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Editorial: Building decision support tools and functions for forest landscape planning and restoration

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Editorial on the Research Topic
Building decision support tools and functions for forest landscape planning and restoration

Introduction

Multiple sources of change are colliding in the 21st century—population growth, climate change, and political and economic instability—creating an atmosphere of risk and uncertainty. Population growth puts an increasing strain on global resources: those that directly sustain human populations (food, water, living space) and those that provide essential ecosystem services (biodiversity, carbon, air quality). As climate change accelerates, the pace and scale of change of nearly all facets of ecosystems are also changing. For example, natural resource management has traditionally focused on site, stand or small watershed scales, but management is now grappling with altered disturbance dynamics and socio-ecological responses operating across large landscapes, ecoregions, and even continents. Political and economic instability amplifies an atmosphere of risk and uncertainty, including impacts to the availability of economic resources to invest in reducing risk and uncertainty. These top-down drivers have the potential to disrupt the ecological foundation that provides essential ecosystem services to support communities and society.

The exponential rate of change is triggering the need for rapid and well-informed responses by managers, policy makers, and practitioners with an array of concerns and desired outcomes, including conservation, restoration, adaptation, and risk reduction. DSTs serve as a platform to collect, store, evaluate, and present data related to any number of natural resource problems. They are commonly built through a co-development exchange between scientists, managers, stakeholders, and partners, reflecting the diversity of interest holders and end-users. As such, decision support lives in the intersection of science, management, policy, and culture; effective DSTs help managers navigate this

intersection and the associated uncertainties for a given spatial scale, timeframe, and management objective. The greater the perceived threats, the more decision support is valuable to shape and implement rapid and effective responses that are well-informed about risks and potential benefits, and that prepare decision makers and constituents for the potential of unintended consequences.

While DSTs have been used to support natural resource management arena for decades, our understanding of ecosystem complexity and the data available to represent that complexity have grown rapidly. DST applications and innovations are experiencing a commensurate expansion, with each application both building on previous work and presenting a unique set of needs and challenges.

Overview of papers in this Research Topic

The nine papers in this Research Topic illustrate and provide examples of the primary facets of the arc of DST development and application in forest resource management. They reflect the ubiquitous and rapid environmental change on natural resources, and the growing challenge facing managers dealing with complex, dynamic and interdependent forest processes. They are a response to the need for effective and timely management intervention, and the high stakes of sustaining healthy and functioning forests into the future. The papers include exploration of specific decision support tools (Reynolds et al., Lämås et al., and Smallman et al.), development and application of environmental modeling packaged in a DST framework to reflect predicted climate impacts (Povak and Manley) and inform climate adaptation strategies (Povak et al. and Maxwell et al.), illustrate specific management applications tailored to inform and enhance the outcome of forest management (Furniss et al. and Scott et al.), and explore the current and future role of DSTs in meeting sustainability and resilience challenges (Manley et al.).

Reynolds et al. report on recent developments and provide an overview of the Ecosystem Management Decision Support (EMDS) system, which has been in development and use for nearly 30 years. It was developed by the U.S. Department of Agriculture to support forest management and policy across the 78 million hectares of National Forest System lands. It represents a national investment in a tool that can serve decision support needs across a broad array of spatial scales (project to national to global) and natural resource topic areas. Similarly, Lämås et al. report on Sweden's decision support system for forest management across multiple values—Heureka Forest. Initially released in 2009, the model now has over a decade of further development and a wide array of applications spanning over 50% of Sweden's forested landscapes. Smallman et al. explore analytical mechanisms for addressing the challenges of integrating information from a diverse array of sources into a single DST. They explore the detailed and complex considerations that go into building multi-function and multi-model decision support tools such as EMDS and Heureka Forest. They provide a compelling case for new data assimilation approaches (model-data fusion (MDF) specifically), as an effective mechanism for multi-sourced meta-analysis. They offer a case study of an MDF approach for carbon modeling—CARDAMOM—a Bayesian meta-analysis approach to estimate and inform national carbon balance and climate sensitivity across Brazil.

Climate impact and adaptation strategies are the focus of the next two papers in this decision support tool Research Topic. Povak and Manley demonstrate an application of reverse climate analog modeling to first derive a representation of the magnitude of climate change across California state, USA, and then to evaluate the potential impacts of mid-century climate across six ecosystem resource "pillars." Povak et al. then apply the interpretations of future conditions derived through climate analog modeling to generate climate-informed "management strategy scores" that can be directly integrated into decision support tools and optimization models. They demonstrate their application in an evaluation of how the location and type of management investments combined with climate affects carbon stocks by mid-century across a 1-million-hectare landscape in the Sierra Nevada mountains of California, USA.

Specific applications with real-life consequences are the ultimate test of the utility and value of DSTs. Furniss et al. built a DST that incorporated spatially explicit outputs from multiple, interacting process-based forest and hydrology models to inform climate-adapted management treatments within several watershed subbasins in eastern Washington State, USA. Their application accounted for 100 years of management and response, and served to identify not only near-term benefits, but also long-term costs, benefits, and trade-offs. Similarly, Scott et al. used multiple models to provide decision support for where and how to salvage dead and dying forests in a manner that minimized impacts to carbon stocks. Their paper provided an example of how to integrate economic and ecological models to evaluate trade-offs. Finally, Manley et al. explore the growth and expanding integration of DSTs into forest and landscape management applications and decision processes. They introduce and explore five primary factors that are fueling and shaping DST development and innovation. They make the argument that DSTs are becoming essential as complexity and uncertainty proliferate with changing climates and human population demands for ecosystem services. Future directions for DST development are virtually unbounded; they are expected to experience rapid innovation and growth, particularly as tools powered by artificial intelligence are incorporated into user-centric DSTs.

Author contributions

PM: Conceptualization, Writing – original draft, Writing – review & editing. NP: Conceptualization, Writing – original draft, Writing – review & editing. KR: Conceptualization, Writing – original draft, Writing – review & editing. PH: Conceptualization, Writing – review & editing.

Conflict of interest

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