ECOSYSTEM SERVICES:
What are the Public Policy Implications?

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For the last few decades, ecosystem services have been a popular theme in conservation policy. By preserving or restoring areas of natural habitat, the argument goes, important goods and services such as clean air and water, flood control, and crop pollination will be provided to society. Those goods and services, if properly accounted for, may even be worth enough to justify the protection of the forests, grasslands, wetlands, and other ecosystems that provide them.

It is not surprising that the logic of ecosystem services has struck a chord. To some, the appeal of ecosystem services is that all the environmental benefits that "the market" has purportedly failed to account for might now be factored into public and private decision-making. To others, the possibility of structuring payments for ecosystem services that assign and respect property rights, and bringing the power of that same "market" to bear, may seem equally appealing.

But the situation is not as simple as these caricatures might suggest. If it is just a matter of structuring payments for the delivery of services of known and agreed value, it is difficult to explain why so much public-sector effort is being put into studying ecosystem services and enhancing their provision.

The views expressed here are the author's own and do not necessarily reflect those of the U.S. Environmental Protection Agency.

Public sector entities are, however, deeply involved in such efforts. An alphabet soup of multinational organizations is engaged, including TEEB (the Economics of Ecosystems and Biodiversity, funded by the European Commission, United Nations, and others), WAVES (Wealth Accounting for the Value of Ecosystem Services, a World Bank program), and IGPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services, funded by several United Nations programs). National governments are also becoming more involved in ecosystem service valuation. The United Kingdom is undertaking a National Ecosystem Assessment that includes, among other aspects, the valuation of several ecosystem services. In the United States, all executive branch departments and agencies are now directed to "develop and institutionalize policies to promote consideration of ecosystem services… and, where appropriate, monetary or nonmonetary values for those services."[1] Even before this directive was issued, the Environmental Protection Agency, Department of Agriculture, U.S. Geological Survey, and the National Oceanic and Atmospheric Administration had each initiated programs on ecosystem services.

What motivates public policy toward ecosystem services? One common answer is that the services afforded by natural ecosystems are, by and large, public goods.[2] Since public goods will not be efficiently allocated by private actors, public policy is required. But some commonly cited ecosystem services are not necessarily public goods. And even if some ecosystem services are public goods, it is not always clear that they serve large enough populations to justify using national governments, let alone international organizations, to allocate them efficiently.

Information is a public good. So perhaps a better argument for large-scale public involvement in ecosystem service policy is that government provision of research will be required to determine the proper values of ecosystem services. But this raises the question: What is such research likely to find? Are ecosystem services really so valuable that an appreciation for them would motivate us to forgo alternative uses of the areas that provide them?

Despite the accumulation of writing on the topic, there continues to be a surprising dearth of reliable evidence on the value of ecosystem services. If compelling cases have not yet been made for their values, one might reasonably ask whether there ever will be. Many approaches to the valuation of ecosystem services remain controversial and are unlikely to ever be wholly convincing. At the same time, as this essay will discuss, simple arguments suggest that the value of many ecosystem services may be relatively modest in most times and places. Moreover, the exceptions may prove the rule: While it may seem paradoxical, the value of ecosystem services might be highest when the incentives they provide for conservation are modest.

If after years of effort and thousands of articles, we have so little compelling evidence concerning the value of ecosystem services, why has interest remained so high? Some historical context is useful in answering this question. The current enthusiasm for ecosystem services is best understood as an episode in a century-long debate between what we might call "nature-for-nature's-sake" conservationists and those who seek to motivate conservation by appealing to instrumental arguments. The new twist in the ecosystem services literature is that some who sympathize with the "nature-for-nature's-sake" argument seem to have adopted the instrumental approach as a sort of reluctant expedient. Having conceded that they will not succeed by appealing to the intrinsic merits of conservation, this new group hopes to salvage a partial victory by making more pragmatic arguments for conservation based on ecosystem services.

