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Building a reliable evidence base: Legal challenges in environmental decision-making call for a more rigorous adoption of best practices in environmental modelling

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ABSTRACT

Environmental decision-making frequently relies on predictive mathematical modelling as an evidence base. Where legal provisions exist to challenge these decisions, models can be particularly vulnerable to such challenges. Defensible models often adhere to rigorous scientific method and the adoption of best modelling practice that ultimately facilitates a more reliable evidence base. While developing and adopting good practices and standards in mathematical modelling are crucial aspects for models, and an active area of research in many environmental disciplines, the implications of not adopting best modelling practice for environmental decision-makers remain largely implicit in the literature. The objective of this study was thus to explicitly identify and document the challenges associated with the use of predictive modelling in the environmental and resource management decision-making process through a systematic review of New Zealand legal decisions. The review produced a rich range of examples (68 legal decisions) where modelling evidence was challenged in legal proceedings and enabled the identification of modelling characteristics and practices which strengthen modelling reliability. All of the legal challenges were substantive, relating to the scientific components of the model (e.g. assumptions, input data, and parameters), model evaluation or application. None of the challenges were regulatory process challenges. There are numerous publications that describe best practice for modelling from a technical perspective, but it appears that these guidelines are not always being followed. If models are to be of substantial help in environmental decision-making then modellers and decision-makers will need to ensure that there is a clear understanding of the purpose of a model, the modelling process is transparent, limitations are acknowledged and considered, and that best practice guidelines are followed.

1. Introduction

Mathematical modelling has emerged as an indispensable discipline in environmental sciences, for example, for describing and exploring complex ecosystem behaviour, substituting or complementing experimental studies (e.g. Green and Coco, 2007; Brown and Davies, 2010; Green, 2011; Henderson and Mullarney, 2013; Hunt et al., 2016), and testing or developing hypotheses (e.g. Pritchard, 2005; Arhonditsis et al., 2006; Fagherazzi et al., 2006; Ranasinghe et al., 2012; Mariotti and Fagherazzi, 2012; Hunt et al., 2015, 2017). Models differ substantially with regards to their purpose, complexity and scope of analysis (Pilkey-Jarvis and Pilkey, 2008; Janssen et al., 2015) and due to numerous potential applications, comprise of a diverse range of approaches and mathematical formulations (e.g. Robson, 2014; Janssen et al., 2015). Models play a vital role in all levels of environmental decision-making (Schmolke et al., 2010) for which there is an increasing need to integrate and synthesise multifaceted interdependencies of environmental complexities with a broad range of other disciplines including economics and sociology (Liu et al., 2008; Kelly et al., 2013).

Developing and adopting good practices and standards in mathematical modelling are crucial aspects for models and an active area of research in many environmental disciplines. For example, Jakeman et al. (2006) outlined ten steps that underpin best practice model development to promote an increase in model credibility and acceptance by scientists and environmental decision-makers alike. Other examples range from domain-specific practical solutions for models in conservation decision-making (Addison et al., 2013) to guidance

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specifically developed as part of the modelling process, including that for model selection (e.g. Kelly et al., 2013), assessment of model uncertainty (e.g. Brugnach et al., 2007), assessment of model performance (e.g. Sutherland et al., 2004; Winter, 2007) and evaluation of model assumption for natural resource management (e.g. Hoshino et al., 2014). Following such proposed good modelling practice frameworks *sensu stricto* may not necessarily be feasible nor desirable for every conceivable case study in all environmental realms (Robson et al., 2008). It is clear, however, that the adoption of minimum standards and transparency on level of adherence can ultimately be expected to benefit the modelling community and those who are relying on models in their decision-making process. However, there still appears to be a disconnect between the published research aimed at providing good modelling practice and the wider adoption of these principles (Schmolke et al., 2010), despite some recent increasing trends in adoption of best practices in some disciplines (Robson, 2014).

Environmental decisions (i.e. decisions concerning the natural and built environment) may have long-term impacts on ecosystems and/or irreversible outcomes, for example, where natural water waterbodies are modified or removed for urban development. Such decisions are particularly susceptible to legal challenge due to conflicting social, cultural, economic and environmental imperatives which are engaged in the allocation, use and protection of resources. Environmental decisions often concern the determination of policy and assessment of impact and both entail projection and conjecture. As a result, the forward-facing nature of environmental decisions requires models to predict or project the future development of a given system. Thus, conflicting agendas merge with ontological and epistemological uncertainty to produce contestation in decision-making processes. In these contests, predictive environmental modelling is frequently utilised as a key decision support tool and is a likely target for challenge.

