Research on the economic valuation of ecosystem services

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Manmade climate change and large-scale alteration of the landscape are affecting the planet and the ecosystem services upon which humans depend. These alterations include loss of forests that were once large carbon sinks, loss of pollination services provided by bees, loss of ecosystem resilience in the face of natural disasters, and many others. While ecologists and policy makers discuss the details of these effects, many have argued that economic incentives provide the strongest impetus for conservation goals. Yet, among ecologists, this approach to

valuation of ecosystem services is particularly controversial. Furthermore, the benefits of this approach are as of yet, largely unproven. Research in the past several years in PLoS One and PLoS Biology has highlighted some of the successes and difficulties with this so-called economic valuation of ecosystem services. These difficulties fall into at least four categories: (1) the difficulty of discretely quantifying continuous variation across multiple temporal and spatial scales, (2) the difficulty of identifying beneficiaries, (3) the difficulty in evaluating the success of such measures, and (4) the difficulty of applying a single approach across a great diversity of economies, cultures, and ecological contexts.

- Ecosystem services are by definition the functions of ecosystems that are beneficial to humans (ecosystem services exclude the intrinsic, i.e. non-human, benefit of ecosystems) and can be categorized into four types:
- Regulation functions – the capacity of ecosystems to regulate essential ecological processes and "life-support" functions through biogeochemical cycles and other processes
- Habitat functions – provision of homes for humans and other organisms
- Production functions – photosynthesis and nutrient uptake by autotrophs provides energy
- Information functions – function as a reference for recreation and aesthetics

Key among ecosystem services are climate regulation, providing a buffer against disturbance, and water and nutrient cycle regulation (see DeGroot et al. 2002).

Research published in *PLoS One* by Guo and colleagues in 2010, suggests that humans have increased their dependence on ecosystem services over time (from 1980 – 2005) and that this increase is likely to

continue. In 92 biodiversity hotspots countries, economic dependence (in terms of the percent of gross domestic product) on roundwood production, hydroelectricity, and eco-tourism increased by 5.2%, 9.1% and 7.5% respectively. This trend of increased dependence on ecosystem services was true in non-hotspot countries as well, though to a lesser degree (3.4, 5.9 and 5.6% respectively).

Furthermore, Dias et al. (2006) in a review published in *PLoS Biology*, found that biodiversity loss is particularly threatening to human well-being. Dias and colleagues found that species diversity, genotypic diversity, landscape diversity and most importantly functional group diversity had a significant influence on production of biomass, nutrient cycling, and resistance and resilience to disturbance. These ecosystem functions were positively associated with ecosystem services like soil retention, water cycle and climate regulation, agricultural pest and disease control, and human disease regulation. The negative impacts of declining ecosystem services due to biodiversity loss are most pronounced for already marginalized populations who have little power in political and economic systems such as subsistence farmers, populations of rural poor, and indigenous groups.

In spite of our dependence upon ecosystem services, there is little consensus on any one framework for measuring their economic value. According to research published in *PLoS Biology* (Chan et al. 2006) this is likely because it is difficult to align conservation goals with ecosystem services. Furthermore, evaluating ecosystem services is a compound abstraction. First, a complex ecosystem must be translated into discrete structures and processes and only then into ecosystem services. This abstraction makes measurement and valuation difficult.

The abstract idea of ecosystem services also makes determining the beneficiaries of ecosystem services difficult. Research published in *PLoS One* in 2011 (Chan et al. 2011), suggests that this difficulty is also

inherent in conservation planning as ecosystem services can fall into one of two economic benefit "bins" when planning conservation strategies. Ecosystem services can be considered intrinsically important target benefits or as co-benefits for other management strategies. However, even when ecosystem services are given economic value, managing explicitly for these services is often not cost-effective. In fact, Chan and colleagues (2011) found that managing for ecosystem services is only cost-effective when the ecosystem service is a co-benefit rather than the targeted benefit. The authors suggest that this is likely due to the opportunity costs, the potential profits missed by not pursuing an opportunity, associated with explicitly pursuing ecosystem service conservation.

Karner blue butterfly pollinating a dandelion flower. Credit: USFWS midwest creative commons license

