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Uncertainty Analysis by Bayesian Inference in Aquatic Ecology

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The credibility of the scientific methodology of environmental models and their adequacy to form the basis of public policy decisions have been frequently challenged. The current challenges make compelling the development of more realistic modelling platforms (i) to elucidate causal mechanisms, complex interrelationships, direct and indirect ecological paths; (ii) to examine the interactions among the various stressors (e.g., climate change, urbanization/land-use changes, alternative management practices, invasion of exotic organisms); and (iii) to assess their potential consequences on ecosystem functioning. The development of novel methods for rigorously assessing the uncertainty underlying model predictions is also one of the priorities of the modelling community [1]. Striving for novel uncertainty analysis tools, I present the Bayesian calibration of process-based models as a methodological advancement that warrants consideration in ecosystem analysis and biogeochemical research [2]. This modelling framework combines the advantageous features of both process-based and statistical approaches; that is, mechanistic understanding that remains within the bounds of data-based parameter estimation. The incorporation of mechanism improves the confidence in predictions made for a variety of conditions, whereas the statistical methods provide an empirical basis for parameter value selection and allow for realistic estimates of predictive uncertainty [3]. Other advantages of the Bayesian approach include the ability to sequentially update beliefs as new knowledge is available, the rigorous assessment of the expected consequences of different management actions, the optimization of the sampling design of monitoring programs, and the consistency with the scientific process of progressive learning and the policy practice of adaptive management. I illustrate some of the anticipated benefits from the Bayesian calibration framework, well suited for stakeholders and policy makers when making environmental management decisions, using the Hamilton Harbour and the Bay of Quinte– two eutrophic systems in Ontario, Canada – as case studies [4].

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