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"Maps have an air of authority": Potential benefits and challenges of ecosystem service maps at different levels of decision making

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ABSTRACT

Maps of ecosystem services are repeatedly mentioned in the "EU biodiversity strategy to 2020" as being necessary to achieve the goals of this strategy. On regional and landscape levels too, maps are more and more often suggested to be essential for proper management of ecosystems and their services. This paper presents results drawn from interviews on a regional level and from a focus group discussion on national and EU levels. Both dealt with the question of how exactly spatially explicit information can be used in decision-making concerning biodiversity and ecosystem services. Amongst others the use of maps as a means of fulfilling reporting duties of the Members States to the European Commission; also mentioned was the use of maps as a communication tool; and to improve the targeting of policy measures. However, a number of challenges in relation to the credibility, salience and legitimacy of maps also came up during interviews and discussion. The challenges identified lead us to the conclusion that while maps can be tremendously helpful, they should be used carefully. From the information gathered we derive a number of recommendations on how to deal with the salience and legitimacy of maps.

1. Introduction

In May 2011 a new "EU biodiversity strategy to 2020" was launched with the aim of "Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss" (European Commission, 2011). Target 2 of the strategy is to maintain and enhance ecosystems and their services by 2020 by establishing green infrastructure and restoring at least 15% of degraded ecosystems. In its supporting Action 5, the European Commission committed itself to assist Member States to map and assess the state of ecosystems and their services in their national territory by 2014, to assess the economic value of such services, and to promote the integration of these values into accounting and reporting systems at EU and national level by 2020. The mapping of ecosystem services is thus presented in the strategic document itself as an important supporting action to achieve its goals.

While not yet standardised in spatial (conservation) planning at regional or landscape level, several case studies argue in favour of considering ecosystem services in planning and management processes in order to better understand the values or trade-offs that arise from changes in land use (e.g. Egoh et al., 2008,2011; Gascoigne et al., 2011; Nelson et al., 2009; O'Farrell et al., 2011). However, the mapping and assessment of the state of ecosystems and their services requires tremendous effort. This justifies asking how exactly spatially explicit information can be used in decision making concerning biodiversity and ecosystem services in order to ensure that these maps are used effectively.

Ecosystem services are available on a range of ecological scales and are supplied to and by stakeholders on a range of institutional scales (Hein et al., 2006). On the political and administrative scale, decisions concerning ecosystem services are made from a global level (e.g. Görg and Rauschmayer, 2009) down to a regional or landscape scale level (e.g. Prager et al., 2012). Each of these levels requires different types of decisions and information. While the new biodiversity strategy, for example, requires decisions about more general goals and strategies relating to biodiversity and

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ecosystem services conservation, the implementation level requires decisions about the practical management of ecosystems and the sustainable use of their services, e.g. in terms of landscape planning (Burkhard et al., 2012; De Groot et al., 2010; Prager et al., 2012). Our assumption was therefore that different levels have different requirements for (as well as differing uses of) spatially explicit information. Following some recent suggestions for more socially engaged and open assessments of ecosystem services (e.g. Cowling et al., 2008; Daily et al., 2009; Menzel and Teng, 2009; Norton and Noonan, 2007; Prager et al., 2012), we investigated this assumption in the context of the PRESS (PEER Research on Ecosystem Services) project. To elaborate the potential benefits and challenges associated with using maps for decision support, we selected a number of representatives from the EU, national as well as sub-national levels in Finland, Poland and Germany for interviews and a discussion. This paper presents the results of our research along with the conclusions and recommendations which follow from our discussion of the results and consideration of background scientific literature.

2. Methods

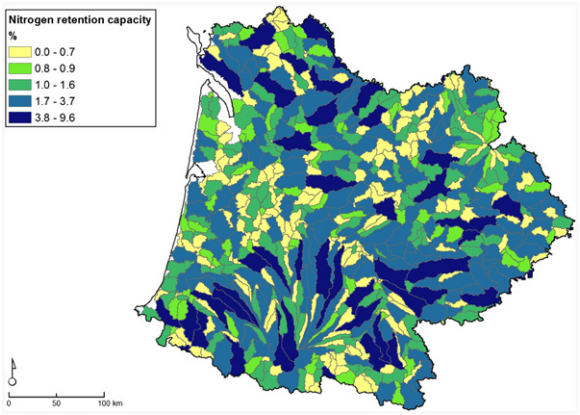
2.1. Focus group discussion at EU and national level

