PANEL DISCUSSION; U.S EPA USING MODELING AND ECOSYSTEM SERVICES TO ENHANCE COASTAL DECISION MAKING

Panelists: Deborah Mangis[1], Marc Russell[1], Betsy Smith[1], Lisa Wainger[2]

1. Environmental Protection Agency Office of Research and Development
2. University of Maryland Center for Environmental Science

Abstract: This panel will discuss the research being conducted, and the models being used in three current coastal EPA studies being conducted on ecosystem services in Tampa Bay, the Chesapeake Bay and the Coastal Carolinas. These studies are intended to provide a broader and more comprehensive approach to policy and decision-making affecting coastal ecosystems as well as provide an account of valued services that have heretofore been largely unrecognized. Interim research products, including updated and integrated spatial data, models and model frameworks, and interactive decision support systems will be demonstrated to engage potential users and to elicit feedback. It is anticipated that the near-term impact of the projects will be to increase the awareness by coastal communities and coastal managers of the implications of their actions and to foster partnerships for ecosystem services research and applications.

Introduction: Today there are increased threats to coastal ecosystems, and more land managers are starting to use ecosystem based management (e.g. NOAA and FWS) to manage their coastal resources. The U.S. Environmental Protection Agency Office of Research and Development (ORD) has focused its ecological research on ecosystem services in the Ecosystem Services Research Program (ESRP): The goal of the ESRP is to transform the way we understand and respond to environmental issues by making clear the ways in which our choices affect the type, quality and magnitude of the services we receive from ecosystems – such as clean air, clean water, productive soils and generation of food and fiber.

Most current coastal decisions that target specific endpoints or indicators rely on regulatory or planning mechanisms for implementation. Ecosystem service endpoints are subtly different from, but complementary to, measurements and metrics currently used by environmental regulatory agencies and natural resource managers. Ecosystem services provide the bridge from biophysical measures, which are fairly esoteric to the lay public, to units of measure that the public can relate to and perceive value in. Ecosystem services thus serve as a valuable mechanism for relaying the benefits of proposed regulatory mandates to the general public they seek to protect. They are also complementary to regulation in that they provide the needed information to bring social and economic mechanisms to bear on the problem.

During the presentations of ESRP projects in three coastal areas Chesapeake Bay, Coastal Carolinas and Tampa Bay we will discuss our use of models and modeling, including:

- Conceptual models for each program and their importance in framing the issues, bringing the right set of collaborators/stakeholders to the table, and establishing credibility for the science,
- Simulation models for forecasting future scenarios, combining processes of differing scales, and representing ecosystem service response functions and economic values, and
- Decision Support models/tools for decision makers and interested parties to evaluate the trade offs between alternative scenarios.

Chesapeake Bay Pilot Project - Repurposing nutrient credit trading to meet multiple environmental goals: Solving one environmental problem at a time can be costly compared to policies that address multiple problems simultaneously. The Chesapeake Bay pilot project aims to address the question: Can policies aimed at meeting water quality goals (e.g., credit trading markets) be modified to deliver additional ecosystem services with little or no reduction in water quality goals? We will explore the cost-effectiveness and legal/social feasibility of alternative policies and institutional arrangements that could allow markets or market-like mechanisms to promote creation or restoration of ecosystem services related to habitat, outdoor recreation, climate regulation and aesthetics, while simultaneously meeting water quality goals.

To inform our analysis, we are developing a spreadsheet-based modeling framework that merges empirical relationships, simulation model output, and conceptual models to test alternative policy scenarios. A set of supply curves has been created to model the expected supply of nutrient credits as a function of price for both point and non-point sources. The supply curves for point sources can also be used to model demand for nutrient credits among point sources or between point source and non-point source credit suppliers.

Spatially heterogeneous data is used to enhance the supply curves for non-point source nutrient practices (agricultural best management, stormwater management, stream and wetland restoration) and to develop ecosystem service production functions. Spatial (GIS) analysis is used to constrain the available supply of land for practice adoption within sub-watersheds and Chesapeake Bay model output by watershed segment is used to model nutrient credit production using basin delivery and in-stream attenuation characteristics. Ecosystem service production functions are being developed from empirical data, when available, or from conceptual models developed from ecological principles and best professional judgment.

The integrated model is intended to be a scenario analysis tool available to decision makers to evaluate potential effects of incentives and regulatory policies on total program costs and effectiveness in terms of nutrient loadings

reduced and ecosystem services generated. We are developing scenarios in concert with various federal agencies tasked with evaluating policy for water quality trading and ecosystem services (EPA's water quality trading group, USDA's ecosystem services program, and several NGOs). In addition, innovative institutions will be evaluated for their ability to suggest alternative means of achieving similar results.

Tampa Bay Outreach and Education Tools for Managers: The EPA's Tampa Bay Ecosystem Services Demonstration Project is focused on providing local to regional scale decision makers with information on ecosystem services produced in their areas of interest so that they can consider potential changes in benefits derived from them due to proposed management decisions. The overarching goal for this pilot project is to have decision makers consider ecosystem service trade-offs in their decision making process.

There are three major phases to our research and development: 1) mapped inventories of current production of services using existing data 2) knowledge gap analysis and research to fill those gaps prioritized by stakeholder needs, economic value, and quantity of scientific knowledge on the ecological functions generating ecosystem services, and 3) predictive models of ecosystem service production, delivery, and consumption developed and integrated into web-based decision support tools for use by stakeholders.

