Protecting Ecosystem Services:  
Science, Economics, and Law

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I. INTRODUCTION

By most measures, modern American environmental law has been a great success. With few exceptions our air is cleaner, our water purer, than in 1970.1 Despite these achievements, however, the last decade has witnessed repeated calls for a significant shift in regulatory emphasis. The top managers and scientific advisors in the United States Environmental Protection Agency (EPA) have consistently declared that maintenance of productive natural systems demands more attention and should, in fact, become one of the agency's highest priorities.2 In recommending that reduced

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2. See, e.g., U.S. ENVTL. PROT. AGENCY, EPA/600/R-98/086, ECOCLOGICAL RESEARCH STRATEGY E-1 (1998) (noting that [e]cosystems provide valuable renewable resources and services such as... water storage and flood control) and acknowledging “great interest in
ecological risk become a primary focus of EPA, its scientists and managers have revealed the single greatest failing of modern environmental law and its greatest challenge today—the inadequate protection of ecosystems and the services they provide.

Largely taken for granted, healthy ecosystems provide a variety of critical services. Created by the interactions of living organisms with their environment, these "ecosystem services" provide both the conditions and processes that sustain human life—purifying air and water, detoxifying and decomposing waste, renewing soil fertility, regulating climate, mitigating droughts and floods, controlling pests, and pollinating plants. Although awareness of ecosystem services dates back to Plato, ecologists, economists, and lawyers have only recently begun systematically examining the extent and implications of these services' valuable contributions to social welfare. Not surprisingly, recent research has demonstrated the extremely high costs to replace many of these services if they were to fail, on

the concept of ecosystem management . . . ."


3. See EPA ECOL. RES. STRAT., supra note 2, at 3-1, 3-32 (identifying the assessment of ecological risk as one of four areas in the EPA's core research program); see also, e.g., U.S. Envl. Prot. Agency, Watershed Ecological Risk Assessment, at http://www.epa.gov/ncer/weracs.htm (last modified May 3, 1999) (explaining that ecological risk assessments will be used to improve decision-making in five watersheds).

4. Consider the blunt conclusion of EPA's senior managers in their widely circulated 1994 statement known as The Edgewater Consensus. They declared that

"[b]ecause EPA has concentrated on issuing permits, establishing pollutant limits, and setting national standards, the Agency has not paid enough attention to the overall environmental health of specific ecosystems. In short, EPA has been 'program-driven' rather than 'place-driven.'"

. . . .

Recently, we have realized that, even if we had perfect compliance with all our authorities, we could not assure the reversal of disturbing environmental trends.

(emphasis added) The Edgewater Consensus, supra note 2.

the order of many billions of dollars in the United States for water purification alone. Such estimates are inherently uncertain, but the extraordinary costs required to substitute for many important services by artificial means are beyond dispute.7

Our unthinking reliance on ecosystem services is due in part, no doubt, to society's dissociation between the milk carton and medicines in our home, on the one hand, and the services of nutrient cycling and biodiversity, on the other, that made these possible. Thus it is perhaps not surprising that many children, when asked where milk comes from, reply without hesitation, "from the grocery store."8 Given their significance, one might expect that ecosystem services would be priced by markets and explicitly protected by the law. With few exceptions, however, neither has been the case.

Despite their obvious importance to our well being, ecosystem services have largely been ignored in environmental law and policy. Provision of services is only rarely considered in cost-benefit analyses, preparation of environmental impact statements,9 wetlands mitigation banking,10 Superfund remediations,11 and oil spill

5. For example, in 1997, the EPA estimated that $34.4 billion was needed to replace and build infrastructure necessary to continue to provide water that meets all regulatory standards, with $138 billion needed to maintain that infrastructure through 2015. The TRUST FOR PUBLIC LAND, PROTECTING THE SOURCE: LAND CONSERVATION AND THE FUTURE OF AMERICA'S DRINKING WATER 5-8 (1997) [hereinafter PROTECTING THE SOURCE]. In 1998, the American Water Works Association estimated capital needs at $325 billion through 2014. AMERICAN WATER WORKS ASSOCIATION, INFRASTRUCTURE NEEDS FOR THE PUBLIC WATER SUPPLY SECTOR S-2 (1998) [hereinafter AWWA].

6. See David Pearce, Review of "Auditing the Earth: The Value of the World's Ecosystem Services and Natural Capital", 40 ENV'T 23 (1998) (critiquing monetary estimates of the absolute dollar value of services but supporting the effort); see also, AWWA, supra note 5. The AWWA attributes their higher estimate of capital needs for water to the use of a wider range of data and more realistic assumptions about costs.

7. For discussions of the value of pollinator systems, see Gordon Allen-Wardell et al., The Potential Consequences of Pollinator Declines on the Conservation of Biodiversity and Stability of Food Crop Yields, 12 CONSERVATION BIOLOGY 8 (1998) (establishing a consensus regarding the extent and magnitude of declines in pollinators, and resulting declines in pollination services); Claire Kremen & Taylor Ricketts, Global Perspectives on Pollination Disruptions, 14 CONSERVATION BIOLOGY 1226 (2000) (summarizing studies from around the world that assess the vulnerability of pollinator systems).


clean-ups. Nor have significant markets arisen that capitalize on the commercial value of these services. We have no shortage of markets for ecosystem goods (such as clean water and apples), but the services underpinning these goods (such as water purification and pollination) are free. The services themselves have no market value for the simple reason that no markets exist in which they can be exchanged. As a result, there are no direct price mechanisms to signal the scarcity or degradation of these public goods until they fail. Partly as a result, ecosystems are degraded.

