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# What is the role of human decisions in restoring a clear lake?

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**Abstract:** Human decisions affect and are affected by ecological systems in multiple ways. Natural resource modelling has commonly focussed on the decisions of resource users or strategic planners. We argue that the dynamics of social-ecological systems (SES), however, emerge from multiple social-ecological interactions that are the result of decisions from different actors. As a first step towards incorporating this social complexity into models of SES, we developed a model that includes decisions by governance actors, ecosystem users and individuals that affect the state of an ecological system. We use the example of lake restoration, i.e. the ecological regime shift from a turbid to a clear water state which is influenced by decisions from lake managers and individual households. House owners affect through their choices of sewage treatment the nutrient inflow as the main driver for the lakes state. The management challenge, in this case, stems from the temporal and spatial decoupling between lake use activities by beneficiaries and the activities from distant actors eventually polluting the lake. Beneficiaries are those that enjoy ecosystem services such as drinking water, fish and recreation provided by the lake. We apply a coupled agent-based and system dynamics model to explore different pathways of managing the activities affecting the lake state back towards the clear state. Hereby, we discriminate between the timing of regulation measures (institutional level), pathways of rule enforcement (individual-institutional link), and the households initial attitude (individual level) in their effects on lake restoration time lags. By our stepwise approach, we enable a faceted understanding of how sensitive lake restoration on the macro level is to the institutional context or individual actor traits in the human-decision model on the micro level. Concluding, we reflect on the importance of the empirical as well as theoretical basis for human-decision modelling to increase its relevance for model-based learning.

**Keywords:** social-ecological interaction; transient dynamics; social pressure; regime shifts; shallow lake restoration;