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# Foreword to the Special Issue on Natural Resource Mathematics

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The sustainable management of our planet's natural resources is perhaps the greatest problem of this century. Many millennia ago, *Homo sapiens* roamed the earth as part of a balanced ecosystem. However, with the onset of agriculture and, much more recently, industrialisation, we are now exploiting our natural resources at unprecedented rates. Every minute, nearly ten football pitches worth of forest are destroyed for forestry and the production of food and commodities to satisfy a growing population [1]. Many of our fish stocks are declining, and environmental disturbances are on the rise due to human-caused climate change [2]. Arguably, we have realised that much of our consumption is unsustainable, yet balancing sustainable resource use and a healthy environment, while still providing eight billion people with economic opportunities and adequate lifestyles is challenging.

From optimisation to dynamic modelling to data analysis, mathematics, nowadays, plays a central role in tackling this grand challenge. It is this recognition that led to the "Workshop on Natural Resource Mathematics" held at the University of Queensland in 2017, and would later seed this special issue of the *Journal of Environmental Modeling and Assessment*. Topics at the workshop highlighted both a wide range of natural resource management problems and the various kinds of mathematics used to tackle them. The main theme running through all the talks was balancing sustainable use of natural resources while simultaneously reducing threats to the environment, such as overexploitation, climate change, habitat disturbance, and invasive species [3–12]. Along the way, we were exposed to several new developments in ecological theory and new methodologies in optimisation, control, dynamical systems, and statistics [13–24].

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Among the important works presented were several new findings yet to make their way into the literature, and hence, we decided a special issue in *Environmental Modeling and Assessment* could provide an ideal venue to highlight them. These were complemented by selected submissions to the journal that best fitted with the former. In the workshop itself, three subthemes naturally arose. The first addressed the optimal management of natural resources given extreme system complexity and uncertainty. In the first paper [25] of this issue, the authors present the problem of managing wildfires with controlled burns to not only protect the environment but also limit accumulating fuel load that can spark massive wildfires with major economic consequences. The work is representative of the types of competing objectives one must often consider in nearly all natural resource management problems. From fires to fisheries, the authors in [26] consider managers facing multiple objectives by presenting a framework for incorporating social objectives in fishery harvest decisions. However, complexities not only occur in the form of multiple objectives; the natural systems themselves are often governed by many nonlinear interactions that can also make resource management problems mathematically challenging. Such complexities are considered in [27], where the authors illustrate optimal harvest strategies for several interacting fish species governed by complex, dynamic, multispecies ecosystem models.

Populations of species that we need to manage are often heavily influenced by species interactions, and while Tromeur and Doyen [27] provides methods for incorporating these into decision-making, we still do not fully understand the rich phenomena such types of complex mathematical models can expose. In [28, 29], the authors emphasise the role of mutualism (positive species interactions) and mixotrophy (organisms that use multiple sources of energy and carbon) to understand species population dynamics. Such theoretical advances in multispecies modelling can, ultimately, improve natural resource management by providing more accurate models for decision-makers to use on the ground.

The final paper [30] of this special issue is focussed on comparing quantitative tools for natural resource mathematics. The authors investigate empirical mode decomposition (EMD) of nonlinear and nonstationary time series tools and assess the sensitivities of EMD to different types and levels of nonlinear and nonstationary environmental data.

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