DISCUSSION PAPER

Biodiversity, Ecosystem Services, and Land Use

Comparing Three Federal Policies

Margaret Walls and Anne Riddle

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Abstract

Natural ecosystems provide a variety of benefits to society, known as "ecosystem services." Fundamental to the provision of ecosystem services in a region is its underlying biodiversity, i.e., the wealth and variety of plants, animals, and microorganisms. Because the benefits from ecosystem services and biodiversity are not valued in market exchanges, private landowners tend to undersupply them. We compare and contrast the different approaches taken to providing ecosystem services on private land in three federal programs—the Endangered Species Act, the Conservation Reserve Program, and Section 404 of the Clean Water Act. The Endangered Species Act (ESA) places restrictions on land uses for private landowners if endangered species, or critical habitats for endangered species, are found on their properties. The Conservation Reserve Program (CRP) compensates farmers for removing valuable property from agricultural production to preserve wildlife habitat, water and soil quality, and other ecosystem values. Section 404 of the Clean Water Act prohibits destruction or damage to wetlands, unless individuals buy credits for equivalent wetlands created by third parties—so-called "wetlands mitigation banks." These three policies run the gamut from a command-and-control regulatory approach to a "payment for ecosystem services" option. We summarize the economics literature on key findings from these programs.

Key Words: biodiversity, critical habitat, conservation, green infrastructure, payment for ecosystem services, public goods, wetlands mitigation

JEL Classification Numbers: Q57, Q15, Q25, Q28

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Introduction

Forests, grasslands, wetlands, and other natural areas can provide a range of benefits to society. In addition to private market values from activities such as grazing and timber production, these natural landscapes can have recreational value, offer flood protection, purify drinking water supplies, safeguard bird and wildlife habitat, sequester carbon, and regulate the climate. These public benefits from nature have come to be known as "ecosystem services." Fundamental to the provision of ecosystem services in a region is its underlying biodiversity, i.e., the wealth and variety of plants, animals, and microorganisms. Biodiversity is necessary for the natural functioning of ecosystems.

Private landowners tend to undersupply most ecosystem services and biodiversity since the values are not captured in market exchanges. The owner of a forested land parcel, for example, may reap the benefits of the timber that is harvested and sold but has no means of capturing the benefits the forest may provide in terms of carbon sequestration, endangered species habitat, clean water in nearby streams and rivers, and other environmental services of the land. Moreover, based on private market values, the landowner may choose to harvest the timber and sell the land for development rather than replant. Without a mechanism to capture the nonmarket values of the standing forest, ecosystem services will be underprovided.

In the United States, most land use regulation is established locally through zoning codes, but the federal government has passed some important laws and regulations that affect land use and thus the ecosystem services that land provides. We describe here the workings of three programs and discuss findings in the economic literature analyzing these programs: (1) the Endangered Species Act—in particular, the provisions in that law that impact private land markets; (2) the Conservation Reserve Program and its voluntary mechanism for agricultural land retirement; and (3) Section 404 of the Clean Water Act, which uses a market-based approach to protecting wetlands. We compare and contrast the different approaches taken to land

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* Margaret Walls is a senior fellow and and Anne Riddle a research assistant at Resources for the Future. We appreciate helpful comments from Robert Deacon.

conservation in these three programs, which range from a command-and-control regulatory option to a more incentive-based mechanism that has features consistent with "payment for ecosystem services."

The Important Role of Private Land in Ecosystem Services and Biodiversity

Approximately 60 percent of land in the United States is in private ownership. Virtually all of the cropland in the United States is privately owned, along with 62 percent of grassland, pasture, and range, and 63 percent of all forestland (Nickerson et al. 2011). According to one recent study, 95 percent of the plants and animals listed as endangered under the U.S. Endangered Species Act (ESA) have at least some habitat on private land (Hilty and Merenlender 2003). Other studies have found that a significant percentage of endangered species cluster in "hot spots" on land that has valuable competing uses (Dopson et al. 1997).

