condition the feasibility of new ecosystem services approaches should be identified, together with the ecological and socio-economic context of ecosystem service use and management.

The aim of our paper is to tackle the challenges of the transition from the segregated model of sector governance to a more integrated model of ecosystem service governance by building on existing governance arrangements geared towards sustainability. We do this by reviewing literature on ecosystem services with the approaches focusing on measuring, mapping and valuing of ecosystem services as well as examples of literature on sustainability driven natural resource and land use governance. We then demonstrate the use and relevance of these approaches with a review of published material on three Finnish governance settings: voluntary biodiversity conservation, urban planning and natural resource programmes. Finally, we analyse the gap between the ecosystem service approaches and their operational implementation and derive conclusions for both context specific and general knowledge needs, with the aim to serve the governance of ecosystem services.

2. Approaches to ecosystem services aiming at integrated analysis and governance

Three debates that relate to ecosystem services and their governance in academic literature are often highlighted as conceptual framings, as drivers of methodological development and as points of operationalization of the concept. On the one hand, the necessity of conserving biodiversity and ecosystem functions for guaranteeing ecosystem services points to the need to identify and measure ecosystem services. On the other hand, the economic benefits and value of ecosystems and the services they provide for humans highlight the need to monetise ecosystem services. Third, falling between these two approaches, are the spatially conceptualised and organised approaches that require mapping of ecosystem services. These approaches aim to provide a platform for merging the information on ecological characteristics and economic values as well as to solve cross-scale coordination challenges. Based on literature, we introduce these three approaches of measuring, mapping and valuing, together with a natural resource governance approach, to demonstrate the operational basis for developing governance of ecosystem services.

2.1. Identifying and measuring biodiversity and regulating services

The ongoing alarmingly fast decline in biodiversity is estimated to lead to a multitude of negative impacts also on ecosystem services (Chapin et al., 2000). When observations are concentrated on biodiversity indicators, the ecosystem service impacts might not be identified, let alone measured. The negative impacts of biodiversity degradation however result in reduction in productivity (Tilman, 1999, Hooper et al., 2005; Isbell et al., 2011), reduced ecological resilience or recovery after disturbance (Elmqvist et al., 2003; Bernhardt-Römermann et al., 2011) and narrowing of the ecosystem functions (Gamfeldt et al., 2008; Isbell et al., 2011). These important ecosystem functions point to a need to identify the key ecosystem features. Once they have been identified, they can be measured for further analytical purposes.

Existing monitoring and governance arrangements might not support identifying and measuring ecosystem services. Particularly

regulating and supporting services and the underlying ecosystem functions fall between or outside monitoring responsibilities, administrative boundaries and sectoral interests. Analysing the linkages between a single ecosystem service, e.g. production of a particular natural resource and its ecological preconditions requires observations that span also spatially and temporally (Anderson et al., 2009). Detecting ecological and social–ecological interdependencies requires observations across landscape and with long time series.

As the understanding of the relationship between biodiversity and ecosystem functions is increasing, the operationalization of this complex relationship for governance and management presents the practice with new challenges (Carpenter et al., 2009; De Groot et al., 2010). The operational decisions are expected to move from using habitat-based approaches, relying on sector specific metrices towards methods that pay attention to functioning and resilient landscapes—across multiple ecosystems and social–ecological systems. Identifying and measuring ecosystem services are a starting point for these governance changes.

2.2. Mapping of ecosystem services for cross-scale coordination and spatial planning

Partly because of the segregated research traditions and partly for more socio-political reasons, ecosystems are typically governed as geographically delimited units that fall under particular jurisdictions and sector administrations (Cash et al., 2006). In the administrative role division, nature conservation would typically be under environmental administration, while use and management of productive ecosystems would fall under some specific natural resource administration, e.g. commercially exploited forests under forestry administration. Land use changes would be a part of physical planning of the built environment.

The different administrative bodies all conduct spatial inventories and planning for a range of purposes, e.g. to set aside areas of conservation value, to plan infrastructure development, harvest or management and to design and monitor budgetary allocations (Kaljonen, 2008; Primmer and Wolf, 2009; Lehtomäki et al., 2009; Söderman and Saarela, 2010). It is exactly these means directly supporting governance that are anticipated to take up the ecosystem service approach, applying and integrating new ways of mapping ecosystem services across landscapes (Carpenter et al., 2009; Niemelä et al., 2010; De Groot et al., 2010).