This perspective raises important questions, and I will conclude this essay by posing if not resolving them. First, do conservation advocates who champion an ecosystem-services approach intend for their arguments to be taken literally? Second, if advocates propose ecosystem service-based arguments in pursuit of ulterior motives, can policymakers be assured that conservation is conducive to community development and well-being? Third, does the ecosystem-services approach to conservation envision a world of human communities that is so closely integrated with ecosystem processes that ecosystems themselves are necessarily diminished as a result? In other words, does the ecosystem services paradigm mistakenly presume that the best way to conserve nature is to use it for its goods and services?

All in all, the value of ecosystem services has not been sufficiently demonstrated. Furthermore, a compelling case has yet to be made that public intervention is required to assure adequate areas are set aside to provide ecosystem services. Will more research resolve the issue? I am not optimistic. Perhaps the most important policy question to ask is the most fundamental: What is it that we as a society wish to save of nature? If we can agree to an answer to that question—admittedly a big "if"—we can better determine what policies will most effectively take us toward the goal.

HOW "PUBLIC" ARE ECOSYSTEM SERVICES?

The claim that ecosystem services are public goods is ubiquitous. Economics textbooks define public goods as non-rival (meaning that my consumption of the good does not reduce your ability to enjoy the same good) and non-exclusive (once the good is provided, I cannot prevent you from enjoying it). Many authors assert that public action is required to ensure that public goods such as ecosystem services are adequately provided, as if it were a self-evident truth. Robin Naidoo and Taylor

Ricketts, for example, write that "Ecosystem services often hold significant economic value, but they remain undervalued within policy decisions because they are poorly understood and typically external to markets."[3] A TEEB report on valuing ecosystem services states that "since most ecosystem services and biodiversity are public goods, they tend to be overconsumed by society."[4] And a recent survey asserts that "Fundamental asymmetries in economic systems leading to undervaluing stewardship of natural capital remain largely unchanged."[5]

These claims raise the question: What should be the appropriate public policy to address ecosystem services? We might begin by appreciating the fact that a good has some "public" aspects is not a sufficient argument for turning to the public sector to provide it. Just because an ecosystem generates *some* public benefits does not assure that those benefits offset the opportunity costs of maintaining the ecosystem. The choice to intervene should also be tempered by the concerns that accompany any public intervention, such as the marginal excess burden of taxation,[6] infringements of individual liberties, and the potential for corruption.

Moreover, public goods may be classified by where they lie along a spectrum of "publicness." There are local, regional, and global public goods. When benefits are local, simple measures may effectively render public goods as private. Some ecosystem services might be non-rival and non-exclusive if small areas of natural habitat are sufficient to provide them. If it is in fact worth the opportunity cost of land use to provide the public good, we would expect one landowner to acquire the necessary holdings and appropriate the benefits of the ecosystem service for herself.

Several ecosystem services fit this scenario. Consider pollination, which is often cited as a classic example of an ecosystem service.[7] If someone maintains an area of natural habitat on her land, bees and other pollinators may be healthier and more abundant. But insects are, of course, mobile. They might fly off and benefit others as well. In this case, farmers might simply purchase enough farmland to appropriate a greater share of the benefits the bees create. Or alternatively, they might reach an agreement with neighboring landowners to set aside enough pollinator habitat.[8]

Similar questions might be asked of a number of other ecosystem services. Trees and natural vegetation may provide barriers against wind and flood, but if they are cost-effective in this role, what prevents landowners or communities from providing themselves with this protection? Commercial or residential land developers often have the choice of how much and where to retain or recreate forests, wetlands, and other areas that would shade buildings, and protect them from winds and floods. If relatively small areas are needed to provide such services, why would a profit-maximizing developer not set them aside? Of course, municipal and local governments *do*

regularly set aside some lands for less-intensive use in parks and other public lands, so it is not clear that higher levels of government need to be involved in the allocation of land for the provision of many ecosystem services.

INFORMATION ON THE VALUE OF ECOSYSTEM SERVICES

Even if private actors or local governments can effectively allocate some ecosystem services, there might be a second public-goods argument for government involvement at national or international scales. It may be that the role for public policy is to provide information on the value of ecosystem services, which can then be used by the public to better determine what is in their individual or collective interest. So let us examine what efforts to provide such information have revealed so far, and what they might be expected to show in the future.