At an initial stage of the project, an analysis of EU policy documents was conducted in order to establish an overview of the extent to which ecosystem services are already implicitly taken into consideration in the fields of environmental policy, agriculture and forestry, transportation, regional development and tourism (Maes et al., 2011). Based on this document analysis, members of relevant General Directorates (DG Environment, DG Agriculture and Rural Development, DG Regional Policy) were invited to participate in a focus group discussion. Representatives from the EU Member States Germany, Finland, Poland and the UK were also invited on the basis of existing contacts. Although our questions also have a bearing on other policy fields (and other countries, of course), we restricted the number of participants so as to allow for a more in-depth discussion among the participants. In the end, the focus group consisted of 10 participants, including members of the DG Environment (biodiversity and water units) and DG Agriculture and Rural Development (forestry and agriculture units). Participants from the Member States represented national ministries from the UK, Finland and Poland, covering the environment, forestry, agriculture and regional development.

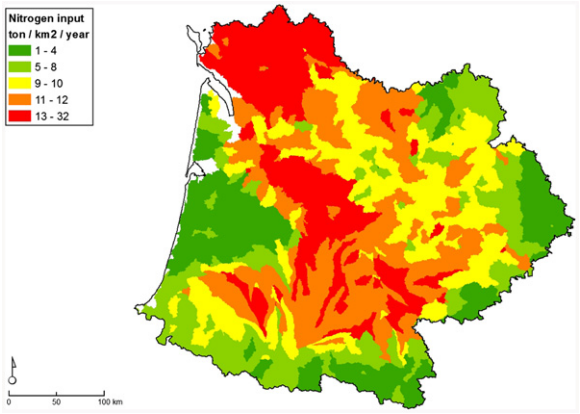
Prior to discussing the issue of maps, the participants of the focus group discussion identified where ecosystem services are implicitly or explicitly addressed in current policies and where potential synergies and trade-offs occur (Maes et al., 2011). They were then presented with a set of maps which showed the spatial trade-off between food production and water quality as a function of nitrogen application and loading. Nitrogen is a key element that provides essential benefits to people, as it increases agricultural production; equally, however, excess nitrogen can contribute significantly to ecosystem pollution (Sutton et al., 2011). All the maps covered the French river basin district of the Adour and Garonne (Maes et al., 2012). The first map (Map 1) showed the capacity of ecosystems to retain nitrogen through various processes in vegetation, soils and water bodies, as an indicator for the ecosystem service "water purification". Nitrogen retention results in improved water quality in downstream parts of the river basin.

Next, a map (Map 2) of the river basin was presented, showing nitrogen inputs for the ecosystem service "agricultural food production".

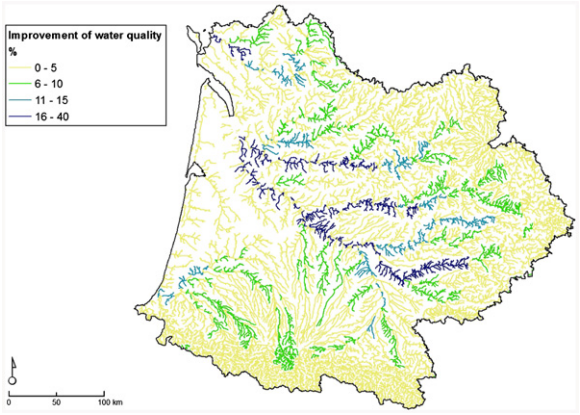
To demonstrate how trade-offs between two ecosystem services can be mapped, another basin scale map (Map 3) was



Map 1. Capacity of ecosystems in the French river basin district of the Adour and Garonne rivers to retain nitrogen through various processes in vegetation, soils and water bodies, as an indicator for the ecosystem service "water purification".



Map 2. Nitrogen inputs for the ecosystem service "agricultural food production" in the French river basin district of the Adour and Garonne rivers.



Map 3. Improvements in water quality, i.e. the percentages of nitrogen input actually removed by the ecosystem and the associated increase of water quality in downstream reaches of the French river basin district of the Adour and Garonne rivers.

presented that showed the improvements in water quality, i.e. the percentages of nitrogen input actually removed by the ecosystem and the associated increase of water quality in downstream reaches.

