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INVITED STRATEGIC ARTICLE

Turning delivery of ecosystem services into a deliverable of ecosystem restoration

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That ecological restoration helps restore natural capital and ecosystem services (ES) of value to human and societal well-being is generally well-accepted. But quantification of these societal benefits is sorely lagging our recognition that they exist. This may be the result of methodological concerns and/or philosophical objections to the monetization of nature's services; it may also be the result of practical challenges in monitoring that already plague restoration. In this article, I argue that, regardless of whether or not restoration efforts come to rely on formal systems of payment for ES, we should be doing a better job of rigorously quantifying the socioeconomic returns of our work. Recognizing the substantial obstacles to this effort, I suggest some possible ways to overcome them.

Key words: ecosystem services, metrics, monitoring, natural capital, quantification, socioeconomic

Implications for Practice

- Ecosystem service impacts of restoration projects should be added to managers' monitoring portfolio alongside biodiversity impacts.
- Quantifying the potential socioeconomic benefits of restoration is fundamental to an evidence-based practice, regardless of philosophical, methodological, or political concerns about the ecosystem services concept.
- Money and expertise to support this additional monitoring task may come from "payment for ecosystem services" programs, funds dedicated to restoration planning, and/or better partnerships between land managers and academics.

A few years ago, I interviewed Australian land managers for a research study about the prevalence of ecosystem services (ES) as a rationale in ecological restoration. A land steward from Tasmania pointed out that his current forest restoration project would benefit society by sequestering carbon, improving water quality, reducing pests, and decreasing wildfire risk. However, none of these variables would appear in his assessment of the project's success. "All my success metrics are for vegetation condition, recruitment, and expansion of habitat," he said. There was no point in arguing for ES provision as a co-benefit of the restoration because "we can't measure it, so there's no deliverable."

Variations on this statement came up time and time again as I spoke with restoration practitioners for that study, and I have heard them repeated many times since. To be clear, it is not that the managers thought that the ES benefits to society should not be quantified; it was that they lacked the funds, expertise, tools, or institutional incentives to do it.

In this article, I call for restoration ecology to commit more fully to showing ecological restoration's impacts on human and societal well-being, by measuring that contribution as rigorously as we measure plant community composition or any other habitat variable. I argue that adopting these metrics need not be contingent on accepting the monetization of ES or involving restoration projects in payment schemes. I also identify obstacles to this effort and suggest ways to overcome them.

Why Embrace ES as a Rationale for Restoration?

ES are the benefits to human well-being derived from the functioning of ecosystems. While no one would disagree that nature provides benefits to people, using ES as a motivation for restoration has been controversial in some circles, with objections both methodological and philosophical. The methodological concerns primarily surround ES valuation (Boyd & Banzhaf 2007), such as how to assign value to nonmarket goods and services, structure payment for ecosystem services (PES) programs, or choose an appropriate discount rate. I believe that these concerns will recede as methods become standardized through waves of implementation and eventually coalesce around a set of agreed-upon best practices. Moreover, there is a long history in conservation of finding policy workarounds to buffer against scientific uncertainty and inadequate methods, such as the cost multipliers and mitigation factors common to U.S. environmental law (Rohr et al. 2018). I should make clear that measuring ES and assigning monetary value to ES are (for most services)

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two separate things; we need not subscribe wholeheartedly to the latter in order to do the former.

Philosophically, the most salient objection to adopting ES rationales for restoration is the claim that it will undermine ethical rationales (Martin et al. 2008), a phenomenon sometimes called "crowding out." Again, it's principally monetization that creates fear: fear that relying on economic arguments will weaken existing motivations grounded in the intrinsic worth of ecosystems and species. A related concern is that if restoration is undertaken expressly for the purpose of providing ES to people, then it may sacrifice ecological and biodiversity goals (e.g. monocultures of nonnative species planted for carbon storage; Lindenmayer et al. 2012).