What does the research tell us about the value of ecosystem services? The answer remains "surprisingly little." Although there are now thousands of published articles on the topic, several survey papers remark on how little has been settled. Kate Brauman finds that a majority of 381 peer-reviewed studies relating water to ecosystem services "failed to adequately link changes in environmental conditions to human well-being, instead stopping at the point of suggesting that one was connected to the other."[9] Concluding their review of ecosystem service studies, Ralf Seppelt et al. state that "less than one-third of all studies provided a sound basis for their conclusions."[10] Ricketts et al. (2004) perhaps inadvertently underscored an irony that persists.[11] "Although the societal benefits of native ecosystems are *clearly immense*, they remain *largely unquantified*," they wrote (emphases added), without explaining how we can be so sure that the benefits are "clearly immense" if they remain "largely unquantified."

Given the lack of robust work on ecosystem service valuation, it is not surprising that, as Laurans et al. report, the literature "rarely reports cases where ESV [Ecosystem Service Valuation] has been put to actual use, even though such use is frequently referred to as founding the goal and justification of ESV."[12] Another survey finds that "In many cases, interest from decision-makers has created demand for information that has outstripped the supply from science."[13]

Since the information that is available now is limited, it may be instructive to consider what basic economic principles imply concerning the value of ecosystem services. The single most important thing to remember when thinking about economic value is that value is determined on the margin. The economic value of a hectare of forest, as one example of native habitat, is determined by the *increase* in services that an additional hectare affords over and above all other hectares of forest—not by the total value of the forest, nor by the average value of a hectare of forest. This principle

is fundamental, but it is often not appreciated by non-economists who have been engaged in much of the research on ecosystem services.

A clearer focus on the basic economics of ecosystem services can help clarify their values and help us understand how to devise defensible estimates of those values. Many ecosystem services are comprised of some natural asset—the ecosystem, or some of its components—that contributes to the production of something. We can then derive the value of the asset providing the service by multiplying the value of the thing being produced by the additional amount of the ecological asset. Moreover, for many types of ecosystem services, the more of the service the ecosystem supplies, the less of the service remains to be performed.

Table 1 gives several examples of this paradigm. For example, think of wild bees as ecological assets. A bee's economic value is determined by multiplying the price at which the fruit that may form from the flowers it pollinates can sell (net of the costs of raising and harvesting it), multiplied by the number of additional fruits expected to result from the bee's presence. Once an egg has been fertilized, the arrival of additional bees makes no difference to its development. The more bees there are, the less likely it is that a flower has not yet been pollinated. So, when there are large numbers of bees, the value of the marginal bee for pollination services is negligible.

Similar considerations determine the value of other ecological assets and demonstrate why those values decline as the assets become more abundant. Forests or grasslands retained in a riparian buffer may remove some of the pollution that would otherwise enter streams and cause environmental damage.[14] But the wider the buffer, the less pollution remains for the marginal meter of buffer to remove. In the case of flood and storm protection, the "production" of protective services might be modeled as the capability to withstand larger and stronger influxes of precipitation. The greater the area set aside to retain rain and snow, however, the lower the probability of a storm large enough to exceed its retention capacity.[15]

Several interesting implications are illustrated in Table 1.

- In some cases, ecosystem services may be of considerable value. This would be the case if the "value of the product" is high, the "capacity" of the marginal unit to provide that product is high, and, crucially, if the ecological assets providing the service are scarce. If there are few ecological assets providing a service, then great potential to provide that ecosystem service remains. For example, if there is little or no riparian buffer to filter pollutants from a stream, then the marginal value of an additional meter of riparian buffer may be quite high.

