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Valuing Natural Capital

The Limits of Complex Valuation in Complex Systems

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Valuing Natural Capital: The Limits of Marginal Valuation in Complex Systems

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In our efforts to solve the macro-allocation problem—how much ecosystem structure should be converted into economic products or degraded by waste emissions, and how much should be left intact to provide vital life support functions and other ecosystem services?—unregulated markets are of limited use, as they fail to indicate the marginal value of ecosystem services. Economists seek to solve this problem by estimating the marginal costs of ecological degradation, which brings up the problem of scale: what unit is appropriate for measuring marginal ecosystem values, the hectare or the landscape as a whole? The answer to this question is urgent, as economic activities are currently threatening wholesale collapse of planetary life support functions.

Perhaps the most serious obstacle to addressing the scale problem is the ignorance and uncertainty concerning ecosystem function. We often fail to recognize the impacts of human activities on species or ecosystems or to understand what services they provide until the species is extinct or the ecosystem is irreversibly degraded (Vatn and Bromley 1994). Compounding the problem, time lags between loss of the species or ecosystem and noticeable loss of the service may be greater than a human lifespan. For example, passenger pigeons were once so abundant that humans mistakenly believed they could never be hunted to extinction. Some scientists believe that with the pigeon's extinction, uneaten acorns led to booms in deer and mouse populations, followed by booms in deer tick populations, and finally in the spirochetes that fed on them, resulting 100 years later in an epidemic of Lyme's disease. Estimates of monetary value can be no more accurate than the knowledge of ecosystem services they are based on.

One reason for our ignorance is the fact that ecological-economic systems exhibit highly complex behavior. Marginal activities, such as the conversion of a forest landscape or even a

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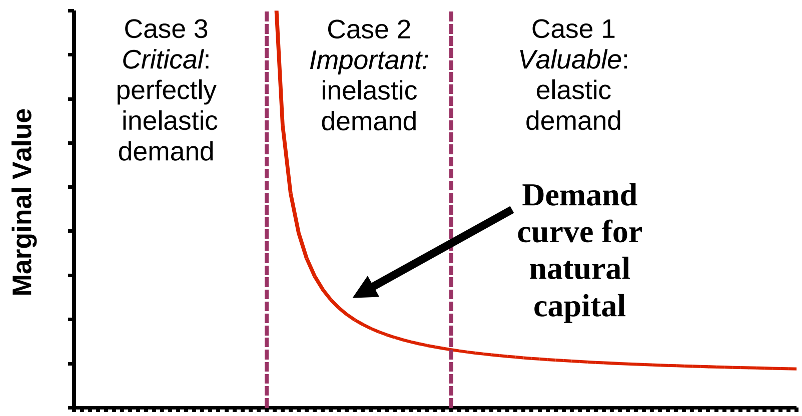
hectare of forest, may lead to reasonably linear changes in the value of ecosystem services over some range, yet highly non-linear changes over another range. Non-linear changes often include the presence of abrupt, irreversible thresholds (Limburg et al. 2002). For example, the Amazon rainforest recycles much of the rain that falls on it. Torrential rains strike the forest canopy, dissipating its energy. Much of the rain evaporates directly from the canopy, while the remainder falls to the ground as a fine mist, where it readily percolates into soils aerated by the extensive root systems. Much of this rain is absorbed by the trees, returning to the atmosphere through evapotranspiration, where it forms clouds and falls again. When forest cover is removed, rain falls on and compacts bare soils, then swiftly runs off into the rivers, where it flows downstream and is lost from the system forever. Studies suggest that if as little as 30 percent of the total forest cover is lost, enough water will drain from the system that it will no longer be capable of spontaneously regenerating itself. Without active ecosystem restoration, the system would flip into an alternative state, such as savannah grassland. Many ecosystems are likely to exhibit such thresholds, where the loss of an additional hectare may lead to the transformation of the entire ecosystem. As the Amazon forest is a critical regulator of the global climate, its loss may have catastrophic, non-linear impacts on the global ecosystem (Salati 1987).

In other words, the loss of the marginal hectare at one point may lead to collapse of the landscape or the extinction of a species, and the loss of the marginal landscape or species may lead to catastrophic, non-marginal impacts at the regional or even global scale. The appropriate question in this case is not whether to value the marginal hectare or the marginal landscape, but rather when does a marginal loss of either lead to non-marginal loss of things people value? Individual landscapes and ecosystems are often sufficiently unique that the sample size for scientific experiments is one, and this is certainly the case for the global ecosystem. We cannot know in advance precisely where such ecological thresholds lie. Even when we find such thresholds by crossing them, with a sample size of one the resulting knowledge is anecdotal.

