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Ecosystem Services: Quantification, Policy Applications, and Current Federal Capabilities

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Abstract

The study describes existing federal policies that permit or promote ecosystem services analysis, management, investments, and markets. Our survey discusses: 1) current programs that stimulate or support the measurement of ecosystem services; 2) existing federal drivers of ecosystem services analysis; and 3) programs that stimulate investment in ecosystem services. Understanding existing capacity is important to federal and other leaders who see opportunities for environmental policy innovations—such as payments, markets, and management practices—based on ecological wealth and services.

Key Words: ecosystem services, natural capital, ecosystem-based management

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Executive Summary

Natural systems such as wetlands, sea marshes, free-flowing rivers, forests, and grasslands provide services such as water purification, coastal storm and flood protection, and air pollution mitigation that benefit human communities. Yet the connection between ecosystems and these services is sometimes neither readily apparent nor easy to measure and translate into market investments. As a result, these ecosystem services are often not taken into account in decisions about land, water, and resource management and use. This neglect has resulted in underinvestment in environmental protection and corresponding losses of natural system functions and their benefits to human communities.

Some current federal policies have the potential to strengthen investment in ecosystem services restoration, enhancement, and protection and to drive the development of markets for these services. This paper highlights policies and planning tools that could expand ecosystem services investments and markets so that human communities, economies, and the environment benefit.

Four "drivers" within the current political and economic landscape have heightened interest in ecosystem services markets and investments.

- *The search for new revenue streams for landowners and land managers to support conservation, open space protection, and sustainable practices*: Florida, for example, now pays farmers to maintain wetlands on their private lands in order to store water.

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- *Potential cost savings for basic community services*: Seattle, for example, has invested in natural landscapes to reduce stormwater runoff at a cost 25 percent lower than that of traditional engineering solutions.
- *Opportunities for more cost-effective regulatory compliance*: Water managers in the Tualatin Basin, Oregon, paid $6 million to farmers to plant trees along streams to meet water temperature requirements instead of spending $60 million on refrigeration systems to cool the water from wastewater and stormwater systems.
- *Potential reductions in costs associated with the loss of ecosystem services*: The costs associated with growing numbers of natural disasters such as floods and hurricanes have highlighted the role of ecosystems such as flood plains and coastal sea marshes in reducing economic and community losses from these disasters.

The federal government's capabilities for decisionmaking to support greater protection, enhancement, and restoration of ecosystem services and the development of markets for these services fall into two broad categories: 1) planning and priority-setting policy tools through which ecosystem services can be identified, quantified, and evaluated and 2) policies that involve public sector payments (grants, loans, and other investments) or regulatory mitigation payments and other reimbursements for natural resources.

1) Planning and Priority-Setting Policy Tools

Federal programs have decades of experience with ecological analysis and quantification, driven by statutory and regulatory requirements. Among the most significant federal planning and priority-setting tools are: 1) evaluations undertaken within the requirements of the National Environmental Policy Act (NEPA); 2) federal public lands planning processes; and 3) the Principles and Standards for Federal Investments in Water Resources. A number of planning and priority-setting tools, with modified guidance and practices, could assist land managers—public and private—in identifying, quantifying, and evaluating how their management decisions affect ecosystem services. Such analysis is a precursor to comparing costs and benefits of different resource management options. Such analysis is also a prerequisite to strengthening ecosystem services investments and markets.

The language in the various statutes that support federal planning tools may support ecosystem services evaluation without legislative changes. However, using these tools to advance ecosystem services investment requires additional implementation guidance on such issues as the cumulative effects of resource management actions and the geographic, functional,

or other scope-of-impact evaluations. Guidance on how to develop ecosystem services measures and metrics could also provide the transparency, consistency, and credibility of ecosystem services evaluations that are necessary to support ecosystem services market development.

2) Policies That Involve Public Sector Payments or Regulatory Mitigation Payments

In addition to planning and priority-setting tools, the federal government has many grants, loans, and other payment programs that support ecosystem protection, enhancement and restoration. The federal government also implements numerous regulations that require mitigation for environmental impacts and compliance with air, water, and other environmental quality standards. Together, these policies provide some foundation for further development of ecosystem services investments and markets.

Key mitigation tools include requirements under the Clean Water Act (CWA) to mitigate impacts to wetlands that result from land management decisions; Endangered Species Act provisions to prevent harm to listed species; Federal Energy Regulatory Commission (FERC) mitigation requirements associated with hydropower licensing; and Natural Resource Damage (NRD) assessments. Generally, these policies could better support ecosystem services evaluation, investments, and markets if their implementation guidance specifically required the evaluation of ecosystem services impacts. Though NRD assessments have included ecosystem services, most other federal ecosystem evaluations focus on biophysical conditions rather than ecosystem services per se. Implementation guidance could also clarify how to address multibenefit ecosystem credits and how to "pool" mitigation at a landscape scale, including through coordination with other ecosystem mitigation and investment programs. Regulatory programs such as Total Maximum Daily Load (TMDL) requirements under the CWA could also benefit from similar guidance on the development of performance measures and associated monitoring.

In addition to mitigation and regulatory tools, the federal government provides payments, grants, and loans for natural resource protection, enhancement, and restoration. Farm Bill programs, CWA revolving loan funds, and Safe Drinking Water Act revolving loan funds provide many billions of dollars each year to farmers, water managers, and communities, for example. These (and other) payment programs could better support strategic ecosystem services investments and market development through 1) a greater focus or guidance on ecosystem services protection as a priority; 2) the allocation of funding based on environmental

performance and verified outcomes; and 3) some consolidation of programs with a common purpose.

The sheer breadth of existing federal capabilities and potential policy innovations presents challenges of its own. Federal policy innovators may need a focused strategy, based on what can be learned from the programs and policies described in this report and elsewhere, for targeting natural resource management and land-use planning decisions to drive the development of environmental markets and to protect, enhance, and restore ecosystem services—generating outcomes that are more environmentally and economically beneficial.

Issues to consider in developing a strategic approach include the following.

3) Evaluating the Scope and Focus of Policy Development

A strategic approach to ecosystem services policy development should first address the practical questions regarding scope. For example, should the strategy center on a handful of specific policy problems, such as water quality and coastal protection, or a few policy tools, such as NEPA planning and Farm Bill conservation measures?

In assessing strategic policy options, four criteria are important.

- *Relevance*: Does the policy initiative address a compelling public concern, such as the need for more cost-effective infrastructure and regulatory compliance, more cost-effective hazards mitigation, or new revenue streams to support priority goals such as farmland protection?
- *Ease of replication*: Can the policy be implemented in multiple locations (for example, on many public land units) using common tools and templates that help reduce implementation transaction costs?
- *Reach*: Will the policy potentially affect decisions across multiple programs and agencies and at different geographic scales?
- *Feasibility*: What are the points of resistance to implementation? Is there broad potential constituent support—for example, from farmers, counties, coastal communities, or others?

Applying these criteria, several policy options and areas of focus have significant potential. These include the following.

- Completion of revisions to the Principles and Standards for Federal Investment in Water Resources that shape water resource project decisions, including specific guidance on requirements for using an ecosystem services framework for project evaluation. A fuller accounting for the environmental benefits and ecosystem services effects of water resource projects is likely to bring greater attention to nonstructural (green) water projects across the nation.
- Issuance of an executive order instructing agencies to evaluate the effects of their programs and policies on ecosystem services and examine ways to incorporate consideration of ecosystem services into program guidance and project assessments. Such an executive order could stimulate changes to Coastal Zone Management planning, Regulatory Impact Analysis, FERC licensing mitigation practices, land-use planning processes for federal agencies, wetland mitigation and conservation banking programs, and other federal activities. The benefit of an executive order is its potential cross-governmental focus, while allowing for tailored agency responses based on the particular statutory authorities and circumstances of each agency.
- Further improving Farm Bill conservation programs to target high-priority ecosystem services protection, enhance performance indicators, and increase environmental returns on investment.