An explicit ecosystem services perspective provides two obvious benefits. The first is political. Understanding the role of ecosystem services powerfully justifies why habitat preservation and biodiversity conservation are vital, though often overlooked, policy objectives. While a wetland surely provides existence and option values to some people, the benefits provided by the wetland's nutrient retention and flood protection services are both universal and undeniable. Tastes may differ over beauty, but they are in firm accord over the high costs of polluted water and flooded homes.

The second benefit is instrumental. Efforts to capture the value of ecosystem services may spur institutional designs and market mechanisms that effectively promote environmental protection at the local, regional, national, and international levels. To realize this potential, however, we must first create market mechanisms and institutions that can capture and maximize service values. If given the opportunity, natural systems can, in many cases, quite literally "pay their way." The key challenge is how to make this happen.

The study of ecosystem services and their implications for environmental protection is a nascent field and we still have much to learn. There has been a great deal of enthusiasm surrounding an ecosystem services approach, and in many cases this may be thoroughly warranted. Yet such an approach offers potential pitfalls, as well. Recognition of the value provided by specific ecosystem services may offer persuasive reasons to strengthen existing protections and resist further encroachments, or it may not. In some

cases, perhaps many, a focus on services will not justify conservation of biodiversity or certain natural habitats. In other cases, the services will not be amenable to market or legal-based solutions and will be largely irrelevant to environmental protection efforts. Thus, while a focus on ecosystem services provides great latent potential to promote environmental protection, its practical implications remain largely unexamined.

There are several important questions that need to be answered. Can we develop robust methodologies for the valuation of services? Absent these, how can we compare the costs of degrading an ecosystem and its service provision with the benefits of the offending activity? If ecosystem services have real but uncaptured value, what are the necessary conditions for market creation to exchange valuable services? And, critically, is the science good enough to tell us how to manage ecosystems for reliable service provision?

This issue of the Stanford Environmental Law Journal explores our current state of knowledge, presenting the results of interdisciplinary research conducted over the past three years on the legal, scientific, and economic aspects of ecosystem services. The articles that follow are the result of an EPA Science to Achieve Results (STAR) grant and an interdisciplinary workshop held at Stanford University in November, 2000. In probing the implications of an ecosystem services approach, Parts II and III of this article explore the ecosystem services of water purification and flood control, describing efforts to capture their value and the resulting challenges. Part IV describes a range of initiatives around the globe to value and protect nature’s services. Part V considers the steps necessary to integrate the emerging science and economics of ecosystem services valuation within a legal framework of rules and incentives. The challenges of valuing and protecting ecosystem services are surely significant, but the potential is there to transform the explicit management of services from enticing anecdote to widespread practice.

II. The Service of Water Purification

Of all ecosystem services, water purification might provide the
greatest chance for galvanizing market or regulatory action aimed at protecting ecologically important lands.\textsuperscript{16} The value of safe drinking water is undeniable and universally recognized. Internationally, water contamination is one of the greatest causes of human disease, illness, and death.\textsuperscript{17} Domestically, drinking water quality is high relative to that found in much of the world, but close to a million Americans still become sick each year as a result of drinking contaminated water, and hundreds die.\textsuperscript{18} Surveys, not surprisingly, repeatedly show that safe drinking water is among the most important environmental issues to the American public. If any ecosystem service is likely to capture the public’s attention, water purification is it.

The linkage between watershed protection and drinking water quality is also clear. When land in the vicinity of a waterway is developed, the uses to which the land is put frequently add contaminants to the waterway. Nonpoint pollution, in the form of runoff from agriculture, livestock operations, construction sites, parking lots, roads, and other uses, as well as the leaching of waste from septic tanks, is today the major threat to the nation’s waterways.\textsuperscript{19} Undeveloped land, moreover, helps reduce contamination. Both wetlands and soils filter out nutrients and other contamination from runoff before the runoff reaches the main course of a waterway.\textsuperscript{20} Vegetation slows down runoff, permitting solid pollutants to settle out, and stabilizes soil, thus reducing contamination from siltation.\textsuperscript{21} Land preservation thus performs double duty in protect-

\textsuperscript{16} For a lengthier discussion of the opportunities to promote watershed preservation by demonstrating to water suppliers the importance of watershed lands to water quality, see Barton H. Thompson, Jr., Markets for Nature, 25 WM. \& MARY ENVTL. L. \& POL’Y REV. 261, 293-307 (2000); Robert L. Fischman, The EPA’s NEPA Duties and Ecosystem Services, 20 STAN. ENVTL. L.J. 497 (2001).


