

Off-Stage Ecosystem Service Burdens: A Blind Spot for Global Sustainability

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Abstract: The interdependence of social and ecological systems has never been more apparent than it is in today's globalized society. Environmental problems can be addressed more effectively using a science-policy framework that considers ecosystem services. Such analyses, on the other hand, frequently fail to take into account the repercussions that are difficult to see up close but are crucial for long-term global stability. Environmental stewardship, which we call "ecosystem service burdens," has off-stage implications on biodiversity as well as ecosystem services that need to be better understood by ecosystem-services scientists. These are especially relevant since they are frequently unfavorable and can have a considerable impact on decisions about ecosystem management. Scientists can better understand the off-stage implications of ecosystem services by including new analytical methods, such as life cycle assessment or risk-based techniques into their work. Both the Intergovernmental Platform on Biodiversity and Ecosystem Services and also the Intergovernmental Panel on Climate Change must consider off-stage ecosystem service burdens in their evaluations of ecosystem health. In order to fully understand cross-scale interactions, it is essential to investigate off-stage loads more thoroughly.

Keywords: ecosystem services, biodiversity, global sustainability, environmental policy, off-stage repercussions, ecology burdens, accountability, climate change.

I. INTRODUCTION

There is a steady decline in Earth's life support systems as a result of an ever-increasing human population, with unanticipated effects for both the present but also future generations¹. The expanding metabolic rate of cities is one manner in which the interconnectedness of social-ecological systems shapes these effects², resources, individuals (e.g. migrants and refugees), and knowledge are all moving vast distances, resulting in increased dependency on environmental assets (e.g. water, fiber, fishery minerals as well as fossil fuels) but also carbon emission fluxes³, entrance of non-native species via commerce, as well as spread of plants and animals infectious illnesses⁴. Countless smaller linked ecological and social systems make up Earth's huge, interconnected human-natural system. Environmental management and human welfare are inextricably interwoven in ways previously unimagined. The Sustainable Development Objectives will be jeopardized if we don't pay attention to the cross-scale implications of consumption and production patterns, which will have unintended and unforeseen repercussions for ecosystems and communities now and in the future (SDGs). Ecosystem governance that

¹ Wiedmann T O, Schandl H, Lenzen M, Moran D, Suh S, West J and Kanemoto K 2013 The material footprint of nations Proc. Natl Acad. Sci. USA

² Seto K C, Reenberg A, Boone C G, Fragkias M, Haase D, Langanke T and Simon D 2012 Urban land teleconnections and sustainability Proc. Natl Acad. Sci. USA

³ Dalin C, Wada Y, Kastner T and Puma M J 2017 Groundwater depletion embedded in international food trade Nature 5

⁴ Perrings C 2016 Options for managing the infectious animal and plant disease risks of international trade Food

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ignores cross-scale implications has a negative impact on regional and local sustainability. Programs that incentivize the import of biofuels may have detrimental consequences for biodiversity, ecological structure, as well as individual's well-being in areas where biofuel plants are cultivated. Fisheries communities' livelihood and the viability of marine ecosystems may be undermined by the importation of seafood from unregulated fishing grounds as well as aquaculture in other locations⁵.

Since the publishing of the Millennium Ecosystem Evaluations, the notion of ecosystem services has been widely accepted by academics and policymakers equally. An increasing number of sub-global ecosystem assessments as well as new policy instruments for conservation like REDD+ are emerging in tandem with the Aichi goals set forth by the Convention on Biological Diversity, IPBES, and also the growing number of sub-global ecosystem assessments⁶. Though fundamental sustainability issues cannot be addressed by the ecosystem service paradigm, it might encourage decisions that have unintended negative consequences elsewhere. In other terms, if the goal of ecosystem-services science is to better understand how ecosystem management affects human well-being, it must not disregard the fact that social-ecological teleconnections have a profound effect on the entire planet⁷. Identification of leakage in evaluations and policy processes like the IPBES as well as the Intergovernmental Panel for Climate Change (IPCC) is still to be more consistently addressed.

Our goal is to highlight and address a significant weak point in ecosystem-services analysis and studies, namely the need to detect off-stage ecosystem service expenses that are created routinely by ecosystem maintenance. We begin by identifying a gap in the rapidly expanding scientific agenda for ecosystem services. Focusing on ecosystem assessments, we present critical instances to show how off-stage loads are overlooked by these assessments. Once we have identified and quantified off-stage ecosystem service constraints in current and future evaluations, like those undertaken by the IPCC and IPBES, we propose alternative but complementary techniques.

