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Editorial

Uncertainty in ecological models

Ecological models, diverse in purpose and structure, are increasingly used to simplify the representations of reality of the natural complex ecosystems. Early models were simple theoretical models designed to produce general predictions unconstrained by the details of a particular time or place. The growth of public interest in solving environmental problems has since provided a new impetus for the development of complex ecological models (Jorgensen and Bendoricchio, 2001; Lek et al., 2005). One practical implication of the complex systems view for the resource manager is the question of how to deal with uncertainty. Increasingly recognized as an issue to address, uncertainty reflects the probability that a particular estimate, piece of advice, or management action may be incorrect.

Being simplified representations of the reality, the simulated ecological models can never be the same as the real nature, i.e. their results are somewhat uncertain. Uncertainty describes deviations between models' results and observed values. Ecologists have tried to deal with uncertainty in several ways and methods have been developed to quantify uncertainty in ecological models. Jager and King (2004) suggested a classification in six categories of methods to explore the uncertainty of spatial models: (1) uncertainty analysis, (2) sensitivity analysis, (3) error analysis, (4) error budget analysis, (5) decision analysis and risk assessment, and (6) hypothesis testing using neutral models.

In spite of the diversity of methods, the uncertainty of an ecological model is caused by both the lack of knowledge (i.e. data imperfection) and the variability of models and parameters (models' sensitivity). Data may contain errors that result from either sampling, measurement or estimation mistakes (Regan et al., 2002). Analysed data are almost always incomplete with large and unknown amounts of measurement error or data uncertainty. Often the expense of data collection prohibits collecting as much data as might be desirable. In addition, most ecological phenomena of interest can only be studied by combining various sources of data; aligning these data properly presents interesting statistical challenges. Models are imperfect being a simplification of real systems, and per definition always contain errors in assumption, formulation and parameterization. Moreover, most of models are not fully validated, because validation data are not available, or techniques for validating models have not been performed.

Uncertainty analysis in the ecological models implies the identification of errors, inexactness, imperfection and unreliability in the models (Wu et al., 2006; Li and Wu, 2006). The field of ecology is becoming increasingly aware of the importance of accurately accounting for multiple sources of uncertainty when modeling ecological phenomena and making forecasts. This development is motivated in part by the desire to provide an accurate picture of the state of knowledge of ecosystems and to be able to better assess the quality of local and global change predictions (Brewer and Gross, 2003; Jager and King, 2004). The considerations of uncertainty in the ecological models have lately increased for several ecological research areas, such as the impact of climate changes (Bergant et al., 2006; Fuentes et al., 2006), habitat sustainability and management (Van der Lee et al., 2006), marine reserve (Quentin Grafton et al., 2005; Halpern et al., 2006), risk assessment of species (Regan et al., 2003), biological conservation (Wintle et al., 2003) etc.

The aim of this issue is to present a thorough investigation and discussion of these various sources of uncertainty that typically play a role in ecological analyses and statistical techniques that enable proper inferences and predictions to be made in light of these uncertainties. The uncertainty will be studied with diverse ecological data and different modeling tools. We selected five contribution papers covering diverse modeling methods and ecological research areas:

- Chave and Norden paper uses the neutral model to predict ecological community of rain-forest trees in response to the large scale patterns of the landscape fragmentation;
- Guven and Howard paper utilize the deterministic-mathematical model to identify the critical parameters of cyanobacterial growth in lakes and rivers;
- Larssen, Hogasen and Cosby use deterministic process-based models to simulate water chemistry under a scenario of reduced acid deposition in northern Europe;
- Pinol, Castellnou and Beven apply the generalized likelihood uncertainty estimation methodology to simulate forest fires in Mediterranean regions of Europe and America;

- Saloranta and Andersen use the Monte Carlo simulations to simulate the vertical dynamic of parameters in lakes.

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