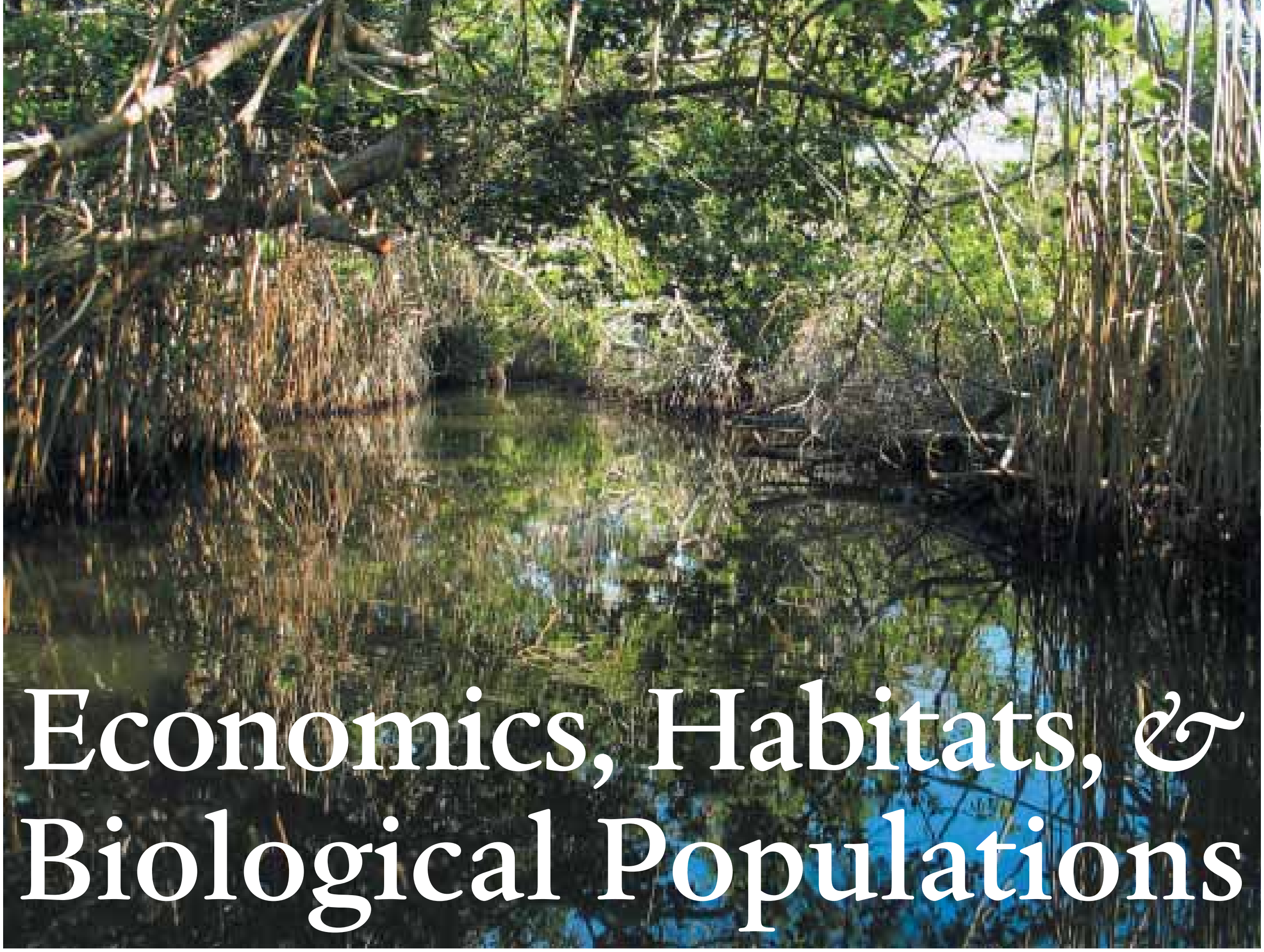

Economics, Habitats, & Biological Populations

FINDING THE RIGHT VALUE

By James N. Sanchirico and Peter Mumby

Imagine a coastal planner confronted with the following decision: whether to allow a tourism development project to go forward and, if so, where and how large an area of the coastal environment to convert? According to Economics 101, the planner would set out to determine the benefits to the local economy from the tourism development and the costs of converting the open space on the coast, where the benefits and costs would depend on the location and scale of the development project. If the total benefits were greater than the total costs, the decision would be to move ahead with the project.

While not necessarily straightforward, the benefits from the tourism project, such as new jobs and increased tax revenue, are easier to quantify and more defensible than the costs of converting the natural environment, which would entail the lost ecosystem functions and services and non-use values. So what should the planner do? Everyone would agree that placing a value of zero on the coastal environment would not be a satisfactory approach. But what is the appropriate value of a beach, forest, coral reef, sea grass bed, or wetland? And what tools can the planner use to determine the value of the habitat? One method is bioeconomic analysis, which traditionally combined population biology and economic modeling but more recently also includes geophysical processes and ecological functions.

