

AN ECOLOGICAL ECONOMIC APPROACH FOR ANALYZING THE COSTS AND BENEFITS OF RIPARIAN RESTORATION PROJECTS

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Ecology is the study of the structure and function of nature, it being understood that mankind is a part of nature.

Eugene P. Odum, 1959

Human societies and ecological systems have been coevolving since the first woman at Makor discovered, about 10,000 years ago, that she could grow wild wheat, not where she found it, but where she wanted it to be. Socioeconomic and ecological systems are inextricably linked by a web of interconnected processes. The biophysical ecosystem places basic constraints on the growth and continuance of societies and human activities. The socioeconomic system, in turn, actively modifies and influences the physical and biological systems. All too often in human history, our prosperity has come at the expense of the ecological systems that sustain us.

Riparian ecosystems are important for both ecological and economic reasons. These systems provide a variety of ecological functions upon which human socioeconomic systems depend for their continued existence and well being. Many human activities both rely on and impact riparian ecosystems.

Throughout the Southwest, thousands of miles of once free-flowing rivers and streams have been altered, degraded, or lost due to construction of dams, reservoirs, impoundments, and diversions for hydroelectric power, irrigated agriculture, and municipal use. Other human activities having significant impacts on these systems include livestock grazing, recreational use, and the introduction of nonnative species. The Verde River, in west-central Arizona, has been affected by all of these human activities.

The legacy of human activities on the Verde River now threatens the system's productivity, functionality, resilience, and long-term persistence. These problems are not amenable to solutions based on narrow, intradisciplinary knowledge, or

to assumptions of constancy or stability of fundamental relationships (Holling 1994). Because the biophysical and socioeconomic systems are interlocked, solutions to the loss of crucial ecological functions and services require an approach that addresses the mutualistic nature of these relationships. The restoration and sustainability of the Verde River ecosystem is not an ecological or economic problem—it is an integrated combination of both.

Conflict and litigation over water use, development, and environmental protection has a longstanding history throughout the Southwest, and the Verde River is no exception. As a result, the Verde River has been the focus of various forms of riparian restoration projects. Most of these projects are aimed at mitigating livestock grazing effects on the aquatic fauna, especially where threatened, endangered, or sensitive species (TES) are involved.

Mitigative measures most often involve deployment of improvements (e.g., fences, water developments, instream structures, plantings of woody species) in conjunction with proposed changes in management. Typically, these mitigative actions have narrow, single-species objectives, yet may have broad ecological and economic consequences. While ecosystem management concepts are increasingly being discussed and implemented, they have not been incorporated in the vast majority of stream/riparian restoration projects. It is becoming increasingly evident that the focus must shift from investing significant amounts of time and money in narrow, single-species projects to a broader ecosystem strategy.

Restoration means different things to different people and views regarding definitions, goals, and methods are muddled in controversy. A common malady afflicting previous restoration projects is a failure to recognize the necessity of establishing

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goals and objectives that take into consideration the diversity of values held by society (Cairns 1995, Hobbs and Norton 1996). Those concerned with ecosystem restoration cannot afford a narrow biophysical focus that ignores the desires of people. While those in the biophysical sciences may eventually devise methods for measuring ecosystem processes and responses to change, evaluation of the importance of those responses is ultimately a socioeconomic decision (Kolb et al. 1994).

An Ecological Economic Approach

Human and ecological systems are inextricably linked by a web of interconnected processes. The biophysical system places basic constraints on the growth and continuance of societies and human activities. The socioeconomic ecosystem, in turn, actively modifies and influences the physical and biological systems.

The disciplines of ecology and economics need to recognize the mutualistic relationship between the biophysical and socioeconomic ecosystems. For economists to exclude the biophysical processes and functions from their cost-benefit equations is as ludicrous as ecologists pretending that there is some natural world out there of which humans are not a part.