Mapped inventories of the production of ecosystem functions related to ecosystem services have been produced for the baseline year of 2006. Many knowledge gaps still exist but we have mapped layers illustrating the spatial distribution of ecological functions such as carbon storage in biomass and soils in terrestrial and wetland forested areas, atmospheric pollutant removal rates from forests, nitrogen removal by forests, wetlands, and open water systems, biodiversity and habitat suitability indices, soil water retention capability, abundance of fish valued for recreational fishing, habitat suitability for pollinator nest sites, and others. These functions either directly or indirectly affect the production of ecosystem services. These ecosystem services include a stabilized climate, useable water, useable air, food and fiber provisioning, recreational opportunities, etc.

Our research prioritization efforts guided us to pursue research focused on ecological processes, such as nitrogen removal, carbon sequestration and storage, and habitat transitions associated with wetlands under various types of watershed influence and under changing water levels. We are also involved in refining estimates of urban forest functions such as atmospheric pollutant removal. These research efforts are feeding system dynamic models that will be able to predict ecological functions under various future land development and climate change scenarios so that ecosystem services can be quantified in space and time and delivered in a useable format for decision makers at spatial multiple scales.

Coastal Carolinas: The Albemarle-Pamlico estuary is the second largest estuary in the United States, and is home to most of the Southeast Atlantic fishes during some part of their life cycle The estuary is also part of the National Estuary Program and has been named an EPA climate ready estuary. The principal goal of the Albemarle Pamlico Watershed Study (APWS) is to provide the information and tools needed to understand how the choices for reactive nitrogen (Nr) management (particularly in areas away from the coast) influence the nature and quantity of ecosystem services received from estuaries and coastal wetlands. Estuarine and coastal wetland ecosystem services require protection because they have potential benefits far beyond the communities surrounding estuaries. Protection of estuarine and coastal wetland ecosystem services, and more generally, consideration of how environmental management decisions influence their delivery, requires an understanding of how watershed-wide environmental management decisions affect the production of those estuarine and coastal wetland ecosystem services. As the down-stream recipients of chemical contaminants and other stressors, estuaries are affected not only by local inputs, but also by decisions made throughout the entire watershed. While there is agreement that up-watershed policies affect estuarine and coastal wetland ecosystem services, the linkages between them are poorly understood.

The APWS will evaluate the impacts of land and demographic changes as well as climate change and sea level rise on reactive nitrogen and ecosystem services. The APWS has already linked process based air quality models with water quality models, with habitat and fishery models in a framework. We are partnering with the NOAA severe storms lab to integrate our linked water quality models with their improved flooding models. We are also partnering with the National Climate Ready Albemarle-Pamlico National Estuary program to improve our outputs by recognizing their indicators of concern. We are using the DPSR- Drivers, Pressures, States, Response model as a conceptual model for the APWS. We will be developing two decision support tools: a Bayesian model for the Neuse River Basin for alternative development scenarios; and an environmental decision tool based on the Regional vulnerability Assessment Program (ReVA) environmental decision toolkit .

Changing the paradigm from reactive decision-making to proactive: the ReVA example: Effectively sustaining the health of ecological systems and the benefits that society receives from them requires a technology that illustrates opportunity costs and other trade-offs associated with alternative environmental policies. Achieving this goal requires integration of socioeconomic forecasting models with existing information about ecosystem function and health, along with a better understanding of the effects of multiple stresses occurring at multiple scales on the delivery of ecosystem goods and services. After 25 years of research on the effects of individual stressors on ecological processes, along with the recent development of landscape assessment technologies, we are now

poised to develop techniques for assessing future ecosystem vulnerability and transfer these techniques to the environmental decision-maker.

Understanding how people are harmed when local ecosystems are degraded is becoming critical to environmental decision-making. Many changes are, for all practical purposes, *irreversible* and if the risks from allowing degradation to progress unchecked are not effectively evaluated, the opportunity to cost-effectively preserve ecosystems goods and services for future generations may be lost. Thus, the need to develop methods to anticipate where current decisions will threaten future provision of ecosystem benefits is clear.

EPA's Regional Vulnerability Assessment (ReVA) program has been conducting research on innovative approaches for evaluating and interpreting large and complex datasets and uses models to assess the current conditions and likely outcomes of environmental decisions, including alternative futures for over a decade. While not extending fully into impacts to ecosystem services in the past, ReVA has always taken a comprehensive approach to assessment, considering multiple stresses and multiple resources simultaneously, and additionally including data and models reflective of changes in human health vulnerabilities and economic viability.

As a result of ReVA's research we have developed a web-based Environmental Decision Toolkit (EDT) that allows users to array available data and model results in a variety of ways to address a suite of assessment questions, and then to view the results of the analyses from a number of decision-making perspectives. Initially designed as a research tool to help compare results of different integration methods, the EDT has evolved significantly over the years to become more user-friendly and customizable with features that allow users to create their own indices, select reference watersheds and compare relative values for these indices over regions, states, and other sub-regional assessment areas. Other features include a menu-driven assessment guide and a mash-up between the original SPlus statistical engine and ESRI's ArcServer to allow access to various levels of detail (broad-scale to fine-scale). New assessment capabilities underway in support of the EPA's Ecosystem Services Research Program (ESRP) will enable us to examine trade-offs among ecosystem services. The EDT will be the framework for decision support in two of the ESRP's place-based studies: the Future Midwestern Landscapes and Coastal Carolinas.

Author Contact information
Deborah Mangis
U.S. Environmental Protection Agency
MD-D301
Research Triangle Park, NC 27711 United States
Ph (919) 541-3086
Fax (919) 541-0715

Mangis.deborah@epa.gov