\textsuperscript{18} See Erik Olson & Diane Cameron, The Dirty Little Secret About Our Drinking Water 4 (Natural Resources Defense Council 1995) (citing a 1987 study by the Centers for Disease Control).


\textsuperscript{21} \textbf{An Ounce of Prevention, supra note 19, at 9}.
ing water quality: it eliminates a major source of contamination, while also protecting the waterway from those nonpoint sources of contamination that do exist.

Recognizing the value to water quality of natural watersheds, a number of water suppliers for years have tried to protect watersheds from development. 22 Although the typical water supplier owns only about two percent of the land in its watersheds of supply, water suppliers in some regions of the country own a much larger percentage, sometimes including a majority of the remaining open space. 23 The interesting question is whether government can use the value of natural water quality services to encourage water suppliers to take additional steps today to preserve ecologically valuable watershed lands.

New York City has inspired hope by embarking on a $250 million program to acquire and preserve up to 350,000 acres of land in the Catskills watershed, one of three major basins from which the city obtains its water supply. 24 A combination of federal regulation and cost realities drove New York City to this program. Under the federal Safe Drinking Water Act, municipal and other water suppliers must filter their water supplies unless they can demonstrate that they have taken other steps, including watershed protection measures, that protect their customers from harmful water contamination. 25 Presented with a choice between building a filtration plant and preserving the watershed, New York City easily concluded that the latter was more cost effective. New York City estimated that a filtration plant would cost between $6 billion and $8 billion to build and another $300 million annually to operate. 26 By contrast, watershed protection efforts, which would include not only the acquisition of critical watershed lands but also a variety of other programs designed to reduce contamination sources in the


23. Protecting the Source, supra note 5, at 3, 14.


watershed, would cost only about $1.5 billion.27

New York City’s Catskills efforts raise a number of issues. First, are New York City’s efforts anomalous, or are they an example of a growing interest in preserving watershed lands for water quality purposes? In the late 1990s, EPA estimated that more than 140 cities were considering watershed conservation as a means of ensuring high drinking water quality.28 The Appendix to this article provides approximately a dozen important examples of this phenomenon. Few of these efforts, however, come close to New York City’s preservation actions in scale or importance. And water suppliers in a few areas of the country actually are divesting themselves of watershed lands.29

Several factors helped make New York City’s decision to preserve watershed lands for water quality purposes relatively easy. First, New York City is the dominant beneficiary of Catskills preservation efforts. New York both draws sizable quantities of water from the Catskills and dwarfs all other cities drawing drinking water from the watershed. As a result, New York City gets virtually the entire benefit in improved water quality of its preservation efforts. A smaller city that draws on only a small portion of the supply from a watershed would face a tougher choice because only a fraction of the water-quality benefits from land preservation would go to it. In deciding whether to acquire land on its own, a smaller city might decide that the benefits were not worth it, and efforts to forge a coalition with other water suppliers drawing water from the same watershed might fail as a result of free-rider problems. Second, in deciding to protect the Catskills watershed rather than build a filtration plant, New York City benefited from century-old regulatory authority over the watershed. New York City is protecting the watershed partly through land acquisition and preservation and partly through local land-use incentive programs, but also through regulation of local uses. Whether New York City would have found it worthwhile to protect the watershed through economic means even if it had not enjoyed the regulatory power is an unaddressed question. Third, most of the land that New York City has slated for preservation is in areas that are still not highly populated and, thus

27. Id.
28. See Protecting the Source, supra note 5, at 20; Chichilnisky & Heal, supra note 26, at 630.
29. See, e.g., An Ounce of Prevention, supra note 19, at 3, 7, 13-14 (noting that water companies in Connecticut sold off approximately 2,000 acres of land from 1991 through mid-1997).
the land is not astronomically expensive. Significant differences in land prices could change the cost-benefit equation for deciding whether to acquire and preserve the watershed land. Finally, the federal government put the city to a choice: protect the watershed or build an extremely expensive filtration plant. It is questionable whether New York City would have chosen to protect water quality by protecting the watershed absent that federal pressure.

The last point raises a second important issue: how can governmental policy help promote water-quality motivated investments in watershed preservation? The government can start by forcing water suppliers to take water quality seriously through regulatory schemes such as the Safe Drinking Water Act. Although consumers might prize safe drinking water, they also savor low water rates and might not be willing to support a rate increase needed to purchase land that would promise water quality services. The government also must not favor technological over natural solutions. New York City chose to protect the Catskills watershed because EPA gave it a choice between a filtration facility and watershed efforts. If EPA had required New York City to build the filtration facility, the city might not have concluded that any additional water-quality benefits from protecting the watershed were worth the cost. Governments similarly must ensure that any funding aid provided to water suppliers can be spent on either technological or natural efforts to promote water quality. Although EPA has extended its revolving loan program for water quality investments to land acquisition, EPA prohibits a state from spending more than ten percent of its loan moneys on the acquisition of fee simples or conservation easements.30