4) Addressing Measurement and Coordination Issues

The ecosystem services policy literature and case studies point to several recurring gaps that limit the potential for the development of markets in ecosystem services and constrain effectiveness in terms of ecosystem services outcomes. Specifically, many ecosystem services activities, policies, and initiatives remain focused on a single benefit stream and provide neither a framework for generating integrated, multifunctional benefits nor tools to support such integration. Despite advances in evaluation tools, many endeavors to invest in ecosystem services still lack measures, metrics, and protocols for evaluating benefits or assessing strategic opportunities in a policy setting. Few policy tools and practices exist to protect benefits at a landscape scale and across jurisdictional boundaries, including international boundaries.

The development of federal guidance on ecosystem services measurements and monitoring could enhance consistency, including common practices for addressing issues such as multiple benefits, additionality, permanence, transparency, and other policy considerations associated with investment in ecosystem services markets. As directed by Section 2709 of the

2008 Farm Bill, the U.S. Department of Agriculture, through the Office of Environmental Markets, is developing technical guidelines for quantifying, reporting, registering, and verifying the environmental benefits produced by land management activities in order to facilitate landowner participation in emerging environmental markets.

In addition to general guidance on ecosystem services measurement, the White House Council on Environmental Quality's NEPA policy guidance and regulations offer another potential platform within which to provide general direction for the inclusion of ecosystem services when evaluating the impacts of federal actions. Areas of particular focus might include definitions pertaining to cumulative effects as well as off-site mitigation. Such guidance could influence the practices of all federal agencies and stimulate investments in and attention to ecosystem services.

5) Identifying Low Transaction-Cost Opportunities

Some investments in ecosystem services present cost-savings relative to traditional, "gray" infrastructure. For example, a regulated entity might meet water quality standards by building a mechanical water filtration plant or by investing in watershed protection. This situation parallels that faced by New York City when it opted to invest in watershed conservation to filter water coming into the city. In this type of scenario, the decision is primarily one of assessing the relative capital and operating costs of ecosystem services versus "gray" infrastructure, which involves engineering, land acquisition, and other cost assessments coupled with performance comparisons of the two approaches. Such calculations are fairly straightforward and present near-term opportunities for ecosystem services investments.

6) Investing in Pilot Projects To Learn and Build Communities of Practice

Another goal of a strategic assessment should be the selection of pilot studies explicitly designed to be policy experiments. These policy experiments will have greatest lasting value when they are used to identify both successes and opportunities on the one hand and failures and barriers on the other. Pilots should feature an experimental design to identify legal, regulatory, and administrative barriers to policy innovation; identify objective performance and accountability measures; relate the relationship of trades, payments, planning rules, or regulations to biophysical outcomes that are socially meaningful and comprehensible to nontechnical audiences; identify the beneficiaries of produced and delivered ecosystem services; identify sources of demand for ecosystem services and associated funding sources or

legal/regulatory drivers; and identify the suppliers of ecosystem services and assess the inducements necessary to stimulate greater supply.

Part I: Introduction

The term "ecosystem services" conveys the concept that natural systems, their components, and functions provide socially and economically valuable services deserving of protection, restoration, and enhancement. For example, natural systems such as wetlands, sea marshes, free-flowing rivers, forests, and grasslands provide services such as water purification, coastal storm and flood protection, and air pollution mitigation that benefit human communities.

When natural systems are thought of as wealth, it is natural to then ask: how can we manage, invest in, or trade that wealth? What comparative costs and benefits result from different management, investment, and trading practices? And what are the roles and responsibilities of government, organizations, and individuals to grow that natural wealth? Several considerations have broadened interest in investing in ecosystem services.

- *Potential cost savings for basic community services*: Investing in natural solutions for the restoration and protection of ecosystems can provide services such as water filtration or stormwater mitigation at costs significantly lower than those for civil engineering and mechanical solutions. For example, the City of New York invested more than $1.5 billion to protect and restore the Catskill Mountain watershed, a web of natural systems maintaining the purity of the city's water supply, instead of spending up to $9 billion on the construction and maintenance of filtration plants. The City of Seattle uses "green infrastructure" to reduce stormwater runoff volumes at a cost 25 percent less than that of the traditional alternative.
- *Cost-effective environmental performance*: The local surface water utility for the Tualatin Basin in Oregon, Clean Water Services (CWS), bundled into a single permitting action the renewals of four wastewater treatment permits and a stormwater permit. CWS used U.S. Environmental Protection Agency (EPA) provisions that allowed for water quality trading in which temperature goals for water systems could be met through "credits" from paying farmers to plant trees at particular locations in the watershed. Rather than investing $60 million in expensive refrigeration systems, CWS worked with the adjacent farming community to plant 35 miles of shade trees along the river to cool water temperatures to required standards. The cost of the ecosystem services approach was $6 million, a tenth the cost of the mechanical cooling equipment.

- *New revenue streams for landowners*: Florida initiated in 2005 its Florida Ranchlands Environmental Services Project to field-test payment for ecosystem services in the northern Everglades ecosystem in a partnership that included Florida's Department of Agriculture and Department of Environmental Protection, the South Florida Water Management District, the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), scientists at the University of Florida, the World Wildlife Fund, and eight participating ranchers. In Phase I of the project, from 2006 to 2009, water management alternatives were implemented on eight ranches, accompanied by the field-testing of a Multi-Service Environmental Documentation Approach that includes measures and practices to certify on-ranch provisioning of water and phosphorous retention and wetland enhancement. In Phase II, beginning in 2010, payments for performance on the volunteer ranches commenced, with a goal of transitioning to a statewide program after 2011. During the pilot, capital costs to ranchers were reimbursed and participation fees were paid based on land rental calculations rather than on direct ecosystem services calculations, as the purpose of the pilots was, in part, to develop relevant ecosystem services data on which to base future payments beyond the demonstration phase of the program. Actual amounts paid to the participants are not available and do not provide a basis for anticipating future program payments because payments will shift more toward ecosystem services payments.
- *Costs associated with the loss of ecosystem services*: In New Orleans, the failure of flood control infrastructure in the wake of Hurricane Katrina made world headlines. But the New Orleans tragedy was not an isolated one. Levee failure in California during heavy rain falls in 2006 triggered emergency state spending to shore up infrastructure. These infrastructure failures are notable as the number of natural disasters rises. Over the past century, "the annual number of natural disasters has increased more than 40-fold: fewer than 10 in the first decades to 400 to 500 in the last decades of the 20th century."[1] These disasters have translated into mounting costs that have climbed from less than $1 billion in 1900 to more than $200 billion in 2005.[2] Eying these mounting costs, communities are reexamining the potential of natural systems to meet their economic, environmental, and safety needs more reliably and affordably than traditional gray infrastructure.
- *Interest in enhancing resilience in a context of changing conditions*: Climate change may result in an increased incidence of high-intensity storm events and more variability in water availability. Resource management options that enhance communities' resilience to such events are receiving renewed attention, with a focus on options that perform

effectively under potentially widely varying conditions, such as investments in the protection or restoration of floodplains, coastal dunes, and sea marshes. For example, an evaluation of beach nourishment and dune protection in North Carolina as a storm protection strategy showed "marked reductions in threatened and destroyed buildings compared to unnourished communities both north and south."[3] EPA has evaluated the benefits of protecting large river floodplains in the Pacific Northwest, concluding that such investments can yield multiple benefits, including improved nonstructural flood storage, while also meeting water quality goals.[4]

These considerations are prompting federal decisionmakers to reflect on existing activities and new opportunities to use ecosystem services analysis as a decisionmaking framework for natural resource management and land-use planning that could target resources to produce more environmentally and economically beneficial outcomes. Traditionally, resource managers have analyzed biophysical impacts of management options and activities and, at times, impacts on current economic activity (for example, fishing, logging, ranching, mining, and so on). An ecosystem services framework supplements such analyses with 1) an assessment of the goods and services (for example, water purification, erosion prevention, water storage, and so on) that natural systems, their components, and functions provide and 2) in some cases, the economic value of those goods and services.