The discussion began by looking at these maps, posing the question about the usefulness and challenges of maps of ecosystem services and providing other relevant information; it proceeded in an otherwise unstructured way. The maps of the French

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river basin were chosen in order to avoid discussions arising about the actual content of the maps (the area shown is far away from the locations where the respondents work) and to stimulate broader discussion. They were also readily available.

2.2. Key informant interviews at regional level

As we assumed that official bodies at different levels of decision making have both differing requirements and uses of spatially explicit information, we used interviews at the regional level to complement the findings from the EU and national levels. For this purpose, 6 key informant interviews were conducted at the regional level: two in Satakunta, Finland, two in Saxony, Germany, and two in Silesia, Poland. One of the interviews in Germany was with a member of a regional planning association responsible for landscape planning, and the other was with two interviewees from the Saxonian State Ministry of the Environment and Agriculture involved in landscape planning. In Satakunta, Finland, we spoke with two key informants at each interview: two people who work with a regional planning authority at the first, and a representative each from a regional division of an agriculture and forestry producers' organisation and a forest owners' organisation at the second. In Poland the two interviews were conducted with just one respondent on each occasion: a member of the Centre of Natural Heritage of the Marshal Office of Silesia, and a person from the spatial planning unit of the Silesian Voivodship Office. An approach similar to the one used for the focus group discussion was chosen for the interviews. First, the maps described above (see Section 2.1 and Maes et al., 2012) where presented, and then the interview partners were asked to elaborate on the possible uses of maps in their work activities as well as the challenges they see.

In addition to these more general interviews, 6 key informant interviews were carried out in Varsinais-Suomi region in southwestern Finland. These interviews were part of a case study embedded in the PRESS project, which mapped pollination services in that area and was aimed at exploring how stakeholders perceive the mapping of ecosystem services. Key informants came from a regional environmental administration body, conservation and beekeeper NGOs, or were beekeepers, farmers or researchers. The informants were shown maps which illustrated the estimated suitability of different habitats for foraging and nesting sites of bumblebees in the case study area. The method used in scoring the different landscape elements according to their value as foraging areas and nesting sites for pollinators was explained thoroughly to the interview partners, thus enabling us to discuss agricultural land-use practices in detail and their effects on pollinators.

3. Results

In the following we describe the potential benefits of maps of ecosystem services for decision making at different levels as discussed in the focus group and in the key informant interviews.

3.1. Potential benefits of maps for decision support

One potential benefit of maps mentioned in the focus group discussion is their usefulness in identifying and framing problems: they can help to identify conflicts and synergies between ecosystem services or between ecosystem services and other land uses and indicate places or areas where particular ecosystem services or aspects of biodiversity are threatened (often indicating thresholds, e.g. an aquatic ecosystem at risk of losing its good ecological status). In this context one participant spoke of maps as an opportunity to highlight and illustrate complex problem situations. Such situations can arise, for example, when several different potential but competing ecosystem services are provided by an ecosystem, such as a forest. The situation is further complicated by the fact that it may well be that not all ecosystem services are recognised intuitively by each of the stakeholders.

It was also mentioned that maps can be helpful in identifying suitable policy measures, improving the targeting of such measures (e.g. by identifying hotspots), and demonstrating or evaluating the benefits of policy measures in relation to their costs. In this respect the participants perceived maps as a scientific contribution towards improving decision making or, as one participant termed it, a contribution to evidence-based policy making. One example mentioned in the discussion was the opportunity to map different farming practices in order to visualise the benefits of agri-environmental measures as compared with other ecosystem services.

Another function of maps repeatedly emphasised in the focus group discussion is the use of maps as a communication tool. They have a pedagogical value in that they support efforts to explain the relevance of biodiversity and ecosystem services to the public - for example, by showing flows of ecosystem services to their beneficiaries and the mechanisms or ecological processes underlying the provision of such services. Beyond the educational value of maps, one participant mentioned the heuristic value of maps in initiating discussions about solutions, especially their capacity to render visual the different options available (simulations). A good example of this function of maps is the visualisation of the spatial consequences of different policy scenarios: this can help to communicate to stakeholders and beneficiaries of services the impact of certain policy decisions and to make them more transparent. Key informants from the Varsinais-Suomi region also mentioned the communication and visualisation of trade-offs when discussing the usefulness of maps. They noted that maps could be used as an interactive exercise or as a tool when negotiating with stakeholders about different land-use options.