With spatial mapping of ecosystem services, attempts have been made to analyse tradeoffs between the production of different services in particular settings (e.g., Troy and Wilson, 2006, Vihervaara et al., 2010; Burkhard et al.,2012) or at a global level (e.g., Naidoo et al., 2008). In addition to numerous technical challenges, integration of different maps and the approaches that precede their development faces the challenges of generalising across spatial units and across sectors (Maes et al., 2011). At a more operational level, integrating ecosystem services mapping into existing spatial planning systems requires the administrative sectors to share information and adapt their existing mapping systems.

2.3. Valuation of ecosystems and their services

The increased scientific and political awareness of ecosystem services can be largely considered to be an upshot from the rise of monetary arguments and approaches linked with specific ecological characteristics of the systems or their parts during the last 15 years. The seminal article demonstrating the monetary value of the world's ecosystems and their services by Costanza et al. (1997) has been followed by numerous studies pointing to the dependence of particular economic systems on the functioning of the ecosystems. Following the boost in identifying the economic benefits and measuring their value with the tools of economics (e.g. Bateman et al., 2011), an interest has emerged in transferring values from one context to another and generalising the identified values across space and time (Barton, 2002; Troy and Wilson, 2006; Naidoo et al., 2008; Chen et al., 2008).

The challenges of generalising and transferring values from one context to another have recently been recognised (Muradian et al., 2010; Sagoff, 2011). The multiple values derived and experienced vary among actors representing different uses of ecosystems in different ecological socio-economic contexts (Hein et al., 2006; Vatn, 2010; Sagoff, 2011; Vihervaara et al., 2012). Additionally, the idea of capturing the ecosystem functions in monetary values has triggered scepticism already early on (Spash and Hanley, 1995; Vatn and Bromley, 1995). For this reason, approaches that highlight different local and cultural framings of the benefits of ecosystem services have been developed to complement and challenge monetary valuation (Hein et al., 2006; Chan et al., 2012).

Despite some critical tones, the general discourse on ecosystem services puts much weight on economic valuation and the operational opportunities that applying a uniform monetary metrix would bring (Kumar, 2010). The relevance of ecosystem service valuation for governance is, however, under dispute. Although new policies tend to favour economic incentives, their use of value arguments remains detached from governance mechanisms and operational management of the public good (Norgaard, 2010; Sagoff, 2011). The added usefulness of valuing ecosystem services as well as transferring and generalising these values and applying them in concrete decision-making situations require further attention.

2.4. Sustainable natural resource management and ecosystem services

Developing concurrent with the understanding of the ecosystem services is the research on management and governance settings relying on traditions on sustainable management of natural resources. Highly relevant approaches to ecosystem service governance include sustainable development and natural capital (Daly, 1990), collective governance of common pool resources (Ostrom, 1990), ecosystem management (Grumbine, 1994, Imperial, 1999) and adaptive management (Gunderson and Holling, 2002; Olsson et al., 2004) as well as the natural resource specific sustainability analyses on forests, fisheries, agricultural land, wetlands and land-use. These research traditions have developed methods and applications that have been tested in practice and should not be ignored when aiming to operationalise ecosystem services for governance.

It is worth pointing out a few examples of analyses, the results of which are directly relevant for ecosystem service governance. For example, forest tree species-mixture and diverse stand structure have been shown to lower management costs, diversify forest income opportunities and reduce vulnerability to abrupt economic and ecological changes (Kelty, 2006; Tahvonen et al., 2010). In parallel, also single species plantations have been found to produce a range of ecosystem services and particularly provide diverse locally important benefits (Vihervaara et al., 2012). At the same time, the structure and stability of tree cover in the forest – and also in urban areas – have been demonstrated to be important for carbon sequestration (Karhu et al., 2011; Vauramo and Setala, 2011). However, like many other regulating and maintenance services, carbon sequestration has been shown to be too abstract to be included into citizens' discourses about ecosystems (Vihervaara et al. 2012). Further, urban green areas have been demonstrated to manage precipitation waters more

cost sparingly than human constructed ones (McPherson et al., 1999). These same areas have also many recreational and health benefits (Maas et al., 2009; Kyttä et al., 2011, Korpela et al., 2010) and may be reflected in house prices (Donovan & Butry 2010). These examples reveal that even without explicit attention to ecosystem services, research on sustainable natural resource management supports the development ecosystem service governance.

