Using Conceptual Models to Capture and Further Our Understanding of Socioecological Connections

El Uso de Modelos Conceptuales para Mejorar Nuestra Comprensión de las Conexiones Socioecológicos

Utilisation de Modèles Conceptuels pour Capturer et Approfondir Notre Compréhension des Connexions Socioécologique

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EXTENDED ABSTRACT

Conceptual models are simplified, visual representations that can be used to communicate our understanding of complex systems and processes. They provide an ideal platform to integrate and synthesize knowledge across different disciplines and roles. In ecosystem-based management (EBM), these roles may include scientists, policy-makers, industry, resource managers, and other stakeholders (e.g. recreational users, landowners, and non-governmental organizations). Conceptual models are also directly applicable to management and show the potential implications and trade-offs of management alternatives. Conceptual models have a rich 60+ year history of applications to ecology (Odum 1957) and to social sciences, including how society interacts with the environment (Sauer 1952).

There is scientific consensus that to optimize management of coastal and marine ecosystems, including marine protected areas, we must implement EBM. One of the fundamental tenets of EBM is that the ecosystem is a coupled socioecological system with humans as an integral component. Thus, to implement EBM we must understand how this socioecological system functions and accurately communicate our understanding of this complex system to resource managers, and stakeholders. One of the earliest examples of applying conceptual models to improve ecosystem management was the use of pressure-state-response models. These models were used as far back as 1993 to aid in the selection of socioecological indicators (Bowen and Riley 2003). This model framework was later modified to become the Driver-Pressure-State-Impact-Response (DPSIR) model that more fully depicted how human society affected ecosystems.

DPSIR has been applied broadly and has proven particularly successful at linking scientific findings with real world applications enhancing the scientific basis for resource management decision-making. As socioecological systems science has advanced in recent years, DPSIR has been critiqued in the literature for not explicitly depicting the benefits humans receive from the ecosystem, how the ecology affects human welfare, and how the ecosystem and its services affect human health and well-being (Elliott et al. 2017). The definition of impacts has been open to a broad interpretation ranging from impacts to ecology to impacts on human health and economy and many other items along this spectrum (Kelble et al. 2013).

This confusion and potential shortcoming with the impacts module in DPSIR, led to simultaneous proposals for modifying the DPSIR framework to more completely capture the socioecological system. One modification, named EBM-DPSER, suggested replacing impacts with ecosystem services and making them the primary focus of the framework, since they are a natural bridge between biophysical and human dimensions science (Kelble et al. 2013). The other proposed modification, named DPSWR, replaced impacts with welfare and made the focus of the framework changes in human welfare attributable to changes in state (Cooper et al. 2013). More recent proposed modifications to the DPSIR framework have tried to combine concepts into a unifying framework, such as the DAPSI(W)R(M) framework (Elliott et al. 2017). Other modifications have been developed to address specific management needs. One example was a framework to be used in disaster planning and response, named DPSERH, that captured our understanding of how disasters lead to disruptions in the delivery of ecosystem services that then impact human health and well-being (Sandifer et al. 2017). There is now a plethora of conceptual modeling frameworks that can be applied to capture the complete socioecological system for EBM.

These conceptual models can and should be applied at every step of the EBM policymaking process (Cormier et al. 2017, Harvey et al. 2017). In fact, developing conceptual models to build consensus about what the ecosystem is and how it functions helps to engage stakeholders, managers, scientists, and other interested parties. Conceptual models help synthesize and integrate knowledge from disparate sources, and set the stage for the EBM policymaking process. It is easier to determine goals, objectives, and management measures, if all participants have a shared vision of what the ecosystem is and how it functions. For example, the Marine and Estuarine goal-setting for south Florida project began by having participants draw their depiction of the ecosystem on a whiteboard and developed EBM-DPSER conceptual models before moving onto indicators and goals (Fletcher et al. 2014).

After developing a conceptual model, the next step in EBM policymaking is to set strategic goals and tactical objectives. To determine goals and objectives and assess our progress toward them requires the use of ecosystem indicators with quantitative targets. Conceptual models have a long history of being applied to select indicators that capture the focal components of socioecological ecosystems (Bowen and Riley 2003). In fact, EBM-DPSER has been applied to develop consistent, comparable, hierarchical indices for both human dimensions and biophysical aspects of the south Florida marine and coastal socioecological ecosystem (Loomis et al. 2014).

Understanding, quantifying, and communicating risk in the ecosystem is an essential step in EBM. Recent advances applying qualitative, semi-quantitative, and network mathematical methodologies to conceptual models have opened up new possibilities and applications for conceptual models. Soceioecological conceptual models depict cause and effect relationships between ecological and social components of the ecosystem. This often connects two ecosystem components with different units, e.g. economic value and nutrient cycling rates. The lack of consistent units makes the application of traditional mechanistic mathematical methods difficult. However, the application of mathematical techniques that can track dimensionless flows and more qualitative techniques allow us to parameterize these connections and use conceptual models as mathematical constructs (Harvey et al. 2016). In the Florida Keys and Florida Bay, network methods were applied to an EBM-DPSER conceptual model to examine the risk posed to ecosystem services from the variety of pressures acting upon the system (Cook et al. 2014). Knowing the relative impact of each pressure upon the delivery of ecosystem services allows resource managers to target management actions at the pressures with the greatest likelihood of negatively impacting the delivery of ecosystem services. This risk analysis can also feed directly into the setting of tactical objectives.

The last step in the EBM policymaking process is setting of management measures. Before implementing management measures, it is best to virtually test proposed management actions and evaluate their relative impacts on the socioecological system (Harvey et al. 2017). This can be done by applying qualitative network models to a conceptual model where connections are scored as positive or negative and assigned a degree of confidence in this scoring (Harvey et al. 2016). Fuzzy-logic cognitive mapping has also been used to capture a diversity of stakeholders' opinions and can evaluate the outcomes of management measures against different conceptual model networks parameterized with the different stakeholders' opinions expressed as the strength of connection between the various conceptual model components (Gray et al. 2012).

Effective and successful EBM relies upon the input and involvement of multiple stakeholders, managers, and scientists. These groups should feel as though their input is being listened to and utilized to produce the best possible EBM policy. Conceptual models provide a clear, transparent method to synthesize and integrate these diverse viewpoints and build consensus. New methodologies integrating mathematical methodologies with conceptual models enable them to provide more quantitative products and analyses and to evaluate the socioecological outcomes of proposed management actions. Conceptual models are not the only tool necessary to develop integrated EBM policies, but they are an important and necessary one.

KEYWORDS: Ecosystem based management, conceptual models, socioecological ecosystem

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