5 Missing Feedback in Payments for Ecosystem Services

A Systems Perspective

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ABSTRACT

A general systems analysis of current approaches to payments for ecosystem services reveals a weakness, a missing feedback that ought to be in place pushing the system toward its goal of balancing human needs with the adaptive capacity of ecosystems. In situations of rising demand for ecosystem services, among limited means for producing them, the likelihood that payment systems effectively shift, but do not preclude ecosystem service losses is high. We propose that explicit price or information signals to ecosystem services consumers would create the necessary feedback, thereby "closing the loop", and increasing the likelihood that efforts to stem declines in ecosystem services will succeed. To date, attention for this feedback loop has been more casual, than concerted. As a result, PES systems have perhaps left unharnessed the full range of opportunities to reduce the growing deficit between rates of ecosystem service supply and the rate that society utilizes (and in many cases, impacts) them. The importance of the construction and conceptualization of these feedback loops, among the various tools at hand for adaptive responses to the challenges of sustainable development, are discussed.

Keywords: ecosystem services, complex systems, feedback, consumption, supply and demand

Introduction

In November 1990, at a café in the central square of Siena, Italy, the theme of the upcoming ISEE conference in Stockholm in 1992 was discussed. The working title of the conference "Maintaining Natural Capital" did not really capture the essence of the issues to be raised. In an intense discussion Herman Daly suddenly proclaimed "Let's use 'Investing in Natural Capital' instead" (Jansson et al.., 1994). The shift from maintaining (in essence preserving the stock of capital) to investing marked recognition of renewable natural capital as a dynamic entity that needs to be understood and actively managed. The shift

> gave credit to the fact that it is not sufficient to assume that if we only live on the rent of the natural capital stock it will be conserved. Instead we will have to find ways to value and manage the capacity of natural capital to generate and sustain the rent, actively adapt to the dynamic nature of complex systems and learn to live with uncertainty and surprise (Costanza et al., 1993; Levin, 1999; Carpenter et al., 2001; Limburg et al., 2002).
>
> Ekins et al. (2003, p. 160)

In the "Critical Natural Capital" special issue in *Ecological Economics*, Ekins et al. (2003) recounted a particularly inspiring moment in ecological economics history, which occurred during a formative period for ecosystem service documentation, awareness-raising, and research. It recalled a shift from *maintaining* natural capital, to *investing in* natural capital, and underscored the need for management of complex natural systems to produce the ecosystem services future generations would need to survive.

The effect of language choice has been important, both in the success of some trajectories of ecosystem service research, and in the conceptual bounds that it places on lines of inquiry. *Investing, capital, value,* and *rent* are all terms deeply resonant with American and other capitalist societies. However, *investment in* natural capital emphasizes supply or holding capacity and the flows into the stock of natural capital, whereas *maintaining* natural capital (as in a stock to be maintained) would attract attention to both inflows and outflows. Herman Daly's work has long called attention to living within the biophysical capacity of the planet, a goal which must be met both by moderating (investing in) the supply of natural capital, as well as the demands placed on it (Daly, 1974, 1996; Daly and Farley, 2004). Yet the body of work produced by ecological economists since 1990 has more often focused on the supply, rather than the demand side of the ecological economics equation. There are exceptions of course, most notably the ecological footprint (Rees, 1992; Wackernagel and Rees, 1996, 1997) and the collective work of Inge Røpke (e.g., Reisch and Røpke, 2004).

There is no question that it is important to invest in the stocks of natural capital for all the reasons Ekins et al. (2003) lay out. However, we argue that it is equally and perhaps more important, given the trajectories of current society, to investigate, experiment with, and socially invest in curbing demands on natural capital systems. This paper adopts a systems perspective to call attention the absence of demand-side information in current approaches to payments for ecosystem services and identifies opportunities for corrective intervention.

Method

As established by Jay W. Forrester at MIT in the 1950's, systems theory was originally developed for military application (e.g., guidance systems). The concept was applied early on to urban dynamics (Forrester, 1969) and world dynamics

(Forrester, 1971), revealing new and often counter-intuitive implications of policy decisions over time. Systems theory has since found resonance within many fields, from business management (Senge, 2006), to macroeconomics (Witt, 1997; Liu, in press), to fisheries biology (Collie and Walters, 1987), and underlies the concept of adaptive management (Walters and Holling, 1990).