Table 1: Examples of ecosystem services and sources of diminishing returns

Example	Ecological asset providing the ecosystem service	Value of product	Capacity to produce ecosystem service	Amount of service still lacking
Pollination	Pollinating insects	Price of fruit	Number of flowers the "marginal pollinator" is capable of visiting	Likelihood that the flowers the marginal pollinator visits would not be fertilized by any other pollinator
Pollution treatment	Meters of riparian buffer	Marginal damage from pollution	Fraction of pollution removed in the "marginal meter"	Amount of pollution that remains to be removed when a contaminated flow reaches the marginal meter
Flood protection	Hectares of wetlands	Losses in the event of a flood	Water storage capacity of the "marginal hectare"	Probability that the volume of precipitation that must be stored to prevent flooding exceeds the storage capacity of all hectares of land available for flood control

- By the same token, ecosystem services must not be of much value if the assets already providing them are abundant. And if the "capacity" of each unit to provide services is high, there may be little left for the marginal unit to do. For example, if pollinators are abundant, and each individual pollinator visits thousands of flowers, then the marginal value of additional pollination services may be low.
- The above considerations give rise to a basic principle: "If a little goes a long way, you don't need a lot." Ecosystem services might be very valuable if provided in

small quantities, but the same "capacity" that makes a little bit valuable necessarily means that marginal values will be negligible when assets are abundant.

- But what if a little does not go a long way? What if the marginal value of an additional meter of riparian buffer does not yield additional benefits for pollution reduction? This would lead to a catch-22 effect. Ecosystem services and manufactured systems are often substitutes. If ecosystems do not perform effectively, it could be more cost-effective to rely on artificial substitutes, such as water-treatment facilities.

It is worth underscoring that these considerations do not mean that ecosystem services are not valuable. To the contrary, they could be very valuable; however, they would only be valuable when they are relatively scarce. Basic economic principles suggest that ecosystem service values might be limited in many cases, and that it is unlikely that an appeal to ecosystem services would motivate large-scale conservation when opportunity costs are significant.

What does this mean for the question of whether public funds should be allocated to estimating the value of ecosystem services? At the very least, it suggests that we should not expect that we are setting aside far too little land for the provision of ecosystem services. But if this is the case, then why is it that the ecosystem services framework is often used to suggest that society is conserving too few native habitats?

ORIGINS AND OBJECTIVES

Ecosystem services may seem to be a modern development in conservation policy, but current debates retrace a century-old conflict over the value of nature. In the early 20th century, John Muir, the founder of the Sierra Club, championed a vision of preserving nature for its own sake. Muir clashed with Gifford Pinchot, who would become the first Chief of the U.S. Forest Service. Pinchot promoted conservation as a means of enhancing the flow of nature's more tangible benefits to society, and, in some instances, advocated more intensive uses of public lands.[16] For most of the last four decades, the latter vision has been ascendant, although the reasons for its rise are complicated. In the case of ecosystem services, some latter-day Muirists seem to have turned defeatist, resigning themselves to Pinchot's utilitarian vision as a less-dreadful outcome than simply throwing in the towel.[17]

The ecosystem services approach might be traced to several earlier writings such as Westman (1977) and Ehrlich and Ehrlich (1981).[18] Another that may have been particularly important, however, was the 1980 publication of *World Conservation Strategy: Living Resource Conservation for Sustainable Development,* by the International Union for the Conservation of Nature.[19] The document signaled a change in course,

away from a vision in which protected areas were to be guarded for their intrinsic merits, and toward one in which such areas would be conserved to promote the sustainable development of the communities in which they are located. The 1990s saw the growth of numerous "integrated conservation and development projects" (ICDPs). The rationale for these ICDPs was similar to that of ecosystem services today. Nature could, ICDP advocates claimed, essentially pay for itself, if only we recognized its value. Natural areas might support sustainably harvested products, provide genetic models for new pharmaceutical compounds, offer recreational destinations for international "eco-tourists," and a host of other valuable goods and services.

