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Overview: Spatial information and indicators for sustainable management of natural resources

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ABSTRACT

Natural resource management (NRM) is becoming increasingly important at all scales, local, regional, national and global, because of an increasing human population and increasing per capita use of resources and space. Conflicts are intensifying between different interest groups. Production and conservation aspects are particularly debated because conservation often conflicts with economic and social sustainability. There is public demand for objective decision based NRM but limitations are all pervasive due to the spatial and temporal complexity and interdisciplinary nature.

This special issue explores the use of spatial data and models to overcome some limitations of NRM decision making. The papers in this issue show modern approaches of natural resources management with a particular focus on spatial data collection, analysis and the development of spatial indicators. This issue presents a balanced mix of review and research papers that give examples of how to find or improve the spatial information base for evidence-based decision making.

This overview makes the argument that understanding complex spatial pattern and processes, and the development of spatial indicators, is an essential aspect of evidence-based NRM. If spatial and temporal patterns are complex, ecological evidence from field data or experiments may have limited value for NRM and observational study designs become more appropriate for understanding complex spatial pattern and processes. Data quality should be documented as a combination of accuracy and spatio-temporal representativeness in order to be useful in the NRM decision process.

1. Introduction

Natural resource management (NRM) relates to the human impact on the natural environment, the productivity of land and water bodies and its impact on ecosystem services and qualities such as water allocation, soil loss, biodiversity but also indirectly with health issues as related to pollution, fire, or dust storms. NRM refers to maintaining quality of life and ethical values related to sustainable management. It influences ecosystems, landscapes and because of off-site impacts and spatial interactions also urban areas. With human population and resources use per capita on the rise, good management is becoming increasingly important at all scales: local, regional, national, and especially global. Debates amongst different interest groups (e.g., producers and conservationists) of management issues are intensifying as resources become limited and because conservation of natural resources often conflicts with economic and social sustainability.

The increasing importance of NRM is paralleled with increasing complexity. NRM issues are increasingly difficult to address because historic influences carry through into the future in an ever increasing intensity and complexity. Past human actions influence the ecosystem states and require continuing adaptation of management (Argent, 2004). Management relies on continuously improved and updated information, but is also highly dependent on the dynamic nature of environmental conditions, most importantly; climate change, water allocation, soil loss and biodiversity loss, with substantial interactions between these environmental issues.

Human impact on the environment has been increasing in the past and will do so into the future. The human footprint is becoming larger because of population and standard of living increases, whist natural resources are limited because of space and thermodynamic constraints. The "tragedy of the commons" remains all pervasive. Mismanagement potentially benefits individual landholders in the short term while it adversely affects society at broad scales and in the long term. But it also needs to be noted that NRM actions are occurring at a property levels (often a very fine spatial scale), whereas benefits can only be felt if actions are coordinated at much broader spatial and temporal scales. The recent debate about local vs. broad scale governance related to biodiversity conservation (Noss, 2010) indicates that resolutions require further discussion into the future. The inherent complexity of inter-

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actions between socio-cultural, economical and biophysical system components makes management based on facts very difficult. Neither the future trajectory of the ecosystems nor outcomes, benefits and costs efficiency of management actions may be predictable in the future because the state of the system approaches levels that we have not experienced before and the scales of influence are unprecedented in human history.

NRM recognises that many conflicts arise because space on the earth is limiting; NRM therefore also is spatial management. There is much evidence that NRM efficiency is increased if spatial differences are considered (e.g., Margules and Pressey, 2000, Naidoo et al., 2006). The realism of management models is increasing rapidly with the improvement of spatial data sources, models and computational power. To be useful for NRM, realism and relevance need to be high. The rich sources of some information layers at high spatial and temporal resolutions may provide this ingredient. Environmental decision support systems make use of increasingly complex and integrative model structures, user friendliness and are increasingly used in stakeholder meetings, which provide the basis for objective discussions and negotiations (Matthies et al., 2007).

This special issue contains a selected set of papers that were presented in the session “Spatial Data for NRM” at the Ecosummit 2007. Papers range from terrestrial to marine and cover key areas of NRM (devising of management units, biophysical and biological condition assessment, generation of productivity and economic information layers and development of models for evaluation of management options). The articles in this issue show modern approaches to natural resources management with a particular focus on spatial information collection, analysis and the development of spatial indicators. Both review and research papers show studies that improve spatial information for the NRM decision making process. The complexity of many NRM issues demands complex linkages of models and data for assessment of realistic future scenarios and evaluation of alternative management options.