Non-environmental regulations sometimes may also influence water suppliers’ decision whether to acquire and preserve watershed lands. Consider, for example, the rate setting system used by public utility commissions to determine how much private water companies can charge for their services. In most cases, water rates are set to permit companies a specified rate of return on the total capital invested in their business. Land is typically included in the rate base, but at original cost. Where a water supplier purchased

watershed lands in the distant past, the land might be worth far more today than its value in the rate base—encouraging the water supplier to find a way to sell the land and capitalize on the land’s increased value. This phenomenon might partly explain why a number of Connecticut water companies have sold off watershed lands in the last decade.31 Indeed, the Connecticut Department of Public Utility Control, whose mission includes reducing the water rates that consumers pay, sometimes has encouraged the water companies to sell such lands and then use part of the proceeds to lower their water rates.32

The simplest means that the government can use to promote water quality through land preservation, of course, would be to mandate that all water suppliers adopt a watershed preservation program demonstrated to ensure an adequate level of water quality. The choice between such an imperative regulation and the current choice given to water suppliers to either preserve the watershed or filter their water comes down to efficiency. In many settings, land preservation will not be the most economical means of ensuring adequate water quality.

A third issue is whether we currently have the scientific knowledge needed to determine which lands to preserve in order to maximize the value to water quality. As mentioned earlier, we know far more about water quality services than most other ecosystem services, but the science is still fairly rough and ready. New York City has chosen which land to preserve based on geography and the “travel time” that it would take runoff from the land to reach the city’s water supply.33

A final issue is the degree of “ecosystem synergy” obtained when water suppliers acquire and preserve watershed land for water quality purposes. Do the preservation efforts just ensure higher water quality, or do they also provide other valuable ecosystem services? It would be nice, for example, if the same land that water suppliers chose to preserve was also high in biodiversity or was habitat for endangered species. We do not have enough information at the moment, however, to know whether this is the case. Worse, the water quality motives that drive water suppliers to acquire and preserve watershed lands might conflict in some situations with other

31. See note 29 supra, Thompson, supra note 16, at 305 (citing An Ounce of Prevention, supra note 19, at 3, 7, 12-14, 17-19).
32. See An Ounce of Prevention, supra note 19, at 12, 17.
33. See National Research Council, supra note 22, at 280.
public goals. Given their water quality goals, for example, many water suppliers do not permit public access to or use of watershed lands owned by the suppliers. Where this is the case, public recreational interests conflict with the water quality goals. Emphasis on one ecosystem service undermines the provision of another.

On the whole, however, investments by water suppliers in watershed preservation provides one of the most exciting and significant examples of how those who benefit from ecosystem services are recognizing the services’ value and taking steps to protect the services.

III. The Service of Flood Control

Flood control also would seem to be a strong motivation for watershed protection. Like drinking water quality, flood protection is of tremendous importance. Floods cause over $4 billion in damages in an average year and lead to dozens of deaths.34 Scientists have a strong understanding of the relationship between watershed preservation and reductions in flood damages. Heavy vegetation can slow the runoff of precipitation into waterways, permitting some of the runoff to seep into groundwater aquifers and reducing peak flows.35 Wetlands similarly serve as natural sponges, soaking up water during times of peak runoff and then releasing the water slowly over time.36 A 1995 study by the Illinois State Water Survey, for example, estimated that every 1 percent increase in wetlands along a stream corridor in the state decreased peak stream flows by an average of 3.7 percent.37 Naturally contoured lands also spread out runoff temporally, more so than do highly developed regions with channelized riverbeds.38 Finally, undeveloped riparian land can help provide safety valves in case of floods: peak flows can be released onto the undeveloped land, reducing the risk of flood


35. See Building Green Infrastructure, supra note 30, at 13; Protecting the Source, supra note 5, at 17-18; Norman Myers, The World’s Forests and Their Ecosystem Services, in Nature’s Services, supra note 14, at 215, 216-17.

36. See Protecting the Source, supra note 5, at 15; Andrew Wilcox & John Harte, Ecosystem Services in a Modern Economy: Gunnison County, Colorado, in Nature’s Services, supra note 14, at 311, 317.

37. See Economic Benefits of Open Space, supra note 34, at 34-35.

38. See id.
damage to developed areas downstream.\textsuperscript{39}

Not surprisingly, therefore, some governmental agencies have invested in watershed preservation for flood control purposes. The Appendix to this article again gives a number of examples. In one of the best known examples, voters in California's Napa County approved an initiative to spend $160 million to acquire 500 acres of flood plain, in the expectation that the acquisition will significantly reduce flood damage.\textsuperscript{40} Local governments near Boston have also decided that acquiring 8,000 acres of wetlands, capable of holding approximately 50,000 acre-feet of water, was a more effective approach to flood control than the construction of a $100 million system of dams and levees.\textsuperscript{41} But flood control has driven far fewer watershed preservation programs than drinking water quality.