The literature discusses legal challenges to models and makes suggestions for managing the problem (e.g. Council for Regulatory Environmental Modeling, 2009; Fisher et al., 2010; Pascual et al., 2013). It is understood that rigorous scientific method and the adoption of best modelling practice may facilitate a more reliable evidence base. The implications of not adopting best modelling practice for environmental decision-makers remain largely implicit in the literature. In practice there are challenges with model quality evaluation and the translation of modelling inferences to decisions, but, to the best of our knowledge, apart from the work of the Council for Regulatory Environmental Modeling (2009) which examines the USA context, there has been little systematic analysis of the legal challenges which may be presented as a consequence of modelled predictions.

The objective of this study was to explicitly identify and document the challenges associated with the use of predictive modelling in the environmental decision-making process through a systematic review of New Zealand legal decisions. In New Zealand, the Resource Management Act 1991 governs resource use and protection and provides a framework for environmental decision-making with strong participatory elements. Where predictive environmental models form part of the evidence base for the decision, the evidence may be challenged by opposing parties, contrasted to the findings of other experts and scrutinised by the decision-maker. This review of New Zealand case law provides insight into the nature and extent of these challenges and any characteristics or uses of models that are the subject of contention. Because the evidence base for a given legal decision may constituted from different sources of information and/or expert opinion, the current study focused on the evidence produced by models. The results are put into the context of existing literature that already provides modellers with tools to rigorously implement good modelling practices. It is envisaged that this study will ultimately contribute to a wider adoption of existing good modelling practice by modellers and regulators alike where modelling is routinely used as part of the environmental decision-making process. While this study focuses on New Zealand, our findings will be applicable to other countries where legal provisions exist to challenge decisions made by governmental agencies.

2. Methods

2.1. Preliminary literature review

A preliminary review of the literature pertaining to environmental modelling and law was undertaken to provide direction and structure for a systematic literature review. This preliminary review allowed potential sources of legal challenges (relating to environmental modelling) to be identified and classified. A previous study by the US Environmental Protection Agency (USEPA; Council for Regulatory Environmental Modeling, 2009) was highly relevant to the nature of challenges to models at issue before New Zealand courts, and provided a framework within which to identify and classify potential sources of challenges. The USEPA study identified two separate categories of challenge as being either (i) “process challenges”, or (ii) “substantive challenges”. Process challenges are those “usually directed at the overall transparency of the modelling exercise and the adequacy of any notice and opportunity for public comment that the agency might be required to provide”; whereas substantive challenges are those “mounted against areas of technical disagreements with the underlying science and assumptions of the model” (Council for Regulatory Environmental Modeling, 2009). The study classified substantive challenges into three distinct areas: (a) “scientific components”, which are related to the scientific assumptions, data quality or quantity, or adjustments made to the model, (b) “evaluation process”, which is related to the validity of the model, or the findings of the peer review process, and (c) “model application”, which is related to the context in which the model was applied, including departures from prior applications, or inadequate explanation of the final output (Council for Regulatory Environmental Modeling, 2009).

The preliminary examination of New Zealand court decisions identified that these classifications fit closely with the nature of challenges to models at issue before New Zealand decision-makers. In essence, at law, a challenge in any of these terms (whether process or substantive) is directed to the admissibility of the expert evidence generated through application of the model. The test for admissibility of expert evidence is if the fact-finder is “likely to obtain substantial help” from the expert’s opinion (s 25 Evidence Act 2006; *Vero Insurance New Zealand Ltd v Morrison* [2015] NZCA 246 at [24]). If inadmissible, the evidence cannot be relied upon by the decision maker, or alternatively, if admissible, the challenge may affect the weight or probative value of the evidence. So legal challenges to predictive environmental models will turn on whether or not the decision maker finds the evidence to be substantially helpful or not. The concept of substantial help depends on three factors: relevance, reliability and probative value. These factors are common to judicial systems and scrutiny of evidence. The fundamental principle in New Zealand law is that all relevant evidence is admissible.

The first factor, relevance, is defined by s 7(3) of the Evidence Act 2006, as “Evidence is relevant in a proceeding if it has a tendency to prove or disprove anything that is of consequence to the determination of the proceeding”. Whether or not the evidence is of substantial help will then be assessed through consideration of reliability and probative value. Reliability describes the extent to which a decision maker may rely upon the evidence in reaching a decision and may be affected by various factors such as the skill and experience of the expert witness and the nature of scientific testing conducted, including mechanisms applied for attaining scientific rigour such as validation/corroboration. The third factor, probative value, can include questions of relevance and reliability, because essentially it is an assessment of the weight or value of the evidence. This is a matter for the decision-maker to weigh on the facts and with regard to all the evidence. Each of these factors may be influenced by process and substantive challenges identified in the Council for Regulatory Environmental Modeling (2009) study.