Furthermore, key informants from the regional level explained that maps are already indispensable instruments in planning activities. For example, they are currently already used in the context of biodiversity protection areas, in minimising conflicts, and in developing sound spatial management plans. In the case of Saxonian landscape planning, maps of some ecosystem services are actually already available (e.g. water retention capacity), even though they are not termed as such. In this context maps are used for ecological risk analysis, e.g. to identify sensitive areas, buffering capacities and risks of pollution. While some maps of ecosystem services are already available, the interview partners mentioned that other ecosystem services with which they are increasingly confronted in their planning activities have not yet been mapped. They said, for example, that maps related to climate change adaptation or climate regulation would be helpful, as would maps dealing with the production of biomass for energy production or biofuel production. The interview partners in the Finnish pollination case study also mentioned the connexion between existing information and the mapping of ecosystem services. Obviously a lot of information is already available which has not yet been transformed into maps. The key informants recommended that the sources should be explored first before any new data are collected.

In one of the Polish interviews, our interview partner pointed out the importance of maps in presenting the spatial dimensions of ecological processes. Both Polish interview partners independently mentioned the potential of maps to identify conflicts and indicate places or areas where particular ecosystem services or aspects of biodiversity are threatened. They thus concluded that

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maps can be useful instruments in planning activities relating to nature and biodiversity conservation and in minimising conflicts.

The interviews with representatives from regional divisions of an agriculture and forestry producers' organisation and the forest owners' organisation in Satakunta, Finland indicated that regional spatial planning is a process that allows fruitful discussions on ecosystem services. Planning is already very much a mapping-oriented process, but this does not yet explicitly include the concept of ecosystem services. The interview partners, who had all been involved in the region's very recent spatial planning process, agreed that ecosystem services mapping could well be incorporated in such a process. They could readily identify several similarities between the hypothetical mapping of ecosystem services and actual spatial planning.

In addition to the above mentioned possibilities, the interviews on pollination mapping generated the following suggestions for the practical use of maps as development and management tools:

- to study, identify and visualise the connectivity of different regions and environments, e.g. by motivating farmers to collaborate with each other in order to design collective, pollinator-friendly farming practices;
- to locate and identify promising places and areas for measures of pollinator conservation;
- to visualise and compare the environment/landscape from different pollinator species' perspectives;
- to identify new locations that are suitable for honey production.

According to some of the interview partners, maps could be further utilised as legal documents, given that they have already been used in land use planning. This could occur, for example, when voluntary conservation measures are developed as part of agri-environmental schemes. Maps that show areas where measures are applicable could serve as legal documents in creating contracts between stakeholders and authorities.

3.2. Challenges associated with using maps of ecosystem services

While maps can serve as an important communication tool and are indispensable for spatial planning, participants from the focus group as well as some of the key informants also mentioned some challenges which arise when working with maps. They emphasised the need for cautious use, as maps have an "air of authority", as one participant in the focus group discussion put it.

For example, the above mentioned option of using maps as legal documents in contracts between farmers and authorities raised concerns among some of the key informants in the pollination case study. Farmers worry about an increase in bureaucracy and administrative control (e.g. the setting of strict boundaries for landscape or land use management). Voluntary conservation is seen as a flexible and adaptive tool which should not be compromised by agreements that are too rigid. Very detailed and strict maps may not be a positive motivation for stakeholders or land owners as they may limit their decision-making options. Further, they may hinder farmers to react to context specific circumstances or emergencies.

Related to the "power of maps" is the perception that identifying problematic areas on a map can result in regions being stigmatised. Another concern emerges from the possibility that ecosystem services maps may indicate areas where exploitation can be increased (e.g. where rivers have the capacity to retain more nutrients). In the pollination case study, the interviewees also pointed out that maps do not only present straightforward facts, they can also omit information and, by doing so, may be biased. Designing maps is thus a means of exercising power. The designer makes decisions on what to include and which scales are to be chosen. The broad range of possible interpretations of the maps requires a high degree of transparency with regard to the specific reasons for mapping, as one of the key informants pointed out.