Private landowners are likely to focus on these competing uses in the absence of any government regulations and incentives to do otherwise, since they do not bear the full costs of the lost ecosystem services and biodiversity if the land is developed nor bear the full rewards if it is not. Likewise, even if the land remains in a natural state, managing it so as to protect the environmental services of the land is unlikely without a policy to induce that behavior. Some recent studies have developed economic-ecological models to illustrate these private market outcomes, though fully integrated models with micro-fundamentals on both the economic and ecological sides are rare. In one recent example, Eichner and Pethig (2006) specify a model in which individuals choose land use for economic activities and any residual land is left over to provide habitat for three species that form a food chain. The size of the habitat determines the diversity and abundance of species, and that biodiversity, in turn, leads to ecosystem services that provide benefits to humans. The authors show that in this setting, the free market outcome leads to zero habitat in the long run and all species are doomed, thus land restrictions are optimal. While highly stylized, this model provides a first step toward a fully integrated economic-ecological model. More research is needed along these lines to better understand the implications for species in a free market setting and the role for policy.[1]

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[1] For an example of a study that links the economics and ecology at a more "market" level, Finnoff and Tschihart (2008) combine a dynamic computable general equilibrium economic model with a dynamic general equilibrium ecosystem model in a fisheries context.

Other studies connect econometric models with ecosystem outcomes, bringing in spatial aspects of land use. Spatial considerations are important; location and degree of contiguity of key wildlife habitat, for example, can be critical to the provision of biodiversity. In one recent study, Lewis et al. (2011) use an integrated econometric-ecological framework to simulate alternative incentive-based conservation policies and their effects on biodiversity. This study reveals the importance of habitat contiguity: a simple voluntary incentive-based policy in which the government offers a fixed payment per acre for all land converted from crop and pasture land to natural areas is shown to be inefficient, especially when the government has a small conservation budget, because of the inability to control the spatial patterns of land use. Adding rules about site selection—in particular restricting conservation to parcels that border other preserved parcels and focusing on larger parcels—can improve efficiency. A large literature exists that examines site selection and optimal targeting of conservation (see, for example, Ando et al. 1998; Newbold and Siikamäki 2009; and Newburn et al. 2004).

The concept of "payment for ecosystem services," or "payment for environmental services" (PES), has arisen in recent years as a means of internalizing the nonmarket environmental benefits of land. Wunder (2007) defines a PES scheme as a "voluntary, conditional agreement between at least one 'seller' and one 'buyer' over a well defined environmental service—or a land use presumed to produce that service." The agreement is conditional in that payment should be made only if it can be verified that the environmental service is continually provided. Sellers are typically private landowners and buyers may be the government, conservation agencies or other nongovernmental organizations, or private individuals or firms.

Despite the appeal of the PES approach in theory, few true payment schemes exist in practice. And in the United States, many land use policies veer far from the PES ideal. Strict regulatory options are prevalent. We begin below with a federal law that establishes land use restrictions rather than using the pricing system, the Endangered Species Act, and then discuss incentive-based policies that are closer to the PES principle.

The Endangered Species Act

The purpose of the ESA is to protect and recover species of plants and animals that are under threat of extinction, along with the ecosystems upon which they depend. Signed into law in 1973, the ESA has several provisions that are designed to limit the actions of both government and private landowners whose properties provide critical habitat for listed species. Section 9 of the Act prohibits the "taking" of endangered species, defined not only as killing, wounding, or

capturing an endangered animal but also as adversely modifying its habitat. So-called "critical habitat" under the Act is defined in Section 3 as specific geographic areas that have physical or biological features that are essential to conservation of a listed species and that may require special protection or management. Section 10 allows the government to grant an "incidental take permit" to authorize activities that would otherwise be prohibited under Section 9. This requires a landowner to develop a habitat conservation plan.[2]