3. Review of governance settings: operationalising ecosystem services approaches

To demonstrate what the ecosystem services concept and its operationalisation encounters in practice, we review here three governance settings from Finland, starting from the challenges that the governance arrangements were set up to respond to and the most apparent governance lessons. Reviewing published material, we pay attention to measurement, mapping and valuation of ecosystem services in these governance settings representing different spatial and time scales.

The first governance setting is Southern Finland Forest Biodiversity Programme (METSO, 2002, Table 1) that has been designed to overcome the escalated resistance against centrally designed nature conservation programmes in 2002 (Paloniemi and Tikka, 2008). The voluntary conservation instruments have been successfully piloted in a limited area in South-Western Finland and based on the experiences from this pilot, a new programme has been developed in 2008 (METSO, 2008), to be implemented in the entire country, excluding the northernmost parts where the conservation void has not been acute.

The second governance setting is urban planning (Table 1), driven by the need to develop housing, which comes with favouring compact building in a predefined area, to minimise urban sprawl (Yli-Pelkonen, 2008). Urban planning takes spatial planning and maps as a starting point and an integrative basis. However, considering different types of ecosystem services in urban areas is only emerging as a practice (Niemelä et al., 2010; Söderman et al., in press). Similarly, detailed modelling or comparison of different ecosystem services has only started (Primmer et al., in press).

The third governance setting is Finnish national natural resource strategies (Table 1). The three strategies, namely the Government Report to Parliament on National Natural Resources (Luonnonvaraselonteko, 2010), The National Forest Programme 2015 (KMO, 2010) and the National Peatland Strategy (Suostrategia, 2011) each have a distinct history in their specific sectors. However, they are all products of an era where cross-sectoral collaboration is a necessity for legitimacy and ecosystem services have emerged as a way of distinguishing the multiple functions and benefits from managing these natural resources sustainably and caring for the ecosystems that they depend on (Primmer et al., in press).

The governance settings demonstrate how the multiplicity of benefits from ecosystem services can be easily identified qualitatively, using appealing welfare and sustainability arguments, particularly at a large scale and general level (Table 1). Sustainable use and conservation are notably important contents in all the governance settings and the terminology of ecosystem services approaches has generally been internalised, however more at the strategy level than on the ground. The most local and specific governance situation of forest biodiversity conservation identifies the least cross-sector connections and benefits.

The interconnectedness of the use of a resource and future benefits are identified by means of information management systems developed for each of the particular governance situations. Biodiversity conservation, land use and natural resource extraction utilise sophisticated ways of identifying the benefits of the relevant ecosystem services, measuring change in relevant factors and utilising spatially referenced inventory and planning with maps (Table 1). However, the interconnectedness of different ecosystems and their use is not evident in these governance settings. Although rural and urban employment and recreational opportunities as well as infrastructure development and connectivity of green spaces are mentioned, their integrated consideration and management are not among the goals of these governance arrangements.

Some valuation analyses of public goods in each of these governance settings have been conducted and reported in academic forums (Table 1). However, evidence for direct application of the valuation results remains anecdotal. Direct weighing between conservation and use with monetary arguments cannot be detected. Monetary values do not appear to guide incentive targeting even in the allocation of voluntary conservation instruments.

4. Discussion: developing ecosystem services approaches for governance

As outlined in Section 2, the ecosystem service approaches seek to measure and map the services and to make their relative changes comparable by valuation (e.g., de Groot et al., 2010). At the same time, policy and operational decision-makers are at least assumed to anticipate that the measuring and mapping would inform the allocation of restrictions and incentives on particular ways of managing ecosystems, even to span across ecosystem and sector boundaries. Somewhat more indirectly, the valuation of services is also assumed to support incentive (and disincentive) development (Norgaard, 2010; Farley and Costanza, 2010; Muradian et al., 2010; Vatn, 2010). The reviewed governance settings, however, demonstrate that these knowledge production expectations might face limitations in operational situations.

