



# Assessment of the effects of forest land use strategies on the provision of ecosystem services at regional scale



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## ABSTRACT

This paper presents results of a case study in Middle Saxony, Germany, where the impact of conversion, afforestation and alternatively introduction of short rotation coppice areas on the provision of ecosystem services was tested in a spatially inexplicit and a spatially explicit way to formulate recommendations for regional planning. While the spatially inexplicit testing did not lead to clear results regarding to what degree forests or short rotation coppice areas are desirable and applicable, the spatially explicit testing revealed that an increase in the forest area or area with short rotation coppice by 29.7% in unstructured agriculturally dominated Loess regions, 14.4% in more topographically structured parts in the North-East of the model region and 23.6% in its mountainous parts would be beneficial. Potentially resulting losses in the provision of bioresources and regional economy can be considerably reduced by replacing afforestation areas with short rotation coppice.

In summary, we found that the spatially explicit analysis of land use scenarios in combination with a more detailed land use classification and including an assessment of changes in land use pattern gave us an improved basis for assessing different possible planning strategies and to enhance the communication between forest management planners and regional planners.

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## 1. Introduction

A most important issue in sustainable land use is how to maintain the functioning of ecosystem processes and to ensure thereby the provision of natural resources, goods and benefits to human beings, nowadays called ecosystem services (de Groot et al., 2010; O'Farrell and Anderson, 2010). Though knowledge and approaches how to assess the monetary or non-monetary value of such services are widely developed and acknowledged, the use and acceptance of ecosystem services as a goal or criterion for success in land use or regional planning is still in discussion (Viglizzo et al., 2011; Fürst et al., 2010a). Reasons therefore might be that (a) monetary terms into which most recent research activities such as TEEB (Jones-Walters and Mulder, 2009; Ring et al., 2010) translate ecosystem services intend to address the scale of thinking in land use (microeconomic) and regional planning (societal needs), but

they focus however much more on conclusions from a macroeconomic (political) point of view. (b) Furthermore, for planning items, the provision of ecosystem services must be translated into demands for land (land requirements), which must be allocated in a spatially explicit way. Such land requirements have to be checked carefully considering interferences between different services to be provided by the same piece of land and planning relevant restrictions such as nature conservation areas, which might impact the prior provision of one or several services by a piece of land (Egoh et al., 2011; Ulgiati et al., 2011; Smith et al., 2010). Land requirements in land use planning (forestry, agriculture) and regional planning are calculated based on criteria such as the expected future demand for wind and bioenergy, drinking water or food, or the expected need for settlement areas and infrastructural facilities (for state regional planning in Saxony see e.g. SMI, 2004). This means that already some of the criteria and underlying indicators in regional planning can be directly linked with the ecosystem services approach, while others are related to socio-economic considerations, which are more indirectly addressed by the ecosystem services approach (Fürst et al., 2012). Furthermore, difficulties arise in assessing the impact of land use (use = management) strategies on the provision of ecosystem

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services on a regional (meso-) scale because data on the concrete management of a piece of land on a micro-scale are often not available in a way that they could be involved in meso-scale assessment approaches (Verburg et al., 2009; Dale and Polasky, 2007). Examples therefore are crop rotation, soil management techniques and fertilization strategies in agriculture, or tending, harvesting and regeneration measures in forestry. They are recorded on a micro-scale, but mostly not mapped, with the result that immense knowledge on possible land-management related impact factors on the provision of ecosystem services is lost (Salmon-Monviola et al., 2012; Fürst et al., 2011). In consequence, also information on the real land use mosaic is missing, and, even worse, available information on how to account for the pattern of land uses or land-cover classes on the provision of ecosystem services is rarely available (Frank et al., 2011; Lautenbach et al., 2011).

Assuming that the ecosystem services concept offers a valuable method for assessing land use and regional planning alternatives and their impact on the constituents of human well-being in a generic, easily communicable and transferable way, we intended to adopt this concept for regional planning questions. In this paper, we present results from a case study in Middle Saxony, Germany, and focus on testing integrated land use strategies in forestry (conversion, afforestation) and at the interface to agriculture (short rotation coppice as a special case; Fürst et al., 2011, 2012). The case study was done in the context of the updating process of the regional plan (Regionaler Planungsverband Oberes Elbtal/Osterzgebirge, 2009).