II. MINDING THE GAP BETWEEN ECOSYSTEM SERVICES SCIENCE AND GLOBAL SUSTAINABILITY

Biological diversity and ecological function are all intertwined, thanks to advances in ecosystem-services research. It has become easier to build cost-effective and equitable policy instruments to protect ecosystems and biodiversity thanks to new accounting technologies, such as WAVES, Wealth Accounting, and the Valuation of Ecosystem Services Plan Of action⁸. There are three types of issues that prevent ecosystem-services science from making a meaningful contribution to global sustainability advances notwithstanding these developments. In the first place, the management of ecosystems for ecosystem services does have a direct effect on the local environment. The end advantages of ecosystems are given more emphasis than the negative repercussions on the species as well as ecological services that sustain those benefits, resulting in an imbalance of attention⁹. The fundamental technique for studying ecosystem services is to establish a research region, identify key ecosystem functions, and assess how various management scenarios might affect such features in policy-relevant units. If a trade-off effect on other ecosystem services within the study's range cannot be demonstrated, researchers tend to ignore the negative consequences of optimizing a narrow selection of ecosystem services. Place-based ecosystem management's effects are often diffused, postponed or indirect. Ecosystem alterations often come from the cumulative influence of numerous interdependent biophysical procedures or stressors, making them complicated and difficult to forecast. Due to the fact that humans and other human assets co-produce ecosystem services, ecosystem management can have a negative impact on non-targeted ecosystem services, both locally and internationally." Overfishing of filter-feeding oysters, for example, is commonly blamed for eutrophication in coastal areas even though the problem is often linked to current flow of nitrogen and phosphorus¹⁰. For the third time, there has been a lack of focus on broader cross-scale or cross-location effects. Ecosystem evaluations, in particular, are primarily addressed at the jurisdictional level and rarely

⁵ Hilborn R 2013 Environmental cost of conservation victories Proc. Natl Acad. Sci. USA

⁶ Naeem S et al 2015 Get the science right when paying for nature's services Science

⁷ Hoekstra A Y and Mekonnen M M 2012 The water footprint of humanity Proc. Natl Acad. Sci. USA

⁸ WAVES partnership 2015 Wealth Accounting and the Valuation of Ecosystem Services (WAVES) Annual Report (Washington, DC: World Bank)

⁹ Schröter M, Albert C, Marques A, Tobon W, Lavorel S, Maes J and Bonn A 2016 National ecosystem assessments in Europe: a review BioScience

¹⁰ Jackson J B C et al 2001 Historical overfishing and the recent collapse of coastal ecosystems Science

concentrate on cross-jurisdictional relationships¹¹. As a consequence, eco-evaluations tend to overlook the costs of ecosystem services that extend beyond local or national borders and harm people's well-being in areas outside the scope of the assessments. So, there is a risk that many uncoordinated local efforts to control ecological services could have a larger-scale impact on other ecosystems.

III. ADDRESSING OFF-STAGE ECOSYSTEM SERVICE BURDENS

Ecosystem assessments and accompanying policy tools are required to assess for and quantify effects on the ecosystem and humans at various locations and sizes if global sustainability is to be realized. Ecosystem assessments are not paying enough attention to off-stage burdens, in part because they are hard to address as well as because there are no efficient institutions in place to enforce responsibility for these kind of burdens, but also since they have still not been identified as significant elements in ecosystem evaluation frameworks. To help integrate system interconnectedness into the assessment of off-stage ecosystem service constraints, we offer four options for research and policymakers:

(i) In order to account for spillover effects that occur off-stage (remote, diffuse, and delayed), employ proxies such as "virtual water" or "CO₂ equivalent emissions." Precautionary measures must be taken due to the unexpected character of ecosystem service constraints. As long as ecosystem-services science isn't able to pinpoint the exact causes of a given shift, it can estimate the danger of cumulative effects.