The ambition of measuring all or a very broad range of ecosystem services is unrealistic. The identification and measurement of the entire range of services is impossible and faces challenges stemming from the ecosystem and sector based governance arrangements. However, a range of services is identified in the reviewed governance settings qualitatively. It is possible that dominating uses of certain ecosystems, managed under sector-specific administrative structures, are further justified by the broader rhetoric of ecosystem service related opportunities that come with continued use. This kind of a strategy of rhetoric assuring coupled with little change in concrete action has been identified other areas of natural resource and environmental policy both among private sector actors and in public policy (Cashore and Vertinsky, 2000; Kivimaa and Mickwitz, 2011).

Although the reviewed governance settings demonstrate that attention is paid to previously un-noticed regulating services and public goods, there is modest evidence of development towards measuring these services beyond previously existing monitoring systems. Perhaps this kind of integrated mapping that spans across administrative and ecological boundaries is an area where the ecosystem service approach has the most radical potential contribution for governance, as has been anticipated (Carpenter et al., 2009; De Groot et al., 2010). However, integrated spatially referenced mapping and planning is extremely challenging to advance both technically and politically and many successful cross-sector and cross-level governance examples are very specific or local (Gunderson and Holling, 2002). The existing administrative hierarchies possess much of the required knowledge capacity but they might not identify the value of more general information systems that would be utilised across administrative

Table 1
Examples of operational governance settings and their use of ecosystem services approaches.

Operational governance setting			Ecosystem services approaches		
Case	Challenges	Lessons	Identifying and measuring	Mapping	Valuation
Conservation of forest biodiversity on private lands	Low coverage and connectivity of conserved forest habitats (METSO, 2002)	Conservation contracting has yielded valuable sites (Mönkkönen et al., 2009)	Policy goals highlight biodiversity conservation and introduce new voluntary instruments as pilots (METSO, 2002)	Using inventory data and weighing biodiversity indicators and connectivity, a proposal for sites to be selected for conservation can be produced but its application is straightforward only on state-owned lands (Lehtomäki et al., 2009).	Threshold values for habitat characteristics affect the cost-effectiveness of site selection, however not applied in practice (Juutinen et al. 2008b)
	Lack of legitimacy of centralised conservation based solely on ecological criteria (Paloniemi and Tikka 2008)	Incentives and positive marketing of voluntary contracting have increased legitimacy (Paloniemi and Varho, 2009)	Ecological site selection criteria are defined in the programme pilot phase (METSO 2002), stated in the second programme (METSO 2008), and further elaborated in its implementation.	Goals other than biodiversity conservation have not been systematically sought for; they are secondary criteria	Goals other than biodiversity conservation have not been measured in economic terms (METSO, 2008).
	Budget limitation (METSO, 2008)	Temporary conservation contracts do not generate savings compared to purchasing (Juutinen et al., 2008a)	Social and economic goals are mentioned as arguments for the new conservation instruments.	(METSO 2008)	Economic income loss is the main; if not sole basis of conservation payment (Raitanen, 2011; Suihkonen et al., (2011)).
Urban land use planning	Planning traditionally takes political and economic conditions as a starting point and pays systematic attention to only legal conservation responsibilities or conservation demands that are expressed vocally (Yli-Pelkonen 2008). The ecosystem service-concept might draw attention to other ecosystem services but is generally considered distant and theoretical (Niemelä et al., 2010).	Integrating ecological and human needs benefits from participatory planning processes (Yli-Pelkonen, 2008; Jokinen et al., 2007)	Recreation has been identified to have health impacts (Korpela et al., 2010) Recreation receives attention particularly if local inhabitants are vocal (Yli-Pelkonen, 2008).	Provision, accessibility and benefits of ecosystem services, especially the cultural ones, can be located. Maps demonstrate the location of green areas and waterways in urban areas and for urban dwellers and are routinely used in urban planning. Further processing of maps in collaboration with ecological experts and different stakeholders can allow better identification and strategic planning of ecosystem service production and use (Jokinen et al., 2007; Yli-Pelkonen, 2008; Niemelä et al., 2010; Söderman and Saarela, 2010, Maes et al. 2011).	Economic valuation of recreational ecosystem services show the importance of urban green space (Tyrväinen, 2001; Maes et al. 2011)
			Precipitation water management has been shown to benefit from open green patches (McPherson et al. 1999) but as it receives only some formalized consideration, the ecosystem services approach might advance the understanding of this (Niemelä et al., 2010). Carbon sequestration in urban areas is dependent on vegetation (Vauramo and Setälä, 2011) but this argument for leaving green areas is new (Niemelä et al., 2010). The impacts of carbon sequestration on microclimate and adaptation are evident.		Economic valuation not used systematically to identify tradeoffs (Primmer et al., in press)
Natural resource strategies	Ongoing economic demand for natural resource extraction coincides with multiple use and conservation demands (Luonnonvaraselonteko 2010).	Considering various interest in programme design makes the programme more cross-sectoral and allows for identifying information	All three natural resource strategies highlight multiple benefits and frame them as ecosystem services. Traditionally acknowledged	Natural resource sectors have their own planning systems that rely partially on spatially referenced inventories. They are	All value arguments are used to justify certain natural resource uses and what can be considered a strategic or political fashion. Attention is paid to a range of

