Costs and benefits of spatial data accuracy on comprehensive conservation planning assessments – a conceptual approach

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Abstract – The planning of protected habitat networks to safeguard global biodiversity requires substantial knowledge on exposure, services, and functions of ecosystems. Spatial-ecological datasets contain important information for the adequate assessment of spatial economic and ecologic interdependencies. However, these data are still lacking in many places. Comprehensive earth observation can play an important role in the provision of such data but it also involves costs. Cost-benefit analyses may answer the question whether the preparation of such comprehensive spatial data is worthwhile and may help to find the appropriate data resolution for conservation planning questions under consideration of costs. We compare several wetland data sets on global, national, and regional scale according to their spatial accuracy of wetland distribution and the costs of data survey, monitoring, and supply. The spatial data are integrated into bioeconomic land use models of different scales to assess benefits and uncertainties of increased data resolution and accuracy.

Keywords: spatial-ecological datasets, global earth observation, wetland distribution, scale-dependency, bioeconomic land use models

1. INTRODUCTION

Conservation programs act from local to regional or national scales. Some efforts involve entire continents as does the Natura 2000 network in Europe (European Commission, 2009). Globally, several international environmental agreements have been established which include conservation issues. Examples are the Convention on Biological Diversity, the Convention on Migratory Species of Wild Animals, the UN Framework Convention on Climate Change, and the Ramsar Convention on Wetlands. A common aim of most initiatives is the protection and restoration of valuable natural sites by providing a functional network of sites. The assessment, coordination, and indication of these sites require specific knowledge on ecosystem and habitat distribution, its functions and services (also under climate change conditions), and on socio-economic and political demands and objectives at different scales. Integrated assessment models may provide the methodological basis for large scale analyses. For sufficiently accurate assessments, however, these models often lack comprehensive spatial-ecological input data (Schleupner, 2011). These data could be provided by modern earth observation and remote sensing techniques. However, the provision of data incurs costs and the question arises whether the benefits of increased data accuracy are worth the costs of obtaining it. Several studies (Bradford and Kelejian, 1977; Klein and Ståhl, 2007; Bouma et al., 2009; Jantke et al., 2011a) show that inaccurate and coarse data may lead to inaccuracies and uncertainties in model results and ultimately may lead to inefficient policy decisions. The Global Earth Observation System of Systems (GEOSS) initiative aims to improve the earth observation information made available to decision makers at supranational scale by collection, interpretation, and sharing of such information cost-effectively (USGEO, 2010).

The aim of this study is to illustrate costs and benefits of increased data resolution at various spatial scales in the case of wetland conservation planning. Many wetlands are anthropogenically modified due to deep drainage for peat extraction, agricultural production, and urban sprawl and often leave the remaining wetlands in a fragmented and degraded state. The prevention and reversal of anthropogenic destruction may be in societies' interest because wetlands provide various ecosystem services. They affect, for example, the carbon, water, and nitrogen cycles, serve as habitat for many plant and animal species, and act both as sink and source of greenhouse gases. Efforts to protect existing and to restore former wetlands have therefore increased over the past years. Here, we apply spatial wetland and nature protection data in economic land use models and GIS-based spatial models at different scales. For each data set, the costs of data survey, monitoring, and distribution are estimated. Subsequently, we will approximate the marginal cost function in order to determine the cost efficient data resolution for trans-boundary conservation planning questions.

During the last years, the benefits of earth observation for various purposes have been well studied (e.g. Katz and Murphy, 1997; Balmford et al., 2002; Williamson et al., 2002; Macauley, 2006). Rydzak et al. (2010) developed a model that evaluates the impacts of different earth observation data in several societal benefit areas. Costs of achieving these data have often been neglected in the past. Recent studies by Sandau (2006) or Fuss et al. (2008) account for these costs as well. The National Oceanic and Atmospheric Administration (NOAA) has begun to account for the

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costs and social benefits of their data products (www.economics.noaa.gov). Fritz et al. (2008) develop the benefit chain concept, a conceptual framework for assessing the benefits of earth observation by implementation of costs. A comparison and integrated analysis across different spatial scales as proposed in our study has not been conducted so far.

Only a few studies estimate the value of earth observation for biodiversity conservation (Scholes et al., 2008; Reyers et al., 2009). Data and analyses of comprehensive nature conservation plans are rare. In general, the concept of systematic conservation planning introduces costs of conservation into land use planning (Margules and Pressey, 2000). However, comparisons of impacts of different data accuracies on the results are seldom applied. Macaulay (2006) shows how space-based earth observations can improve natural resource management and Jantke et al. (2011a) illustrate the benefits of increased data resolution on nature conservation options and evaluate the costs of conservation for European wetlands. It is shown that increased data resolution can reduce opportunity costs for species protection. This study contributes to filling this knowledge gap.

2. METHODOLOGY

2.1 General

We apply the benefit chain concept by Fritz et al. (2008; 2009) to our study. It assumes that better information leads to improved decisions with economic benefits.

Here, we compare the results of different spatial scales ranging from global to continental, national, regional, and local. The same input data are simultaneously used at all scales. Figure 1 illustrates the concept of the study. The input data and resulting scenarios are differentiated between GEOSS and non-GEOSS (cf. Fritz et al., 2008; Jantke et al., 2011a).

Non-GEOSS data refer to the existing data whereas GEOSS data are based on regional, national, and global earth observation products and have a higher resolution and spatial accuracy. The GEOSS data are currently only available for certain countries or regions but not at global level (Fritz et al., 2008).