Another problem mentioned both at the regional level and in the focus group discussion is that the scale of ecosystem services maps and the scale of decision making are not necessarily identical. The same applies to the scales and boundaries of administrative units (national or regional/local borders) and ecological units (e.g. an ecosystem delimited by watersheds). An example given both at the regional level and in the group discussion was that of watersheds. In terms of water use planning and conservation, it would make sense to have a map of an entire watershed. However, regional planning is usually done within administrative boundaries and it is not always possible to cooperate across boundaries. This entails the risk that interregional effects, e.g. downstream pollution, are overlooked by upstream planning.

A related problem is the resolution of the maps. Two things are problematic here. The first is the more general question as to what amount of detail is appropriate for which decision-making level. Synergies between ecosystem services perceived at a watershed scale may not reflect specific trade-offs observed at the local scale. Second, detailed maps are needed for decision making especially at the regional and local level. However, detailed data are often not available, while collecting and processing them is costly. An example was given by the beekeepers who were interviewed. They explained that many of their everyday practices and decisions are dependent on micro-level factors in the landscape (e.g. wind conditions and air temperature) so that the maps presented to them would not be a useful tool for their work. The interviews revealed more generally that pollination as an ecosystem service takes place at lower scales than current land-use planning processes. Maps at higher scales may hinder the identification of nesting or foraging sites important for pollinators. One possible solution to the data problem that was suggested by one participant was to focus on the mapping of the most important ecosystem services. This suggestion generated an extremely lively discussion, as other participants argued that such a decision is very difficult to make, given that preferences vary considerably across regions.

In addition to the general lack of data, one participant raised the point that some ecosystem services are not spatial in nature and are therefore difficult to map. In many cases non-marketable ecosystem services (cultural and regulating ecosystem services) are very hard to render visible; for this reason, sound information on them is scarce. This issue will require extra effort in future analysis and mapping. The participants also mentioned that not all ecosystem services can be presented easily (if at all) on maps. Such services are, for example, cultural services related to the personal identities of people or to their level and type of education. The temporality of events constitutes another challenge for mapping: for example, how can seasonal events (or demands) be presented on a map?

4. Discussion

4.1. Maps as a panacea?

Using maps as an instrument for reporting and targeting EU policies and measures is not a new idea or practice. For example, the Water Framework Directive relies heavily on mapping for monitoring in a spatially explicit way the ecological and chemical status of surface waters, groundwater resources and protected

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areas, each for several purposes. Maps are used in the context of assessing the impacts of the directives and their specific measures and also as a means of identifying areas in which the envisaged good status has not been achieved. Maps are also recommended as a means of identifying water bodies which are subject to pollution resulting from the impact of human activity (Directive 2000/60/EC[1]). Another example of the use of maps in the past is the Habitats Directive, where submission of maps showing the distribution and range of all Annex I habitat types and Annex II, IV & V species present in a Member State is a basic requirement of Article 17 which specifies reporting obligations (Directive 92/43/EEC[2])[3]. In 2007 an even broader directive, the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive (Directive 2007/2/EC[4]) came into force. The aim of the INSPIRE directive is to create a European Union (EU) spatial data infrastructure. This data pool is to enable public sector organisations to share environmental spatial information and assist decision making related to policies and activities that may have a direct or indirect impact on the environment, even across boundaries.

In science, too, there is an understanding that maps can be particularly helpful for spatially explicit decision making and monitoring of the consequences of decisions. Conservation science especially – and more specifically conservation biogeography – has contributed significantly to today's conservation planning approaches (Whittaker et al., 2005). More recently, scientists have started to make use of spatially explicit economic models and to analyse alternative land use patterns in order to maximise biodiversity conservation objectives for given levels of economic return (Polasky et al., 2008). A growing number of publications recommend the use of a spatially explicit assessment of ecosystem services for planning and management throughout all levels, from the global level (e.g. Naidoo et al., 2008) down to the regional or local level (e.g. Egoh et al., 2008). For example, Turner et al. (2007) developed a method for exploring the potential to safeguard biodiversity and ecosystem services simultaneously at the global level. The authors found that there are opportunities for safeguarding both, albeit with regional variations. They therefore propose a fine scale analysis to further indentify synergies and develop economic and policy tools to exploit such synergies. Along the same lines, Naidoo and Ricketts (2006) found that spatial cost-benefit analysis can help in understanding the synergies and trade-offs that exist between biodiversity conservation and the provision of ecosystem services. They conclude that spatial cost-benefit analysis can inform conservation planning. This aspect was also highlighted by the interview partners and focus group participants.