Purpose and Scope of This Study

This study describes existing federal policies that permit or promote ecosystem services analysis, management, investments, and markets. Federal agencies have significant existing capacity—scientific and institutional—to measure, evaluate, and manage natural wealth. Understanding this existing capacity is important to federal and other leaders who see opportunities for environmental policy innovations based on ecological wealth and services. This study provides a typology for categorizing these policy tools, offers examples within each policy type, and briefly assesses their effectiveness and potential for stimulating markets in environmental goods and services.

Policy innovation that strengthens federal capacity to promote ecosystem services investments and management hinges on the ability to measure and evaluate accurately the relationship between policy interventions and ecosystem services production and delivery. Our survey discusses 1) current programs that stimulate or support measurement of ecosystem services; 2) existing federal drivers of ecosystem services *analysis*; and 3) programs that stimulate investment in ecosystem services.

Part II: Quantification of Ecosystem Services—Applications and Existing Capacity

The quantification of ecosystem goods and services involves three components: 1) measurement of biophysical outcomes; 2) measurement of how the biophysical outcomes affect the quantity and quality of ecosystem goods and services; and 3) economic valuation of those ecosystem goods and services.

Environmental economists have a growing repertoire of analyses that strive to value ecosystem goods and services across the globe; in the United States; and within states, regions, and individual communities.[5] Scientists, too, have significantly advanced scientific understanding of ecosystems, their functions, and the goods and services these functions provide that are relevant to sustaining human communities.[6]

What makes measurement and analysis of ecosystem services difficult? First, it requires collaboration and interaction between biophysical and social scientists. Second, the complexity of and interactions between natural systems complicate biophysical analysis and measurement. Third, the fact that ecosystem goods and services tend to be nonmarket public goods complicates economic and social analysis; market data, including prices and inventories, are not available.

Numerous federal statutes, regulations, incentives, and programs include requirements, tools, or aspirations to measure 1) damage to, 2) creation of, and 3) protection of ecosystem goods and services. These provisions have varying analytical objectives and practices. For example, in some instances, quantification focuses on the biophysical characteristics of a resource or place. Such analysis describes biophysical conditions, such as wetland extent and type, the extent and type of vegetative cover, and so on, but does not link those conditions and features to their functional benefits, such as water purification or erosion mitigation. In a few cases, ecosystem goods and services are now included in these evaluations. In these cases, the evaluation describes ecosystem features and the benefits associated with these features. Finally, in some instances, ecosystem characteristics, goods, and services are translated into economic terms. Funding sources and implementation responsibilities also vary.

In reviewing examples of the quantification of ecosystem goods and services, we briefly explore five questions.

- What are the basic statutory provisions and requirements?
- How are the analyses and practices financed?
- What are the analytical practices and areas of focus in terms of biophysical evaluation, ecosystem services evaluation, and economic valuation?

- What lessons might be drawn from these quantification efforts?
- How might these efforts be relevant to the development and use of actual ecosystem payments, markets, and incentive-based policies?

Natural Resource Damages Assessment (National Oceanic and Atmospheric Administration, Department of Agriculture, Department of the Interior)

Basic Provisions and Responsibilities

Several U.S. environmental statutes establish liability for injury to natural resources. Current natural resource damages (NRD) liability provisions are primarily guided by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Oil Pollution Act, and the National Marine Sanctuaries Act.[7]

In physical terms, NRDs refer to damages to land, fish, wildlife, biota, air, water, groundwater, and other resources, including changes in the health of a habitat or population and in the underlying ecological processes on which they rely.[8] In legal terms, the definition of NRDs is restricted to resources owned, controlled, or managed by federal, state, or other governmental entities, including foreign governments.[9] Injuries to natural resources on or associated with private property can lead to NRD claims if there is a "substantial degree of government regulation, management, or other form of control over the property" that is injured.[10]

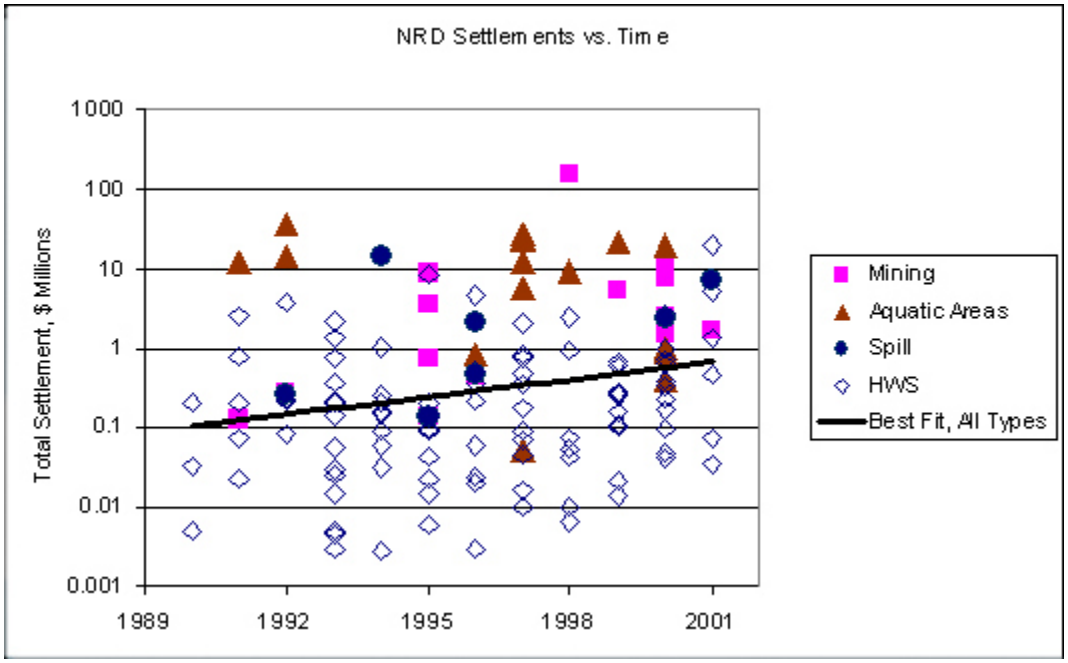
Funding and Compensation

Defendants found liable for NRDs face three primary liability components: first, the cost of resource restoration to baseline conditions; second, compensation for "interim losses," that is, the lost value of injured resources pending full restoration; and third, the reasonable cost of the damage assessments themselves.[11] In economic terms, the goal of federal NRD liability is to "make the environment and public whole" following a pollution event.[12] In principle, this is straightforward. In practice, determining compensating remedies can be difficult and highly controversial.