Nature, however, didn't necessarily cooperate. In fact, in many instances it turned out to be "worth more dead than alive," as John Terborgh put it.[20] A number of reports documented problems with the sustainable-use approach of ICDPs.[21] Hopes for some natural products were dashed when the markets for them turned out to be smaller than advocates anticipated. In other situations, the ICDPs may have backfired; some destinations were "loved to death" by excessive flows of tourists.[22] Projects intended to promote the sustainable harvest of natural products may have resulted in disturbances to the ecosystems the projects were intended to protect.[23]

At the most basic level, the economics of ICDPs rarely made sense. In some respects, nature is too generous. Some of the goods and services ICDPs were supposed to provide are so abundant that people are willing to pay very little for them. This appears to be the case with "bioprospecting," the search among naturally occurring organisms for chemical compounds that might be valuable in industrial, agricultural, or pharmaceutical applications. In the early 1990s, an agreement between Merck Pharmaceuticals and Costa Rica's National Biodiversity Institute (known by its Spanish acronym as *INBio*) was hailed as a major development in conservation policy.[24] *INBio* would provide Merck with samples of indigenous plant and animal species for research, and Merck would compensate *INBio* for the samples. The compensation offered was relatively modest, however, and some conservation and development advocates railed at the alleged "biopiracy."[25] Yet such modest compensation is exactly what one would expect in a world in which species that have not yet been tested for their pharmaceutical potential still number in the hundreds of thousands.[26] In the years since the Merck-*INBio* deal was announced, enthusiasm for bioprospecting has generally faded.[27]

Other ICDPs foundered because ancillary infrastructure was lacking—the world may be filled with natural wonders, but many are located in places that are too inaccessible and dangerous to attract many tourists.28 Moreover, low-intensity use of natural systems can only exist as long as the products or services being provided

are of relatively little value. At higher prices, more intensive exploitation displaces sustainable use of diverse systems.[29]

The experience with ICDPs poses uncomfortable questions for ecosystem services: If nature-based ventures would be profitable, why would the public sector have to subsidize them?[30] There does not seem to be a compelling answer. So why is there renewed enthusiasm among ecosystem service advocates for the idea that nature can be made to pay for itself?

The likely answer is that conservationists still perceive a mismatch between their goals and the means to achieve them. Some authors have used the image of a "silver bullet" in describing ecosystem service-related approaches to conservation.[31] Conservation can be an expensive proposition. Preserving the natural areas that shelter biodiversity requires amassing sufficient funds to compensate their owners for the opportunity costs of not converting forests, wetlands, and other areas to alternative uses. It may also require ongoing expenses to monitor natural areas and assure that they are kept intact. Conservation advocates and their funders seek ways to motivate more habitat conservation without bearing the full cost.

This hope of getting a lot for a little has animated several advocates. Gretchen Daily and Pamela Matson write of "a growing feeling of Renaissance in the conservation community" arising from working with "a much more diverse and powerful set of leaders… for new approaches that align economic forces with conservation."[32] Heather Tallis and Peter Kareiva give a sense of what the conservation community hopes to gain from an appreciation of ecosystem services: "…realization of the market worth of ecosystem services has the potential to increase conservation funding by orders of magnitude. Ecosystem services also have the possibility of aligning conservation value and poverty alleviation."[33]

Tallis and Kareiva's emphasis on aligning conservation and development interests underscores certain challenges that arise in international conservation policy. The concept of ecosystem services came to prominence at roughly the same time as did concerns over preserving global biodiversity. Appeals to ecosystem services are often made as part of a strategy for conserving biodiversity.[34] Biodiversity, as measured by numbers of species, tends to be concentrated in the countries of the less-developed global South.[35] To many ecosystem service advocates, then, the conservation challenge was to find a way to motivate these generally poorer nations to see biodiversity conservation as in their own best interests. As Armsworth et al., put it, "In the face of a sea of poverty, demonstrating the ignored links between nature and elements of well-being—safe drinking water, food, fuel, flood control, and aesthetic and cultural benefits that contribute to dignity and satisfaction—is the key to making conservation relevant."[36]

The claim that preserving nature—and with it, the ecosystem services it provides—will help the world's poor is problematic on a number of levels. Tallis and Kareiva note that "Functioning ecosystems provide clean, disease-free water, fertile soil and numerous other basic human needs."[37] Perhaps they do. As Hobbes famously noted, however, life in the midst of ecosystems that function as nature may have intended also tends to be "solitary, poor, nasty, brutish, and short." Why would the poor be better served by continued immersion in the "nature" from which wealthier people have largely distanced themselves?

