Marine InVEST

natural capital PROJECT

A DECISION-MAKING TOOL FOR MAPPING AND VALUING ECOSYSTEM SERVICES PROVIDED BY COASTS AND OCEANS

Coastal and ocean environments provide a number of important benefits and services to people. Unfortunately, a growing variety and intensity of human activities (e.g., energy production, fishing, coastal development, transportation) threaten the sustained delivery of these ecosystem services. Despite their importance, the ecosystem processes that people rely on for food, recreation, coastal protection, and other services, are poorly understood, scarcely monitored, and often only appreciated after they are lost.

The Marine Initiative of the Natural Capital Project is dedicated to using the framework of ecosystem services to inform ecosystem-based management of marine and coastal waters. With funding from the Gordon and Betty Moore Foundation, we are developing and applying a suite of ecosystem service models called InVEST (Integrated Valuation of Ecosystem Services and Trade-offs).

Marine InVEST is highly flexible to accommodate application across multiple scales in coastal and marine regions with diverse habitats, policy questions, and stakeholders. Our approach identifies where ecosystem services are provided and where they are consumed. It reveals how resource management decisions will affect multiple aspects of the economy, human well-being and the environment. Marine InVEST can help answer questions such as:

Mapping and modeling ecosystem services—their flows and changes under alternative management scenarios—can elucidate the true costs and benefits of natural resource management options, and can lead to improved decision-making and outcomes for both people and the ecosystems on which we depend.

- What kinds of coastal management and fishery policies will give us the best returns for sustainable fisheries, shoreline protection and recreation?

- Are revenues from activities such as recreational fishing or scuba diving likely to rise or fall under an integrated coastal zone management plan?

- How does marine spatial planning help to ensure that current and future generations benefit from the value of coral reefs for providing food, potential for economic prosperity, and biological diversity?

The aim of the Natural Capital Project is to align economic forces with conservation. Our focus is on ecosystems, earth's living natural capital. If properly managed, natural capital yields a flow of vital "ecosystem services," including the production of goods (e.g., food), life-support processes (e.g., water purification), and life-fulfilling conditions (e.g., beauty, opportunity for recreation), as well as the conservation of options for the future (e.g., genetic diversity to cope with environmental changes).
The Natural Capital Project is a joint venture among Stanford University, The University of Minnesota, The Nature Conservancy, and the World Wildlife Fund.

The Nature Conservancy — Protecting nature. Preserving life.

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A Scenario Assessment Tool

Our process begins by identifying critical management choices being considered by decision makers or other stakeholders. From these, we develop alternative scenarios that either show present delivery of services or how they look in the future under different policies or a changing climate. Marine InVEST is used to model how these alternative futures influence ecosystem structure and function, and how such changes affect the flows and values of ecosystem services and biodiversity. Model outputs are maps, balance sheets and tables.

The Models

Marine InVEST incorporates ecosystem services and valuation approaches into planning. Our models show how various sectors—from aquaculture to energy—are affected by how humans choose to interact with the marine environment. Marine InVEST also provides biodiversity outputs to look at trade-offs and synergies between ecosystem services and other conservation objectives.

Our models are based on production functions that define how an ecosystem's structure and function affect the flows and values of ecosystem services. Previous focus on the patterns of service supply (e.g., living habitats as buffers for storm waves) did not account for the potential uses, or demand, of the service. For example, are there people and infrastructure that would be affected by coastal storms?

Marine InVEST meets this need by providing:

- biophysical outputs (e.g., reduction in height of storm waves by living habitats)

- ecosystem service outputs (e.g., reduction in flooding of property)

- economic or social outputs (e.g., avoided costs from flooding, number of people affected)

Marine InVEST is spatially explicit to account for differences in the delivery of and demand for services across land- and seascapes. Since data are often scarce, we initially offer relatively simple models with few input requirements. These models are best suited for identifying patterns in the provision and value of ecosystem services and to inform marine spatial planning. We are developing more complex, data intensive models that may be more appropriate for informing payment for ecosystem services or other programs that require more certainty and specificity in results.