In trying to evaluate the role that ecosystem services can play in ecological preservation, the important question is why flood control has proven a less significant force in watershed protection efforts. Why have numerous steps been taken to preserve watersheds for water purification and few for flood control? Here, one currently can offer only educated guesses. As noted earlier, flood control is economically extremely valuable, and traditional engineering approaches to flood control are very expensive.\textsuperscript{42} Although detailed studies are lacking, the economics of "natural" solutions to flood control would seem to favor such methods over engineering approaches. Water suppliers have recognized for decades the value to water quality of a protected watershed, but flood control agencies historically have relied on technological solutions to flood risks. Part of the reason for this difference might be our historical failure to understand the importance of natural terrains and features to flood potential and mitigation. The willingness and eagerness of the United States Army Corps of Engineers to become involved in flood control, along with federal funding for flood control construction, also has inevitably biased thinking toward engineering rather than natural solutions.\textsuperscript{43} Whatever the reason for the traditional bias toward engineering, habits die hard. Flood control experts have spent far more time studying and perfecting engineering solutions than natural solutions, and government officials

\textsuperscript{39} See id.
\textsuperscript{40} Id. at 35.
\textsuperscript{41} Id. at 37.
\textsuperscript{42} See supra notes 26-27 and accompanying text.
\textsuperscript{43} See Thompson, supra note 16, at 303 (noting impact of federal funding).
trying to protect populations from flood loss are more likely to turn to the tried and true. The dominant role of the federal government in flood control also contrasts with water purification, a traditionally local activity. In the tradition of local experimentation (letting a thousand flowers bloom) one would expect a far greater range in approaches to water purification than to flood control. Controlling floods through watershed preservation also might be more difficult than providing water quality through watershed protection. In many cases, water supplies are captured, stored, and diverted from the upper reaches of a watershed where development is light and land prices relatively low; flood control, by contrast, may require land preservation up and down the reaches of a waterway, including land in prime development locations.

Governments can help overcome the traditional bias toward engineering solutions by providing both expertise and funding for natural solutions. The Army Corps of Engineers in recent years, for example, has begun to work with local communities on natural flood control measures (in part sensing that this is the growth field of the future).44 Efforts to rectify the bias toward engineering solutions, however, have been much slower in coming to flood control than to water purification.

Ecosystem services furnish not only a new approach to flood control but a new way of thinking about floods because scientists increasingly are recognizing that floods themselves can provide some valuable services. Floods, for example, can bring new and rich topsoil to riparian land.45 The potential value of floods suggests that governments should be thinking more in terms of flood management than flood control. Permitting floods to occur in some areas might both minimize flood damage elsewhere while adding a natural service value to the flooded area.

Research and restoration work currently being conducted on the Cosumnes River in California demonstrates not only the benefits of watershed preservation for flood control, but also the potential opportunity to capitalize on multiple ecosystem services through land preservation.46 Scientists believe that a restored

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45. Prof. Jeffrey Mount, Presentation at Ecosystem Services Workshop, Stanford University (Nov. 16-17, 2000); see also JEFFREY MOUNT, CALIFORNIA RIVERS AND STREAMS (1993).
46. For more information, see Cosumnes River Preserve, at http://www.cosumnes.org (last updated September 13, 2000).
Cosumnes River watershed can help reduce flood risks by storing runoff and reducing flow velocity. But scientists also believe that watershed restoration and preservation can provide additional water supplies by promoting groundwater recharge and supporting base flows; improve water quality; increase neighboring soil quality by regulating sediment flux, serving as a sink for fine sediment and nutrients, and providing a source for increased soil moisture; improve air quality by trapping airborne particulates, moderating air temperature, and sequestering carbon in floodplain forests and wetlands; and serve as valuable habitat for both fish and regional wildlife.47

IV. Initiatives Abroad

Efforts to protect ecosystem services are occurring well beyond the United States. Indeed, the most innovative mechanisms for capturing service values and rewarding economically those who protect the underlying ecosystem assets have been developed abroad. In both developed and developing countries, these initiatives have involved a range of groups—government agencies, NGOs, and private enterprises—from local to national levels. They provide an important and growing set of experiments for exploring new institutional terrain, evaluating what works and what doesn’t, and improving implementation in different social and economic circumstances.

In some of these initiatives, the potential values of services have influenced public land management decisions. In Madagascar, for example, a recent government decision to establish the 2,300km² Masoala National Park was based not only on a national policy to promote biodiversity conservation, but also on the anticipated capture of local ecosystem service benefits including sustainable forestry, production of non-timber forest products, and ecotourism.48 In the Ha Tinh Province of Vietnam, changes in community-level institutions have produced significant incentives for ecosystem service-based conservation. One village, Ky Thuong, has voluntarily established a reserve for the protection of biodiversity and supply of local ecosystem services, and others are attempting to follow suit.49

47. Prof. Jeffrey Mount, supra note 45.
48. See Claire Kremen et al., Designing the Masoala National Park in Madagascar Based on Biological and Socioeconomic Data, 13 CONSERVATION BIOLOGY 1055 (1999).
49. Personal communication from Vo Quy, at annual meeting of the Pew Fellows in Conservation and Environment, in White Stallion Ranch, Ariz. (Oct. 6, 1994).
Similar efforts are underway in India; although at an earlier stage of development, they are yielding promising changes in farming practices to preserve important ecosystem goods, such as valuable plant species.  