When marginal activities may cause non-marginal outcomes, how do we apply marginal valuation? It is most important to answer this question for critical natural capital—those resources of nature that are essential for sustaining human welfare for which substitution is difficult or impossible, such as energy (including food), water, ecological life support functions (e.g., climate stability and protection from ultraviolet radiation), and the biodiversity that sustains most other ecosystem services. When we degrade or destroy natural capital to the extent that it can no longer provide services essential to human welfare or is no longer capable of reproducing itself, we have reached a critical threshold (De Groot et al. 2003). The cost of passing this threshold is essentially infinite—marginal change in an activity leads to non-marginal outcomes, and marginal valuation fails.

The marginal value of a resource determines its demand curve. When natural capital is relatively abundant, it is used for both important and unimportant activities. As natural capital becomes more scarce, we first sacrifice its least important uses, and would therefore expect lost marginal values to be quite low. The level of redundancy in most ecosystems and their resulting resilience means that marginal values should also change quite slowly. However, as the natural capital stocks decline or suffer degradation, we must sacrifice increasingly important uses. In addition, as we snip the threads that hold an ecosystem together, redundancy decreases, more ecosystem services are threatened, and we expect a more rapid rise in marginal values with further declines in natural capital. As the natural capital approaches a critical threshold, it provides increasingly essential benefits for which substitution is increasingly difficult, which are the conditions for price inelastic demand. This means that small changes in quantity will lead to large changes in marginal value (think of the California electricity crisis). When we reach the threshold of criticality, the demand curve becomes vertical, as the marginal value approaches infinity. Figure 1 depicts a hypothetical demand curve for critical natural capital.

Figure 1



Stocks of critical natural capital or ecosystem services (e.g. Amazon forest, global biodiversity, waste absorption capacity for CO2, etc.)

We can thus identify three distinct areas on the demand curve for natural capital, with three distinct characteristics regarding marginal valuation and policy implications, which apply to either hectares or landscapes.

Case 1 on the right hand side is characterized by low marginal values and slow changes in marginal value. Monetary valuation may be appropriate,[1] and estimated marginal values are likely to remain fairly constant over a large range of natural capital. Under these circumstances, it may be possible to calculate marginal values, and then send them to a central authority that either internalizes them into prices of commodities whose production degrades them or pays for their provision.

Case 2 occurs when natural capital stocks decline and demand becomes inelastic. Technically it may still be possible to calculate marginal values, but in the time it takes to conduct a valuation study, publish results, then feed the results to decision makers so that they might act on them, the quantity of natural capital—and hence its value—is likely to change, so the estimated marginal value will no longer be accurate. An attempt to internalize externalities through prices would require an army of technocrats constantly calculating marginal values, who then supply them to a central authority, which would incorporate this knowledge into prices, presumably through taxes or user fees. Markets, however, are prized precisely because they "utilize knowledge which is not given to anyone in its totality" (Hayek 1945). Rather than using prices (economic signals) to determine the appropriate level of resource use, it would be much simpler and more compatible with free markets to fix supply based on ecological factors (e.g., set a cap) and allow supply to determine price (e.g., through tradable permits). Valuation might help us decide when to implement such a system: when non-market marginal values begin to increase rapidly, it would suggest we are nearing criticality thresholds. Valuation might also be useful for educating decision makers and assessing the relative importance of non-market benefits relative to market benefits. However, the presence of time lags, our ignorance of ecosystem function, and the fact that markets ignore the preferences of future generations means that we should be very leery of relying on value signals alone.

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[1] Monetary values are generally based on the principle of one dollar, one vote, as market demand curves are determined by preferences weighted by income—a plutocratic approach. Many people, myself included, believe that the allocation of public good resources provided by nature should be more democratically determined—votes should not be weighted by income.

Case 3 occurs when depletion of natural capital passes the criticality threshold and either human welfare or the ecosystem is doomed to collapse in the absence of intervention. Marginal valuation is entirely inappropriate. Many natural scientists are convinced that we are extremely close to critical thresholds for biodiversity, climate stability, and in a number of key ecosystems around the world, if we have not passed them already. Fortunately, ecosystems are often very resilient, and there may be a significant time lag before the collapse. With human intervention, it may be possible to restore natural capital even after we have passed critical thresholds, and restoration is the only appropriate policy response. Rather than estimating a demand curve for restoration to determine values, we should estimate supply curves: these tell us little about value, but they do tell us where to most cost effectively target restoration efforts. Supply curves consist of opportunity costs and implementation costs. The latter in this situation will not exhibit conventional behavior because the healthier the ecosystem becomes, the better it can reproduce itself without human intervention.