Nonetheless, NRD settlements increased through the 1990s, with total payout averaging about $100 million per year from 1998 to 2001 for CERCLA-related settlements.[13] Payouts, however, vary widely from year to year depending on whether any very large settlements have occurred. Some individual settlements have exceeded $100 million.[14] Moreover, both the number and value of NRD settlements "have been increasing rapidly, doubling every three to four years. Continued increases at this rate would greatly increase total NRD settlements."[15] Increases

largely result from more cases being identified and litigated, resulting in settlements, and more refined analysis of the extent of damages.

Figure 1. Total Cost of CERCLA-Related NRD Settlements Over Time and by Type



Notes: Different types of sites are those impacted by mining and/or smelting ("Mining"); "Aquatic Areas," which are sites defined as a river system or bay (e.g., the Housatonic River, Commencement Bay); "Spills" are spills of hazardous materials other than oil, for which NRDs were collected under CERCLA; and "HWS" refers to the rest of the sites. Note that the Y-axis is logarithmic.[16]

Analytical Issues and Requirements

Restoration, assessment, and settlement of NRD claims are undertaken by federal, state, and tribal trustees. The principal federal trustees are the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of the Interior (DOI).[17] The agencies use two sets of rules to guide their respective Natural Resource Damage (NRD) assessment procedures.[18] These damage assessment rules, together with the analysis of a specific site, largely determine the nature and scale of NRD recoveries.[19] Federal rules generally favor on-site restoration, but some states allow for "pooled" compensation, whereby monetary recoveries are applied to restoration at other sites, and federal agencies have approved some off-site restoration.

Determining appropriate levels of on-site physical restoration is complex, given the technical challenges associated with restoration and the need to estimate baseline conditions against a background of natural variability. In many cases, off-site restoration must also be part of the remedy to achieve full social compensation for two reasons.

1. Complete physical restoration of the injured resource may be impractical. For instance, complete restoration of a damaged site is often cost-prohibitive. If so, some other form of compensating restoration will be pursued, usually involving the enhancement of another comparable, but not identical, resource.
2. Interim losses of natural resource services must be compensated. Restoration of a site to prerelease conditions does not compensate for these interim losses. Supplemental restoration actions, either on-site or off-site, must be undertaken to compensate for those types of losses.

Determination of on-site and off-site restoration levels requires valuation-based comparisons of ecosystem services across different sites or across different types of natural resource services. Numerous challenges are associated with this kind of comparison. For example, monetary valuation is one way to make such a comparison, but monetization of natural resource services is difficult in the absence of revealed market prices for such services.

Valuation Methods: Though the legal authority for the collection of NRDs is well established in the United States, valuation issues complicate the implementation of relevant NRD provisions in U.S. law. DOI published damage assessment rules in 1986.[20] Those rules established two basic procedures: Type A for small releases of oil and hazardous waste and Type B for large and complex releases.[21] These original rules took a relatively narrow view of the types of injuries that were compensable, the scope of compensation, and the methods to be used in damage assessment. The rules strongly favored a market-oriented approach to damages and established a hierarchy of assessment methodologies. Only when market values were unavailable were "nonmarket" procedures to be used. Nonmarket procedures have been, and remain, a controversial aspect of NRD law.

Under subsequent, updated rules crafted partly in response to several court rulings, nonuse values such as option, existence, and bequest values are compensable.[22] The 1994 DOI-revised rules acknowledge that "the mere presence of a competitive market [for resources] does not … ensure the price will 'capture fully' the value of the resource."[23] Though the court ruling validated nonuse values analysis, such tools continued to be used sparingly as they sparked controversy and litigation, delaying restoration decisions.

Although mainstream economics now accepts the validity of nonuse values at a conceptual level, the methods used to calculate those values remain controversial and subject to huge uncertainties. Both the Oil Protection Act (OPA) and CERCLA give DOI and NOAA

significant latitude to resolve valuation issues and do not limit damages to those that can be directly measured in markets or that are based on observable resource uses.[24]

Restoration Focus: In 1996, NOAA followed the 1994 DOI rules with its own rules, to be applied to assessments authorized under OPA for which NOAA has lead responsibility.[25] The NOAA rules define the goals of compensation and establish procedures to assess injury, establish causality, and calculate damages. Any settlement requires adherence to the broader compensation goals established by the rules.[26] Current emphasis is on restoration rather than a monetized estimate of lost value as the measure of damages. With a restoration focus, agencies assess engineering, land acquisition, and other costs to protect and restore habitat rather than calculating the values of resources damaged by oil spills, chemical contamination, or other prohibited actions.

For damage assessments in which DOI has lead responsibility, DOI has also revised its NRD assessment rule to strengthen the resource restoration focus of its NRD program.[27] The earlier regulations described "compensable value" as the economic value of public losses, including the physical and biological functions performed by resources. The new regulations clarify that compensable value includes the option of using the cost of projects that restore lost natural resource services, instead of estimating the economic value of these lost services.[28] The new DOI rule does not require restoration-based valuations, but places greater emphasis on restoration actions.

Cost is relevant to the determination of remedies for both DOI and NOAA. Technical feasibility and cost-effectiveness must be considered in the choice of restoration projects.[29] In addition to restoration, however, the rules allow for compensatory damages, which relate to the loss in value experienced between the time of injury and full restoration.[30]

Both DOI and NOAA rules favor restoration over monetary measures largely because restoration costs are easier to estimate.[31] Restoration cost estimates rely on easily computable capital and labor costs (e.g., the costs of dredging, species reintroduction, or contaminant neutralization). These costs are easier to predict, rely on fewer economic valuation methodologies, and are verifiable.[32] Prior procedures emphasized determining a monetary value for the loss of use of the injured resources. Instead of collecting damages and then determining how to spend that money on restoration, the goal of assessment is now focused on timely, cost-effective restoration of the natural resources that have been injured.[33]

The other advantage of a restoration focus is that, by definition, both lost use and lost nonuse values are eventually restored. Even with restoration, however, it is necessary to

compensate for losses arising in the period between an incident and full restoration—a period that can span decades. Compensation for interim losses, by definition, cannot be achieved via on-site restoration. Additional payments for lost income or, sometimes, off-site restoration that replaces damaged resources may be required to compensate for interim losses.

In general, there remains a pronounced desire to avoid monetization of losses and gains related to nonuse values. Monetization, though not prohibited, is rarely favored.[34] NRD rules provide trustees with wide latitude to choose among alternative valuation methodologies, including valuation methods based on market prices, appraisal methods, hedonic analysis, and travel cost methods.[35] The estimation of nonuse values raises significant methodological concerns and is viewed with particular alarm by potentially liable parties. For this reason, an independent panel was convened in 1993 to assess the validity of the so-called contingent valuation methodology to measure nonuse values. The NOAA panel established a set of guidelines for the use of contingent valuation methods.[36] The NOAA rules now permit contingent valuation for estimating use and nonuse values, but only when "no use values can be determined."[37]

Policy Implications and Potential

NRD provisions in the Oil Pollution Act and CERCLA have resulted in substantial funding of conservation and restoration activities. However, several issues limit their overall relevance and utility as a source of funding for investments in the protection of ecosystem services.

- *Retrospective damages*: Payments under NRD must be directly linked to assessments of resource damages resulting from oil spills or other pollution. NRD payments, thus, are retrospective and designed to return resources to their condition prior to the damaging event. Such payments are not available for general natural resource protection and enhancement.
- *Public resource damages*: The focus of NRD payments is on public resources and their restoration. With several specific exceptions, NRD payments do not provide funding to support private lands protection, restoration, and enhancement.