In several southern African nations, by contrast, private cattle ranchers are cooperating to develop eco-tourism with no government encouragement (indeed, in the face of major disincentives such as government subsidies for cattle). They are removing livestock, pooling their land and eliminating internal fences, and re-establishing native wildlife for safari purposes. The amount of land under conservation is growing substantially as a consequence, and has more than doubled in some large regions.

The largest experiments in protecting services are now underway in Costa Rica and Australia, where national initiatives already operate on relatively large areas and are being designed for further scaling up. Expansion will be possible with additional funding of the programs, which is anticipated with growing government and private-sector investment in carbon sequestration, and in more sustainable development generally, and with greater monitoring and accountability project results. Expansion is also likely to result from the great effort presently going into innovative policies to align economic incentives with environmental conservation. Costa Rica has been a leader on these fronts, recognizing the value of its ecosystem assets before they were badly degraded and attracting national and international investment in them. In fact, most of Costa Rica's major ecosystem investments are preventive, aimed at preserving threatened ecosystems that are still supplying services.

Costa Rica's efforts have focused on services provided by forests. Through the 1940s, most of the country was covered with forest and rates of deforestation were low. By the 1960s through the early 1990s, however, Costa Rica had one of the highest deforestation rates in the world (ca. 4.25%/yr). Today, the country retains 44% of its original forest cover, and is still undergoing deforesta-

50. See Madhav Gadgil et al., New Meanings for Old Knowledge: The People's Biodiversity Registers Program, 10 ECOLOGICAL APPLICATIONS 1907 (2000).
tion, although at a somewhat lower rate. The current government has established a goal of protecting remaining primary forest, encouraging regrowth of secondary forest, and promoting tree plantations on degraded soils to meet demands for timber and paper.

The 1997 amendments to Costa Rica's 1996 Forestry Law provide the legal and regulatory basis to compensate landowners for "environmental services" from their lands. The services include (i) watershed protection, (ii) carbon sequestration and storage, (iii) protection of biodiversity resources, and (iv) protection of key "life zones." By encouraging watershed protection, the government hopes to ensure the purification and supply of drinking water to urban centers, production of hydroelectric power (the main source of power for the country and a major export to neighboring countries), and flood control. By rewarding carbon-related services, Costa Rica hopes to be well-poised to capture benefits from the anticipated global market in carbon storage. By protecting biodiversity and key life zones, the country will be able to capitalize on pharmaceutical development and ecotourism.

The program has been funded primarily by a national sales tax on fossil fuel consumption, a contract with a private hydropower producer in Costa Rica (Energía Global), joint carbon sequestration implementation projects (with the United States, Norway, and the Netherlands), contracts with pharmaceutical companies for biodiversity prospecting, and from tourism admission fees to protected areas. Landowners engaged in forest protection or restoration receive approximately US$50 per hectare per annum. In regions important for ecosystem service provision, the major alternative land use is cattle ranching. This subsidy exceeds the rents for active pasture (typically $20 to $30 per hectare per annum) and may exceed the profits from cattle ranching ($8 to $125 per hectare per annum). Initially there was some concern that few landowners would volunteer to participate. Within a short time, however, the program was vastly oversubscribed, and new sources of funds are being sought to expand it.

Like Costa Rica, Australia is undertaking a systematic national

55. For details on environmental services payments and the institutional mechanism for their disbursement, see René Castro et al., The Costa Rican Experience with Market Instruments to Mitigate Climate Change and Conserve Biodiversity, MiNAE and FUNDECOR, San José, Costa Rica, April (1998).
56. Id.
assessment of its ecosystem assets and seeking ways of capturing their value. Its principal asset of concern is also forest cover, but for very different reasons than in Costa Rica. Australia's actions have been primarily restorative, reacting to extreme forms of ecosystem degradation and service impairment with severe socioeconomic consequences.

Australia has been undergoing a long period of deforestation—starting with European settlement and continuing today. Over time, the steady removal of native tree cover has allowed naturally occurring salts in the soil to rise to the surface and poison large areas of agricultural and grazing land. Deeply rooted, native trees act as pumps, transferring vast amounts of water from the soil to the atmosphere, thereby keeping the water table (and its salts) below the rooting zone of plants. With removal of native trees and other deeply rooted vegetation, this hydrological pumping service has diminished greatly: crops and pasture grasses do not transpire water to the atmosphere at nearly the same rate as the vegetation they replaced. As a result, the water table has crept invisibly upward, bringing with it the naturally occurring salts. Once the saline water table reaches the rooting zone of vegetation, it causes severe socioeconomic impacts.

Scientists fear that appreciation of the service provided by native tree cover has come too late in much of the wheat belt of Western Australia. Reversing the process of salinization is costly and slow. In the Murray-Darling River Basin (spanning Queensland, New South Wales, Victoria, and South Australia), however, there is more hope and there are major efforts to restore hydrological services and to reap many other ecosystem benefits at the same time. Even here, there is no guarantee of success. Within the New South Wales region of the Basin, 15% of the irrigated land is already degraded by salinity and 70-80% is under threat.