The taking and the critical habitat provisions of the Act have been particularly controversial and, by many accounts, have led to some counterproductive outcomes. Together they provide strong incentives for landowners to avoid having their land designated as critical habitat, and evidence suggests that some landowners have engaged in a number of preemptive practices in advance of critical habitat designation (Adler 2008; Innes et al. 1998). In North Carolina, some forest landowners in the 1990s preemptively harvested timber in order to reduce red-cockaded woodpecker habitat on their land (Lueck and Michael 2003); the woodpecker was (and remains) an endangered species. Similar actions have been alleged in the Pacific Northwest with respect to the northern spotted owl, a threatened species. Other evidence of preemption has shown up in econometric analysis of data on land development: land in Arizona that was to be designated as critical habitat for the endangered cactus ferruginous pygmy owl was developed about a year earlier than similar land that was not so designated (List et al. 2006). And studies have documented that the mere listing of a species can discourage private landowners from participating in conservation efforts. Property owners within range of habitat of the endangered Preble's meadow jumping mouse, for example, revealed in surveys that they often would refuse to give biologists permission to conduct research on their land (Brook et al. 2003).

Several studies have shown that critical habitat designation has a negative effect on property sales and property values. In an analysis of 13 years of data on building permits in California, one study found that a proposal of critical habitat in a municipality resulted in a 23.5 percent decrease in the supply of housing permits in the short run and a 37 percent decrease in the long run (Zabel and Paterson 2006). Another study, using a calibrated spatial general equilibrium model, found spillover effects from critical habitat designation (Quigley and Swoboda 2007). Demand for housing outside of areas designated as critical habitat rises, leading to higher housing prices and land rents. This redistributes welfare among landowners and

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[2] More information on the ESA can be found at http://www.fws.gov/endangered/laws-policies/.

consumers in the region. The model showed that the principal distributional impact is to reduce the welfare of housing consumers. The location of the critical habitat lands was also found to matter—the closer those lands are to city centers or other highly urbanized areas, the more valuable they are in development and the higher the costs of critical habitat designation.

The impacts on land values and housing prices are to be expected; any regulation comes with a cost. The question is whether the ESA has generated benefits in excess of those costs. Most economists are doubtful. Since the law's enactment, nearly 2,000 species have been listed as endangered or threatened, but less than 50 have been removed from the list. As of July 2008, the Fish and Wildlife Service, which administers the Act in conjunction with the National Oceanic and Atmospheric Administration, could identify only 21 species recoveries, as some of the delistings are due to data errors or extinctions (Adler 2008). No one has attributed any species recoveries directly to the regulation of habitats on private land.

Many experts have pointed out that the essential flaw in the ESA is that it penalizes landowners, rather than rewards them, for having critical habitat (Polasky et al. 1997; Adler 2008). Instead of receiving direct payments for the biodiversity resources on their land or enjoying a higher land value, they are penalized in reduced property values and the direct costs of maintaining the habitat. The Conservation Reserve Program, described in the next section, provides an alternative policy approach.

The Conservation Reserve Program

The Conservation Reserve Program (CRP) was passed into law in 1985 as part of the Food Security Act. It pays farmers to retire land from production, targeting highly erodible land, wetlands, streamside buffers, wildlife habitat, and other land that is determined to have ecosystem service benefits. Landowners can also receive compensation from the CRP for up to 50 percent of the costs of approved conservation practices on their land. The CRP is by far the largest federal conservation program—at nearly $2 billion per year, it accounts for approximately one-third of all land conservation spending by the federal government (Walls et al. 2009). In 2009, 32 million acres of land were enrolled in the CRP, approximately 8 percent of all cropland.[3]

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[3] For more information on the CRP, see
http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp.

