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The Paradox Persists: How to Resolve It?

CIARA RAUDSEPP-HEARNE, GARRY D. PETERSON, MARIA TENGÖ, AND ELENA M. BENNETT

The environmentalist's paradox refers to two apparently contradictory trends: declining supplies of ecosystem services and increasing human well-being. If humans are truly dependent on nature, then human well-being should deteriorate as ecosystem services are degraded. Our article (Raudsepp-Hearne et al. 2010) examined the evidence for and against four proposed explanations of this paradox. By evaluating multiple explanations, we aimed to contribute to a stronger science of sustainability by encouraging dialogue among the disciplines that address sustainability but emphasize different ways of explaining this paradox. In our article, we critically reviewed empirical evidence from a broad multidisciplinary literature about the relationship between human well-being and ecosystem services and identified areas for future research to address the important gaps in our understanding of this relationship. Consequently, we broadly agree with both Nelson and Duraiappah (see Viewpoints, this issue) that more research and data at multiple scales are needed to resolve the environmentalist's paradox. However, our perspectives differ from theirs in terms of trends in well-being, stocks and flows of ecosystem services, and the role of technology in mediating the relationship between ecosystems and human well-being.

Duraiappah suggests that examining human well-being subglobally may reveal evidence of declines in human well-being. There may very well be ways that human well-being is decreasing at smaller scales, but as yet no indicators show this decline at the global scale. There are indexes that capture additional dimensions of well-being, such as the multidimensional poverty index cited by Duraiappah (Alkire and

Santos 2010), but the spatial extent or the lack of time-series data for these indexes means that, at least so far, the data do not contradict the positive global trend of human well-being that we demonstrated in our article. However, research on multiple dimensions of human welfare—in particular, how cultural and regulating ecosystem services enable social and psychological well-being (e.g., Albrecht et al. 2007)—is sorely needed to determine whether the trends we found globally will continue to hold true as additional dimensions of human well-being are considered.

A main conclusion of our article is that researchers lack a complete understanding of how ecosystem service trends affect human well-being at different scales. There is clear evidence that human impacts on the biosphere are reducing the necessary conditions for human well-being in some places. However, data scarcity, especially at subglobal scales, makes it difficult to identify the instances in which well-being is most affected by or at risk from ecosystem degradation. Raising the living conditions of poor and vulnerable people across the globe will mean improving their ecosystem services; however, the lack of a clear understanding of how this connection works means ecosystem service management approaches that include monitoring, evaluation, and synthetic research are needed if we are to achieve long-term and equitable successes.

We argue that the concept of ecosystem services is very useful for analyzing the sustainability of social-ecological interactions, but as Nelson mentions, operationalizing the concept is challenging. Variability, dynamics, bundles, social-ecological feedbacks, and cross-scale interactions are all major challenges for ecosystem

service research (Bennett et al. 2009). Nelson and Duraiappah both raise the issue of the ability of ecosystems to produce services; Nelson in terms of natural capital, and Duraiappah in terms of inclusive wealth (which attempts to include natural capital in national accounts). We agree that understanding how natural capital produces ecosystem services is important to improving the ability to assess sustainability. The natural capital that produces multiple ecosystem services is changing, and this area is ripe for further study. However, it is easier to separate capital and services in theory than in nature. For example, for regulating services such as climate regulation or water infiltration, determining how to quantify the stocks and flows is not obvious (DeGroot et al. 2010). How changes in natural capital alter the future supply of ecosystem services is the focus of our fourth hypothesis (that there is a time lag before declines in ecosystem services have an impact on human well-being). We examined the evidence for the existence of tipping points in relation to declining stocks of services and changes in the underlying processes, such as biogeochemical cycles, and found evidence of a growing risk of tipping points that, if reached, could cause collapses in the provision of multiple ecosystem services. However, how and when these tipping points might be reached should be a major focus of scientific research.

Our assessment of the third hypothesis, that technology and social innovation have decoupled human well-being from ecosystem degradation, showed that humanity has improved the efficiency of our use of ecosystem services, but has used this increase in efficiency to exploit more services. Nelson argues that

technology is a crucial component of human adaptation and a way to avoid of the risks of ecosystem service degradation, and we agree that technology is part of the solution. However, our analysis of hypothesis three shows that scientists need to fundamentally rethink how technology is applied to the problem of ecosystem service declines. Technology will not replace functioning ecosystems, but it may allow us to improve our capacity to work in synergy with ecosystems. Researchers must develop technologies that not only reduce our impact on ecosystems but also enable people to better work with ecological dynamics to ensure that human impacts on ecosystems can be positive for both people and ecological functioning. In our article we identified agroecosystems and urban ecosystems as two areas that could greatly benefit from ecotechnological innovation.

Interest in assessing, understanding, and managing ecosystem services continues to expand. Programs to pay land managers for producing ecosystem services continue to gain momentum and interest, especially those programs related to carbon and water (e.g., Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, REDD and REDD+). These programs need a better understanding of the amounts of human well-being

generated by the multiple ecosystems services produced by ecosystems, as well as the uncertainty and complexities connected to these estimates. We hope that our article constitutes a step toward this goal by encouraging cross-disciplinary research that addresses concepts, data, and governance limitations in understanding how ecosystem services produce human well-being.

Although it has improved globally, human well-being still needs to greatly increase, particularly among the world's one billion undernourished people. We must learn to enhance the well-being generated by nature without undermining the ecosystems that provide the means to achieve this well-being. Each discipline has its own favorite explanations for the environmentalist's paradox, yet rarely do we engage in cross-disciplinary discussion of these concepts and their implications for research and policy. By bringing evidence from multiple disciplines to bear on this important question, we can confront disciplinary perspectives that see only pieces of the global whole, and come to a more complete understanding of how to effectively and sustainably enhance human well-being. We argue that doing so requires creating a science of sustainability capable of integrating the complexities of culture, human well-being, agriculture, technology, and ecology.

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