De Groot et al. (2010) recommend maps – in combination with models to analyse and visualise the impact of management on ecosystem services – as a means of answering questions about how and where landscapes can be changed in order to enhance the provision of one or more ecosystem services, and which are the right management approaches to do so. Feld et al. (2010) argue in a similar fashion and propose the development and use of indicators which assess and monitor (policy) responses directly by looking not only at the services themselves but also at trends in the strength of the drivers and pressures for ecosystem services change. This too fits well with our empirical results.

There are also a growing number of analyses on various spatial scales that map and analyse trade-offs between different ecosystem services (e.g. Haines-Young et al., 2012; Raudsepp-Hearne et al., 2010). Nelson et al. (2009) apply the modelling tool "Integrated Valuation of Ecosystem Services and Tradeoffs" (InVEST) to stakeholder-defined scenarios of land-use/land-cover change in the Willamette Basin, Oregon. In doing so, the authors show that quantifying ecosystem services in a spatially explicit manner and analysing the trade-offs between them can help to make natural resource decisions more effective, efficient and defensible.

Recently, attempts have been made to merge information on the spatially explicit supply of ecosystem services with that of the locations of the various demands for these services (Burkhard et al., 2012). Willemen et al. (2012) go even further, presenting and testing a modelling approach which combines: (i) the multifunctional character of a landscape, (ii) the different spatial levels at which interactions between ecosystem service supply, demand and land management occur, and (iii) trade-offs in service supply as a result of land management activities.

Like our interview partners and focus group participants, the literature reviewed for this paper suggests the use of maps as communication tools, especially in combination with scenarios. For example, Cowling et al. (2008) emphasise that the spatially explicit depiction of alternative futures allows stakeholders to envision the consequences of particular policy frameworks. Indeed, as stated above, the use of spatially explicit scenarios to provide information to decision makers is not new. Hulse et al. (2004) describe an alternative futures analysis approach to inform community decisions regarding the likely effects of different options for future land and water use.

4.2. Credibility, salience and legitimacy of ecosystem services maps

While great enthusiasm can be found in both our empirical results and the literature for mapping ecosystem services, each source identifies a number of challenges and drawbacks, which can be related to the three categories identified by Cash et al. (2003), namely, the credibility, salience and legitimacy of assessments. According to Cash et al. (2003), credibility involves the scientific adequacy of the technical evidence and arguments. Salience deals with the relevance of the assessment to the needs of decision makers. Legitimacy reflects the perception that the production of information and technology has been respectful of stakeholders' diverging values and beliefs, and unbiased in its conduct.

In terms of credibility, one of the biggest technical challenges identified is the scarcity and lack in accuracy of data for mapping ecosystem services (Maes et al., 2011). Even when an ecosystem service such as food or timber can be mapped directly (Feld et al., 2010), data are not always available and, if they are, they are not always available at the appropriate resolution (Hermann et al. 2011). Another technical challenge is that not all ecosystem services can be mapped directly (e.g. most cultural services) and that indicators have to be used to represent services which cannot be represented directly. Finding the appropriate indicators remains a challenge, especially in respect of data needed to regulate and support ecosystem services (Díaz et al., 2007; Egoh et al., 2008; Lara et al., 2009) as well as data providing information on cultural services, as the discussion with our focus group participants showed.

Technical challenges are not only related to credibility but also to salience, i.e. the relevance of maps to stakeholders. Pierce et al. (2005) showed, for example, that scientists frequently use

[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:327:0001:0072:EN:PDF (accessed 10.05.2012).

[2] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1992:206:0007:0050:EN:PDF (accessed 10.05.2012).

[3] Assessment & reporting under Article 17 of the Habitats Directive. Explanatory Notes & Guidelines for the period 2007–2012. Final Draft July 2011. Compiled by Douglas Evans & Marita Arvela. European Topic Centre on Biological Diversity.

[4] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:108:0001:0014:EN:PDF (accessed 10.05.2012).