The program is voluntary. Farmers submit parcels for enrollment, along with a set of proposed conservation practices. The offer receives a score based on a government-calculated Environmental Benefits Index (EBI), which allots points for (i) perceived benefits to wildlife, including trees and habitat cover and whether the land is in a designated wildlife priority zone; (ii) water quality benefits, which are based on the expected impact on surface water and groundwater quality due to reduced erosion, runoff, and leaching; (iii) an erosion factor; (iv) an estimate of enduring benefits, which are points based on the likelihood that the land will remain out of crop production even after the CRP contract expires; (v) air quality benefits from reduced erosion; and (vi) costs—if the farmer is willing to accept less than the maximum rental rate established by the government for the parcel (which is based on soil productivity and average agricultural rents) and willing to forgo cost-sharing assistance from the government on its conservation expenditures, the project is assigned higher points in the EBI calculation. The first three components are weighted more heavily in the EBI than the last three, and of the last three, the cost factor receives the least weight. The EBI methodology was introduced in 1990; in prior years, the choice of parcels was based purely on soil erosion.

Clearly the CRP works with private landowners in a very different way than the ESA. Instead of mandating and regulating private land activities that are harmful to ecosystems, the CRP provides financial rewards for beneficial practices. Moreover, the EBI approach attempts to tie selection of parcels to ecosystem service benefits achieved. Although the index approach is less than perfect, as several authors have pointed out, one estimate suggests its use has nearly doubled the annual benefits from the program compared with the pre-1990 system while leaving costs about the same (Feather et al. 1999). In contrast to the destructive preemptive practices documented in the ESA, farmers interested in the CRP program have been known to plant trees and wildlife cover in order to increase their EBI and the likelihood that their bids will be accepted. These activities, in turn, make it less likely that CRP lands will return to cropland after the end of the 15-year contract period and thus more likely that the ecosystem benefits are long-lasting (Roberts and Lubowski 2007).

The primary ecological benefits of the CRP are water quality improvements and increased wildlife habitat. A 1990 study by researchers at the USDA's Economic Research Service (ERS), which has conducted several analyses of the CRP over the years, estimated the net present value of improvements in surface water quality at $2 billion to $5 billion and habitat protection at $3 billion to $5 billion (Young and Osborn 1990). Overall, the program was estimated to have positive net benefits. A 1999 ERS study estimated the CRP's recreation benefits over the 1992–1999 period from water-based recreation, pheasant hunting, and general

wildlife viewing (Feather et al. 1999). That study concluded that the benefits totaled $555 million per year. Among conservationists and wildlife advocates, the CRP is generally considered the single most important reason for the recovery of many North American waterfowl populations since the mid-1980s. In the "duck factory" of the Prairie Pothole Region, which includes portions of Minnesota, South Dakota, North Dakota, Iowa, Nebraska, Montana, and Wyoming, 4.7 million acres of CRP lands account for over 14 percent of the remaining native grasslands in the region, habitat that is essential for migratory waterfowl. Conservation organizations such as Ducks Unlimited have conducted studies identifying CRP lands as critical to the survival of some important species, including five common duck species, pheasants, and 12 grassland songbird species (Ducks Unlimited n.d.).

Despite the general consensus of positive net benefits from the CRP, several researchers have pointed out some shortcomings in the program. Because the rental payment is based on soil productivity and average agricultural rents but not directly tied to the EBI, the program has some built-in inefficiencies. Some farmers are overpaid while others may not even participate, even though their lands have high environmental values (Kirwan et al. 2005). Farmers can be overpaid when they have a low reservation rent but high EBI—a situation typical of highly erodible lands. Because the government caps rental payments, on the other hand, some farmers with high EBIs but high reservation rents may not be offered a high enough rental payment to participate.

One suggested solution to this problem is constructing a payment scheme in which payments vary directly with the EBI, i.e., a kind of per-unit subsidy payment (Kirwan et al. 2005). Other authors have suggested the use of a "quota" auction, in which the government would limit the number of parcels it would accept that have high EBI scores but low agricultural reservation rents. Experimental evidence has shown that competition would arise in this setting, which would lower bids and thus program costs (Hellerstein 2010). Another suggestion is that landowners be allowed to ask for payments higher than those established by the government cap, in order to bring in parcels with high EBIs but high reservation rents (Hellerstein 2010).