Despite these limitations, several NRD implementation trends show potential for using NRD funds to supplement other conservation funding to achieve broader goals for restoring and sustaining ecosystems and their benefits.

- *Off-site restoration*: The growing focus on restoration and replacement equivalency off site—instead of on-site restoration actions where such actions are unlikely to achieve restoration goals—presents opportunities for leveraging NRD monies with other funds to protect, restore, and enhance habitat and other natural resources. For example, $3 million in NRD funds resulting from a settlement regarding harbor contamination in Rhode Island were combined with private-sector and nonprofit funds toward the purchase of 1.5 million acres of loon nesting habitat in Maine.
- *Collaborative projects*: Increasingly, NRD funds are combined with other funding sources to achieve multiple resource protection goals. For example, $400,000 in NRD funds were combined with Coast Guard and nonprofit funding to protect, manage, and monitor 42 acres of common eider nesting habitat. The U.S. Fish and Wildlife Service (FWS) estimated in 2009 that it leverages its annual NRD settlement funding allocation by a seven-to-one ratio.[38]

Water Resources Development Acts and the Principles and Guidelines for Water and Related Resources Implementation Studies (Army Corps of Engineers and others)

Basic Provisions and Responsibilities

Water Resources Development Acts (WRDAs) govern how the U.S. Army Corps of Engineers (the Corps) plans, constructs, operates, and maintains water resource projects. These projects cover a wide range of activities with potentially significant implications for the delivery of ecosystem goods and services. WRDAs authorize habitat and watershed mitigation and restoration, shore protection and flood control, navigational and harbor projects, and water supply projects and analysis.

WRDAs are omnibus laws that bundle a diverse collection of projects into a single bill. WRDA projects are typically requested or nominated by a state or local government, nonprofit organization, or business group. A congressional sponsor will then request a project evaluation by the Corps. WRDAs authorize both evaluations and projects designated for implementation. Traditionally, WRDAs emerge from Congress every two years, though in recent years that pattern has not held. The most recent act (WRDA 2007) authorized more than 900 projects nationwide, including significant investment in Everglades restoration. WRDA authorization is then followed by an appropriations process that can lead to project modifications. It is not uncommon for authorized projects to be denied subsequent appropriations. [39]

Corps analysis of water resource projects is usually authorized via periodic WRDA reauthorizations. Thus, these acts can shape the Corps' analysis of restoration and mitigation projects, and any other project with significant ecological consequences, by defining project scopes and purposes.

Funding and Compensation

Recent WRDAs have authorized billions in project expenditures—$5.4 billion (1996), $6.3 billion (1999), and $7.3 billion (2000). WRDA appropriations thus represent a significant set of impacts (both positive and negative) relevant to ecological outcomes. Moreover, the dollars involved and the geographic extent of projects could provide a significant basis for ecosystem services market activity if mitigation of impacts to ecosystem services were routinely required. Only a fraction of these dollars go to ecosystem services analysis, but the overall scale of WRDA appropriations means that Corps ecological evaluations can be influential and can affect decisions where large ecological effects are at stake. For example, these projects include flood protection and water storage infrastructure, river diversions, levees, navigation channels, and other water-related projects throughout the United States. If the Corps systematically evaluated ecosystem services benefits and losses in its project analyses, these analyses could provide building blocks for ecosystem services analyses associated with other agency projects and actions.

Each authorized project has its own funding characteristics, but all involve matching funds provided by nonfederal partners and sponsors. Since WRDA 1986, nonfederal sponsors share the costs of project evaluations, construction, and long-term operations.[40]

Cost shares aside, WRDA funds are taxpayer dollars used, in some cases, to subsidize environmental restoration, mitigation, and management projects. In a broader set of cases, WRDA funds pay for the analysis of economic and environmental impacts (though again, the costs are shared by the Corps and the nonfederal project sponsors). The scale of WRDA authorizations means that the Corps has a significant role to play in the quantification and analysis of ecological functions and outcomes.

Analytical Issues and Requirements

Once authorized and funded, Corps project evaluations are governed by the *Principles and Guidelines for Water and Related Resources Implementation Studies* (P&G).[41] The P&G describes an analytical framework and set of evaluation practices to forecast and describe natural resource conditions, formulate project alternatives, and evaluate and compare alternatives.

Ecosystem evaluations have been conducted under the P&G since the mid-1980s.[42] The P&G already applies to agencies besides the Corps, including the Bureau of Reclamation, the Soil Conservation Service, and the Tennessee Valley Authority.

The current P&G (proposed revisions to the P&G are discussed below) does not explicitly refer to ecosystem goods and services delivery, restoration, or enhancement as a goal. However, the P&G does provide guidance on the evaluation of "environmental projects" and ecological outcomes that are difficult to capture and evaluate in monetary terms. Traditionally, water resource projects were evaluated on the basis of "national economic development" (NED) objectives, which can include human health benefits or flood risk reduction benefits expressible in monetary terms. The traditional presumption was that the project alternative that "maximized NED" was the one to be chosen. During the 1980s, however, this principle was relaxed for so-called restoration projects, out of recognition that the benefits of ecological restoration are often extremely difficult to measure in monetary terms.[43]

As a 1995 the Corps report notes, "one of the weaknesses of existing techniques to place monetary values on environmental resources lies in the complex connections between environmental outputs and socially valued services."[44] When monetary benefits cannot be assessed, the P&G and associated Corps guidelines prescribe cost-effectiveness analysis, where the goal is to identify the least-cost approach to achieving a given ecological goal.

Policy Implications and Potential

The most recent act (WRDA 2007) urged revisions to the P&G.[45] The White House Council on Environmental Quality (CEQ), the Corps, and other federal agencies are in the process of reviewing and revising planning practices.[46] An emphasis of this reform movement is greater analysis of ecological costs and benefits across all projects, not just those considered to be "environmental." As stated in the press release issued by the White House,[47]

> The Administration's proposal reiterates that federal water resources planning and development should both protect and restore the environment and improve the economic well-being of the nation for present and future generations. While the 1983 standards emphasized economic development alone, the new approach calls for development of water resources projects based on sound science that maximize net national economic, environmental, and social benefits.

The inclusion of "environmental" benefits in the NED calculus implies greater analytical attention to ecosystem services and their monetary benefits. It deserves emphasis that the Corps has been conducting environmental benefit assessments for decades, though these analyses have

generally not applied an ecosystem services framework. They have, instead, focused more on biophysical characteristics and how they are affected by Corps projects. However, the proposed P&G revisions seek to expand the application of ecosystem accounting (and monetary assessment) to a wider range of projects.

If the revisions lead to significant changes in ecological analysis and the scope of projects where it is applied, the revised P&G has the potential to affect projects associated with billions of dollars in annual government spending. In addition, the P&G could influence ongoing operational decisions across all past investments in water infrastructure. Thus, the revision of the P&G has potentially far-reaching implications for water resources, ecosystems, and human well-being nationwide.

For example, a fuller accounting for the environmental benefits of water resource projects is likely to bring greater attention to so-called "green infrastructure" or "nonstructural" water projects. Green infrastructure alternatives emphasize protection and restoration (of floodplains, for example) as more effective and affordable methods than the construction and maintenance of levees, dams, and other built infrastructure.

The proposed P&G revision is an important statement of the aspiration to have ecosystem costs and benefits factor into water resource planning decisions on equal footing with traditional cost–benefit factors. Close attention should be paid to what this ultimately means for analysis, of course. Monetary assessment of ecosystem services benefits requires additional attention to the biophysical and economic analysis of ecological effects. It is likely that new assessment practices, tools, and protocols will be developed as a result of P&G revisions.