Table 1 (*continued*)

Operational governance setting			Ecosystem services approaches		
Case	Challenges	Lessons	Identifying and measuring	Mapping	Valuation
		voids and conflicting interests (Primmer and Kyllönen, 2006)		not merged to support cross-sectoral planning Primmer et al., in press	identified values but tradeoff analysis does not exist (Primmer et al., in press).
	Forestry income and timber-use based economic activity rely on the large tracts of Finnish forests that are used for multiple purposes (KMO, 2010).		provisioning services and the economic income as well as new business opportunities generated by their use are at the core of the strategies. Biomass, biofuel production and climate regulation are also acknowledged.	Forest planning relies heavily on national forest inventories and timber removal targets are derived from the supply estimates that these inventories have produced. Spatial planning is not used to support strategic planning of the sector at the national level (Primmer et al., in press)	
	Peatlands are used for raw material for energy production despite its likely negative carbon balance impacts and large tracts of peatland have been converted to forest land but the peatland habitat is an important characteristic ecosystem in Finland and is used also for recreation (Suostrategia 2010)		Biodiversity conservation receives heightened attention in the forest and peatland strategies and also recreation, traditional uses and cultural identity are acknowledged.	Peatland conservation site selection has been based on nature inventories and peat extraction areas are reserved in a master plan.(Primmer et al. in press).	

sectors. Integrating mapping systems might be particularly difficult if it entails giving up some sector-specific administrative power (Norgaard, 1994).

Although public goods have been valued in all the reviewed governance settings, there is little evidence of direct use of the results of these analyses, in line with what has been noted by those analysing the connections between valuation and institutions (Vatn, 2009; Norgaard, 2010). However, it might suit the decision-makers to highlight the identified ecosystem service values in situations where they are defending these particular services. This observation brings little change to the traditional governance setting where the goals for governing are defined politically, engaging and steering conservation and management (Rydin and Falleth, 2006; Primmer, 2011), but having little impact on the resource use (Sagoff, 2011). In the light of the reviewed governance settings, operationalising valuation of ecosystem services requires more work in concrete governance settings, rather than as distinct research activities.

The expectations of both the academic community and policy signal three trends familiar from environmental and natural resource governance. The first one highlights scientific knowledge, inferring that more information leads to more sustainable solutions (Sutherland et al., 2004). This notion familiar to every scientist, albeit often not explicitly spelled out, is challenged by the complexity and uncertainty of the ecosystem functions as well as the different ways humans and societies perceive and organise rights and responsibilities to manage ecosystems (Funtowicz and Ravetz, 1993; Vatn, 2009). As these challenges are extreme, knowledge production should be organised to service collectively identified minimum knowledge needs that would serve many sectors and many actors governing many ecosystems. It is also possible that the observed meagre integration of the sophisticated systems can be explained by the already existing familiarity with tradeoffs by those responsible for natural resource governance. The practitioners might not see added value in generalisations and large scale analyses (Sagoff, 2011). Another explanation can lie in the sometimes lighter emphasis that the existing knowledge systems place on biodiversity, as biodiversity is interwoven into the current ecosystem service approaches (TEEB, 2010; Mace et al., 2012). In any case, the use of the developed ecosystem service measuring and mapping should be tested, to get a firmer grip on their potential for analysing real-world tradeoffs between different uses of ecosystems. Maes et al. (2011) show that trade-offs between biodiversity and natural resources as well as other uses of land are unavoidable. In addition to resource and land use sectors paying attention to ecosystem functions and biodiversity, another extremely important issue is the capacity of the actors and discourses geared towards biodiversity conservation to capture other ecosystem services.