Some experts have proposed smaller changes to the existing system that would improve outcomes. Roberts and Lubowski (2007) show that existing participants in the CRP are more likely to keep their land in the program than are new entrants to sign up. These authors conclude that the program should thus offer different levels of payment depending on whether farmers are renewing or signing up for the first time. Other research has highlighted the importance of geographic location of CRP lands for ecosystem benefits, which in turn has led to proposals to include geographic location in the EBI (Hellerstein 2010). One suggestion is to include additional points for parcels located next to wildlife habitat or other preserved parcels in order to

prevent habitat fragmentation. Location is just one example of additional information to improve the targeting in the program. Other suggestions include better measures of the water quality benefits of the land, perhaps from water quality models, and general measures of ecosystem services (Yang et al. 2005).

The CRP has many elements of a payment for ecosystems services program. Private landowners receive payments to maintain and protect their land for conservation and environmental purposes. However, the payments come from the government. A market for ecosystem services is not developed with exchanges between private agents leading to land protection. In our final section we discuss a program that has created such a market in the United States, albeit a nascent one: the wetlands mitigation banking program in the federal Clean Water Act.

Wetlands Mitigation

Section 404 of the Clean Water Act is one of the few federal statutes written explicitly with ecosystem services in mind. It prohibits the discharge of dredge or fill materials into any U.S. waters unless a permit issued by the Army Corps of Engineers authorizes such a discharge. For every authorized discharge, the permittee must avoid and minimize to the greatest extent practicable any adverse impacts to wetlands, streams and other aquatic resources. If impacts are unavoidable, compensatory mitigation is required—that is, replacement of the lost wetland and its associated functions. This has become known as the "no net loss" of wetlands rule. Methods of compensatory mitigation include restoration, establishment, enhancement, and preservation of wetlands; the Army Corps of Engineers or an authorized state agency determines the appropriate form and amount of mitigation required for each project.[4]   In fiscal year 1999, approximately 21,500 acres of permitted wetlands losses took place, offset by approximately 46,000 acres of compensatory mitigation (U.S. EPA 2001). Other studies have estimated annual average acreage in the 2000s at approximately these same levels (Kihslinger 2008).

As an alternative to undertaking their own mitigation (or sometimes paying a "fee in lieu"), permittees are allowed to meet the mitigation requirements through purchases from a wetlands mitigation "bank." A mitigation bank is a wetland that has been restored, established,

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[4] More information on the wetlands provisions of the CWA is available at
http://www.epa.gov/owow/wetlands/facts/fact16.html#one.

enhanced, or preserved and then set aside to compensate for future conversions of wetlands for development activities. It may be created by a government agency, a corporation or individual, or a nonprofit organization. When the regulated entity approaches the mitigation bank for a purchase, the bank quantifies the wetland functions or acres restored or created in the transaction and calculates the value of the credits needed. The permittee purchases the appropriate number of credits from the bank, and after the transaction the bank owner becomes the party responsible for meeting requirements under the law concerning long-term management of the land, site protection, and defense of easements.

The use of mitigation banks started in the early 1980s, but final federal guidance wasn't released until 1995. Since that time, they have become a mainstream way to meet the requirements of the Clean Water Act and have generated a market for wetlands conservation activities. A 2005 inventory by the Army Corps of Engineers documented a total of 450 approved mitigation banks and an additional 198 banks in the proposal stage (Scarlett and Boyd 2011). A 2003 estimate by the Environmental Law Institute (ELI) put annual spending on wetlands mitigation banking at $2.3 billion, interestingly topping federal spending on the CRP (ELI 2007). This same study estimated that more than 14,000 acres of wetlands are preserved annually through the banking program. ELI research also found that, out of a sample of 291 banks in existence in 2005, 71 percent had been created by private entrepreneurs to serve multiple clients, suggesting at least the potential for wetlands credit sales to have some of the features of competitive markets. Of the remainder, 25 percent were private and served a single client and 4 percent were created by a public agency (Wilkinson and Thompson 2006). The number of private banks serving multiple customers increased greatly in the early 2000s as landowners and permittees became more familiar with the approach.