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arbitrary planning units such as grid cells. Often, however, these units are not useful to land-use planners, who usually require information applicable to actual land management units—they generally work with cadastres. Another problem is described by Müller et al. (2010), who observed that many scientists focus on larger scale processes and interactions and deduce the potential consequences for stakeholders from that perspective. The authors suggest, however, that mapping and modelling could also be done in a bottom-up manner, i.e. taking stakeholder perceptions and views as starting points. In fact, many of the scientific papers reviewed for this article which propose frameworks, methods and models for mapping ecosystem services for decision support (e.g. Burkhard et al., 2012; Egoh et al., 2008; Feld et al., 2010; Gascoigne et al., 2011; Naidoo et al., 2008; Polasky et al., 2008; Raudsepp-Hearne et al., 2010; Turner et al., 2007; Willemen et al., 2012), claim that their work can support decision making. However, their approaches are only rarely developed in collaboration with, for example, planning practitioners or other decision makers, while the degree of acceptance of the results by stakeholders (and thus their relevance and impact) is generally not assessed either. Surely the inclusion of stakeholders in developing maps and mapping approaches would solve not only some of the problems related to salience but also some relating to legitimacy.

With respect to the legitimacy of maps, there is a rich fund of literature on "critical cartography" that reveals a range of problems associated with using maps. Two prominent examples are "How to lie with maps" by Monmonier (1996) and "The Power of Maps" by Wood (1992). More recently, this work has been followed up with the updated version "Rethinking the Power of Maps" (Wood, 2010) and "Mapping: A Critical Introduction to Cartography and GIS" by Crampton (2010). The social implications of geographic information systems (GIS) are described in a book by Pickles (1995).

Major points of criticism in all these books revolve around the role and intentions of the creators of maps. The choice of what to show on a map and, more importantly, what to ignore, as well as the choice of symbols and colours, and so on, are influenced by what the creators of the map value and the criteria they find appropriate. Taking the example of international conservation NGOs, Whittaker et al. (2005) show how NGOs use maps to "sell" their convictions in order to facilitate fundraising for biodiversity. A further example is given by Cidell (2008), who describes a case of local stakeholders challenging airport noise maps by considering the political motives and other subjectivities underlying the design of the maps. Another point of critique, brought forward by Pickles (1995), is that mapping produces space, geography, place, territory and even political identities. Similarly, in his book on the power of maps, Wood (1992) describes how maps construct states as we know them by drawing boundaries and naming places and, by doing so, set up a place for identity and a claim to ownership. Cidell's (2008) example of airport noise mapping describes a more recent process, showing how the production of space can work. When familiar features such as roads and airports are placed on a map in a correct relationship to each other and to other features, these other features (such as lines of noise contours) are more easily accepted as accurate and stable (Cidell, 2008). Yet another example is provided by Porter and Demeritt (2012), who explored the use of the flood map in the UK, developed in the context of the EU Floods Directive (Directive 2007/60/EC[5]). Created as a technical instrument for risk communication and flood risk management, the map shaped and was in turn shaped by institutional tensions between the British Environment Agency and local planning authorities regarding political mandates, institutional priorities, and planning and flood risk management.

Closely interwoven with the literature on critical cartography is the literature on public participation GIS (PPGIS). The growing body of research contained in this literature examines the social and political implications of GIS and explores the extent to which the use of this technology may empower (or disempower) different actors and institutions (Elwood, 2002). Perkins (2007), for example, reviewed five cases of collaborative community mapping in the United Kingdom. Mapping practices usually employ geospatial technologies (GPS, GIS, digital cartography), and Perkins concludes that, with the help of these tools, community mapping offers marginalised groups new opportunities for emancipatory activities.

However, while participation can solve some problems of legitimacy, in some cases it may trigger others. The problem arising in this respect is that "the community" or "the public" are not homogeneous and that maps are influenced by existing power structures within these groupings (Elwood, 2002; Kyem, 2004). Hein et al. (2006) show that stakeholders at different spatial scales can have very different interests in relation to ecosystem services. Thus when stakeholders from one level (e.g. European) are included in the mapping process – e.g. by asking them to select appropriate or relevant ecosystem services, indicators or thresholds – there is a risk that the maps will not be perceived as legitimate by stakeholders from other levels.

