CORRECTED 9 DECEMBER 2011; SEE LAST PAGE

SUSTAINABILITY

Paying for Ecosystem Services—Promise and Peril

Payment mechanisms designed without regard to the properties of the services they cover may be environmentally harmful.

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The Millennium Ecosystem Assessment concluded that over the past 50 years, 60% of all ecosystem services (ES) had declined as a direct result of the growth of agriculture, forestry, fisheries, industries, and urban areas (*1*). This is not surprising: We get what we pay for. Markets exist for the products of agriculture, aquaculture, and forestry. But the benefits of watershed protection (*2*), habitat provision (*3*), pest and disease regulation (*4*), climatic regulation (*5*), and hazard protection (*6*) are largely unpriced. Because existing markets seldom reflect the full social cost of production, we have incorrect measures of the scarcity of some ES and no measures for the rest.

There is growing support for using markets to induce people to take account of the environmental costs of their behavior (*7*). Markets that allow trading of industrial emissions or fishery harvest rights have been in use for some time (*8*). These have recently been supplemented by development of marketlike mechanisms—payment for ES (PES) schemes—that allow governments and nongovernmental organizations to pay for environmental public goods, such as habitat provision, watershed protection, or carbon sequestration (*9*). Although they involve buyers and sellers in service provision contracts, PES schemes do not generally allow free exit and entry, or iteration toward a clearing price. Mechanisms of this kind promise much, but if poorly designed they can make things worse, not better. We identify both the main failings in existing environmental markets and marketlike mechanisms and the conditions that need to be satisfied for new mechanisms to do better.

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Market Promise, Not Panacea

Markets, among the most durable of human institutions, tend to arise when resources are recognized to be scarce (*10*, *11*). It is not surprising, therefore, that they initially emerged around basic ingredients for survival, nor is it surprising that they failed to emerge for resources whose impacts on well-being were simply unknown (e.g., the impact of early industrial emissions on health). What is surprising is that markets have not developed for many scarce ES long recognized to affect human well-being. The explanation lies partly in the public-good nature of those services (e.g., climatic regulation through carbon sequestration), partly in the lack of well-defined property rights (e.g., sea areas beyond national jurisdiction), and partly in the various costs of forming markets (e.g., the cost of reversing historic pollution rights in agriculture).

Many environmental markets created in recent years are intended to address these issues, but markets are not a panacea. Prices are only useful indicators of changes in resource scarcity if they capture all significant effects of resource use (*12*). Mechanisms require careful design to be effective. The first U.S. market for sulfur dioxide (SO_2) emissions, for example, recently collapsed because the design addressed only one of many interacting pollutants. Court rulings acknowledging transboundary effects of these interactions led to proposals to form new market structures, but not before resulting uncertainty had driven SO_2 market permit prices to zero (*13*).

Mechanism Design and Implementation

Effective mechanism design demands understanding of both the linkages among biodiversity, ecological functioning, and ES (*14*–*16*) and the incentives for private provision of these resources, created in part by their public-good nature. There are four main mechanisms for motivating people to provide scarce ESs that are public goods (*17*):

(i) Regulation and penalty. Zoning restrictions, emission limits, or access rules are enforced through penalties for noncompliance. (ii) Cap and trade. The emerging carbon markets, for example, allow users to buy and sell emission rights within the constraints imposed by a cap. (iii) Direct payments. Providers receive payment for supplying services. (iv) Self-regulation. Voluntary agreements and social norms encourage "good" behavior while penalizing noncompliance.

Which mechanism is "best" depends on the properties of the ES in question and on prevailing socioeconomic and political conditions (see the table). Mechanisms that work for public goods that are the sum of the efforts of many countries [e.g., carbon sequestration under the Reducing Emissions from Deforestation and Forest Degradation (REDD) scheme] may not work for public goods that depend on efforts of one country (e.g., control of emergent zoonotic diseases through market interdiction).

Ecosystem service markets and PES schemes, types (ii) and (iii), are emerging as the preferred mechanisms (*18*–*20*). PES schemes exist for carbon sequestration in China (*21*) and the United Kingdom (*22*); watershed protection in South Africa (*23*) and Mexico (*24*); and biodiversity conservation in the United States (*25*), Costa Rica, and Nicaragua (*26*). But often these mechanisms are imposed without due regard to the properties of the services they cover (see the table). Nor are the prices they generate directly responsive to changing conditions. Some ES markets are too "thin" (early carbon-offset markets involved too few trades for prices to track conditions), and others suffer from design flaws (the U.S. SO_2 market described above). Often the science is uncertain or ignored (PES schemes for water supply through afforestation face uncertainty about the net effects of changing forest cover), or payments reflect goals other than the scarcity of resources (the poverty alleviation goals in PES schemes for biodiversity protection in agricultural landscapes limit payment sensitivity to habitat condition) (*27*).