Linked national and state programs, many of which are just now being implemented, pay landowners for protecting or re-establishing native vegetation on critical recharge and riparian lands.


for establishing tree plantations on such areas, and for introducing more suitable cropping systems (perennial or salt-tolerant pastures or intercropping of high- and low-water-using crops to minimize “leakage”). So far, funds have come from government and from private industry. State Forests of New South Wales, for instance, has a contract with Tokyo Electric Power to establish forest for carbon sequestration and storage. The forest will be planted strategically to secure salinity control benefits, as well.

Salinity targets for 2010 have been set for “end-of-valley” and “within-valley” locations in each catchment. A flexible mix of market-based mechanisms, strategic government investment, promotion of new business opportunities, and regulation is being used to achieve these targets. Through adaptive management, a wide array of pilot projects has been implemented, with ongoing assessments of their success. For instance, the Hunter Salinity Trading Scheme, established in 1995, allows trading between power stations and mines of their rights to discharge saline water into the Hunter River. The scheme has permitted economic development without increasing river salinity and may be implemented elsewhere. Further support of market-based approaches will come in the form of an Environmental Sustainability Index, to be introduced by the Australian Stock Exchange, to support individuals and fund managers in directing funds toward environmentally and socially responsible investments.59 Momentum is also building behind the idea of creating and trading “biodiversity credits” along with salinity and carbon credits.60

V. Next Steps

In assessing the promise of an ecosystem services approach—an explicit focus on protecting and restoring services—the bottom line is whether this approach leads to beneficial changes in the behavior or priorities of the government and private sector. The increasing number of initiatives to value and protect ecosystem services, both within the United States and abroad, suggests that in many instances it will. There is increasing evidence that the beginnings of a broad shift are underway within environmental law and policy both in the United States and abroad—from protection of ecosystems to protection of ecosystem services.

59. Id.
60. Personal communication from David Brand, in Katoomba, Australia (April 10, 2000).
How can we spur this transition and realize the full potential of an ecosystem services approach? Part of the challenge is educational. Most people realize neither the critical role ecosystem services play in their lives nor the threats to service provision. Part is scientific. We need to understand better the linkage between ecosystem function and provision of services so we can appropriately weigh the ecosystem management options. Part is legal, since we have little experience with institutional design and regulatory instruments to protect services. And part is economic. We need to better value services and identify the institutional barriers to their commodification.

As in environmental policy generally, there is no one-size-fits-all solution for ecosystem service protection. We suggest, however, that there are four basic issues that must be seriously examined to determine which services hold the potential for greater legal or market protection, and the form such protection should take.

The first issue is *identification of the service*—delineating its range, status, and salience. What is the service’s scale of delivery? Local services, such as pollination, raise very different issues than regional services such as flood control or global services such as climate stabilization. Is provision of the service stable, declining, or increasing? If the service provision does raise cause for concern, what are the threats to the service? And, of critical importance to developing appropriate policy responses, is the importance of this service generally recognized by its recipients? This is generally less of an issue with water purification, for example, since we all pay for water, than for “free” goods that rely on services such as pollination or soil fertility.

The second issue is *valuation of the service*—assessing its economic benefits. Even if the service is under threat, we have limited resources and a wide range of pressing needs. Those services that are most valuable (to people) will receive priority. To value the service, one must ask whether it is a public or private good, and whether the service is scarce or redundant. Is it a joint service? If so, the valuation methodology should consider the various streams of benefits (e.g., in determining a wetland’s value, calculate benefits of water purification and flood control and nursery habitat, etc.). Even if the service is valuable, it may still be less costly to provide the service through built structures. Thus, one must ask, are there more efficient substitutes?

The third issue concerns *market development*—examining the obsta-
cles to capturing the service’s benefits. Assuming the service is under threat and sufficiently valuable to warrant resources for protection, we must still identify the most efficient policy tool (or combination of tools) to do so. If relying on economic instruments, the threshold question is whether current market mechanisms signal changes in provision of the service. Are there market signals of service degradation? If not, what are the barriers to commodification of the service? Perhaps the problem is one of split incentives or free riders. Do the costs and benefits accrue to the same actor? Perhaps the problem stems, at least in part, from transaction costs. Does protection require collective action?

The last issue is regulatory development—crafting appropriate policy tools to protect the service. Market instruments rarely, if ever, operate outside regulatory proscriptions. What are the potential uses of taxes, subsidies, and fees? What are the barriers to their use? Is it feasible to create and allocate property rights? What about creating new institutional authorities, such as ecosystem service districts?

Each service will provide different answers to many of these questions, and the answers will vary depending on location, as well. In the pages that follow, volume 20, issue 2, of the Stanford Environmental Law Journal presents current research grappling with these questions, providing an intellectual base to ground the shift from theory to practical implementation. Our hope is that reading these articles will spur further interest in ecosystem service protection and shape research agendas that develop this exciting and promising approach to environmental law and policy.
APPENDIX: EXAMPLES OF Ecosystem Investments in Watershed 61

This appendix lists examples of actions by states and local governments in the last decade to preserve watershed lands for either water quality or flood control purposes. This list does not include other actions taken by states or local governments in local watersheds, such as direct land use regulation, the encouragement of voluntary best management practices, or the longstanding ownership of watershed lands by water utilities. It also does not discuss efforts to preserve watershed lands for other purposes, such as fisheries protection or recreation.