Ecology, like economics, concerns itself with the movement of valuable commodities (matter and energy) through a complex network of interconnected systems of inputs and outputs, producers and consumers. Both disciplines attempt to understand and predict the behavior of this connected complexity, and are concerned with the efficient and optimal utilization of scarce resources among competing users (Gosz et al. 1978, Aber and Melillo 1991). Because economics is the construct that human societies use to guide the allocation of scarce resources, the success or failure of endeavors to restore and sustain ecological systems will ultimately require some form of economic analysis.

There is currently a great deal of deliberation regarding ecosystems, restoration, and sustainability. Ecological economics addresses these issues by asking the following questions. Restoration and sustainability of what, how, for whom, and why? What are the interactions, structures, functions, and processes that are crucial for the long-term health and sustainability of the biophysical and socioeconomic ecosystems? What are the costs and benefits considering the whole biophysical and socioeconomic ecosystem, how are they related,

how are they accounted for, and what is their distribution?

These questions are both ecological and economic. They ask about what is desired, about what matters, and as always, about values. Addressing these questions recognizes that the relationship between socioeconomic and biophysical ecosystems is one of mutualistic connectedness.

Cost-Benefit Analysis

The very mention of the term *cost-benefit analysis* has been known to induce desultory mutterings and twitchings from its more ardent and frantic critics that are reminiscent of St Vitus's dance. Volumes have been written documenting its use and abuse as an efficiency criterion. There are some who would go so far as to say that the primary purpose served by cost-benefit analysis has been to obscure the true worth (worthlessness) of public undertakings (Gregory 1972).

We do not advocate its use as a sovereign, efficiency-decision criterion. Rather it should be considered as a framework and a set of organizational procedures that provides information, albeit incomplete, about the tradeoffs involved in a decision. As such, the responsibility of the analyst is to inform all stakeholders in a given social choice. Viewed in this light, cost-benefit analysis should not dictate choices. Its purpose is to describe the consequences of alternative courses of action and the distribution of those consequences (Freeman 1979, Brown and Peterson 1993).

While the analysis should articulate the distribution of costs and benefits, it does not provide conclusions about whether any particular distribution is preferable. There will be winners and losers, and it will be individuals and communities that pay the costs. It is crucial to identify who will receive the benefits and who will bear the costs. This identification will allow an informed choice among alternatives.

Riparian ecosystems have important attributes that provide a variety of services and ecological functions. To conduct any analysis of the costs and benefits associated with investments in stream/riparian ecosystem restoration, we must first be able to describe and quantify ecosystem functions, processes, and relationships. The ability to predict the consequences of human actions on these relationships is crucial. We have to be able to define and determine what we will gain or lose when we alter these systems (Richardson 1994, Bingham et al. 1995).

At present, information is lacking about the physical changes to ecosystems and the socio-economic consequences that might result from alternative courses of action, and the value of those changes (Bingham et al. 1995). This situation exists because ecological and economic methods and linkages for dealing with riparian ecosystem functions and processes are in their infancy. We need to know what is important to measure, how to measure it, and why.

The Case of the Spikedace (*Meda fulgida*)

The Spikedace is a threatened species of short-lived minnow that lives in the upper Verde River. They usually grow to around 40 mm in length and seldom live longer than 4 years. The Spikedace has evolved and adapted under conditions of periodic drought and extreme flood events. Disagreement exists as to the cause(s) of declining Spikedace populations and what should be done. Speculation about the causes of Spikedace habitat degradation include impoundment construction, dewatering of streams for irrigation, and groundwater mining. In addition, the introduction of nonnative fishes has affected the species through predation and competition for food and habitat. Last (but apparently not least, as efforts are invariably focused on it almost to the virtual exclusion of all other potential causes) livestock grazing has been implicated in the decline of Spikedace habitats and populations through streambank deterioration (Neary et al. 1996).