Bioeconomic analysis is an appropriate tool in environmental and resource economics for a couple of reasons. First, it requires one to specify how a fish, bird, or animal population changes over time by incorporating the life-cycle characteristics—such as the speed at which a population grows—

of the species under consideration. Second, the costs and benefits either from harvesting the species or from nonconsumptive uses or both can be explicitly accounted for. Putting these parts together in one framework permits an analyst to understand the full economic and ecological trade-offs involved in managing animal populations. For example, sustaining larger populations comes at the cost of lower levels of extraction; bioeconomic analysis can help shed light on what the benefits and costs are for different population sizes, given the goals of the resource manager and society more generally.

Coastal mangroves above water.

Valuing Mangrove Habitat

To set the coastal planner's problems in a more specific context, we can use the example of coastal mangroves to show what bioeconomic analysis can contribute. Coastal mangroves are intertidal forests located throughout tropical regions around the world (see photographs). Current estimates are that between 35 and 50 percent of mangroves worldwide have already been lost, with current deforestation rates greater than those of tropical rainforests. The primary threats to these systems are coastal development and conversion to shrimp aquaculture. One reason why mangroves are threatened is that the economic value of the harvestable products, like wood, and the "services" they provide, including hurricane and tsunami protection, have not been properly determined and considered in the clearing decision.

Here, we will focus on just one function, the role of mangroves in the "production" of coral reef fish species. Some exciting new scientific studies have shown that coral reefs in close proximity to mangrove habitats exhibit larger abundances of some species and greater biodiversity. Species that show this benefit, such as snapper and parrotfish, apparently hide in the root structure of the mangroves during their juvenile stage to avoid predators. This refuge allows them to grow to a size such that when they migrate to the coral reef in their adult stage they can escape predators on the reefs.

How can we capture the production value of the mangrove habitat to help inform the coastal planner of what the costs of conversion are? From an economist's perspective, the mangroves are similar to the machines and other inputs that produce economic outputs (here the coral reef fish). Unlike labor, where there is a market to determine the going wage rate, no market exists for this ecosystem function. We can, however, calculate the value of the mangroves by incorporating their role in species population dynamics. That is, we can use bioeconomic analysis to investigate the difference in the value of a fishery with and without the mangroves present.

Our findings show that for any number of fishing boats and fishermen, the profits from fishing are greater with the mangroves present than without them. This benefit results from the greater abundance of fish that are protected from predators by the refuge in nearby mangroves. Another interesting implication of having coastal mangroves in the vicinity of the coral reefs is that the fishery can support greater levels of fishing effort than without the mangroves. We can measure the value of the mangrove or "mangrove effect" by simply calculating the difference between fishing profits with and without mangroves present.

The size of the mangrove effect depends in some complicated ways on ecology, economics, and governance—how the fishery is managed. On the ecological side, what matters is how the species utilize different habitats in their life cycle and where the fish are subject to the greatest levels of pre-

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Coastal mangroves below water.

dation. On the economic side, the size of the mangrove effect depends on the price of the fish and the costs of fishing. For example, the higher the price or lower the fishing costs, the greater the value, holding all else the same. In terms of governance, the potential value depends on how many fishing vessels are permitted to fish and the nature of their rights to the total catch. If local fishery managers do not implement rights-based tools, such as a harvesting cooperative or individual fishing quota system, then there might not be any value to the fishery from the mangroves. The important role of governance and institutions in determining the value of ecosystem services is a point often lost in discussions on the provision of these services.

Balancing Costs and Benefits

Let's return to our coastal planner. How might he or she use this information? In addition to the costs of converting the mangroves in terms of lost storm protection, lost non-use values, etc., we can add in the costs resulting from the reduced profits from fishing the species that depend on them. In other words, the larger the development project (in terms of the number of hectares of mangroves converted), the greater the opportunity costs of converting the mangroves. Together these are the economic costs of the development project.

On the other hand, there are benefits to the development project. Balancing the costs and benefits, we can determine the efficient size and location of the project. We find that when the coastal planner ignores the value of the mangroves to the fishery, the size of the development project is larger and possibly in the wrong location. It could also be the case that the opportunity cost of clearing the first hectare of the mangrove is so high in this particular location that no development project of any size is initiated.

Again, the size of the project that just balances the benefits and costs with and without considering the mangroves will depend, in part, on the same factors that lead to greater fishing profits. That is, it depends in non-trivial ways on the economics, ecology, and governance.

As a tool for helping policymakers and regulators understand the value of ecological functions and the value of the services provided by habitats, such as wetlands, forests, coral reefs, mangroves, and by biological populations, bioeconomic analysis is well developed and perfectly suited for such demands. Modeling tools by their very nature, however, are part science and part art. Therefore, we recommend using such analysis as a means to inform the policy process, not as a blunt metric yielding a "yes or no" answer.

Currently, academia, government, and NGO communities are discussing the need for interdisciplinary approaches to help address some of the more difficult conservation decisions we are facing in the 21st century, including valuing ecosystem functions and services and setting up private and public payment systems for these services. Since its origins in the late 19th century and its blossoming in the middle of the 20th century, bioeconomic analysis has been and will continue to be an important tool for determining the value to society of biological populations and habitats—and one that is interdisciplinary at its core. ■