Water Quality

California

Contra Costa Water District. The district is negotiating “land management agreements” with private landowners near its Los Vaqueros Reservoir. The district appears to have long owned 18,500 acres around the reservoir, some of which it has rented to farmers and ranchers. It is currently reconfiguring these leases “to minimize impacts to environmental resources and reservoir water quality.”

Florida

Dade County. The county imposes a 3% surcharge on water bills that is used to fund land acquisition for watershed protection.

Maine

Portland. The city is currently purchasing a small number of properties within 1,000 feet of its main reservoir and tributaries. Portland also funds a small “Plant Grant Program” that provides matching funds to other private landowners to establish buffers to control erosion.

Massachusetts

Boston. The Metropolitan District Commission has been actively purchasing lands in its three watersheds since 1985, primarily through the use of bond funding. The land acquisition program has helped it increase the percentage of the watersheds that it owns

61. For more information about these and other examples, see Protecting the Source, supra note 5; An Ounce of Prevention, supra note 19; Building Green Infrastructure, supra note 30; Economic Benefits of Open Space supra note 34.
as of 1999 from 8% to 22% in the Wachusetts watershed, from 31% to 37% in the Ware, and from 51% to 57% in the Quabbin. The commission plans to spend another $100 million over the next decade on additional land acquisition that will bring its ownership of land in the Wachusetts to 30% and in the Ware to 60%.

Minnesota

**Rochester.** The city has started a program that pays riparian farmers to establish buffer zones along key water bodies to protect the city’s water supplies.

New Jersey

**Ocean County.** In 1997, county voters approved a new property tax to provide nearly $4 million annually for acquisition of sensitive lands, including watershed lands important for protection of the county’s water supply.

**Sterling Forest.** In a joint effort, the states of New Jersey and New York have purchased over 70,000 acres of land in Sterling Forest, the watershed for almost a quarter of New Jersey’s population. With help from non-profits like the Trust for Public Land and the Open Space Institute, 90% of Sterling Forest has now been acquired for $55 million, far less than the cost of a water filtration plant.

New York

**New York City.** In one of the best known examples, New York City has committed to investing over $250 million in the acquisition of up to 350,000 acres of land in the Catskill watershed in order to avoid constructing a filtration plant at a capital cost of $4-8 billion with an annual operation cost of $300 million. The land acquisition is part of a larger watershed-protection program that includes paying to improve sewage facilities in the watershed and updating and extending the city’s regulation of watershed activities. The total cost of the watershed-protection program is estimated at about $1.5 billion.

**Syracuse.** The city, like Rochester, Minnesota (see above) pays farmers riparian to its key water supplies to establish a buffer zone along the water bodies. The city is spending $17 million on watershed protection in an effort to avoid spending up to $40-50 million on filtration.
North Carolina

In 1996, the North Carolina legislature authorized at least $30 million a year in state funds to protect water resources, including funds for the purchase of watershed land and easements. As of early 1999, approximately 40% of the $92.5 million in grants issued had gone toward land acquisition.

- Charlotte-Mecklenburg. Charlotte-Mecklenburg Utilities uses a portion of its capital improvement budget each year to acquire watershed lands along Mountain Island Lake, the utilities' major source of drinking water. Gaston and Lincoln counties are also acquiring watershed frontage.

- Waynesville. In 1995, EPA issued a $250,000 grant to the city for watershed land acquisition.

Rhode Island

- Providence. The city collects a small per-gallon tax to fund watershed acquisition.

Texas

- Austin. In 1998, city voters approved a $65 million revenue bond to purchase land and easements as part of a 15,000-acre watershed buffer zone.

Utah

- Salt Lake City. The city assesses its water customers a small monthly fee to pay for land preservation in the city's Provo River watershed; to date, the city has acquired over 1,000 acres. Like New York City, Salt Lake has significant extraterritorial jurisdiction over land use in its watersheds that it also uses to protect water quality.

Washington

- Seattle. Through land exchanges with the federal government starting in 1962, Seattle has acquired close to 100% of the land in its Cedar River watershed. The city has developed a habitat conservation plan under the Endangered Species Act for the Cedar River watershed that will establish an ecological reserve on about 64% of the land; it will permit commercial harvest of timber on other portions of its land. In 1998, Seattle engaged in a land exchange with Weyerhaeuser to increase its ownership of land in its other major watershed, the South Fork Tolt River watershed, from 30% to 70%.
Flood Control

California

Napa County. The county plans to spend $160 million to acquire 500 acres of flood plain in an effort to reduce flood potential, which has led to $500 million in damages in the last four decades of the 20th century.

Colorado

Littleton. The city has acquired over 600 acres of land for combined flood control and park recreation purposes.

Massachusetts

Boston. Local governments in the Boston area have acquired rights to 8,000 acres of wetlands that they believe are capable of holding some 50,000 acres of water during potential flood periods.

Texas

Harris County. The Harris County Flood Control District is partnering with non-profit organizations to acquire agricultural land in the Katy Prairie near Houston, Texas, to protect habitat while also serving as a safety valve for seasonal flooding.