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PREFACE

Integrated modelling of natural and social systems in land change science

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The need to model the coupled natural-human environment is becoming increasingly important. Climate and global change initiatives now require projections that account for both the biophysical and human dimensions of land change as well as the complex interdependencies between them. Indeed, an understanding of the interlinked processes of land systems is needed if we are to avoid negative consequences of human activities in the future (Kok et al. 2007). Although several studies have looked at human-nature interactions, fewer have considered the complexity of the coupled land system as a whole (Liu et al. 2007). A holistic consideration of the land system is important as it allows us to take into account feedbacks between different elements of the system (be they social or physical), to identify thresholds and trigger points for change within the system and to identify unexpected or emergent behaviour (Bennett and McGinnis 2008).

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Consideration of the coupled land system demands approaches and tools which are able to deal with the complexity involved and to represent the varied processes operating in environmental and social systems. A variety of approaches are used, including agent-based models to represent human decision-making. Inevitably this leads to the use of integrated computer models which can be used to simulate both the elements and elemental interactions of the land system (Claessens et al. 2009). Success in integrated models, is however, dependent on our understanding and description of the system itself and our ability to couple different modeling approaches. The papers in this special issue represent a variety of modelling approaches for analysis and projection of change in the land system as a coupled natural-human system.

The Global Land Project (GLP), a project of the International Geosphere-Biosphere programme (IGBP) and the International Human Dimensions Programme on Global Environmental Change (IHDP) (GLP 2005) recognises the importance of integrated modelling, with the need to 'measure, model and understand the coupled human-environmental system' being its main goal. In February 2008, the GLP Nodal Office on Integration and Modelling held a workshop on 'the design of integrative models of natural and social systems in land change science'. The workshop took a broad overview of the state of integrative models of natural and social systems in land change science. During the workshop participants considered the system we are trying to model, the modelling approaches being used (from detailed agent-based approaches to framework approaches) and requirements for the design of effective integrated models. Participants discussed different aspects of land system modelling, using their own work to debate more general scientific issues. Case studies and examples were drawn from change in agricultural systems, urban systems, and systems in both developed and developing countries. Examples also included a range of different modelling approaches, from multi agent systems to neural networks.

This special issue represents an output of the GLP workshop. It brings together case study and theoretical papers from workshop participants and their wider network of collaborators. All papers have been completely revised following the presentations and debate at the workshop before being submitted for peer review. The first two papers both give examples of different modelling techniques being integrated into a single model. The first, by Gaube et al. (2009) gives an overview of the Simulation of Ecological Compatibility of Regional Development (SERD) model and its application to Reichraming, an area in Austria for which it was developed. The SERD model combines an agent-based model, a GIS-based land use module and a stock-flow model of carbon and nitrogen flows. The second paper by Verburg and Overmars (2009) considers the Dyna-CLUE model which combines approaches to describe top-down allocation of land use change with bottom-up algorithms of vegetation dynamics determined by local conditions. The merits of using top-down approaches which can be used to understand hierarchical linkages in combination with bottom-up approaches have been pointed out by Wu and David (2002).

The paper by Verburg and Overmars (2009) is followed by three papers which consider land system change in areas dominated by forests, cropland and livestock farming respectively. Aguiar et al. (2009) present a modeling approach to estimate changes in the Brazilian Amazon, one of the most rapidly changing areas on the Earth. As in the paper by Verburg and Overmars (2009), they combine top down and bottom up approaches. Lakes et al. (2009) explore cropland abandonment in post socialist Central and Eastern Europe, another geographic area experiencing rapid change, using Artificial Neural Networks (ANN) to combine socio-economic and environmental datasets. Neumann et al. (2009) model the distribution of livestock across Europe as determined by environmental and anthropogenic factors.

An integrated modelling approach can be particularly useful when describing land system changes in areas dominated by anthropogenic influence. Given that just over half of the world's population now lives in cities, an understanding of urban land systems is important. Papers by Irwin et al. (2009) and Fontaine and Rounsevell (2009) discuss the modelling of land system change in urban areas. The former presents an overview discussion of some of the issues and techniques used in modelling urban systems whilst the latter gives a specific example using an agent-based approach for an area of the UK.

During the GLP workshop a wide range of techniques as applied to a variety of geographic areas were discussed and this is reflected in the variety of papers included in this SI. This led to discussion at the workshop of the need for methods which allow model comparison, to facilitate the exchange of ideas and approaches. The last paper in the SI (Polhill and Gotts 2009) addresses this topic by considering how common ontologies can be used to facilitate integrated modelling of coupled human-natural system.

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References

Aguiar MD, Moreira EG, Costa SS et al (2009) Dynamic coupling of multiscale land change models: Interactions and feedbacks across regional and local deforestation models in the Brazilian Amazon. Landscape Ecol (this issue)

Bennett D, McGinnis D (2008) Coupled and complex: human-environment interaction in the Greater Yellowstone Ecosystem, USA. Geoforum 39:833–845

Claessens L, Verburg PH, Schoorl JM, Veldkamp A, Geraedts L (2009) Modelling interactions and feedback mechanisms between land use change and landscape processes. Agric Ecosyst Environ 129:157–170

Fontaine CM, Rounsevell MD (2009) Agent-based modelling; multi-agent systems; urban growth; land-use change; regional landscape; residential demand; household behaviours; location choices; preferences. Landscape Ecol (this issue)

Gaube V, Kaiser C, Wildenberg M et al (2009) Agent-based model, carbon flows, land-change science, integrated

modelling, nitrogen flows, scenario analysis, socio-ecological systems, stock-flow model. Landscape Ecol (this issue)
GLP (2005) Global land project. Science plan and implementation strategy. IGBP Report no. 53/IHDP Report no. 19. IGBP Secretariat, Stockholm
Irwin EG, Jayaprakash C, Munroe DK (2009) Towards a comprehensive framework for modeling urban spatial dynamics. Landscape Ecol (this issue)
Kok K, Verburg PH, Veldkamp TA (2007) Integrated assessment of the land system: the future of land use. Land Use Policy 24:517–520
Lakes T, Mueller D, Krueger C (2009) Cropland change in southern Romania—a comparison of logistic regressions and artificial neural networks. Landscape Ecol (this issue)
Liu J, Dietz T, Carpenter SR et al (2007) Complexity of coupled human and natural systems. Science 317:1513
Neumann N, Elbersen BS, Verburg PH et al (2009) Modelling the spatial distribution of livestock in Europe. Landscape Ecol (this issue)
Polhill G, Gotts N (2009) Ontologies for transparent integrated human-natural system modeling. Landscape Ecol (this issue)
Verburg PH, Overmars KP (2009) Combining top-down and bottom-up dynamics in land use modeling: exploring the future of abandoned farmlands in Europe with the Dyna-CLUE model. Landscape Ecol (this issue)
Wu J, David JL (2002) A spatially explicit hierarchical approach to modeling complex ecological system: theory and applications. Ecol Model 153:7–26