The risks are not to be casually dismissed. A survey of restoration motivations (Hagger et al. 2017) found that projects primarily driven by ES goals tended toward more compromise in ecological outcomes than those driven by biodiversity goals. Valuation of ES may be misapplied in inappropriate contexts (e.g. in uniquely threatened ecosystems) and ES-driven projects may result in biodiversity loss (Temel et al. 2018). However, on the question of whether crowding-out occurs, the literature seems to be heavier on speculation than documentation that it exists, and some studies have even pointed to "crowding-in"—that is, a strengthening of conservation-minded behavior by the addition of monetary incentives (cited in Wunder 2013).

Practically speaking, though, none of these concerns likely loom as large with restoration practitioners as the concern that we are falling behind in the effort to reverse environmental degradation. Restoration is currently performed for a whole hodgepodge of reasons (Clewell & Aronson 2006), including economic ones: restitution for damage to coastal fisheries after oil spills (e.g. Deepwater Horizon), job creation (e.g. Working for Water in South Africa), prevention of natural disasters (e.g. prescribed burns), and more. The main problem with restoration funding is not that it comes from the wrong sources or for the wrong reasons; it is that there just is not enough of it. As far as I am concerned, whatever notion of value puts a gleam in a decision maker's eye is the notion of value that will get more restoration projects done.

I subscribe to the simple logic that expanding the set of arguments that could catch the attention of a legislator (or a donor, or a landowner, or a taxpayer) will yield more support for restoration, not less. PES programs will likely represent a net gain of funding, because they tax service beneficiaries who are not currently paying for what they enjoy (e.g. water ratepayers) or make economic actors pay in new ways for environmental degradation (e.g. carbon offset programs). Outside of PES programs, conservation projects that join ES co-benefits to biodiversity enhancement have been shown to add to the total funding available for conservation by tapping a greater diversity of funding sources (Goldman et al. 2008).

But here's the rub: if we want to talk up ES co-benefits of what we are doing in restoration, we are going to have to put our measurements where our mouths are.

How Can We Measure Restoration's Impacts on Human and Societal Well-Being?

So far, we are not doing this very well. A review of the published literature in 13 journals from 2000 to 2008 concluded that restoration ecologists were vastly underselling the socioeconomic benefits of restoration (Aronson et al. 2010). The value of ES was rarely referenced, and then mostly at the landscape or ecosystem scale. Down at the project scale, a review of Global Restoration Network data showed that social and economic values such as ES provision, though frequently cited as project goals, were infrequently measured (Hallett et al. 2013). Similarly, a wide-reaching meta-analysis turned up just 56 published studies that quantified an ES and compared outcomes from restoration to degraded and reference sites (Benayas et al. 2009); these were mostly focused on basic ecosystem functions, like primary productivity and nutrient cycling. Wortley et al. (2013) found 301 articles that measured restoration outcomes, of which a mere 3.5% included social and economic attributes. As a final example of how little we have to work with, an analysis showing that restoration routinely pays back more in benefits than it incurs in costs (De Groot et al. 2013) had to rely on extremely coarse assumptions about the effect of restoration on ES, because published studies quantifying the benefits were simply unavailable.

Monitoring the change in fluxes of ES at the project scale would provide critically needed data to inform decision-making processes that increasingly incorporate ES information, including cost–benefit analyses, disaster relief funding, scenario planning for climate mitigation, and spatial models of land-use change (Guerry et al. 2015). Typically these processes rely on benefit transfer—the idea that the value of nonmarket goods and services estimated in one place can be applied in another—to fill in data gaps (Richardson et al. 2015). More localized data, and especially data that can distinguish levels of services between degraded, restored, and undisturbed systems, will help refine these estimates.

What I am calling for is a tall order, I know. Restoration practitioners already struggle to effectively measure project success (Suding 2011), and many smaller organizations have no funding for monitoring beyond what is required for project compliance. However, to the extent that organizations are able to devote resources to monitoring, ES provision should definitely be in the portfolio. And as PES programs proliferate, they may provide built-in funding for monitoring, by requiring verification of the benefit as a condition for payment. Another promising opportunity I have recently explored with managers is to make the argument to funders that the results of prior restoration projects should inform planning for new ones; in this way, funding dedicated for project planning can be leveraged to monitor outcomes at existing sites, and practical knowledge builds on itself.