We tested our forest land use strategies (a) in a spatially inexplicit way to identify possible general recommendations for our model region and (b) by using the software platform GISCAMÉ (Fürst et al., 2010a,b) in a spatially explicit way for some representative sections of our model region. The spatially inexplicit testing represents thereby the scale of thinking in state regional planning, where policy aims are translated into very generally formulated land requirements; (b) represents the scale of thinking in regional planning, where such land requirements must be concretely located. This can be complemented by additional information such as locally specific priorities for land management strategies, e.g. no-till areas to reduce water erosion.

The paper introduces first the software platform GISCAMÉ and the embedded multicriteria evaluation framework which was implemented for the spatially inexplicit and the spatially explicit testing of the land use strategies including some underlying assumptions related to our land use classification and the selected ecosystem services. Then we provide an overview on the land use scenario matrix which was used for testing in both cases. We compare spatially inexplicit and spatially explicit conclusions and discuss their implications for planning. Lessons learnt from spatially inexplicit and explicit testing, from the use of the GISCAMÉ software platform and from the discussion with our actors are part of the discussion and conclusions.

## 2. Material and methods

### 2.1. Model region and basic data

Our aim within the case study was to assess the impact of forest and agricultural land use scenarios on the provision of a set of ecosystem services (see 3.2). The land use scenarios were defined in the course of updating the regional plan (Regionaler Planungsverband Oberes Elbtal/Osterzgebirge, 2009) together with the planning authority and the working groups for (i) agriculture, (ii) forestry and (iii) land management of three ILE (Integrated Rural Development) regions within the district of the planning authority, namely “Dresdener Heidebogen”, “Silbernes

Erzgebirge” and “Sächsische Schweiz”. These three ILE regions represent well typical environmental and socio-cultural conditions in the model region and were therefore considered as appropriate reference for the scenario development. In result, recommendations for regional planning should be given, where and how land use should explicitly be addressed by priority or preference areas for specific agricultural or forest land uses to increase the provision of some so far underrepresented services and to achieve an optimal balance in the regional ecosystem services portfolio. Fig. 1 shows the land cover mosaic of our ~10,000 km<sup>2</sup> large model region in the middle of Saxony, eastern Germany, in the way that it is displayed in the software GISCAMÉ (see 2.3); Table 1 provides an overview on some land cover and land ownership statistics, which are later on relevant for the scenario formulation (see sections 2.4 and 2.5).

### 2.2. Selected ecosystem services

In our case study, we identified a set of six services to be assessed when testing land use and land cover change strategies (Fürst et al., 2011, 2012). We used a participatory process with actors in our planning district including the three ILE regions, which came from forestry, agriculture and regional planning including private land owners, land owner associations and representatives from the public sector (governmental and sub-governmental organizations). We started our assessment in using the ecosystem services concept in the understanding of the Millennium Ecosystem Assessment (MEA, 2005). The indicator and criteria selection process itself was based on extensive literature studies, expert recommendations and stakeholder knowledge on available and applicable information in the regional context as described and critically discussed by Koschke et al. (2012) and Fürst et al. (2012). In the assessment process and following the arguments and planning questions of our actors, our understanding of ecosystem services had to be modified and adapted compared to the original understanding in MEA (2005; see Fürst et al., 2011; Fürst et al., 2012). Our set for this case study comprises provisioning services (“bio-resource provision” including timber, food and fibers; “human health and well-being” related to the provision of fresh water and air), regulating services (in our case named “mitigation of climate change impact”), cultural services (“aesthetic value”) and supporting services (contribution to “ecological integrity”). Additionally, a service called “regional economy” (private and public income from direct and indirect land use) had to be integrated to meet the needs of our regional actors (Fürst et al., 2011, Fürst et al., 2012, Fürst et al., 2010a; see also Menzel and Teng, 2009). Noteworthy is that the naming and definition of what these services imply in the regional context came directly from our actors, who selected also the criteria and indicators for the evaluation (see Table 2) and that it was exclusively developed for the planning questions to be answered. Therefore, these services should not and cannot be compared to and understood in the sense of more complex scientific concepts which are normally addressed, for instance, by “ecological integrity” or “climate change mitigation”.

### 2.3. GISCAMÉ and the multicriteria assessment framework

GISCAMÉ is a software platform which combines a GIS module with a cellular automaton module and a multicriteria evaluation framework (Figs. 2 and 3). Application area of GISCAMÉ is to assess the impact of land cover and land use change scenarios on planning goals, which can be expressed by ecosystem services or other, to a higher or lower degree, aggregated target figures (Fürst et al., 2010a,b).

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