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Essay

Ecosystem services

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The Indonesian mangrove habitats shown above are relatively low in biodiversity (compared to other tropical habitats), yet are among the world's most valuable ecosystems when one accounts for their storm protection, fisheries production, and water supply. In fact mangroves are estimated to provide ecosystem services at a per hectare rate ($9,900 per year) nearly five times higher than the per hectare rate for tropical forests, which are noted for their high biodiversity. Thus, at a global scale, high biodiversity does not necessarily correspond to the greatest ecosystem services — a reality that may cause conservation efforts to broaden their goals beyond simply maximizing biodiversity.

Humans have always depended on nature for environmental assets like clean water, nutrient cycling and soil formation. These have been called by different names through human history, but are presently gaining global attention as 'ecosystem services'. Gretchen Daily defines ecosystem services as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life". Until recently, we have tended to take ecosystem services for granted, as they have generally been 'free', despite their obvious economic value to humans. In fact, a recent global analysis by the Millenium Ecosystem Assessment concluded that well over half of the world's ecosystem services are being degraded or used unsustainably. With a global population soon to number nine billion people, ecosystems services are becoming so degraded that many regions in the world risk ecological collapse. It may be time for the era of free ecosystem services to come to an end. The idea of paying for ecosystem services is causing corporations, private land owners, conservation organizations and governments to take note. Even prominent business-oriented magazines such as *The Economist* have recently featured ecosystem services on their cover (see the 21 April 2005 issue).

If we are to start paying for ecosystem services, we have to know how much to pay. Economists and ecologists are just beginning to credibly assign economic value to ecosystem processes, transforming these processes into tradable, marketable services. This approach gives us a common currency to assess the relative importance of ecosystem processes and other forms of capital (physical, social, cultural, intellectual). Economic valuation need not cover all values of ecosystems; progress is made simply by capturing values that are presently egregiously overlooked. As a society, the modern world routinely uses cost–benefit analyses to judge between alternative pathways. The valuation of ecosystem services facilitates difficult decisions about how to proceed with development to keep up with ever-expanding human populations. Without economic valuation, decision-makers and governments implicitly assign ecosystem processes a value of zero and, not surprisingly, then select actions that reap rewards according to values everyone already understands (like a new factory). Hence valuation, even if it is flawed, may get ecosystem processes on the table and lead to more sustainable policies.

Several attempts have been made to classify and exhaustively list ecosystem services. There is no present consensus on a useful taxonomy, though de Groot and coworkers and the Millenium Ecosystem Assessment have both established groupings that align ecosystem functions with goods and services. For example, the Millenium Ecosystem Assessment identified functions as provisioning (food, water, fuel, fiber), regulating (prevention of soil erosion, flood control), cultural (recreation, spiritual value, sense of place) or supporting (soil formation, nutrient cycling, oxygen from photosynthesis).

Regardless of the ways they can be grouped, ecosystem services have been brought into the limelight largely due to interest from multiple, usually disparate, sectors. Corporations and private land owners have begun to recognize that their resource bases are finite and are, in some cases, factoring ecosystem well-being into the corporate or individual balance-sheet. For instance, British Petroleum gained support from the public, and even some conservation organizations, in their bold move to break from the fossil fuels industry by publicly recognizing the association between fossil fuels and climate change, and then selecting a corporate strategy that reflected the role of carbon sequestration and reduced emissions in climate control. On a less grand, but equally relevant scale, cattle ranchers and foresters may use ecosystem services as another commodity that can be sold beyond beef or timber, as long as they can find someone willing to pay for clean watersheds or erosion control.

Box 1

Mangroves: from $2000 shrimp to tsunami protection.

Mangroves have long been the poster child of ecosystem services. The list of the services provided by mangroves is long and well appreciated by subsistence communities globally. Many of these services have already been targets of valuation studies, including finfish and non-finfish commercial and subsistence fisheries, timber and firewood, dyes, tourism, medicinal remedies, education, physical coastal protection, carbon storage, and even existence and option values. The power of such valuations was shown early on, when the Fijian government temporarily stopped mangrove reclamation in the 1960s and 1970s after seeing the results of a partial valuation study.

A later case study showed the economic and ecological perils of neglecting the value of mangroves. A large mangrove area on India's east coast houses a shrimp farming industry that relies on wild brood shrimp. But, mangroves were cleared for new farms subsidized by the government and the remaining mangrove area is half of that required just to provide enough wild brood shrimp for existing farms. Overdevelopment has led to a wildly fluctuating brood shrimp market where a single shrimp can sell for as much as $2000 USD. Analyzing the partial value of mangroves for brood shrimp provision alone would have clearly identified the optimal number of farms, saving subsidy money, providing a sustainable industry and retaining more mangroves.

Mangroves have also illustrated the importance of understanding what ecosystem characteristics are necessary for particular services. The recent Indian Ocean tsunami provided a textbook example of the role of mangroves in coastal protection. Most areas in Sri Lanka with relatively good mangrove status before the tsunami were protected and received little wave damage as expected, but some were severely damaged. In other words, the mangroves acted like an insurance policy against storm damage — nature's insurance policy, with no premiums charged to anyone. Of course, if all of the coastal regions bludgeoned by the tsunami had recognized the value of mangroves, much damage and suffering could have been averted.

Interestingly, just as is the case with regular insurance policies, the details matter. A closer look at the patterns of damage and the coastal vegetation showed that the damaged areas had dominant mangrove trees like *Rhizophora* sp. in good condition, but had understories dominated by less typical mangrove associates (species not always found in mangroves). This detail of forest character, not visible from satellites, made all the difference. If mangrove restoration efforts spurred by the recent disaster focus on expanding the extent of major mangrove species while ignoring understory species, the region could face an equally grave threat from the next tsunami.