Another obstacle is the sheer variety of ES that might be measured. Who will provide the expertise to monitor water quality and pollination and carbon storage and nutrient cycling and wildlife viewing, and so on, everywhere? Clearly, it is impractical for managers to monitor every service; however, we do need to look at multiple services simultaneously, and this could be more feasible if academic scientists collaborated better with land managers. Yes: monitoring is highly "unsexy," and research grants to academic scientists prioritize answering cutting-edge questions, not data collection. However, research into the question of ES bundles and trade-offs (Raudsepp-Hearne et al. 2010)—that is, whether particular services are maximized or minimized in concert with others—does attract research dollars, and such work could easily involve project-scale monitoring. We can also observe interest from governmental conservation agencies in developing multivariable "rapid assessment" methods for wildlife and resource management outcomes, and infer that this interest is extensible to ES.

Assuming a project manager has funding and personnel for monitoring, which are the most important services to consider, and what metrics should be used to quantify them? Some of the most abstract or intangible services, such as esthetics, defy easy measurement; others have multiple metrics to choose among. (A recent paper on pollination services [Liss et al. 2013] found a total of 62 different combinations of measurement variables in 121 papers.) My advice to managers is, all else being equal, to choose: (1) services that are more directly affected by the restoration activity than those that are less directly affected (e.g. carbon storage over air quality in a restored coniferous forest); (2) higher-order/integrated metrics over lower-order/individual metrics (e.g. visitor surveys over simple visitor counts for wildlife viewing); (3) greater relevance to local beneficiaries over lesser relevance to local beneficiaries (e.g. pollination in an agricultural region, recreation in an urban region); and (4) more relatable or tangible benefits to humans over more abstract benefits (e.g. reduction of flammable fuel load as a benefit of invasive species removal, over reduction of soil N saturation). No one is going to be able to measure everything; seriously, measuring *anything* would be a good start.

There is one other obstacle, one that plagues all conservation efforts: an aversion to taking any measurements that could show funders that the project is not as successful as promised. This may manifest itself as choosing the quantification of effort (kilometer of fencing to exclude stock) over the quantification of outcomes (improved water quality from stock exclusion). This is certainly understandable when managers have control only within the boundaries of a project that is set within a larger landscape context. As one floodplain manager put it, "I don't want metrics; too many things are outside my control. If I say I expect doubled smolt production on my fish passage project, and someone puts in a barrier downstream, I'm screwed." Compounding the problem is that restoration is often slow and messy and full of initial disturbances that can make the recovery of ES benefits lag the restoration effort by years. Frankly, I do not have a good solution for this problem, except to say: We are either an evidence-based discipline, or we are not. We need to evaluate restoration success; we need to choose metrics that make sense in our temporal and spatial contexts; we need to apply them even if the answers might dismay us; and we need to explain our failures as well as our successes.

Again, I recognize that asking land managers to add ES to their monitoring portfolio is asking a lot. But I see signs that it can be done. Recently, an effort to restore wet meadows in the Sierra Nevada mountains of California went forward with funding from the state's cap-and-trade program for greenhouse gas emissions. In addition to the hydrological work itself, funding was budgeted to develop protocols to measure the projects' climate impacts, including carbon storage in soil and biomass, and fluxes of CO_2, N_2O, and CH_4. At the outset of the project, it was unknown if the restoration could indeed promise a deliverable of net carbon sequestration, or if greenhouse gas emissions from the meadow rewetting would tip the balance the other way (and, in fact, the data are not all in yet). The important thing is, the funders and project leaders were willing to devote the resources to figuring it out. As ecologists and practitioners, we should be seeking any such opportunity to measure the good that we do.

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