Our Approach
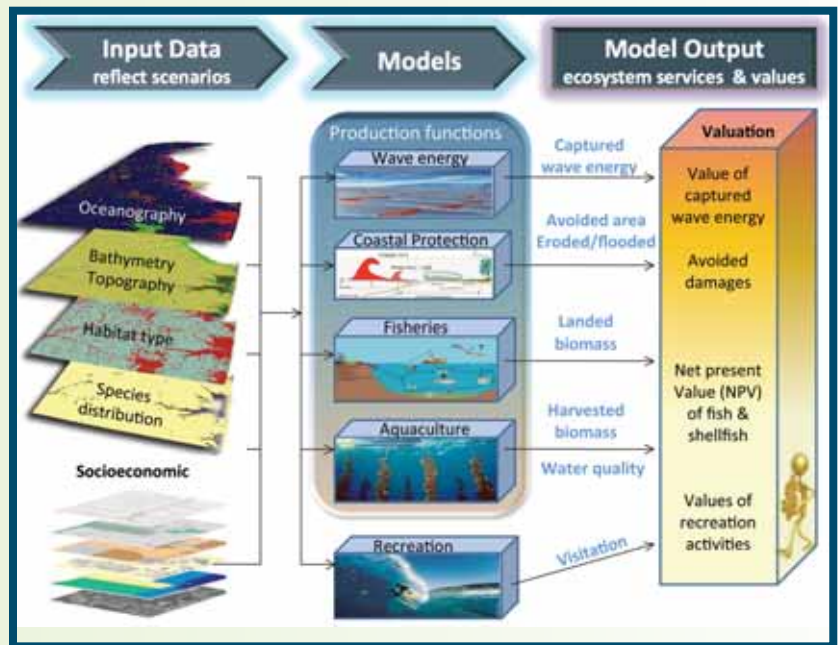
Models for different services are linked through input data layers that reflect scenarios about management actions (e.g., restoration of eelgrass, increase in aquaculture) and climate change (e.g., sea-level rise, water temperature).

Marine InVEST in Practice

Marine InVEST can inform a variety of policy, management and conservation approaches.

Ecosystem-based management (EBM) and Coastal and Marine Spatial Planning (CMSP) are integrated approaches to management that aim to achieve specific ecological, social and economic objectives. Marine InVEST can inform EBM, CMSP, and associated adaptive management and **marine conservation agreements**, by assessing the current and potential status of ecosystem services under alternative, spatially-explicit future scenarios.

Markets and payments for ecosystem services (PES) are contractual and voluntary transactions for the delivery of an ecosystem service, or implementation of management practices likely to secure that service (e.g., **fisheries catch share programs**). Marine InVEST can support the design and implementation of PES programs by identifying how payments can meet multiple goals, where to distribute payments or establish new programs, and how to improve efficiency of investments.

Ecosystem-based climate adaptation aims to preserve and restore natural ecosystems so they can provide cost-effective protection against adverse effects of climate change and continue to provide a full-suite of ecosystem services. Marine InVEST can inform adaptation strategies by showing how future changes in ecosystem structure and function will influence the delivery of services needed to maintain human well-being under future climate conditions.

Ecosystem Services We Map and Value

FOOD FROM FISHERIES

Fisheries provide an important source of food and basis for livelihoods, but in some cases overharvesting and loss of supporting habitats threaten fisheries' sustainability. Our models determine how changes in fishing practices and habitat abundance affect amount of landed biomass and its value. We provide both simple models for key species and methods for wrapping around more complex models in areas where they exist. Our next step is to develop approaches to valuing the contribution of nursery habitats to landed biomass.

Outputs: landed biomass and net present value of fish and shellfish, distribution of landings and value to communities

FOOD FROM AQUACULTURE

Aquaculture is an increasingly important source of food for humans, yet its activities can have detrimental effects on marine environments. Our models show how the location, size and density of aquaculture farms influence the production and value of finfish and shellfish (e.g., salmon, shrimp, oysters), which is a function of farm configuration, water flow and other environmental conditions. We also are developing methods to quantify export of wastes from aquaculture farms and the filtration capacity of suspension-feeding shellfish.

Outputs: harvested biomass and net present value of fish and shellfish, distribution of biomass and value to communities

Philip Chou/SeaWeb/Marine Photobank

COASTAL PROTECTION

Marshes, mangroves, corals and other living habitats can buffer coastlines from storm-induced erosion and inundation. They also can help to regulate natural processes of erosion and sedimentation that are critical to maintaining beaches. Our models predict how the extent and density of living habitat, as well as dunes and other coastline features, influence the area of land eroded or flooded, and alter longer-term patterns of beach formation. The models can help us understand where it is critical to preserve and restore habitats for coastal protection.