2. What factors limit objective NRM decision making?

The strength of a chain of decisions depend on the weakest link of the available information. Too often critical spatial information layers are difficult to come by at the appropriate spatial resolution and extent, hence reducing the overall strength of the combined evidence. Many processes (e.g., carbon, water, nutrients and pollutants transport) or patterns that are either directly of management relevance or control critical processes are difficult or impossible to measure at the most relevant spatial or temporal scales. Decisions rely on more or less substantiated assumptions and are limited by our lack of understanding of the temporal dynamics of spatial pattern and their trajectories into the future.

3. Causes of spatial patterns and processes

Spatial complexity is apparent at all scales and humans play a key role shaping the land (e.g., Tasser et al., 2008). Simple visualisation of surface reflectance from satellite imagery shows the most obvious causes of pattern (Fig. 1). Broad scale spatial pattern that are visible at scales from 1:100 million to 1:10 million are most strongly influenced by geology, topography and global climatic pattern as influenced by latitude and geography of continents. Human influence, even of such densely populated metropolitan areas as Beijing, China is not yet strongly evident. At scales of 1:1 million, human actions are clearly visible in highly populated areas; but also

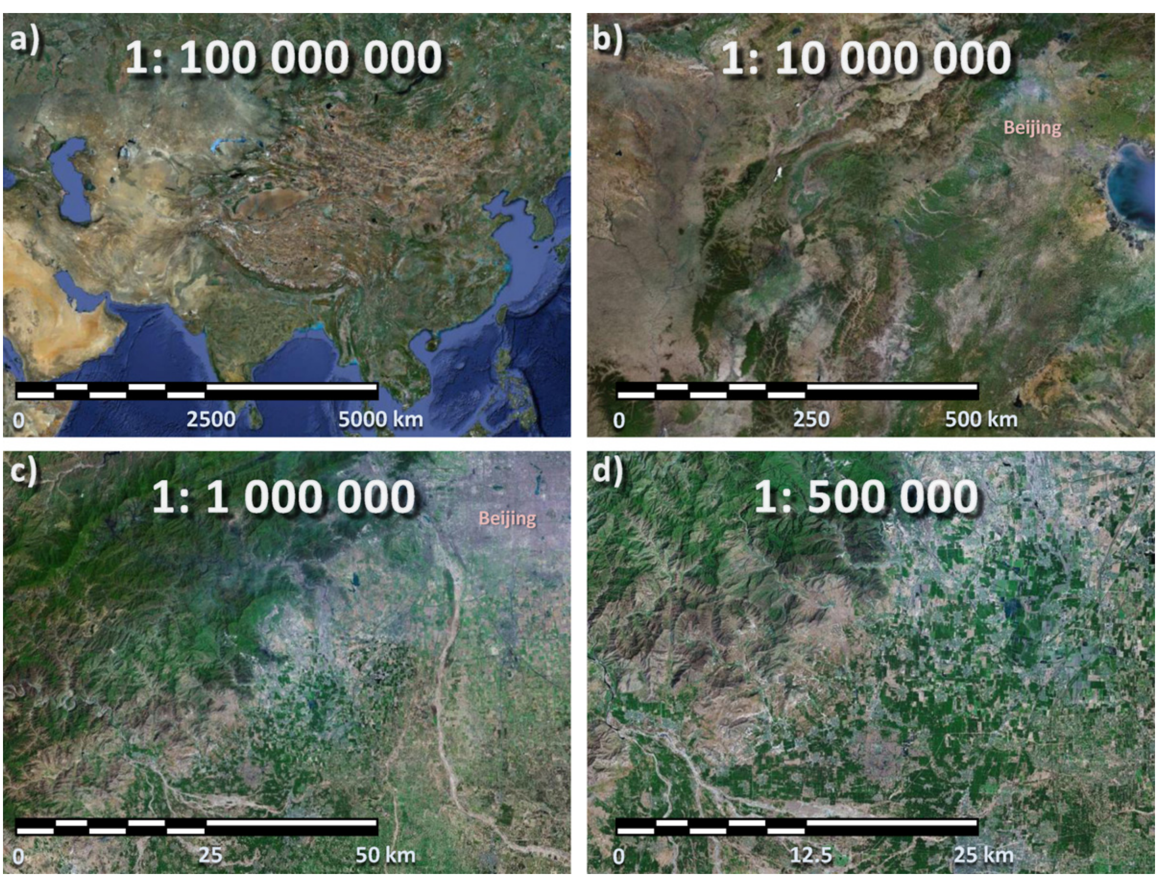

Fig. 1. Earth surface pattern at different scales (source Google Maps). Whereas at continental and global scales pattern are mostly natural, at 1:1 million the influence of humans on shaping land surfaces are one of the strongest factors.