Coastal Zone Management Act (NOAA, other federal agencies, states)

Basic Provisions and Responsibilities

The Coastal Zone Management Act (CZMA), which was enacted in 1972 and has been amended several times ,[48] encourages states to protect and, where possible, restore valuable coastal resources, including wetlands, floodplains, estuaries, dunes, coral reefs, and barrier islands and to protect the fish and wildlife reliant upon these ecosystems. Participation by states is voluntary, but the federal government provides grants to states that develop and implement Coastal Management Plans (CMPs). These plans must give "adequate consideration of the national interest involved in planning for, and managing the coastal zone, including the siting of facilities . . . which are of greater than local significance." In addition, plans must include "procedures whereby specific areas may be designated for the purpose of preserving or restoring

them for their conservation, recreational, ecological, historical, or esthetic values."[49] This language could accommodate consideration of ecosystem services, but only 2 out of 35 states have developed criteria by which to consider the services provided by natural ecological systems, functions, and components.

States with CMPs approved by the Office of Coastal Resource Management in the Department of Commerce can restrict development inconsistent with their plans. Plan approval requires that states include mechanisms for affected federal agencies to participate in their coastal zone management programs. Federal agencies, in turn, must carry out their responsibilities in ways that are consistent "to the maximum extent practicable with the enforceable policies of approved state management programs."[50] Under the CZMA, effects include both environmental effects and effects on coastal uses. These effects include both direct and indirect (cumulative and secondary) effects that are reasonably foreseeable.[51]

Currently, of the 35 coastal states and territories, approximately one-third include standards and authorities pertaining to the consideration of ecosystem functions in their CMPs. Just two states—Maryland and Louisiana—expressly reference ecosystem services values. J.B. Ruhl, in *The Law and Policy of Ecosystem Services*, reviews state CMPs and state coastal protection statutes with respect to their inclusion of ecosystem functions and services. Ruhl concludes that, for the most part, these laws and plans do not include ecosystem services "as an explicit criterion for issuance of approvals" for land uses.[52] But the CZMA language cited above is sufficiently broad to allow for a reshaping of state CMPs. Florida's coastal management requirements, for example, expressly state that, within a delineated coastal construction control line, any construction seaward of the line must not reduce "the existing ability of the [beach and dune] system to resist erosion during a storm."[53] In addition, artificial dune systems must "meet or exceed the protective value afforded by the natural frontal dune system."[54]

Funding and Compensation

Section 309 of the CZMA authorizes a grant program that provides federal funding to states for actions that identify, develop and implement CZMA program changes in nine categories that include public access, coastal hazards, wetlands, cumulative and secondary impacts, marine debris, special area management planning, ocean resources, aquaculture, and energy and government facility siting. Every five years, states review their CMPs and identify priorities from the nine enhancement areas and establish strategies for addressing those priorities. Federal funding for the CZMA grant program is approximately $69 million annually.

Analytical Issues and Requirements

While the nine categories identified in the CZMA grant program do not explicitly refer to ecosystem goods and services, the nine enhancement areas implicitly acknowledge benefits associated with the protection of ecosystems and their components. However, an examination of state plans and Section 309 strategies indicates that the analytical focus has largely been on biophysical valuations rather than on explicit evaluation of ecosystem goods and services or a quantification of their economic values.

Relevant information to support ecosystem services evaluations is often still lacking. For example, in its most recent Section 309 strategy, Mississippi reports that "accurate information regarding the historic extent of wetlands in the coastal zone is not readily available. The same is true for specific acreages with regards to the current extent."[55] This gap pertains to acreages. More detailed information on specific wetland site processes, components, and functionality—precursors to ecosystem goods and services evaluation—is even less available.

NOAA's Coastal Services Center has begun developing environmental indicators for use in evaluating alternative coastal development options. These indicators include biophysical indicators such as "natural" versus "managed" acres, extent of vegetated buffers, water consumption, area with impervious surface, and nonpoint pollution runoff (using EPA's Smart Growth Index), as well as indicators associated with recreational and economic use such as dock area and extent of paths, trails, and sidewalks. Along with the indicators, the Coastal Services Center provides tools for comparing different development scenarios. The tool also has an economic component, but the focus is on estimating development cost differences attributable to the different design scenarios rather than on actually valuing the ecosystem goods and services associated with different site design options.

Policy Implications and Potential

The CZMA establishes a planning framework for coastal ecosystem management, with state management plans providing the primary planning tool. Like other planning frameworks, the CZMA does not itself provide direct resources to support ecosystem services investments. However, it plays a potentially important role in stimulating the incorporation of ecosystem services values into public decisions and private transactions through the capacity of its planning provisions to foster further development of ecosystem services metrics and baseline information and its potential to strengthen state incentives for incorporating ecosystem services values into decisionmaking.

To fulfill the CZMA's potential role regarding ecosystem services, several policy options are relevant:

- *State CMPs*: The act requires that state plans give "adequate consideration of the national interest involved in planning for, and managing the coastal zone, including the siting of facilities . . . which are of greater than local significance," and plans must include "procedures whereby specific areas may be designated for the purpose of preserving or restoring them for their conservation, recreational, ecological, historical, or esthetic values."[56] This language could accommodate the consideration of ecosystem services. Two federal actions could stimulate state plan revisions that incorporate ecosystem services criteria and baseline information: 1) guidance on development of state plans to provide ecosystem services definitions and support tools and 2) CZMA grant criteria that prioritize funding for plan updates or revisions to incorporate ecosystem services.
- *NOAA alternative development options*: NOAA's environmental indicators tool for evaluating different coastal development options could be expanded beyond its current cost and environmental impact analysis of different development options to include ecosystem services indicators and valuations.

National Environmental Policy Act Evaluation (all federal agencies)

Basic Provisions and Responsibilities

The National Environmental Policy Act (NEPA), enacted in 1970, sets forth procedural requirements for federal agencies in the executive branch to assess the environmental and other effects of proposed federal actions or projects that involve federal funding. The purpose of the act is to: "declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man."[57] The act requires the evaluation of the environmental impacts of proposed federal actions and alternatives. It sets the basic foundations for federal environmental policy and articulates goals of protecting, maintaining, and enhancing environmental values. Specifically, the act directs agencies to "insure that presently unquantified environmental amenities and values . . . be given appropriate consideration in decision-making along with economic and technical considerations."[58] The act also established CEQ, which oversees NEPA and has developed overarching regulations since 1978 that guide how agencies implement their NEPA responsibilities.

Funding and Compensation

Agencies required to perform NEPA evaluations generally fund the completion of environmental impact statements, environmental assessments, and other related analyses. In some instances, where the agency action involves permitting of private-sector activities, the prospective private-sector permittee funds the agency NEPA work. The permittee also pays for any permit requirements and mitigation actions that result from the NEPA process.

Project impacts identified through the NEPA process can be mitigated through both on-site and off-site actions. In 2008, for example, the Bureau of Land Management (BLM) issued policy guidance for the use of off-site mitigation, which "consists of compensating for resource impacts by replacing or providing substitute resources or habitat at a different location than the project area."[59] Off-site mitigation supplements on-site mitigation and must demonstrate a sufficient relationship to the agency's mission to manage public lands. It may only be used when BLM can demonstrate that such off-site mitigation is "reasonably necessary to accomplish an authorized BLM purpose."[60] Under BLM policy, off-site mitigation may include in-kind replacement or substitution of resources of the same type as those being affected; out-of-kind mitigation with resources that, "while related, are of equal or greater overall value to public lands;"[61] and in-lieu fees, which are payments to BLM or a natural resources management agency, foundation, or other organization "for performance of mitigation that addresses impacts of a project."[62]

Analytical Objectives and Requirements

Neither CEQ regulations nor agency regulations and guidance requires *explicit* consideration of ecosystem services in project planning and review, though NEPA requires assessment of all project environmental impacts. Moreover, court interpretations of the act have often centered on procedural requirements rather than on the robustness of quantitative evaluations of biophysical impacts.