At its simplest level, a "system" is characterized by at least one stock (an accumulation of matter, energy, information, etc.) and at least one flow into or out of that stock. An open system is one where outflows respond to but do not influence inflows. A closed system is one where outflows both respond to and influence inflows allowing for learning and adaptation via information feedbacks (Figure 1).

The feedback loop is a defining structure of complex adaptive systems and the logic underlying systems theory. Feedback loops drive the non-linear behavior seen in many natural and social systems (e.g., predator-prey population cycles, neo-classical economic laws of supply and demand). Positive feedback loops reinforce flows into or out of a system, pushing it away from equilibrium, while negative feedback loops regulate flows, bringing a system closer to a desired state or equilibrium. To "close the loop" requires a stock (state of the system), information about that stock (perceived state), and a decision rule (goal) affecting the flow into and out of the stock.

Systems analysis is a field of inquiry seeking to understand and increase the efficiency and effectiveness of any number of social, ecological, industrial, organizational, and other systems by taking a "systems approach" and therefore explicitly exploring feedback loops. By understanding how a system is functioning (identifying its stocks and flows) one can catch a glimpse of leverage points at which change can be targeted to increase performance (Meadows, 1999).

A general systems analysis of current approaches to payments for ecosystem services (PES) reveals a weakness. Current programs are set up as open systems, within which there is not sufficient information to create a feedback loop that addresses the discrepancy between the perceived state of the system and the

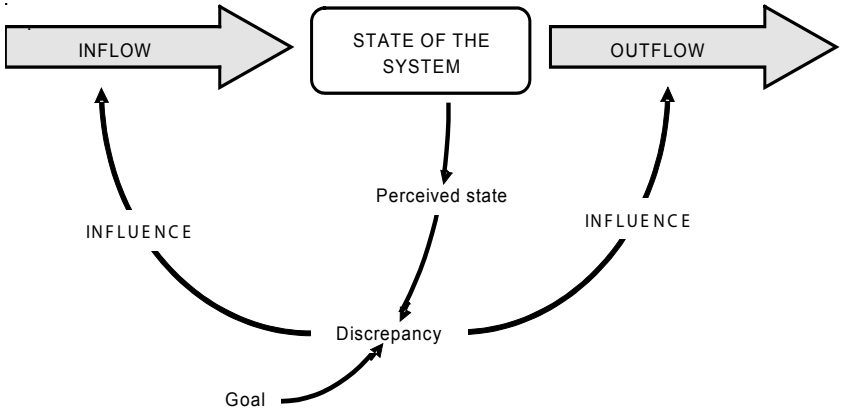

Figure 1 Basic system diagram (based on Meadows, 1999)

stated goal or desired outcome. The next section will apply the systems perspective described above to PES approaches. We explore the stated goals, structure of payer-payee relationships, and targeting methods. We conclude with a conceptual solution as well as directions for future research.

The Problem

Ecosystem services declines are well documented and the drivers of this decline—population growth, affluence, technology, land use change, etc.—widely explored (MEA, 2005; Rees, 2006; Ehrlich, 2008; Ehrlich and Daily, 1992; and many others). The declines are symptomatic of a reduced planetary ability of natural systems to adapt and regenerate, and translate to a reduced biological capacity to support human life on Earth. Concerns for the rapid rates of decline have lead to calls for quantification, assessment, monitoring, and investment in critical natural capital (e.g., De Groot, 2003). Natural capital represents an extension of the concept of 'land' as a factor of production, has both nonrenewable and renewable dimensions, and includes generation of ecosystem services and other life-supporting functions (De Groot, 1992; Costanza and Daly, 1992; Ekins, 1992). Critical natural capital has been defined as that part of the natural environment that performs important and irreplaceable functions (see special issue in *Ecological Economics*, Ekins et al., 2003).

Payments for ecosystem services (PES) have recently been brought forward as a market-based response to declines in ecosystem services, largely through spurring investment in natural capital, especially in the biodiversity rich tropics. There are four general characteristics of a PES transaction (Wunder, 2005):

1. Voluntary;
2. Well-defined service;
3. Well-defined buyer(s) and seller(s); and
4. Contingent on actual service provision (subject to monitoring, verification).