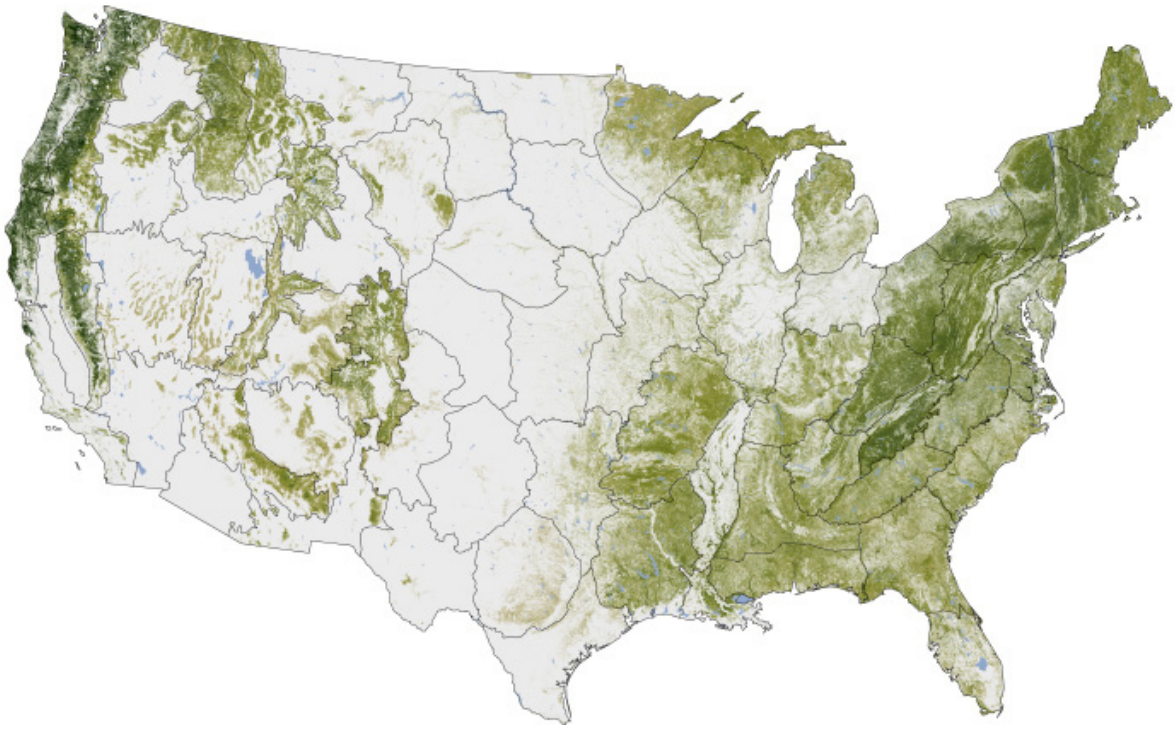
In addition to the difficulty in evaluating ecosystem services, evaluating the success of these efforts is equally difficult. In China, results are mixed for improved ecosystem services with the implementation of rehabilitation policies. Lu and colleagues (2012) found that rehabilitation efforts paired with strong socioeconomic incentives in the threatened Loess Plateau, caused significant increases in soil conservation and carbon sequestration but decreased regional water yield. Furthermore, the region experienced an increase in grain production in spite of a net loss of farmland to rehabilitation efforts. Lu and colleagues also express uncertainty over the long-term sustainability of these policies for the region which lacks a long-term monitoring initiative.

Conservation plans that rely on ecosystem service valuation are often only applicable for a given ecosystem. Thus, the process of evaluating each new situation is slow and cumbersome making implementation equally slow and significantly more expensive than alternatives. Villa et al. (2014), in recent research published in *PLoS One*, propose an integrated modelling framework for valuing ecosystem services called "Artificial Intelligence for Ecosystem Services", or ARIES, to enable rapid assessment of ecosystem services. This framework gives equal value to the economic value, socio-cultural value, and ecological value of ecosystem services. According to Villa and colleagues this allows for a direct link between ecological factors and their socioeconomic implications across spatial and temporal scales. Programs like ARIES rely on probabilistic modelling to incorporate the uncertainty inherent in such a dynamic system. Furthermore, Villa and colleagues provide a flexible structure that incorporates many indirect values over long time

periods to provide a rapid assessment.

While methodologies like ARIES provide new options for valuing ecosystem services, the question remains – should we? In a 2009 editorial for Conservation Biology, Redford and Adams outline many prominent issues with placing economic value on ecosystem services. First, economic arguments will begin to outweigh noneconomic justifications for conservation. Second, not all ecosystem services provide an immediate benefit to humanity and placing economic value on ecosystem services often ignores indirect benefits. Perhaps most importantly, markets only exist for some ecosystem services, economic valuation therefore focuses on these ecosystem services and ignores others. In turn, management strategies follow suite. Redford and Adams further argue that placing economic value on ecosystem services places more power in the hands of the already wealthy who are often buffered from the majority of harm from loss of ecosystem services. Many also argue that this power imbalance allows developed countries to displace their environmental harm rather than change damaging practices.

In spite of these ideological issues, global initiatives like the United Nations Reducing Emissions from Deforestation and forest Degradation (UN-REDD and REDD+) rely on arguments rooted in ecosystem service valuation. Understanding and evaluating these arguments is crucial for estimating the effects of the Paris Climate Agreement, which has now been signed by 175 countries (as of April 22nd 2016). If these initiatives are successful, they may provide real and tractable solutions for reducing carbon emissions and arresting climate change, but in the process we may permanently and irreparably change how we as humans relate to our environment.



Tree cover and carbon storage in the United States. Credit: NASA Earth Observatory creative commons license

PEFS patrollers at work in the jungles around Macooih. Credit: ADF creative commons license

More information: Ferdinando Villa et al. A Methodology for Adaptable and Robust Ecosystem Services Assessment, *PLoS ONE* (2014). DOI: 10.1371/journal.pone.0091001

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