However, the language of the act and associated agency implementation guidance provide strong foundations to support the inclusion of ecosystem services evaluations. As one NEPA analyst notes, "valuation of ecosystem services is exactly the kind of assessment NEPA envisions, providing a means to inform the public and decision-makers about what we stand to gain or lose in several alternative scenarios."[63]

Means and Measures: Several aspects of the act lay the groundwork for incorporating ecosystem services evaluations within environmental impact statements. First is language in

Section 101 that calls upon agencies "to use all practicable means and measures" to achieve the goals of the act.[64] Procedural requirements in Section 102 also are consistent with inclusion of ecosystem services valuations.[65] These include requirements that agencies: 1) use interdisciplinary approaches to "insure the integrated use of the natural and social sciences" in agency decisions; 2) use ecological information in planning and implementing projects; 3) "identify and develop methods and procedures . . . which will insure that presently unquantified environmental . . .values may be given appropriate consideration;" and 4) prepare environmental impact statements that, among other criteria, must address "the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity."[66]

Cumulative Effects: Drawing from the statutory language, CEQ regulations provide a basis for incorporating ecosystem services evaluations within NEPA analyses. The regulations require that each environmental impact statement include an analysis of "cumulative effects". Cumulative effects refer to the effects on ecological and socioeconomic resources, including recreation, quality of life, and economic activity that result from the incremental impacts of an action when added to other past, present, and reasonably foreseeable future actions.

The concept of cumulative effects builds on the recognition that a single, incremental action may have minimal ecological effects but, combined with other actions in the same geographic area, may cumulatively impact resources and ecosystem components.[67] CEQ regulations define ecological effects as impacts to "the components, structures, and functioning of affected ecosystems."[68] This language offers a clear nexus with the evaluation of ecosystem goods and services. Such evaluation "would help generate some of [the] baseline data, particularly for ecosystem processes, such as nutrient cycling or water purification."[69]

Cumulative effects analysis, through its broadened geographic and temporal focus, allows NEPA analysts to examine the effects of actions that alter general ecological processes, such as changing hydrological patterns and sediment transport. But cumulative effects analysis has sometimes generated controversy and litigation regarding assumptions about the geographic area of analysis, baseline conditions, and the overall time frame of the analysis. For example, a BLM planning unit may not encompass an entire watershed, raising questions about whether analyses should extend beyond the individual planning unit within which an agency action occurs. Currently, CEQ has not established specific formulas for determining the appropriate scope of the cumulative impact analysis.

Beyond CEQ regulations, some agency NEPA guidance also supports inclusion of ecosystem services analysis in EISs. In a 1999 report on cumulative impacts, EPA suggests that: "By expanding the assessment to consider the full array of wetland functions and their importance within a broader context, cumulative impacts could be more fully assessed."[70] Such functions might include, for example, the role of wetlands as nurseries for aquatic species valuable for both recreational and commercial fisheries; their ability to minimize downstream flooding; and their ability to improve water quality.[71]

EPA's 1999 NEPA guidance on ecological processes describes ecological functions and services. The guidance sets forth 10 processes comprising ecosystem functioning that should be assessed in NEPA analyses. Several, such as "hydrologic patterns, nutrient cycling, and purification services have the most direct connection to market substitutes that can be used to estimate their service value."[72]

Despite statutory, regulatory, and other policy provisions pertaining to NEPA analysis, most agencies do not directly incorporate ecosystem services evaluations into NEPA documents. EISs include descriptions of biophysical resources and the impacts of proposed agency actions in terms of disturbing those resources. Some analyses also include an assessment of how different ecosystem functions, such as water filtration or soil retention, may be affected by agency actions. But agencies have not generally assessed how the alteration of these functions affects the provision of ecosystem goods and services (such as water quality for communities or erosion mitigation); nor have they assessed the economic value of those services.[73]

Policy Implications and Opportunities

In theory, the incorporation of ecosystem services analysis into NEPA evaluations could result in some fundamentally different land management decisions. For example, land-based energy projects that reduce the quantity or quality of water supplies to communities could receive closer scrutiny. Water projects that interrupt flows or imperil water quality could require measures to reduce impacts. Using ecosystem services valuations, different land uses could be evaluated to assess the comparative economic benefits of, say, resource extraction and use (e.g., dam building or logging) versus maintaining intact ecosystems and their associated benefits, such as flood protection, source water protection, or other services.

Analyses such as these have been undertaken for several development projects in China, the Philippines, and elsewhere, sometimes with results showing greater benefits from retaining ecosystem functions than from resource extraction, use, or transformation. Numerous academic studies have estimated the economic values of ecosystem services at specific locations in the

United States.[74] However, NEPA analysis in the United States has not included economic valuation of ecosystem services or comparative analysis of the economic effects of different project options on ecosystem services.

Short of specific regulations and policy guidance, planning and funding requirements pertaining to ecosystem services valuations could result in paperwork compliance without fundamental decisionmaking changes. Moreover, several information and analytical challenges could limit useful analysis. Many areas in which agency actions would be subject to NEPA analysis lack relevant baseline data. In some instances, the individual project scale is insufficient to affect ecosystem functioning, highlighting the importance of cumulative effects analysis. But setting the geographic and temporal boundaries for such analysis can be controversial.

CEQ has chosen not to revise NEPA regulations in many years. However, CEQ and agencies could take several steps toward supporting the inclusion of ecosystem services into NEPA analyses, including the following.

- *Updating cumulative effects guidance* to include definitions and methods for evaluating ecosystem services.
- *Updating NEPA Implementation Guidance* to describe procedures, methods, and tools for linking ecosystem services evaluations into decisions about alternatives selections and mitigations.
- *Developing off-site mitigation guidance* to achieve policy goals similar to those set forth in BLM's policies for the use of off-site mitigation. Such guidance could stimulate the evaluation of ecosystem services, a precursor to evaluating 1) off-site mitigation opportunities for in-kind replacement or substitution of resources of the same type as those being impacted; 2) out-of-kind mitigation, where the results add greater overall value to public lands; and 3) in-lieu fees, which are payments to the natural resource management agency or other organization for the performance of mitigation.

Regulatory Impact Analysis (all federal agencies and Office of Management and Budget)

Basic Provisions and Responsibilities

The Office of Management and Budget (OMB) reviews all new or significantly modified regulations and regulatory programs. Under Executive Order (EO) 12866 (1993) "significant"

new regulations must be preceded by a Regulatory Impact Analysis (RIA) that evaluates the costs and benefits of the proposed rule.[75]

RIA requirements are broadly applicable. There is no single federal entity responsible for conducting these analyses. Rather, RIAs are created through the federal sphere by programs promulgating new regulation. In principle, any major regulation that affects environmental costs and benefits will have an RIA analysis of those costs and benefits.

Within OMB, the Office of Information and Regulatory Affairs is responsible for evaluating RIAs and providing agencies with guidelines for accepted methodologies, tools, and procedures. Of particular relevance to environmental regulation is OMB Circular A-4 (dated September 17, 2003), which provides guidance on how regulatory analysis is to be conducted.