Broadly considered, PES schemes attribute market characteristics to ecosystem service production. The most specific of these translate ecosystem services (e.g., carbon sequestration) into something that can be traded, such as carbon credits. Some interpretations of ecosystem services are more general and don't enter markets in a tradable sense, for example conservation easements which are strictly place-based.

Further, there are three criteria commonly considered for targeting PES systems to maximize economic efficiency and conservation effectiveness (Pagiola, 2008; Wünscher et al., 2008; Wendland et al., forthcoming):

1. Level of service provision (benefits);
2. Risk of land conversion and therefore service loss (vulnerability); and
3. Landowner participation cost (foregone income, transaction costs, etc.).

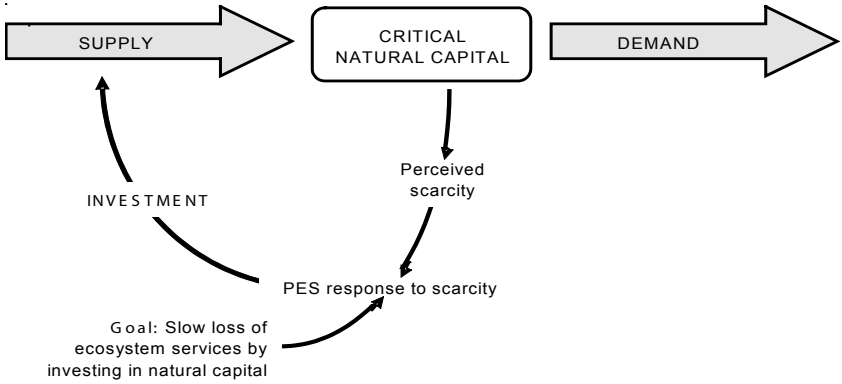

Figure 2 PES as an open system, supply-side focused intervention

The stated or implied (often it is not directly stated) goal of PES schemes is to slow the loss of ecosystem services, by investing in and improving the supply of ecosystem services. We argue that, from a systems perspective, this is necessary, but not sufficient as a goal because it does not reflect a desired system *state*, leaving the system "open" and devoid of necessary feedback (Figure 2). Imagine that your doctor told you she was going to help you bleed to death more slowly by carefully infusing more blood. Would you feel optimistic about your overall, long term health? If a second treatment option were offered that would not only slow the bleeding, but stop it and provide you with information on how to avoid injury in the future would you feel more secure and empowered to change your behavior, even if it were more expensive?

The implicit goal, too often unstated or understated, of sustainable development is "the maintenance of ecological functionality within the context of economic and social wants and needs" (Straton, 2006, p. 409). It is towards this goal that PES programs, individually and collectively, and along with the entire suite of conservation, restoration, and sustainable development mechanisms ought to strive. PES systems currently focus almost exclusively on slowing the loss-rate by constructing mechanisms for service providers to receive payment for supplying valuable ecosystem services. As supply-side interventions, PES (and other approaches not addressed here) are currently missing the opportunity to also engage and impact consumer demand for ecosystem services.

The Solution

Among the principal drivers of ecosystem services declines are population and consumption (Ehrlich and Holdren, 1971; Ehrlich and Ehrlich, 1990; MEA 2005). In situations of rising demand (population growth and increasing affluence) for ecosystem services, among limited means for producing them, the likelihood

that payment systems effectively shift, but do not preclude ecosystem service losses is high. In other words, if declines in ecosystem service provision are symptomatic of the loss of productive and adaptive capacity within ecosystems (including those that are "protected" from conversion), then current PES investment solutions are necessary but not sufficient to solving the more fundamental problem.

If, however, mechanisms can be developed that provide accurate, current, digestible information about the state of critical natural capital (to individuals, governments, etc.) behaviors and regulations can react, can adapt, and push the system in the right direction. It is important that these mechanisms include the full suite of available social actions, not only from the supply side but also demand side in order to maintain critical natural capital and maximize net social benefit.