These arguments assume non-substitutability, but many economists claim that we can develop substitutes for any resource. However, only market goods have a price that signals scarcity and spurs the market to develop substitutes. Even if estimate marginal values of non-market services, markets will generally have no incentive to provide them in the absence of public funding. In addition, many historical examples of substitution or increased productivity rely heavily on cheap energy. It now takes an estimated 10 calories of fossil hydrocarbons to produce one calorie of food in industrial agriculture. In spite of massive investments in the search for more oil or for oil substitutes, in response to the price increases of the 1970s, discovery rates have declined steadily since the mid-1960s, no adequate substitute exists, and the rate at which we develop new uses for fossil fuels dramatically exceeds the rate at which we develop substitutes. The current trend is to convert food into energy, with very low energy returns on energy investments, threatening dramatic increases in food prices. There is little evidence that we will ever be able to develop meaningful substitutes for climate stability and biodiversity. It is, of course, impossible to predict future technological advances. However, if substitution for vital services proves easy, then there is no harm in mandating protection (e.g., a cap) today to jump start us on the substitution process. If substitution instead proves difficult or impossible, then we must mandate protection as soon as possible.

Sadly, many economists ignore the importance of critical resources and inelastic demand, and the fact that money exhibits diminishing marginal benefits. As a result, Noble Laureate Robert Schelling tells us that global climate change is not that important, since it primarily affects agriculture and forestry, which is only 3 percent of our GNP. He goes so far as to say that the harm from losing one-third of agricultural production is negligible. When we place monetary values on everything, each dollar is a perfect substitute for the other, and we can just as easily find a substitute for food as we can for any other commodity. The Stern Review suggests that we could reduce the risk of catastrophic climate change to an acceptable level if we spend 1 percent of GNP annually to address the problem, but many economists argue that this is too expensive. Per capita GNP grows at 2 percent per year. Those economists opposed to such expenditures argue that accepting our living standards from six months earlier is too great a sacrifice. Presumably, such absurd views arise from the belief that money alone fails to exhibit diminishing marginal utility.

I believe there has been a dangerous tendency among economists to assume that the market model can solve all problems, if only we can get the prices right, and that their valuation efforts will achieve this. My view is that relying on any one discipline or method to make important decisions about critical ecosystems is foolish to the extreme. Our proximity to critical thresholds determines whether we should estimate monetary values of ecosystems services and try to internalize them into market prices (case 1), fix supply according to ecological constraints and let it determine price (case 2), or focus on restoration (case 3). To estimate such unknown thresholds, we should bring together transdisciplinary teams to build scalable systems models of ecosystems, the services they provide, and their links to human welfare. Many such models have already been built, and many more are under constructions. These models can be used to test important hypotheses that cannot be tested in the real world, test policy options, and help identify critical thresholds beyond which marginal valuation becomes irrelevant. Such models have numerous shortcomings, but at the very least their construction gives an opportunity for different disciplines to share their knowledge, thus leading to a better understanding of the whole—the process of constructing the models may be more important than their output.

We would be foolish to bet the planet on the accuracy of either systems models or valuation studies. In a constantly evolving and unpredictable world in which facts are uncertain, decisions urgent, stakes high, and values matter, decisions must be weighted by our moral values and our ethical obligations to future generations, and will therefore never be objective and value free, even when based on the best available science. Given the stakes, we should err on the side of caution when we act and avoid irreversible outcomes and potentially catastrophic losses. Many economists believe that sacrificing economic growth would be catastrophic. However, collaborations between economists, psychologists, neuroscientists, and evolutionists have improved our understanding of human welfare and show that, beyond a fairly low threshold, monetary wealth does little to improve happiness, satisfaction with life as a whole, or health. Americans' assessments of subjective well being in 1969 were about as high as they are today, and the Genuine Progress Indicator, a measure of sustainable economic welfare, was much higher. Since 1969, per capita GNP in the United States has tripled in real terms. The empirical evidence therefore suggests that sacrificing up to two-thirds of our per capita consumption in the wealthy nations to protect critical natural capital would do us no harm and might do a world of good.

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