Ecosystem services have also piqued the interest of the public sector and national governments. For example, several agencies within the US government (USEPA, USACE, USDA) recently showed their interest in ecosystem services when they commissioned the National Research Council to produce a report on the topic and the status of aquatic ecosystem services in the US. These government agencies recognize the utility of ecosystem service valuation for its potential to inform policy decisions that include consideration of trade-offs, for providing damage assessments and for incorporating environmental assets and services into national income accounts.

Conservation organizations have several reasons to be interested in ecosystem services. Private donor dollars presently pay for most domestic and international conservation activities. Though these funds have set aside vast tracts of pristine systems, they alone will not be enough to protect the majority of the earth's ecosystems and the species they house. In comparison, realization of the market worth of ecosystem services has the potential to increase conservation funding by orders of magnitude. Ecosystem services also have the possibility of aligning conservation value and poverty alleviation. Functioning ecosystems provide clean, disease-free water, fertile soil and numerous other basic human needs.

The paradigm of ecosystem services is not accepted by everyone, and even among those who champion this new way of thinking about nature, differences of opinion can be dramatic. For example, some scientists suggest a virtual one-to-one mapping between ecosystem services and biodiversity. Others point out that there are many cases where low diversity systems can provide tremendous ecosystem services, and that modest losses of biodiversity may not substantially undermine ecosystem services. Many conservationists also fear that placing values on ecosystem services will lead to the loss of appreciation of species for their own sake. History has shown that markets are generally unkind to natural systems. Others see markets as tools that can instill conservation value into lands under human use that would traditionally not be valued if the only measure were biodiversity.

Possibly the boldest move to embrace and understand ecosystem services to date is the Millennium Ecosystem Assessment, mentioned above. This assessment of the status of the earth's ecosystems was requested by the United Nations Secretary General, Kofi Annan. As stated in the report: "the objective of the Millenium Ecosystem Assessment was to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being". The assessment cost over $20 million and involved 1300 scientists who volunteered their time synthesizing and analyzing data and models.

All of this interest is derived from a healthy base of theory and only a few real-world examples that scratch the surface of possible tools for the sticky business of assigning values to ecosystem functions. The point of economic valuation is to estimate the importance of changes in ecosystem services to human welfare. There is an active movement to formalize ecosystem service values in public and private sectors by creating markets for ecosystem services, and at a minimum changing policies away from perverse subsidies.

The most common and most appropriate approach to non-market valuation is called total economic value (TEV). This approach does not necessarily assess the total value of an ecosystem, but rather allows changes to be calculated for all values (use and non-use values) associated with one or several ecosystem functions. Any calculation of TEV will depend heavily on the spatial and temporal scales being assessed, so analysts must be clear about the intended scope of their study. TEV can be assessed as willingness to pay (WTP) or willingness to accept (WTA) payment. WTP is the more common method, as more tools for estimating economic value are relevant to this approach and WTP can usually be considered a conservative estimate in cases where WTA would be preferred. The recent NRC report reviews the many methods for calculating WTP and should be consulted for details and guidelines.

Many problems must be solved before the valuation of ecosystem services can become a mainstream activity. Primarily, we need to acquire sufficient information about ecosystem processes to make valuation possible. Beyond that basic biophysical information, we also lack an understanding of how economic value scales with ecosystem processes. For instance, a single wetland grass plant does not cycle enough nutrients to be of value to an upland cattle farmer. But how many plants are considered valuable? 100 plants? One hectare of wetland? And how does this answer change with seasons, climate fluctuations and land use change in the watershed?

Another challenge lies in our ability to devise pragmatic programs for the monetization of services. Hardest of all may be finding someone willing to pay, when the tradition has been to receive these services for free. Ecosystem service valuation will only achieve its promise if there are markets and buyers for the service, or some other form of incentive. Some payment systems are already established and functioning for selected ecosystem services. For example, there are at least five active carbon markets in the world, and farmers in parts of the US are subsidized to leave fields fallow for several years to encourage soil formation and retention. The Perrier bottled water company pays fees to landowners in watersheds upstream of their springs to retain forests, guaranteeing a clean, reliable water source. But even these tools will be difficult to apply in non-capitalist countries or developing regions with minimal infrastructure. Economists and multilateral international agencies will need to apply creative thinking in impoverished countries to help the value of ecosystem services be realized in places where no one can afford to pay for much of anything.

Valuation of ecosystem services is but one of many tools that will be used in the continual struggle to allow coexistence of humans and the suite of species and ecosystems that make our lives possible. Ecosystem services and their dollar value is one of the few ideas that resonate in corporate and governmental board rooms, on stock exchanges and in farm houses, mud huts, eco-tourist lodges and palm palapas. Investing in ecosystem services is a risky business. Ignoring their potential may be even riskier as species continue to blink out of existence and ecosystems continue to collapse around us.

Fish for personal consumption caught by net from a coral reef in Indonesia. Although the importance of coral reefs for fisheries is well-known, unsustainable practices such as blast fishing commonly squander these ecosystem services, and leave future generations deprived. In this Indonesian community, blast fishing had been halted, and local people enjoy a bountiful harvest of fish. If blast fishing yields too much short-term economic gain due to exports to Japan or elsewhere, the wisdom of sustainable practices does not so easily triumph.

Further reading

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www.ecosystemservicesproject.org (CSIRO initiated project studying ecosystem services and how to consider these services in land management decisions)

www.ecosystemvaluation.org/ (fundamentals of dollar valuation, with links to indicators of ecosystem value)

http://esd.uvm.edu/ (NSF funded ecosystem services database and search tool)

www.actionbioscience.org/environment/esa.html (Ecological Society of America factsheet on ecosystem services with links)

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