We propose that where possible, payments for ecosystem service schemes should be modified to create an explicit price or information signal to ecosystem services consumers of the scarcity of critical natural capital, creating the missing feedback and thereby "closing the loop" (Figure 3). PES schemes structured around a more direct link between service producers and end consumers via higher prices for and more complete information regarding the source and impact of consumable natural resources provide the opportunity not only to secure supply (by compensating landowners/managers) but to also inform and reduce demand.

The price needs only to be high enough to pass information to the consumer about the impacts of their behavior on the stock of critical natural capital. This may be accompanied by additional, non-monetary information relevant to strengthening the link and the power of the regulating feedback loop.

There are various degrees of this feedback loop functioning in current PES programs. The feedback loop can be said to be functioning depending on the degree to which the payment or accompanying information succeeds in moderating consumer behavior (in conjunction with other options such as addressing supply).

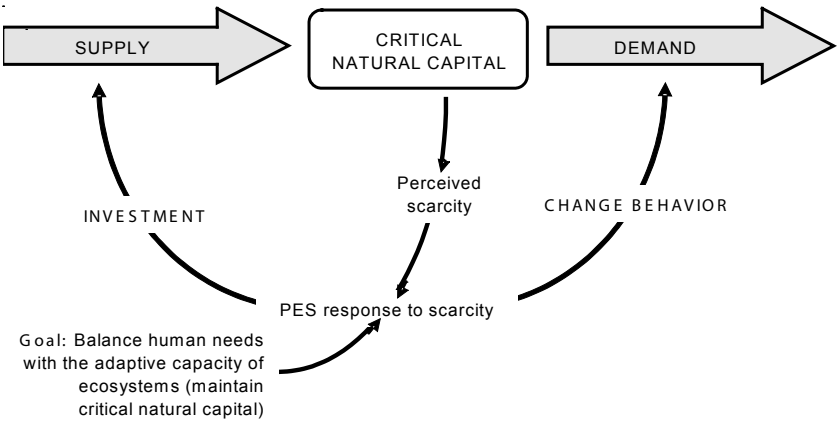

Figure 3 PES as a closed system, supply- and demand-side interventions

One example would be a successful bottle return program, wherein consumers are charged the full cost of the bottle upfront but reimbursed the waste disposal fee when they make the effort to recycle. Consumer behavior is directed towards recycling in an effort to reduce demand for the waste assimilation services of nature.

The right-side feedback loop is not functioning when neither payment nor information feeds back to the consumer, thereby missing an opportunity to address ecosystem service scarcity by reducing demand. One example of a payment system not functioning is when a conservation organization pays a forest landowner not to convert land to a strip mall, while the demand for strip malls is such that development occurs elsewhere (also known as leakage). Here the ultimate driver of development, consumer demand, is unaffected by the conservation action. A similar situation exists within the voluntary carbon market. While some consumers choose to pay to offset their carbon footprint many others opt not to, either because of a lack of or dismissal of available information. A mandatory carbon tax, on the other hand, would eliminate the free-rider problem; higher prices reflecting more of the true costs of consumption would be passed onto consumers. Ideally, this would positively influence demand-side pressure on the ecosystem service of climate-regulation, whereas a supply-side approach would be to (philanthropically or otherwise) incentivize carbon sequestration.

Closing the Loop: A Costa Rican Application

Costa Rica's national PES program is among one of the first and most widely known PES systems (Russo and Candela, 2006; Chomitz et al., 1999; FONAFIFO, 2005). Some have concluded that the simple, flat payment structures would be more effective if payments were targeted towards areas of high value, high vulnerability, and low cost (Sanchez-Azofeifa et al., 2007; Hartshorn et al., 2005). We would posit a second critique that because the program was designed to maintain and increase the *supply* of ecosystem services and because payments were largely funded through grants and a fuel tax (not directly related to the services themselves) the opportunity was lost to connect to both supply and demand.

Current lines of research have focused on how effective the Costa Rica PES program has been in addressing in-country and global declines in ecosystem services. Some have suggested that declines in deforestation may have resulted, even in absence of the PES systems (Sanchez-Azofeifa et al., 2007; Hartshorn et al., 2005). The rapid establishment of tourism may have acted as additional incentive to retain forest, but as an industry with high net impacts to natural capital (Gössling and Hall, 2008), may ultimately create additional ecosystem service pressure, rather than reduce it. We draw attention to this issue because, at the broadest scale, incentivizing the supply of ecosystem services from forested areas while at the same time increasing the demands on those areas is an example of the open system problem we believe PES systems can, with consideration, better address in the near future.