The market-based nature of wetlands mitigation banks gives them great appeal. They provide a low-cost way for permittees to meet the requirements of the Clean Water Act. Compared with on-site mitigation, or even mitigation off-site through individual one-on-one transactions with landowners, purchases from an established wetlands bank may be easier and have lower transactions costs. Moreover, the market in wetlands credits, by generating competition and bargaining in market exchanges, should help to bring down the costs of meeting the "no net loss" requirements.

Some research suggests, however, that the wetlands mitigation program has failed to live up to its promise (Turner et al. 2001; National Research Council 2001). In reviews of permit requirements, studies have found many unfinished projects. Moreover, permit conditions are not being met even in finished projects, and studies have found the mitigation area acreage to

sometimes be less than required in the permit and even less than the acreage lost to development. Wetlands functions are also not being replaced in many projects as required by the law; studies have found that only about 20 percent of sites met the ecological equivalent of the displaced wetland (using measures of vegetative cover and hydrological function). Some of these documented problems are due to poor monitoring and uneven administration of the program and not necessarily to the use of banks and credit trading, but studies have found that banks may create additional problems. In some locations, banks are not meeting the definition of wetlands but rather are just general conservation areas. And of the true wetlands in banks, many have been found to be in poor condition. A 2007 study of 45 wetlands banks, covering over 119,000 acres of land in Florida, concluded that full wetlands function had not been achieved in the banks even though such function was assumed when transferring credits (Reiss et al. 2007). The authors of that study offered several suggestions for improvement of the program, including allocating a higher percentage of credits for achieving success criteria and a lower percentage for completion of specific tasks.

ELI research estimates the costs of wetlands mitigation at approximately $2.9 million per year, but it places fairly wide uncertainty bands on the estimates because of poor data on costs (ELI 2007). Whether benefits exceed these costs is unclear. Although the problems we mentioned above seem to suggest that the program is not meeting the "no net loss" goal, it is clearly protecting wetlands over a no-policy baseline. Many studies have used stated and revealed preference methods to value wetlands and these studies have generally found positive values, though results vary greatly by location and wetland type (McConnell and Walls 2005). One meta-analysis in the early 2000s concluded that the value of wetlands averages just over $900 per acre but that the range of values across studies is quite high (Woodward and Wui 2001). Wetlands that provide opportunities for bird-watching were found to have the highest value, at more than $1,200 per acre. The general conclusion the authors reached was that the benefits of wetlands are highly site-specific. This makes it difficult to conduct an overarching benefit–cost analysis of the wetlands mitigation banking program.

Conservation Banks and "Green Infrastructure"

The wetlands mitigation banking experience has led to the creation of "conservation banks." Conservation banks are natural lands set aside to protect rare habitat and support threatened and endangered species. Initiated in California in the mid-1990s, conservation banks are intended to operate in the same way as wetlands mitigation banks but for purposes of meeting habitat requirements under the ESA and potentially other regulations. Formal federal guidance

for the use of conservation banks under the ESA was established in 2003, making the Fish and Wildlife Service responsible for the administration of conservation-banking markets. These banks are still in their infancy, however, and little systematic information is available on them (Walls et al. 2009). It appears that only California has seen any significant use of conservation banks. For a time, observers expected the conservation banking idea to take off nationwide. This optimism arose from expectations over climate policy; a carbon cap-and-trade program or other climate legislation that gave value to carbon sequestration in forests and other natural areas might have created a significant demand for conservation and increased the use of conservation banks and a market-based system for land conservation more generally. This appears unlikely in the foreseeable future.