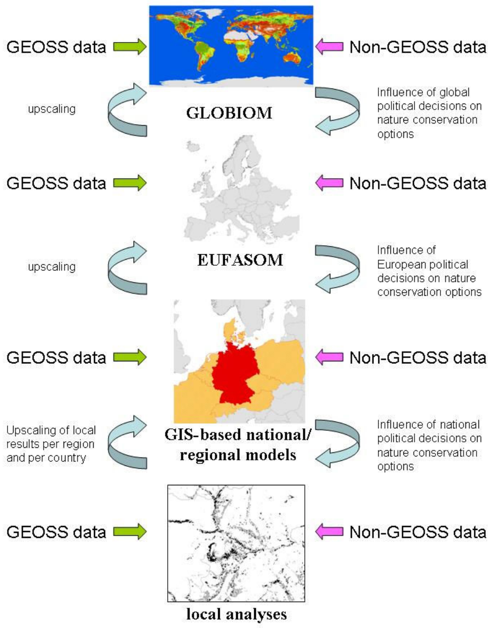

Figure 1. Conceptual Overview of the study.

2.2 Models used

We use several models for our integrated analysis. In the following they are described in short:

GLOBIOM (Global Biomass Optimization Model, Havlik et al., 2010) – the global recursive dynamic partial equilibrium model integrates the agricultural, bioenergy and forestry sectors with the aim to provide policy analyses on global issues concerning land use competition between the major land-based production sectors. The flexible model structure allows to easily change the model resolution.

EUFASOM (European forest and agricultural sector optimization model) – a multi period partial equilibrium model of the European agricultural and forestry sectors, which has been developed to analyse changing policies, technologies, resources, and markets. It illustrates land use change between agriculture, forestry, nature reserves, and energy crop plantations. Amongst others, it is further described in Schleupner and Schneider (2010).

HABITAT – a spatially explicit deterministic reserve selection model based on the principles of systematic conservation planning. It estimates area requirements for conservation as well as costs of habitat protection. For more information see Jantke et al. (2011b).
National/regional models and local analyses – they are based on Geographical Information System (GIS)

applications developed within this study (see Schleupner, 2009).

2.3 Data used

Costs of data survey, monitoring, and supply are estimated through intensive literature review.

Spatial input data to the different models are differentiated in GEOSS and non-GEOSS data. Depending on the scale of application, non-GEOSS data may also be used as GEOSS data at coarser scales. Figure 2 illustrates this in more detail and Figure 3 exemplarily shows some of the differences between GEOSS and non-GEOSS data.

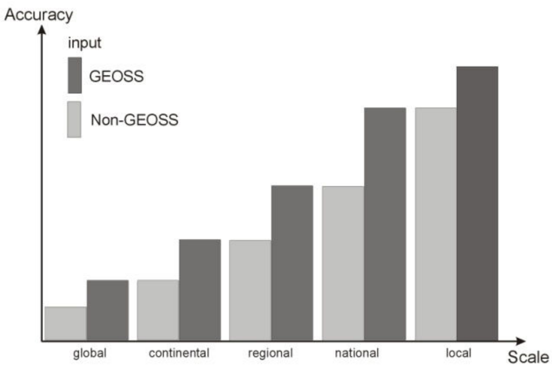

Figure 2. Scale dependency of GEOSS versus non-GEOSS data.

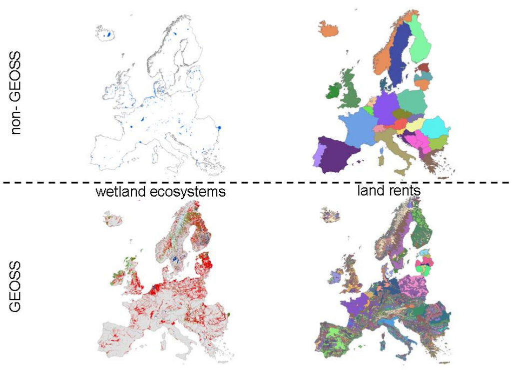

Figure 3. GEOSS and non-GEOSS data for wetland ecosystems and land rents in European scale.

2.4 Application

Through the application of different models we are able to quantify the differences in costs of implementation of nature conservation options at various scales. We examine the variability of model results with respect to the different input data under consideration of costs. Costs are differentiated in costs of data provision and implementation. Thus, through the comparison of the results the quantification of the benefits is possible by analyzing the avoidance of the costs of the wrong decision (cf. Fritz et al., 2009). Figure 4 shows the conceptual implementation of costs at various scales.

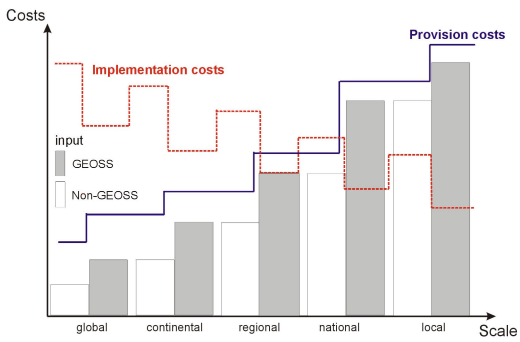

Figure 4. Theoretical development of provision and implementation costs at different scales.

3. DISCUSSION AND CONCLUSIONS

The study described here, is still in its implementation phase but results will be available for the ISRSE Symposium.

By running the model suite on different data inputs and scales we are able to trace out a marginal cost-benefit ratio as a function of data resolution. The identification of optimal earth observation resolutions in the context of nature conservation considers scientific, economic, societal, and regulatory imperatives (USGEO, 2010). This study will contribute to this topic by providing a better understanding of the cost-benefit dynamics of datasets and scales used for comprehensive conservation planning.

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