We also see existing PES programs serving as positive examples to be built upon. For example, the FONAFIFO PES program includes a nominal water tariff. In 2005 this fee was increased and committed to within-watershed conservation via payments to upstream landowners. Charged to holders of water use permits and passed onto commercial and household consumers, the fee represents a shift from voluntary agreements to compulsory payments (Pagiola, 2008). Two things about this approach are notable: first, it is helping to raise baseline household awareness of what ecosystem services are (clean drinking water), where they come from (forested areas), and how they are enriched (through conservation and restoration). This information is contributing to a positive (reinforcing) feedback loop on the supply side by connecting forest conservation with an increasingly popular image of 'green' Costa Rica being used to market other environmental services to outsiders, for example through tourism ventures. Second, it is creating a direct price signal that, along with the information passed onto the consumer, may reduce demand. Due to the small monetary value of the fee, it could not yet be said to be regulating demand (creating a negative or balancing feedback loop), but does create a placeholder in which such a feedback can develop over time.

Conclusions and Future Research

Payments for ecosystem services policies, programs, and research have demonstrated numerous benefits. Yet there are also weaknesses, namely an inability to deal with the modern penchant for consumption bordering on *affluenza* (De Graaf et al., 2001) and an accompanying reticence to examine and autoregulate consumption decisions. This paper has explored, from a systems perspective, the consequences of a (to date) fairly narrow focus in constructing payment for ecosystem service schemes. We argue that this has emphasized investment in the supply of natural capital without concomitant attention to maintenance of natural capital from the demand side.

Ours is only a conceptual solution to the problem, namely the use of price and information signals within PES schemes as carriers of information on the scarcity of critical natural capital back to its consumers. However, we see potential to be explored with more concerted and specific research and examples. Obviously creating such a closed loop PES system that directly engages both producers and consumers is difficult, or else we would be doing it already. Crafting such a system requires data sources and collection frameworks that are at present unavailable or underdeveloped (Beier et al., 2008). Efforts to quantify and spatially link production and consumption of ecosystem services such as fish, timber, recreation, carbon sequestration, water provision, waste assimilation, etc. should be encouraged. Non-consumptive uses of ecosystems are frequently impacted by consumptive uses. Therefore we also stress the importance of directing thought, consideration, and research toward the considerable challenge of how to create the same informational feedback (signal) for non-marketable ecosystem services

(e.g., biodiversity existence value, cultural values). Additional areas of inquiry may be how to bundle these services with other, marketable services (e.g., water, carbon), or account for dynamic economic transitions (such as the transition from agrarian to tourism industries in the Costa Rica example, above).

Our point is not to argue that the capitalist system is ultimately capable of correcting declines in ecosystem services and sustaining critical natural capital, even if payments for ecosystem services are more directly connected to consumer demand. This will require much broader, more comprehensive reform. Left particularly unaddressed (both in this paper and by the capitalist system more fundamentally) are the unmet needs of equity and distribution. Similar challenges exist for applying market based solutions to ecosystem service deficits, and further documentation is needed to confirm whether PES has corrective potential in this area (Wunder, 2008).

Implementation of a more direct and closed system broadly seeking the goal of balancing human needs with the adaptive capacity of ecosystems also demands an accompanying shift in thinking about personal and collective responsibility for stewardship of the planet, and extensive research and emphasis in the areas of behavioral change and quality of life. Consumption is closely tied to current measures of wellbeing (e.g., GDP) and, by extension, reducing consumption is still widely viewed as causing suffering or reducing wellbeing (Redefining Progress, 1995; Cummins et al., 2003), it often incites argument over the distributional impact of conservation and sustainable development policies (e.g., "green" tax reform, see Metcalf, 1998; Turner et al., 1998), and stimulates concerns that efforts to curb deficits in ecosystem services will result in further exploitation by others (e.g., Jevon's paradox as described by Wackernagel and Rees, 1997). These fundamental and sensitive issues need further exploration from multiple perspectives and scientific fields. Ultimately, the demand side of ecosystem services is fertile, largely uncharted territory for transdisciplinary investigation in the field of ecological economics.

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