In an era of strained public budgets, the conservation-banking idea and market-based approaches to conservation in general may have great appeal. Many communities are facing high costs to meet EPA's Total Maximum Daily Load (TMDL) restrictions on nitrogen, phosphorous, and sediment pollutants in local streams and rivers. Municipal stormwater systems and combined sewer-stormwater systems are expected to need significant and costly upgrades to meet the requirements. So-called "green infrastructure" alternatives focused on land conservation are receiving a great deal of attention as low-cost alternatives to the traditional "gray infrastructure" approach. Similar green options for flood protection have been advocated as well. And many communities are realizing the recreational, aesthetic, and habitat co-benefits the natural lands would provide. The accompanying box (below) presents a brief summary of two prominent examples of green infrastructure programs. More research is needed on the costs and benefits of these green alternatives to traditional gray options, including their impact on land markets.[5]

Concluding Remarks

Land use is inextricably linked to the provision of ecosystem services and biodiversity. In the absence of government intervention, private landowners will undersupply these public goods. The question then is exactly how to intervene in land markets to best provide them. We discussed three federal government policies in the United States: the Endangered Species Act, the Conservation Reserve Program, and wetlands mitigation banking in the context of the Clean Water Act. These three programs run the gamut from a strict command-and-control approach to

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[5] See Kousky et al. (2011) for an analysis of the benefits and costs of using green infrastructure for flood mitigation, with an example for a watershed in Wisconsin.

a flexible market-based option, thus providing a laboratory to study what works. The programs also have very different effects on private landowners and on land conservation.

Examples of Green Infrastructure[*]

New York City. New York City's investment in land conservation to protect drinking water supplies is one of the best-known examples of green infrastructure. The city has an unfiltered water supply, which comes from the Catskills/Delaware watershed upstream of the city. To avoid EPA filtration requirements in the early 1990s, the city adopted a novel approach: it began acquiring land and easements on private property in the watershed to protect land as natural areas. It now has over 70,000 acres of land conserved at a cost of about $1.5 billion. The city estimates that if it had opted to build a filtration plant instead, it would have spent approximately $6 billion up front plus an additional $250 million per year on operating and maintenance costs.

Milwaukee. Milwaukee, Wisconsin, experienced several consecutive floods and storms of unexpected severity in 1997 and 1998, causing millions of dollars of damages. This prompted the Milwaukee Metropolitan Sewerage District (MMSD) to look at natural water management techniques to augment existing gray infrastructure. In 2002, the Greenseams program was created. Similarly to the Catskills/Delaware watershed program for New York City, the MMSD purchases lands or obtains conservation easements in targeted areas to prevent them from being developed, using local stormwater fees and funds from the state. Over 2,100 acres of land have been protected using fee-purchases and easements. The MMSD estimates that the protected areas can hold an estimated 1.3 billion gallons of water, at a present discounted cost of approximately $27.7 million. By contrast, the city's main overflow prevention system, the Deep Tunnel system, currently holds 405 million gallons and cost about $3 billion.

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[*]For more information on these two programs, see http://www.epa.gov/region2/water/nycshed/filtad.htm and http://v3.mmsd.com/greenseams.aspx. For more information on green infrastructure in general, see http://www.conservationfund.org/green_infrastructure and http://cfpub.epa.gov/npdes/home.cfm?program_id=298.

Research by economists suggests that the CRP has been the most successful, protecting ecosystem services on privately owned farmland and doing so in a relatively low-cost manner relative to alternative approaches. Questions remain about the program—whether an improved design could increase net benefits by lowering rental payments and enhancing the environmental benefits achieved—but the CRP remains one of the better-designed ecosystem services programs in the United States. By contrast, the ESA creates perverse incentives for private landowners—to preemptively reduce habitat to avoid the requirements of the law. And while wetlands mitigation banking is closer to a true market-based, payment for ecosystem services approach, it has been plagued with some problems related, at least in part, to the difficulties involved in defining and measuring the services provided by wetlands. This highlights an important issue for payment for

ecosystem services programs in general: it is often difficult to accurately measure, monitor, and enforce in such a way as to optimally provide these nonmarket goods and services.

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