



LETTERS

edited by Jennifer Sills

Carbon Shifted But Not Sequestered



Release. Carbon dioxide returns to the atmosphere as speleothems form.

leothems), the associated carbon dioxide will be returned to the atmosphere. If carried into the oceans, it may be sequestered as shells or reefs, again with the release of the carbon dioxide. There will therefore be no net sequestration of carbon dioxide, but rather a transfer to the oceans, where it will equilibrate over time with the atmosphere.

Because a mole of fossil carbon dioxide from limestone is remobilized by the reaction of a mole of atmospheric carbon dioxide, there is also a net increase in the carbon dioxide cycling between the atmosphere and the oceans.

Chemical weathering of basic igneous rocks, where there can be net sequestration of carbon dioxide to form insoluble carbonates, is the substantial inorganic “carbon sink,” as shown by the enormous deposits of carbonate rocks worldwide.

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Response

CURL MAKES A VALID POINT ABOUT THE BEHAVIOR of carbonate minerals on multimillion-year time scales. Our interest, though, is in the much shorter time scales of decades to centuries. Considering remaining uncertainties in measuring some aspects of the global carbon cycle and the relatively rapid environmental changes under way in the atmosphere and oceans, quantifying carbon budgets in relevant geological systems for these shorter time periods may be more complicated (1). Our task is to better understand rates and processes associated with mineral weathering and impacts on carbon cycling.

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THE NEWS & ANALYSIS STORY “AN UNSUNG CARBON SINK” (C. Larson, 18 November 2011, p. 886) states that the erosion of limestone by carbonic acid formed from atmospheric carbon dioxide may constitute an “underappreciated carbon sink,” partially mitigating the increase of carbon dioxide from anthropogenic sources. This mitigation is only possible if the captured carbon dioxide is sequestered in an unreactive form. In this case, it is not.

Weathering of limestone consumes carbon dioxide to form soluble bicarbonates in solution.

If redeposited as calcite (e.g., as travertine or spe-

leothems), the associated carbon dioxide will be returned to the atmosphere. If carried into the oceans, it may be sequestered as shells or reefs, again with the release of the carbon dioxide. There will therefore be no net sequestration of carbon dioxide, but rather a transfer to the oceans, where it will equilibrate over time with the atmosphere.

Because a mole of fossil carbon dioxide from limestone is remobilized by the reaction of a mole of atmospheric carbon dioxide, there is also a net increase in the carbon dioxide cycling between the atmosphere and the oceans.

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Ecosystem Services: Heed Social Goals

IN THEIR POLICY FORUM “PAYING FOR ECOSYSTEM SERVICES—Promise and peril” (4 November 2011, p. 603), A. P. Kinzig *et al.*

identify a series of conditions that would need to be satisfied for payments for ecosystem services (PES) to succeed. They also highlight the reasons that potential ecosystem service buyers feel uncertain about the system, potentially choking the demand for services. However, Kinzig *et al.* fail to account for the role of service providers and the factors that might spur or undermine their willingness to supply ecosystem services in exchange of payment. Growing evidence shows that non-economic factors are highly influential in shaping service providers’ sustained participation in PES (1).

Kinzig *et al.* describe PES as an instrument that primarily pursues cost-effective conservation goals regardless of collateral social implications. Such decoupling is ethically untenable in a growing number of places where top-down PES schemes are quickly spreading without proper understanding of service providers’ needs and the potential impacts of PES on their livelihoods. When parachuted into rural communities of the developing world without market power or political voice, PES—including payment related to clean development mechanisms and REDD (Reducing Emissions from Deforestation and Forest Degradation)—can enhance existing inequalities in income, access to resources, and decision-making if pro-poor management measures are not considered (2, 3). On the ground, institutional complexities can easily lead to misrepresentation of the poor and “elite capture” (in which some benefit more from the services than others) (4).

Taking fairness and participation issues into account might be somewhat discomfiting to some scientists and practitioners working on market-based instruments for conservation. Nonetheless, PES that separate conservation effectiveness from distributive and procedural impacts risk delegitimizing the tool. Furthermore, such an approach may be counterproductive for PES effectiveness, insofar as the joint provision of positive outcomes for conservation and livelihoods is more likely when users participate actively

in transparent rule-making aspects of ecosystem governance (5, 6). In the actual global economic climate where markets are disproportionately burdening the poor, PES should thus not become a source of environmental and social injustice.

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Ecosystem Services: Free Lunch No More

IN THEIR POLICY FORUM "PAYING FOR ECOSYSTEM SERVICES—Promise and peril" (4 November 2011, p. 603), A. P. Kinzig and colleagues cite the Millennium Ecosystem Assessment report's finding that 60% of the world's ecosystem services have declined over the past 50 years, and declare the statistic unsurprising given that "we get what we pay for." Yet, the very concept of ecosystem services stems from the fact that these services are provided, pro bono, by the natural environment. There is such a thing as a free lunch.

This helps explain the lack of emerging markets for ecosystem services. As any salesperson can attest, trying to raise the cost of a good or service with existing customers is generally a more difficult task than raising the cost for new customers. This is because consumers are more willing to pay additional costs for services they do not currently possess, or for an increase in quality of services

already received, than simply paying for services that were previously free (1). Creating markets for ecosystem services that already exist for free (even if those services are deteriorating) was never going to be an easy task.

Given these difficulties, it is not surprising that many existing ecosystem services markets, such as the SO₂ example cited by Kinzig *et al.*, have required regulatory enforcement to at least kick-start the process. Many currently scarce ecosystem services were previously abundant, and it will take time and often regulatory prodding to move these services into a true incentive-based economy. Integrating an understanding of consumer psychology will help overcome the barriers to success.