A similar approach to that of critical cartography is the theoretical consideration of space and spatiality, which is missing from debates and literature on ecosystem services mapping but is popular in human geography literature. This promising approach conceives of space, ecosystem services and the trade-offs between them not as a given and neutral platform on which ecosystem services exist and can be mapped but rather as a relational achievement. For example, the way people use land also determines which ecosystem services or bundles of ecosystem services can develop and how they relate to each other (on the relational understanding of space, see e.g. Davoudi and Strange, 2009; Jones, 2009; Massey, 2005; Murdoch, 2006). A relational approach would be useful to the discussion of ecosystem services maps because ecosystem services are relative by their very nature: only what is valued, needed or required by humans can be called an ecosystem service (Jax, 2010). Thus landscapes and the ecosystems and services provided by them are shaped by what is valued, needed or required. A related point is the fact that not all ecosystem services are perceived in the same way – as equally beneficial, for example – by different groups of stakeholders. Sagoff (2011) gives the example of pollination of fruit trees by bees. While pollination is usually perceived as something good and necessary and thus as an ecosystem service, for some citrus tree farmers pollination by bees entails considerable financial damage. This is due to the fact that trees cross-pollinated by bees produce fruits with seeds, which attract only a quarter of the price of unseeded ones. This shows that ecosystem services might not be what a society values, needs or requires but by what a certain group of people values, needs or requires. Thus decisions about how to design the system to produce certain services and about the actual provision of these services can be subject to power struggles between different stakeholders. Creating maps of the potential benefits of ecosystem services thus becomes difficult as these benefits are not predefined by nature but are rather defined by those stakeholders who most dominantly assert themselves. The potential benefits that would emerge if other stakeholders made their views heard are not shown.

[5] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:288:0027:0034:EN:PDF (accessed 10.05.2012).

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5. Conclusions and recommendations

Based on the literature we reviewed for this paper about mapping ecosystem services, we conclude that most of the problems revolve around technical challenges such as finding the right scale, finding sufficient data and, more generally, ensuring the scientific credibility of maps and associated models (e.g. De Groot et al., 2010; Naidoo et al., 2008). Additionally, however, some papers also call for more useful and user-friendly maps in order to ensure the relevance of the maps to decision makers (Cowling et al., 2008). Pierce et al. (2005) describe a promising process in this regard: first assess the decision makers' needs concerning spatially explicit information and then develop appropriate maps in an interactive process. Maps can also be accompanied by handbooks and map books that provide practical recommendations for conservation plans and measures (Pierce et al., 2005). However, the issue of the legitimacy of maps, as emphasised by the participants in the focus group discussion and key informant interviews and which can also be found in the literature, is hardly mentioned at all in research literature on ecosystem services mapping.

Despite all the problems and challenges listed above, we do not intend to argue against the use of ecosystem services maps for decision making. Instead, we argue that they should be created and used with caution and care and with a high degree of responsibility. We also agree with Crampton and Krygier (2006), who recommend a careful analysis and identification of maps' attributes, which are often taken for granted.

Given that the distribution of ecosystem services directly affects many people, we recommend not only that discursive valuation methods should be carefully designed, as Hermann et al., (2011) suggest, but also that mapping methods should be applied in a similarly, careful way. Participation should be ensured throughout the map making process to make it as transparent as possible. Furthermore, it should be ensured that a broad range of citizens is involved. In most cases, however, not all citizens can be involved and problems of representativeness remain. For this reason, information should be available to map users in the form of handbooks or mapping books in order to ensure transparency, to provide a basis for discussion, and to facilitate interpretation of maps.

The literature on participatory GIS contains some very good examples of how to make practical use of maps in decision making and how to include local or regional stakeholders in mapping processes (e.g. Brown et al., 2012; Jankowski, 2009; Perkins, 2007). We have also observed an increase in experience in compiling maps among officials at higher administrative levels, such as the EU level; so far; however, it seems that maps are used more for purposes of awareness raising. The usefulness and applicability of maps for decision making at EU level is currently being debated by the Working Group on "Mapping and Assessment of Ecosystems and their Services" established by the European Commission. In order to tackle the interrelatedness of ecosystem services, the different needs of stakeholders at different levels and the resulting wide range of information needs, multi-scale mapping approaches hold special promise. Precisely how detailed and how interrelated these maps at the different levels need to be so that they can be put to practical use and taken into account in decision-making processes remains an exiting challenge ahead.

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