Untangling the Environmentalist's Paradox: Better Data, Better Accounting, and Better Technology Will Help

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The recent article in *BioScience* by Ciara Raudsepp-Hearne and colleagues, "Untangling the Environmentalist's Paradox: Why Is Human Well-being Increasing as Ecosystem Services Degrade?" (Raudsepp-Hearne et al. 2010) sheds light on a conundrum facing classical ecologists. As the authors explain, "The environmentalist's expectation could be articulated as 'ecological degradation and simplification will be followed by a decline in the provision of ecosystem services, leading to a decline in human well-being.'" But, they note, human well-being in fact appears to be increasing in the face of degraded ecosystem services.

I agree with this description of the environmentalist's expectation with a slight but significant word change: Ecological degradation and simplification will *eventually* be followed by a decline in the provision of ecosystem services, leading to a decline in human well-being. The addition of "eventually" makes explicit the time dimension in the "paradox," which is otherwise potentially lost. It also allows me to recast some of the issues in the article using two concepts from the economist's toolbox.

The first is the distinction between "stocks," a resource pool that doesn't have a time dimension, and "flows," an input or output that is measured per unit of time. An ecosystem service is a flow; it has a time dimension and a quantity associated with it (e.g., metric tons of wheat produced per hectare per year). Potentially, stocks of resources (e.g., nutrients in the soil in which the wheat is grown, the groundwater pool or precipitation from which the plants draw moisture) can combine to yield a variety of ecosystem services (e.g., liters of water and kilograms of plant nutrient over the cropping period). This distinction between stock and flow helps to untangle the paradox highlighted in the title chosen by Raudsepp-Hearne and colleagues. Drawing down stocks makes it possible to provide ecosystem services for extended periods. Eventually, however, the decline of stocks makes it impossible to continue providing the same level of services and human well-being will be reduced, and the paradox is eventually resolved. The authors allude to this possibility in their fourth hypothesis for the paradox—the idea that there are time lags between ecosystem degradation and effects on well-being—specifically citing research by Wackernagel, Vitousek, Worm, and others that have explored this theme.

It is notable, however, how many times Raudsepp-Hearne and colleagues use such expressions as "might be," "it is possible that," and "it could be." Their uncertainty highlights a central concern I have with the empirical analysis Raudsepp-Hearne and colleagues have undertaken and their proposal for additional research topics: the reliance on existing data and the expectation that new data will be available for new research.

Data scarcity is one of two key challenges to assessing whether the environmentalist's expectation has been or will be fulfilled. The first is the sorry state of available data on ecosystem services and the stocks of resources that provide them. It is a sad fact that I can get higher-resolution elevation data for Mars than for Earth, and the elevation data set for our planet is one of the few good global data sets! We desperately need to collect time-series data on the state of the planet's ecosystems at high spatial resolution. The technological cost of collecting these data has declined substantially in the past few years, but we are still missing the global will, and perhaps the institutions, to do it.

To illustrate the second key challenge to untangling the paradox I need to return to the economist's toolbox and bring out the concept of externalities. An externality exists when a resource that provides a useful and thus valuable service is not effectively controlled by anyone (an open-access resource), and when the use of it by one person affects the value of the service to others. Initially, using the service does not damage the resource (one fisherman with a pole harvesting fish in a large lake cannot deplete the stock of fish significantly), but the more the resource is used (say, multiple fishermen with large nets), the more damage eventually occurs, and the quantity of the service that the resource can provide therefore declines.

Can human behavior be altered to use resources sustainably? In a series of publications, Ester Boserup argued that human development is essentially a sequence of repeated steps of developing institutions to convert open-access resources into private property—a once freely available resource becomes overused, and a set of rules, regulations, and new technologies is created to manage the resource sustainably (see, e.g., Boserup 1965). Private property rights give the resource-owner exclusive use and presumably an incentive to use it sustainably.

Discrete resources such as land or small bodies of water are relatively easy