To an economist, the objective of "aligning" conservation and poverty alleviation is suspect. "Economic forces" are what they are: People have preferences over what they wish to consume and enjoy, and biology and technology impose constraints on the degree to which those preferences can be satisfied. It seems that at least part of the intent of ecosystem services advocates is to change the preferences people have between nature and the things that imperil it.

There may, however, be a fine line between changing preferences and providing better information. Do arguments for reliance on ecosystem services convey new information to people who might benefit from them? I have argued above that they may not provide much information. But it may also be prudent to consider the interests of the sources purveying the claims. Armsworth et al. write that "Nature for nature's sake resonates only with the already converted."[38] The religious imagery of "the converted" suggests that the real goal is to motivate those who failed to receive the conservationists' revelation. If the masses are too venal to have appreciated appeals to "nature for nature's sake," why are they not venal enough to appreciate what is in their own best interest? Moreover, it is troubling to read an exhortation by ecosystem service researchers "to plan our research programs from the desired endpoint and work backwards from there."[39] One would hope that research, and particularly publicly funded research, is not intended to support the predetermined conclusions of advocates.

Some authors suggest that the conservationists' claims concerning ecosystem services were not intended to be taken literally. Gómez-Baggethun et al. refer to ecosystem services "as a pedagogical concept designed to raise public interest for biodiversity conservation."[40] Norgaard describes them as "an eye-opening metaphor intended to awaken society to think more deeply about the importance of nature," and Janet Fisher and Katrina Brown ask if they are "just a rhetorical tool."[41]

Fisher and Brown conclude that, regardless of how they were originally intended, ecosystem services are not just a rhetorical tool now. This raises further questions. Would some conservation advocates be happier if ecosystem services were regarded as

simply a rhetorical flourish, or had never been proposed at all? Some would. Douglas McCauley alleges that the approach of setting values on ecosystem services is "selling out on nature."[42] Richard Norgaard claims that an emphasis on ecosystem services diverts attention from more fundamental environmental concerns.[43] And Michael Soulé writes that an ecosystem services paradigm in which human and natural systems are more closely integrated "would hasten ecological collapse globally, eradicating thousands of kinds of plants and animals and causing inestimable harm to humankind in the long run."[44]

Why might some conservationists oppose emphasizing ecosystem services as a tool for conservation? An answer might be found in a current controversy over the future of conservation.

In recent work, Peter Kareiva, Robert Lalasz, and Michelle Marvier advanced a vision in which "conservation will measure its achievement in large part by its relevance to people, including city dwellers. Nature could be a garden—not a carefully manicured and rigid one, but a tangle of species and wildness amidst lands used for food production, mineral extraction, and urban life."[45] Other conservation advocates—or rather, advocates for different interpretations of conservation—reacted angrily.[46] The acrimony of the resulting debate sparked appeals by the scientific community for conservationists to reconcile their differences.[47] Yet the need for such appeals reveals fundamental differences in the objectives of conservation scientists.

Importantly, not everyone's vision of conservation is, as Kareiva, Lalasz, and Marvier write, "wildness amidst lands used for food production, mineral extraction, and urban life." To others, a crucial objective of conservation is the preservation of large enough areas of relatively wild habitat to assure the survival of large carnivores *in situ*.[48] Yet much of the ecosystem services literature implies that we should value—and presumably, retain—ecosystems that provide services in the midst of otherwise human-dominated landscapes. Flood protection services are most valuable when they adjoin expensive, densely inhabited areas that need to be protected against floods. Pollution treatment services are most valuable when the natural wetlands and vegetation that provide them are located between decidedly unnatural sources of pollution and large concentrations of people. Native pollinators are most valuable when there is a large expanse of cropland nearby for them to pollinate.