(ii) The promise, difficulties, and prospects of an ecologically based LCA¹². Dispersed ecosystem service impacts can be taken into account in environmental science and technology (EST) techniques. Using ISO protocols, life-cycle assessments (LCAs) examine all aspects of a product's lifecycle, including all of its subsystems, that may be causing stress or change to ecosystems. A few examples of how operations such as mining for raw natural resources, recycling or dumping trash, and manufacturing might impact ecosystems and its associated services include. However, the long-term effects on ecosystems as well as the services they support are not considered. Ecological LCA and current ecosystem assessments could be used to map and characterize the scope and degree of risks and consequences caused by different areas' management of ecosystems based on their geographic location. Using remote ecosystems accounting for ecosystem services which assist to industrial manufacturing of finished goods and services would be different from current attempts. To assess the effect of administration on products and services, such as diving eco-tourism (cultural ecosystem amenities), as well as other variables, like future possible mid-point contamination impacts on the marine existence elsewhere, e.g. via eutrophication potential as an ecosystem service tension, where administration stands a chance to affect the environment. Ecosystem services inside the telecoupled Anthropocene may also need utilizing data as well as tools from other ways that track material flow across geographic levels¹³. Eventually, new inventive ways will need to be created to address repercussions that are yet uncertain, such as those resulting from the introduction of non-native species or pathogens, as well as the accidental disruption of fragile ecosystems.

(iii) Countries that export natural assets and consequently bear the domestic cost of ecosystem services could adopt a national approach to accounting that is centered around the ecology of the nation in question. It is necessary to develop new natural scientific measures in order to evaluate ecosystems for numerous services and pay particular attention to those that are most vulnerable because we lack preventative, risk-adjusted, equitable wealth accounting¹⁴. Ecosystems may be monitored over time to see if they are nearing tipping points or other damaging thresholds that could jeopardize future supply, and this approach will do this by tracking the state of the "source ecosystems" over time. rather than simply tallying up the imports of palm oil or hardwood trees from tropical forests, analyses would include biophysical risk concerns, such as the likelihood that the harvesting of palm oil or hardwood trees in source habitats would impact ecosystem flows (including carbon sequestration or water regulation). Optimal interoperability would be provided by such risk-adjusted, cross-national financial accounts. It is expected that countries that import raw materials as well as ecosystem services will take into account the effect of their trade choices on off-site physical financial assets as well as their related ecosystem services.

¹¹ Scholes R J, Reyers B, Biggs R, Spierenburg M J and Duriappah A 2013 Multi-scale and cross-scale assessments of social-ecological systems and their ecosystem services *Curr. Opin. Environ. Sustain.*

¹² Othoniel B, Rugani B, Heijungs R, Benetto E and Withagen C A 2016 Assessment of life cycle impacts on ecosystem services: promise, problems and prospects *Environ. Sci. Tech.*

¹³ Liu J, Wu Y and Li S 2016 Framing ecosystem services in the telecoupled Anthropocene *Front. Ecol. Environ.*

¹⁴ Mace G M, Hails R S, Cryle P, Harlow J and Clarke S J 2015 Review: towards a risk register for natural capital *J. Appl. Ecol.*

(iv) Enable knowledge regarding the potential internalization of ecosystem service constraints into policy by harmonizing methodological components from other well-established study domains dealing with environmental effects and risk analysis. In addition to the current ecosystem evaluations, this would necessitate connecting other sustainability fields of research, such as environmental affect assessment¹⁵, such as area-based territory footprint accounting as well as fusion physiological and financial environmental elongated (multi-regional) input-output analyses. These fields include, but are not limited to: Models for identifying resource fluxes and environmental services trade-offs over distant locations could potentially be helpful in this effort¹⁶.

IV. CONCLUSIONS

Accountability for ecosystem service loads in a telecoupled globe is vital for achieving global sustainability as well as living within key physiological limits¹⁷. There is a lack of recognition and quantification of the off-stage repercussions of place-based environmental administration decisions and actions that usually have an effect beyond the jurisdiction or biophysical level of ecosystem analyses. Distant ecosystems could be brought closer to biophysical limits as a result of these effects, or they could have a negative influence on people's current and future well-being, making them undetectable to decision-makers at the regional or jurisdictional level. The first stage in resolving this gap is to recognize and quantify the currently unrecognized ecosystem service burdens. But neglecting the impact of off-stage ecosystem service obligations does not solve the problem. For off-stage ecosystem services to be exposed, we believe a revolution in ecosystem-services research is required. The policy ramifications of properly accounting for these costs would be enormous. Carbon leakage is already being addressed through REDD+ projects in poor nations, which show a strong desire to succeed forest conservation management worldwide rather than place-based.

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¹⁵Geneletti D 2013 Sustainability assessment. Pluralism, practice and progress Impact Assessment and Project Appraisal

¹⁶Harfoot et al 2014 Integrated assessment models for ecologists: the present and the future Glob. Ecol. Biogeogr.

¹⁷Steffen W, Richardson K, Rockström J, Cornell S E, Fetzer I, Bennett E M and Sörlin S 2015 Planetary boundaries: guiding human development on a changing planet Science

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