Few schemes address multiple ES, yet interdependence between services generates unwanted feedbacks. Incentives that encourage production of one service may have adverse effects on others (*28*). For example, incentives for carbon sequestration under the REDD scheme may simply cause carbon-emitting activities to be relocated. Incen-

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tives for biofuels production that promote conversion of tropical forests to tilled fields may reduce both carbon storage and habitat that supports biodiversity (*29*). Incentives for habitat protection that create corridors between protected areas may increase disease risks by increasing contact between wild and domesticated animals (*30*). Where ES are jointly produced, paying for only one service can be as damaging as paying for none.

Private Incentives Are Not Enough

Payments for ES may replicate the incentive effects of markets in cases where the provision of environmental public goods depends on private activity. But there are many cases where payment systems will simply not be appropriate (e.g., where ES derive from lands or seas beyond national jurisdiction).

Where it is not possible to use prices as indicators of the scarcity of ESs we need other metrics. Physical indicators of the state of ecosystems need to be integrated into national income and product accounts and made comparable to other measures of income. Progress has been made in developing satellite accounts for environmental flows through the United Nations System of Environmental and Economic Accounts (SEEA). Although separate from the national income accounts, these still allow comparison with conventional measures of economic activity and can be reproduced consistently over time (*31*). Proposals exist to extend the national income and product accounts to include environmental flows (*32*) and to develop consistent, comprehensive wealth accounts that include changes in environmental assets (*33*). Although the tractability of these approaches has been demonstrated, too few countries, including the United States, are doing any of this, in part because it would make implications of resource allocation transparent.

Finally, for ES that may benefit from payment systems, how we pay is critical. Payment schemes should capture all effects of ecosystem management (e.g., affecting multiple ES). They should consider scale (e.g., how country-to-country payments translate into within-country payments to landholders) and lead to measurable, verifiable outcomes that go beyond what would have happened in the absence of the payment scheme. Most important, they should not be burdened with objectives such as income transfers that go beyond delivery of ES. This is one of the hardest lessons of decades of politically driven agricultural subsidies. One reason for the popularity of PES systems is their potential role in poverty alleviation (*34*). Poverty reduction is a laudable goal, but it should not prevent PES schemes from signaling the scarcity of ES. Every payment system has implications for equity; although these effects may be extremely important they should be addressed separately, not through payments made under the scheme.

Ecosystem service	Public-good type (A): Reflects the efforts of many	Reflects the efforts of a few	Depends on strongest provider	Depends on weakest provider	Verifiability (B): Local	National	International	Space (C): Providers, beneficiaries colocated	Providers, beneficiares not colocated	Time (D): Benefits accrue now	Benefits accrue in the future	Jurisdiction (E): Local	National	International (subglobal)	International (global)	Mechanism (F): Regulation and penalty–Type (i)	Cap and trade–Type (ii)	Direct payments–Type (iii)	Self-regulation–Type (iv)
Air-quality regulation		✓			✓			✓		✓			✓	✓		dark	dark	light	medium
Carbon sequestration	✓				✓		✓		✓		✓				✓	light	medium	dark	light
Disease control				✓	✓	✓	✓		✓	✓					✓	light	light	light	light
Freshwater provision		✓			✓			✓		✓		✓	✓			medium	light	dark	light
Habitat provision		✓	✓		✓	✓			✓	✓	✓		✓	✓		light	medium	dark	medium
Marine capture fisheries	✓					✓	✓		✓	✓	✓		✓	✓	✓	light	medium	light	light
Storm protection		✓		✓	✓			✓		✓			✓			medium	light	medium	light
Water-quality regulation		✓			✓	✓		✓		✓			✓			dark	medium	dark	light

Characteristics of ecosystem services and payment mechanisms. The table schematizes authors' impressions of the effectiveness of incentive mechanisms (column F) in providing environmental public goods. Column A classifies a sample of ES as public goods (*35*). Column B indicates the scale(s) at which delivery of a service can be verified (*20*). Column C denotes the geographic location of providers relative to beneficiaries (*27*). Column D and E indicate timing (*20*) and the governance level(s) needed to achieve effective outcomes (*36*). Darker shading in column F indicates mechanisms considered more effective for achieving the socially optimal level of provision, although effectiveness is context-dependent.

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10.1126/science.1210297

ERRATUM

Post date 9 December 2011

Policy Forum: "Paying for ecosystem services— Promise and peril" by A. P. Kinzig *et al.* (4 November, p. 603). An acknowledgment should have stated: This document was prepared by participants of a special workshop of the Global Land Project (International Geosphere–Biosphere Programme and International Human Dimensions Programme) held at the Global Land Project 2010, Open Science Meeting, Arizona State University, Tempe, AZ, 17 to 19 October 2010. Support specific to the workshop was provided by NSF (SBE 1025699), National Aeronautics and Space Administration (NNX10AK05G), and National Oceanic and Atmospheric Administration (through the University Corporation for Atmospheric Research).