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Introduction to Models and Risk Assessment

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Models, whether they be qualitative, quantitative, or a combination of both, play a fundamental role in risk assessment. Since the initial application of single-point deterministic analyses in the 1990s, ecological risk assessments have progressed to consider multi-stressor and multi-outcome assessments in dynamic environments. These advances have demanded an increase in the sophistication of the models we use, while meeting users' requirements of greater realism and transparency in decision-making processes. Notwithstanding these advances, the premise of risk and risk assessments remains unchanged. Risk is the chance, within a time frame, of an adverse event occurring with specific consequences, and risk assessment is a process used to collect, organize, integrate, and analyze information for use in a planning environment, where the outcome is the analysis and prioritization of risks or hazards to a stated objective. The objective of a risk assessment is to improve the understanding of the risks for a given system, and to guide the identification and implementation of appropriate risk management strategies to minimise, monitor, and control the probability or impact of adverse events.

Increasingly, models are seen as a fundamental element of risk assessment, promoting evidence-based and tractable decision-making, and ideally increasing the confidence of stakeholders in the process (Pollard *et al*. 2008). However, in achieving this, we are challenged by the multifaceted composition of risk, where models need to reflect the varying sources and levels of uncertainty, the variability in intensity of the events or threats, and the dynamic, probabilistic, and often nonlinear nature of the environments on which the system's vulnerability and resilience depend (Haimes 2009). The complexity of the problem, and the methods we use to manage this, are defined through the problem framing process. Consequently, the models we develop to fulfill our risk assessment needs vary considerably, often reflecting the breadth and depth of the problem being addressed.

In this special issue, "Models and Risk Assessment," we introduce a diversity of articles that address the use of a range of modeling methods in risk assessments. The modeling approaches discussed address single issue and multi-objective problems,

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explore the way space and time are represented and handled, and consider the ultimate needs of the decision-maker.

Broad-scale problems are generally handled using highly aggregated or "lumpy" risk analysis models. In this issue, Bartolo *et al.* (2012) used a relative risk ranking assessment approach to model broad pan-continental and catchment scale problems, considering a range of stressors and endpoints. Additionally, Sandhu *et al.* (2012) explored the complexities in making tradeoffs between multiple objectives, by constructing a tool that allowed agricultural agencies to assess the tradeoff between opportunities for exploitation and risks to ecological systems. The basis for tradeoffs was a structured qualitative interview process. Thomas *et al.* (2012) also explored the complexities of tradeoffs, targeting the relationships between coral reefs, agriculture, and tourism in the Great Barrier Reef, again from the perspective of protecting ecosystem services. A Bayesian network model was developed using aggregate inputs from a range of data types, including other models. Glendining and Pollino (2012) and Bayliss *et al.* (2012) also exploited the integration and multi-stressor modeling platform that Bayesian networks provide, to assess risks to biophysical systems. Glendining and Pollino (2012) developed a modeling tool to inform investments in stream rehabilitation activities, while Bayliss *et al.* (2012) explored the nature of risks from stressors derived from mining and landscape scale sources on biodiversity. These articles provide useful insights in how multiple-stressor problems, multiple endpoints, and tradeoffs in decision-making can be better handled through models.

In contrast, the remaining articles are focused on in-depth assessments of the relationship between a stressor(s) and its environment. Kirono *et al.* (2012) used downscaled global climate projections and linked these to a water balance model to predict the risk of climate change to impacts on salinity and water levels in closed salt lake systems. Topping and Lagisz (2012) developed an exploratory agent-based model to examine the spatio-temporal dynamics of interactions between an insecticide and a population of beetles. Hester and Cacho (2012) also focus on the spread of invasive species, but used optimization algorithms to explore the tradeoffs between investigating in search efforts and the likelihood of detecting the presence of the invasive species. The final article in this special issue is by Murray and Skerratt (2012), where machine learning techniques were applied to develop a model for assessing the potential for the spread of a pathogen in amphibians.

This issue comprises a sub-set of articles that explore the challenges of understanding the nature of multiple-stressor environments, tradeoffs, and emerging threats, such as climate change and invasive species and pathogens. These contributions represent only a sub-set of the emerging approaches in the continually evolving area of "Models and Risk Assessment," and demonstrate the increasing sophistication in the application of models to deal with complex, multifaceted problems, while strengthening risk-based decision-making processes.

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