Outputs: avoided area of land eroded or flooded, avoided beach nourishment and costs, avoided damages to property and infrastructure, number of people affected by erosion or flooding

Jason Valdez/Marine Photobank

CARBON STORAGE AND SEQUESTRATION

Marine ecosystems help regulate Earth's climate by adding and removing greenhouse gasses (GHG's) such as carbon dioxide from the atmosphere. Coastal marine plants such as mangroves and seagrasses store large amounts of carbon in their standing stocks. They also bury carbon in their sediments, creating large reservoirs of long-term carbon sequestration. Our models estimate how much carbon is stored in coastal vegetation, how much carbon is sequestered in the sediments, and the social value of carbon storage and sequestration.

Outputs: carbon storage, carbon sequestration, economic value of storage and sequestration

Katie Arkema

RECREATION AND TOURISM

Marine and coastal recreation and tourism activities generate significant economic value. This value depends on the quality and availability of marine resources over time, as well as the geographic location of activities. Our models will provide users with the ability to assess how economic values or user groups associated with different recreational activities change as the quality and quantity of marine resources is altered through different management scenarios.

Outputs: economic value of recreational activities, visitation rates, community access to activities
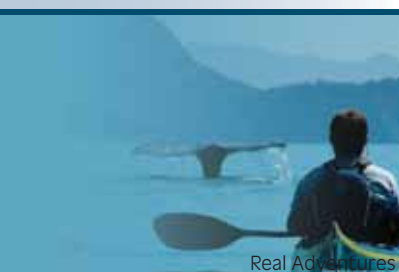
Real Adventures

Marine InVEST to inform National Integrated Coastal Zone Management Plan for Belize

The coast of Belize is a complex and dynamic marine ecosystem that supports innumerable ecological processes and includes diverse marine life and habitats such as a vast array of reef fish, mangrove forests, estuaries, and atolls. Belize's coastline is also home to the outstanding Belize Barrier Reef Reserve System-World Heritage Site, the longest barrier reef in the western hemisphere. The reef ecosystem is important to Belize for its biologial and culural significance, as well as its function as a valuable center for tourism, research, and fisheries. Over the years, rapid economic development and population growth have taken place in the coastal zone and inland areas of Belize. In 1999, over BZ $300 million were generated from commercial and development activities within the coastal zone. While the Belizean economy has benefited from coastal development, the health and integrity of its coastal and marine areas have been severely compromised by human activities including mangrove clearance, overfishing, and pollution.

We are partnering with the Coastal Zone Management Authority and Institute (CZMAI) to use Marine InVEST to inform the development of a comprehensive National Integrated Coastal Zone Management (ICZM) Plan for Belize. CZMAI was established in 1998 as the designated body for coordinating the sustainable use and management of resources within Belize's coastal zone. The goals of the ICZM plan are to put an end to ad hoc development, to protect the integrity of marine ecosystems and biodiversity, and to guide the sustainable use and management of the coast for the long-term benefit of Belizeans. Marine InVEST will provide the best available science, methodology, and valuation of ecosystem services for the preparation of the Plan. Our goal is to advance the planning process beyond sector-specific issues and to provide a platform for stakeholder and government discussions about trade-offs. Our models for fisheries, tourism and recreation, coastal protection, aquaculture, and carbon storage and sequestration are all highly relevant to coastal zone planning and management issues in Belize.
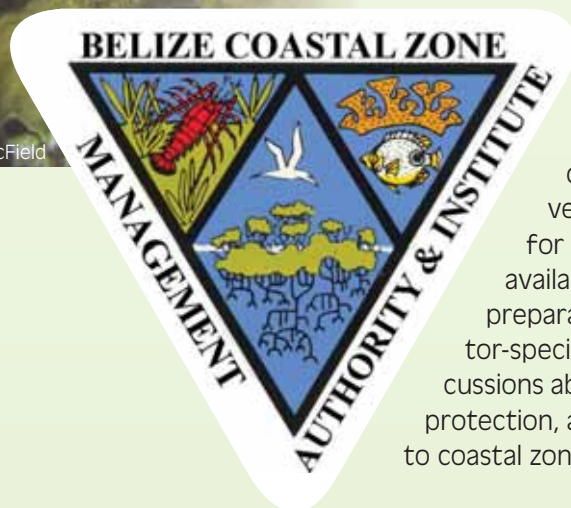
Melanie McField

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