Ecosystem-service-based arguments, if taken literally, are not arguments for conservation in some generic and universal sense so much as for the conservation of *particular types* of areas. Many of the arguments for ecosystem services are, implicitly, exhortations to create checkerboard landscapes consisting of numerous small pockets of "natural" habitats situated within areas devoted to less-intensive cultivation,

production, or settlement. If land is used less intensively in production, however, it means either less will be produced or more land must be used to maintain the level of production, and human activities would expand further into the remaining "wild" areas of the planet.[49]

CONCLUSION

Do we as a society want a world with many small areas devoted to conserving a limited suite of native species, or one in which production and human habitation are more intensive in some areas while more of the landscape is left relatively untrammeled? I don't propose to answer this question; what society wants should be worked out through society's institutions. This, however, is why the current interest in ecosystem services, particularly among national and international policymakers, is problematic. Many advocates speak and write as if it were an established fact that ecosystem services are undervalued and that public policies should be enacted to assure that the ecosystems providing them are sufficiently protected. I have argued that these propositions are not, in fact, well established on a broad basis.

That is not to say that there are not important reasons to be concerned with the decline of natural ecosystems. There may well be, as some have suggested, systemic risks inherent in degrading systems whose workings we do not fully understand and whose failure might not be preceded by actionable warnings.[50] Moreover, many of us feel ethical or even spiritual obligations to be good stewards of the natural world. Current research on ecosystem services, however, has little to say about these questions. Instead, it seems intended to create the impression that technical calculations can inform conservation choices. Such a view would fit neatly into a paradigm in which regulators determine the externalities inherent in land-use choices and restrict property rights accordingly. In our society, however, we rightly set a high bar to such "takings." At present, there is not enough reliable information about the value of ecosystem services to justify a regulatory approach, and there is no indication that science will progress quickly enough to change this state of affairs any time soon.

ENDNOTES

1 Executive Office of the President of the United States. Memorandum for Executive Departments and Agencies. "Incorporating Ecosystem Services into Federal Decision Making." October 7, 2015.

2 In this essay, I will only address whether *setting aside land* for the provision of ecosystem services should be regarded as a public good and/or the focus of public policy. I will not consider the *effects* of other factors on lands that provide ecosystem services, for example, how acid precipitation affects the health of forests.

3 Naidoo, R. and T.H. Ricketts. 2006. "Mapping the Economic Costs and Benefits of Conservation." *PLOS Biology.* 4(11).

4 TEEB. 2010. *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations.* Edited by Pushpam Kumar. London and Washington: Earthscan.

5 Guerry, A., et al. 2015. "Natural Capital and Ecosystem Services Informing Decisions: From Promise to Practice." *Proceedings of the National Academy of Sciences.* 112(24): 7348–7355.

6 Because tax collection imposes a deadweight loss, the social cost of a dollar of tax revenue typically exceeds a dollar because economic behavior is distorted by the tax.

7 See, e.g., Ricketts, T. H., et al. 2004. "Economic Value of Tropical Forest to Coffee Production." *Proceedings of the National Academy of Sciences.* 101(34): 12579–12582; or Armsworth, P.R., et al. 2007. "Ecosystem Service Science and the Way Forward for Conservation." *Conservation Biology.* 21(6): 1383–1384.

8 The usual argument suggested against such arrangements is that the larger the area that must be acquired in order to appropriate the benefits of conserving some habitat, the more difficult they become to institute and monitor. Would this make sense in the context of pollinators, however? If agreements must cover large areas, it would be because pollinators have very wide ranges. If native pollinators can easily cover wide ranges, however, why are those that remain abundant in areas farther from existing farms not sufficient to serve the farms?

9 Brauman, K.A. 2015. "Hydrologic Ecosystem Services: Linking Ecohydrologic Processes to Human Well-Being in Water Research and Watershed Management." *WIREs Water.* 2(4): 345–358.