It has been suggested that the exclusion of livestock from along the river is necessary to mitigate perceived negative impacts on Spikedace populations. Doing so will require the construction of many miles of fence along both sides of the river at a cost of approximately \$6,000 per mile of fence (i.e., \$12,000 per mile of river). Fencing off the river will deprive the livestock of their principle source of water. This will require the development of alternative water sources. Putting in wells, pumps, tanks, and pipelines will become very expensive, very quickly. The maintenance costs associated with each of these structures is significant and long term. There is also the opportunity cost of lost carrying capacity in the excluded area. These costs are readily quantified. But what of the benefits?

We are not aware of any evidence from the literature that would allow us to predict a positive response in Spikedace populations as a result of these actions. Let's ignore this rather disturbing obstacle for the moment and assume we can pre-

dict and quantify a positive result on Spikedace populations. What is it worth to us? Just how much do we value a potential increase of say 5 percent in Spikedace populations? Are we willing to incur the costs described above? What if many of the costs had to be incurred by the permittees and in so doing we put the cattle growers out of business? What if we spend all this money, put ranchers out of business, displace families, and do not increase Spikedace populations?

... and the only persons to whom he gives offence are those whom he deprives of their fields and houses to bestow them on the new inhabitants. Those who are thus injured form but a small part of the community, and remaining scattered and poor can never become dangerous.

Niccolo Machiavelli, 1513

Let's examine another of the potential causes of Spikedace habitat degradation and population decline. The state of Arizona invests hundreds of thousands of dollars annually in hatchery and stocking programs for nonnative sport fishes on the Verde River. At the same time, we are faced with the increasing loss of native fishes and legal mandates of the Endangered Species Act (ESA). It is irrational to continue to spend large amounts of money on artificial habitats for nonnative predatory fish, while spending even more money for barriers to their movement for the postulated protection of TES native fish species in the same stream (Beschta et al. 1994, Baker and Medina 1997).

What if it were determined that sustaining the Spikedace would require elimination of nonnative predatory fish and, in turn, the accompanying recreational fishing? The real cost of anything is what must be foregone in order to have the other. Are we willing to forego recreational fishing on the Verde?

Neary and Rinne (these proceedings) suggest that the greatest potential threat to base flows and, therefore, the entire upper Verde River system, is groundwater mining associated with rapid urban growth in Prescott and the Chino Valley. One need only look as far as the Gila and Salt "Rivers" in Maricopa County or the Santa Cruz "River" in Pima County to see the destructive effects of urban growth and groundwater withdrawal on our Southwestern desert streams.

Thus, even if we kill all the nonnative fishes and prohibit destructive recreational activities, eliminate all the cows and cowboys, and turn all the alfalfa fields into asphalt, we may destroy the

Verde River, and the Spikedace is no more. We ask again: Restoration and sustainability of what, how, and for whom? What are the costs and benefits, considering the whole biophysical and socioeconomic ecosystem, how are they related, and what is their distribution?

In Closing

The preceding example serves to illustrate that a narrow single-species approach to riparian restoration that does not take a holistic, systems perspective is likely to fail. Chances for successfully achieving restoration of habitats and species of interest are greatly increased by shifting the focus to the integrity of the entire system, which includes human beings.

It should be evident that many of the costs and benefits (values) involved in social choices and decisions do not lend themselves to easy measurement and quantification. Many (if not most) basic and essential values are likely to fall outside the realm of monetary accounting. Riparian restoration and sustainability may be such a value. Economics is the science and study of value, and need not be restricted to money alone (Peterson and Brown 1996).

Rather than bemoan the human influence on the biophysical ecosystem, we must deal with it by adopting a systems view that goes beyond the narrow boundaries of academic disciplines. Humans are embedded in nature and human values are an integral part of any consideration of restoration and sustainability. The way in which resources and our environment are managed has and will continue to depend on our values. An ecological economic approach to riparian ecosystem restoration is one that recognizes the relationship between ecology and economics as one of mutualistic connectedness.

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