The second trend is in line with what can be called liberalisation of environmental policy, relying on the assumption that environmentally and socially effective solutions can be reached with voluntary solutions, as long as values are identified. This trend has led to voluntary incentives in one of the reviewed governance settings. However, as has been prominently demonstrated (Ostrom, 1990; Norgaard, 2010; Muradian et al., 2010; Vatn, 2010), there is little or no automation in designing policies based on values of ecosystem services. Where the status and functioning of ecosystems is difficult to observe, where ecosystem services are difficult to distinguish because they are so systemic and where rights to ecosystem services and to manage ecosystems are poorly defined, the governance solutions are not automated (Sagoff, 2011).

The third inference from our comparison of ecosystem service approaches and concrete governance situations echoes with more

open and collaborative governance: alertness and tuning to solving concrete governance challenges at hand requires input from a broad range of actors at a relatively local level (Ostrom, 1990; Rydin and Falleth, 2006; Carpenter et al., 2009). Although participation and direct interaction of actors was observed, the review of the governance settings did not explicate potential local level observations that actors might share about ecosystem services and their interconnectedness. It is possible that local level governance arrangements would be best suited to new tackling new emerging ecosystem service challenges (Gunderson and Holling, 2002). Particularly those ecosystem services that are of collective and public character might benefit from governance at a local level where ecosystem interactions can be meaningfully detected and their use controlled (Ostrom, 1990). Measuring, mapping and valuation should therefore be supplemented with more detailed local level analyses of relevant ecosystem services.

5. Conclusions

The governance of natural resources and land-use has traditionally aimed at maximum sustainable production and solving acute sustainability problems. Some harmful effects have been identified and policies have been directed at solving them, whilst aiming at the continued use of the resource. Governance systems have increasingly paid attention to local environmental issues, social expectations and multi-functionality but the solutions have mostly been sought for with sector-specific technical and decision-making arrangements. Even though these arrangements are often backed up by extremely elaborate knowledge systems relying on long-term monitoring and spatial analyses, they do not sufficiently serve governance across ecosystem and sectoral boundaries.

The recently developed ecosystem service approaches aim at integrating the evaluation of various environmental problems and sustainability issues by paying attention to a broad range of ecosystem functions and services, their interdependencies and their social demand both in environmental as well as natural resource use planning and decision making. The knowledge tools for integration, offered by the academics working on ecosystem services, aim at identifying the range of services and making them apparent by measuring, mapping and valuing them. These approaches aim at cross-comparability and trade-off analysis and assume operational usefulness of cross-comparisons.

Our analysis demonstrates that at a qualitative level, identifying a broad range of ecosystem services is easy and appealing but cross-comparison and tradeoff analysis encounter two major challenges: (1) measuring all services is impossible and (2) measuring and valuing services does not directly lead to increased use of this knowledge. The knowledge use challenge is augmented when analysis shifts to regulating services that are of a non-market, public or collective character and extremely difficult to transfer physically or e.g. re-establish after destruction. The seriousness of ecosystem degradation and scarcity of the services as well as the existing institutional context should always be the starting point for designing analysis and governance solutions.

The mismatch between governance needs and ecosystem service approaches can thus be closed only if the tools are developed so that they build on existing knowledge systems and governance arrangements but aim at communicating across ecosystem and sector boundaries. Such knowledge systems will require generalisation but their development should not sacrifice the existing sector specific and local level knowledge that support ecosystem governance in specific social, economic and institutional contexts.

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