10 Seppelt, R., et al. 2011. "A Quantitative Review of Ecosystem Services Studies: Approaches, Shortcomings, and the Road Ahead." *Journal of Applied Ecology.* 48(3): 640–646. Their criterion for a "sound basis" was that one could draw a clear path between the premises and conclusions of a study, not whether the inferences made along such a path were logically sound. The fraction might be lower yet if one also applied a filter for conformance with received principles of economic valuation.

11 Ricketts, T.H., et al. 2004. "Economic Value of Tropical Forest to Coffee Production." *Proceedings of the National Academy of Sciences.* 101(34): 12579–12582.

12 Laurans, Y.A., et al. 2013. "Use of Ecosystem Services Economic Valuation for Decision Making: Questioning a Literature Blindspot." *Journal of Environmental Management.* 119: 208–219.

13 Guerry, A., et al. 2015. "Natural Capital and Ecosystem Services Informing Decisions: From Promise to Practice." *Proceedings of the National Academy of Sciences.* 112(24): 7348–7355

14 See, e.g., Mander, Ü. 2008. "Riparian Zone Management and Restoration." *Encyclopedia of Ecology.* Edited by S.E. Jørgensen and B. Fath. Amsterdam: Elsevier. 3044–3061.

15 Simpson, R. D. 2015. "Developing 'Reality Checks' on Ecosystem Service Values: Characterization and Bounding Results for a Broad Class of Models." Paper presented to the 17th annual meeting of the BioEcon Network, Cambridge, United Kingdom.

16 Another fascinating instance of history repeating itself may be found in the rise and fall of "economic ornithology" in the early 20th century. (See Kronenberg, J. 2015. "Betting Against Human Ingenuity: The Perils of the Economic Valuation of Nature's Services." *BioScience.* 65(11): 1096–1099; I am grateful to Mark Sagoff for bringing this example to my attention). If one did not notice the dates in the text, attempts conservation advocates made at the time to assign a value to the pest control services provided by native bird populations might be mistaken for a current submission to a journal such as *Ecological Economics.*

17 Armsworth, P.R., et al. 2007. "Ecosystem Service Science and the Way Forward for Conservation." *Conservation Biology.* 21(6): 1383–1384.
18 Westman, W. 1977. "How Much are Nature's Services Worth?" Science. 197: 960–964; Ehrlich, P. and A. Ehrlich. 1981. *Extinction: The Causes and Consequences of the Disappearance of Species.* New York: Random House.
19 International Union for the Conservation of Nature, United Nations Environment Program and World Wildlife Fund. 1980. *World Conservation Strategy: Living Resource Conservation for Sustainable Development.* Switzerland: Gland.
20 Terborgh, J. 1999. *Requiem for Nature.* Washington, D.C.: Island Press.
21 See, e.g., Wells, M. and K. Brandon. 1991. *People and Parks: Linking Protected Areas with Local Communities.* Washington, D.C.: World Bank; or Terborgh, J. and C. van Schaik. 2002. "Why the World Needs Parks." In *Making Parks Work: Strategies for Preserving Tropical Nature.* Edited by J. Terborgh, C. van Schaik, L. Davenport, and M. Rao. Washington, D.C.: Island Press. 3–14.
22 Honey, M. 2008. *Ecotourism and Sustainable Development: Who Owns Paradise?* 2nd edition. Washington, D.C.: Island Press.
23 Chomitz, K. and K. Kumari. 1998. "The Domestic Benefits of Tropical Forests: A Critical Review." *World Bank Research Observer.* 13: 13–35; Terborgh, J. 1999. *Requiem for Nature.* Washington, D.C.: Island Press.
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50 One may say what one likes about the Ehrlichs' "rivets" analogy (see Ehrlich, P. and A. Ehrlich. 1981. *Extinction: The Causes and Consequences of the Disappearance of Species.* New York: Random House; losing species, the authors say, is like removing the rivets from an airplane; some may be inessential, while the loss of others might cause a catastrophe), but it is difficult to say definitively at what point—if any—planetary stresses could become existential threats.