Regional spatial framework to support coupled human-natural systems for decision-making

Dr. Kelly Dunning, Dr. Lizhu Wang, Dr. Timothy Davis, Dr. Kurt Kowalski, Jeff Tyson, Emily Joyce, Angelica Moncada

Coastal stakeholders face hazards that range from discrete events such as Hurricane Harvey to more long-term processes like nutrient or pollution influx that can lead to recurrent biological coastal hazards such as harmful algal blooms. Understanding the ecological, economic and societal impacts of either of these types of hazards individually is difficult and the interaction between discrete and reoccurring hazards has not been well studied. Furthermore, coastal regions also face challenges in landscape degradation that often present tremendous opportunities for restoration. These are a few examples of catalysts that change social, ecological, and economic systems ("socio-ecological systems"). Currently, the coupled human and natural systems that constitute socio-ecological systems are poorly understood, and where empirical research does exist, there are often gaps translating research into policy. People routinely make decisions about actions in the coastal zone, but they don't have the tools necessary to understand socio-ecological systems fully and make optimal decisions for coastal zone management. Therefore, we propose a spatial framework of socio-ecological systems models ranging from the regional to the local scale. The framework and associated database would have a gridded interface where users are aware of different resolutions or availability of data for a given area based on the gridded interface. One of the many uses of the framework is to develop models that simulate socio-ecological systems interactions to inform policy-making across scales.

The development of such models and decision tools must be driven by stakeholder-identified priorities, including real-world scenario planning. A stakeholder need could be, for example, a comprehensive planning process for a coastal community or a stormwater management system in a coastal county. Scenarios that help address this need could test how low, medium, or high levels of wetland clearing for development influence policy options. The models and tools would use these scenarios to characterize changes to ecosystem services that would result from that given management action. For example, a loss in wetlands in a coastal community may result in an increase in real estate development, but a decrease in the value of coastal erosion and flooding protection services provided by wetlands. This geospatial framework would allow planners or decision-makers to assess the gains and the losses side by side, despite the high amount of data and complexity typically required to make such decisions.

The spatial framework and models and tools develop from it would only be as good as the input data. Specific inputs to these types of models could include geospatial data (e.g., wetland extent and type in a given area), socio-economic data (e.g., housing development patterns and values across a given landscape), traditional ecological knowledge (e.g., tribal traditional uses and knowledge of the natural resources), and ecological data (e.g., carbon sequestration ability in a given area of wetlands). Inputs could also be discrete policy or planning scenarios relevant to the decision-making needs of the user (e.g., identifying areas that are most conducive to wetland restoration). Outputs could include changes to direct values (real estate values after development) and indirect values (changes to erosion protection value of wetlands) in a total economic value of a given policy change. This would allow coastal decision-makers to use a range of policy options, and a range of systems data across social and ecological lines, to inform decisions and reduce the uncertainty of what outcomes could result from policy or management choices. Tradeoff analysis could then help reduce uncertainty of outcomes associated with meeting stakeholder needs.

The value of a framework like this would be three fold. First, geospatial models created under this framework act as decision support tools for real world policy and resource management questions and would allow for exploration of exploration of cumulative impacts of actions at regional scales. Second, there are many ecosystem service valuation models and methods out there, but this one could specifically analyze interactions between discrete disturbances (e.g., hurricanes) and long-term drivers of change (e.g., non-point source pollution or climate change). Third, the HUB framework described in the NSF workshop would allow NSF to serve as a literal data hub for data, models, and code all kept in one place and be linked to specific location for applications in different regions.

The idea for this framework was created with an eye cast toward foundational work in the field on similar frameworks such as the Millennium Ecosystem Assessment and the European Union’s The Economics of Ecosystems and Biodiversity project and the Great Lakes Aquatic Habitat Framework. The proposed framework for modeling and other uses is not reinventing the wheel but is filling the gaps for coastal decision-makers by moving this type of work from the theoretical to the world of data-driven policy-making.