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Response

WE AGREE WITH CORBERA AND PASCUAL that payments for ecosystem services (PES) should be deployed only if they improve overall human wellbeing. We also agree that the credibility and acceptability of PES schemes likely require that participants view both the process and the outcomes as fair. We do not, however, agree with Corbera and Pascual's idea that the payments made to providers of ecosystem services can simultaneously signal the scarcity of those resources, meet the poverty alleviation goals of governments, and reduce income inequality. Multiple objectives require multiple mechanisms.

The central argument in our Policy Forum is that if people have no measures of the scarcity (the true social opportunity cost) of environmental resources, those resources will be misused, with potentially serious consequences for current and future human wellbeing. PES schemes have the potential to enhance the ways ecosystem services are used and protected by signaling the scarcity of environmental resources, and that should be their goal. Using PES to address social justice or poverty alleviation at the same time means that they will likely miss this goal. In the most comprehensive review of the successes and failures of PES schemes to date, Pattanayak, Wunder, and Ferraro report that government-funded schemes with prominent distributional goals are significantly less effective than user-funded schemes in securing additional ecosystem service flows (1).

Poverty alleviation and income redistribution are both important objectives and may

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well be critical to the acceptability of PES schemes, as Corbera and Pascual say, but payments made for ecosystem services will not be effective in meeting those objectives. The payments made under existing PES schemes have been shown to help the poor in some cases, but the benefits of participation are generally very small relative to governments' poverty-alleviation targets (1). Poverty alleviation and income redistribution are better met through other mechanisms, such as investment in public goods that benefit all members of a community, technology transfer, retraining programs, cash "dividends," and annual enrollment benefits.

The evidence gives little comfort to those who want to kill two birds with one stone. The main advantage of PES schemes is to signal the scarcity of environmental resources. Redistributing income requires a different mechanism. Although both may be part of the same package, they should not be conflated.

Joppa suggests that implementation of PES schemes is difficult in part because people are reluctant to pay for things they previously got for free. It is true that people are reluctant to give up rights that give them positions of privilege. However, when such rights no longer serve current needs, societies have frequently found the political will to abrogate them, increasing well-being in the process. The earliest modern examples include the curtailment of historic rights to pollute both air and water and to harvest marine resources (2). All address the overexploitation that comes from open-access rights to common pool environmental resources (3). The effectiveness of such an approach is sensitive to the design of new rights, as we argued in the case of the U.S. SO₂ control. However, it has been shown that the abrogation of open-access

Letters to the Editor

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rights to marine resources has averted the collapse of many wild capture fisheries (4). We expect such changes to occur again. Rights to a free ride on ecosystem services provided by others are inefficient—they reduce global well-being. Corbera and Pascual would argue that they are also unfair. For both reasons, it is worth the effort to overcome the reluctance of people to lose a position of privilege.

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CORRECTIONS AND CLARIFICATIONS

Reports: "Fear erasure in mice requires synergy between antidepressant drugs and extinction training" by N. N. Karpova *et al.* (23 December 2011, p. 1731). An author was left out of the author list. Amine Bahi should be listed between Yumiko Akamine and Regina Sullivan. Bahi's affiliation is the Department of Anatomy, Faculty of Medicine and Health Sciences, United Arab Emirates University, Al-Ain, United Arab Emirates.

Reports: "Formation and spread of aircraft-induced holes in clouds" by A. J. Heymsfield *et al.* (1 July 2011, p. 77). The photo used in Fig. 1A was incorrectly credited. The credit should read, "Photo provided by Eric M. Brown, technical background by Michael Carmody." The credit has been corrected in the HTML version online.

TECHNICAL COMMENT ABSTRACTS

Comment on "Phonemic Diversity Supports a Serial Founder Effect Model of Language Expansion from Africa"

Michael Cysouw, Dan Dediu, Steven Moran

We show that Atkinson's (Reports, 15 April 2011, p. 346) intriguing proposal—that global linguistic diversity supports a single language origin in Africa—is an artifact of using suboptimal data, biased methodology, and unjustified assumptions. We criticize his approach using more suitable data, and we additionally provide new results suggesting a more complex scenario for the emergence of global linguistic diversity.

Full text at www.sciencemag.org/cgi/content/full/335/6069/657-b

Comment on "Phonemic Diversity Supports a Serial Founder Effect Model of Language Expansion from Africa"

Chuan-Chao Wang, Qi-Liang Ding, Huan Tao, Hui Li

Atkinson (Reports, 15 April 2011, p. 346) reported a declined trend of phonemic diversity from Africa that indicated the African exodus of modern languages. However, his claim was only supported when the phonemic diversities were binned into three or five levels. Analyses using raw data without simplification suggest a decline from central Asia rather than from Africa.

Full text at www.sciencemag.org/cgi/content/full/335/6069/657-c

Comment on "Phonemic Diversity Supports a Serial Founder Effect Model of Language Expansion from Africa"

Rory Van Tuyl and Asya Pereltsvaig

Atkinson (Reports, 15 April 2011, p. 346) concluded that language originated in western Africa and that, due to a serial founder effect, languages repeatedly lost phonemes the farther they moved from the African point of origin. Independent examination of the published data tends to refute both these claims.

Full text at www.sciencemag.org/cgi/content/full/335/6069/657-d

Response to Comments on "Phonemic Diversity Supports a Serial Founder Effect Model of Language Expansion from Africa"

Quentin D. Atkinson

Concerns have been raised about my proposal that global phonemic diversity was shaped by a serial founder effect during the human expansion from Africa. I welcome this discussion of new data and alternative interpretations. Although this work highlights interesting questions for future research, it does not undermine support for a serial founder effect model of expansion of language from Africa.

Full text at www.sciencemag.org/cgi/content/full/335/6069/657-e

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