Funding and Compensation

Funding for RIAs comes from the agency proposing the new regulation. Typically, the RIA process is administered and financed by the specific program office with responsibility for the new rule.

There is no standard funding or staffing model for RIAs. Funds for analysis, the time frame over which analysis occurs, and the types of expertise involved are highly idiosyncratic to the specific new regulation being proposed. This is not to say that centralized analytical capabilities do not exist. EPA's National Center for Environmental Economics, for example, acts as an internal reviewer of agency economic analysis. However, primary expertise and responsibility lies with program offices, which usually control the data, models, etc. associated with their programs.

Analytical Objectives and Requirements

RIA guidelines (as in EO 12866 and Circular A-4) promote cost–benefit analysis of new regulations. In principle, if all benefits and costs are assessed in dollar terms, the regulatory option that yields the highest net benefit is preferred. (Note that this is conceptually identical to the "net economic development" principle associated with federal water projects, as described in the section on WRDA and the P&G).

Ecological costs and benefits, of course, are the most difficult to measure in this way. EO 12866 acknowledges that "some costs and benefits are difficult to quantify." When it is not practical to put monetary value on environmental benefits, the guidelines advocate cost-effectiveness analysis (analysis of the costs of achieving a nonmonetary environmental goal).

The Circular A-4 states that "it will not always be possible to express in monetary units all of the important benefits and costs. When it is not, the most efficient alternative will not necessarily be the one with the largest quantified and monetized net-benefit estimate. In such cases, you should exercise professional judgment in determining how important the nonquantified benefits or costs may be in the context of the overall analysis."

OMB guidelines for analysis of environmental benefits and costs can be summarized as: 1) if possible, monetize all costs and benefits, including environmental benefits that may not have a "market price;" 2) if monetization is impractical, quantify the environmental costs and benefits associated with the regulation (e.g., in biophysical terms); and 3) if you can neither monetize nor quantify, describe them qualitatively.

In practice, it is common to see monetary estimation of some, but not all environmental benefits, accompanied by qualitative descriptions of ecological impact and justification.

Policy Implications and Opportunities

Many regulatory programs over the past decades have conducted environmental cost–benefit analyses in support of RIA requirements. A detailed review of analytical practices is beyond the scope of this study, but existing RIAs provide a wide range of examples of ecological analysis, many featuring monetary assessment. Agency capacities to conduct RIAs are an existing source of expertise on ecological quantification and its practical application to policy questions. Some agencies have developed their own guidelines for economic analysis, designed to be consistent with and complementary to OMB guidelines.[76]

As a practical matter, political negotiation and legal analysis strongly affect the timing and deadlines associated with RIAs. This, in turn, affects the kinds of analytical techniques employed by agencies. Tight deadlines have in some cases certainly inhibited the collection and analysis of new data. A hypothesis that we cannot necessarily prove is that OMB review of RIAs creates an incentive to stick with "tried and true" types of ecological evaluation. Typically, only "novel" forms of analysis trigger expert review by third-party advisory panels, contractors, or internal bodies. The costs and delay associated with such reviews likely inhibit the development of more innovative (and accurate) methods of ecological assessment.

We are not currently aware of any efforts to modernize or revise OMB's RIA guidelines and review practices. However, as in the case of revisions to the P&G, RIA guidelines and practices provide an opportunity for debate and innovation around the quantification of ecosystem services. Note that EO 12866 already calls for the monetization of ecosystem services

impacts (even if that precise language is not used) by calling for the monetization of all costs and benefits associated with new regulatory alternatives.

The policy question is whether RIA guidelines and practices can be revised to *encourage* innovations in ecological analysis and quantification? In order to ensure the adoption of scientifically defensible ecosystem benefit assessment methods, but also facilitate experimentation and innovation, we suggest the creation of an advisory body with representation from OMB, agency evaluators (for example, from specific EPA program offices and the National Center for Environmental Economics) and outside experts in ecosystem services evaluation methods. Such a body could define and develop pilot studies removed from the time and administrative pressures of a particular rule-making and develop consensus recommendations for acceptable methodological innovations.

Specifically, it could address the barriers associated with the collection of new data. While the desire and need to collect new data on ecosystems and their services seems self-evident, it is discouraged by the Paperwork Reduction Act, which requires agencies to submit an Information Collection Request (ICR) for review by OMB. In practice, ICR reviews require so much time to process that they cannot be completed during the duration of a given regulatory review. As a result, agencies do not even attempt to collect new information. A recent EPA Science Advisory Board concluded, for example, that "With a time limit of one or two years, at most, to conduct a [RIA] study, [ICR] review significantly limits the scope of analysis the Agency can conduct. Because EPA most often has not been able to collect new information, the Agency has, by necessity, relied heavily on transferring ecological and social values information from previous studies to new analyses."[77]

Other issues to be addressed by an advisory body include the hurdles presented by external peer review requirements for "novel" assessment methods. This requirement, too, inhibits adoption of state-of-the-art methods—even if it is broadly accepted within academia—because of the time lags involved.[78]

Finally, such a body could explore and develop scientifically defensible quantification methods (as opposed to monetization methods) to respond to Circular A-4's call for benefit quantification when monetization is impractical. Agencies struggle with the quantification issue because there is relatively little precedent for its use in RIA analyses.

Critical Habitat Designation (FWS, NOAA)

Basic Provisions and Responsibilities

Under the Endangered Species Act (ESA), FWS and NOAA are responsible for identifying and listing species as threatened or endangered based on a review of the status and threats to species populations. Once a species is listed under the act, the agencies must designate critical habitat for those species. The act further specifies that areas may be excluded from such designation if the economic benefits of exclusion outweigh the habitat benefits to the species.[79]

Designation of areas as critical habitat "has not been interpreted as authorizing direct regulation."[80] ESA's provisions primarily affect federal agency actions and private-sector actions with a federal nexus, such as those requiring federal approval, permitting, or funding. Critical habitat designations can be relevant to agency land acquisitions and to the development of Habitat Conservation Plans (HCPs) under the Section 10(a) provisions of the ESA. HCPs enable nonfederal parties (private landowners, municipalities, and others) to develop species protection strategies and conserve the ecosystems upon which listed species depend as part of an application for a permit for activities that might result in the "incidental take" of a species. However, critical habitat designations themselves do not create refuges or special conservation areas, and listed species are protected under the ESA whether they are found within critical habitat or elsewhere.

Funding and Compensation

Critical habitat designations are funded by the regulating agencies (FWS and NOAA) and do not involve the allocation of grants or other revenues to landowners.

Analytical Objectives and Requirements

In conducting the economic analyses for critical habitat designations, FWS and NOAA generally consider the monetary costs that could result from restrictions on uses of resources (such as logging, water flows for hydropower, housing developments, road construction, and so on) resulting from a critical habitat designation. They do not consider the potential economic benefits, including direct and indirect ecosystem services benefits and nonuse values of species and habitat, in their critical habitat designation analyses.[81] Indeed, in 2004, FWS noted that the calculation of these monetary benefits of critical habitat designation was subject to too many uncertainties.[82]

Neither the ESA nor other FWS guidance explicitly provides for the consideration of ecosystem services valuation in the economic analysis accompanying decisions to designate critical habitat for threatened or endangered species.

NOAA's National Marine Fisheries Service (NMFS) economic analysis guidelines apply to the preparation of economic impacts associated with fishery management actions and other regulatory actions of the agency, including its implementation of ESA provisions. The guidelines do not explicitly cover economic evaluation of ecosystem services, nor do they prescribe methods. Rather, they "identify analytical elements that should be addressed and the scope of analysis required under applicable law."[83] The guidelines identify four primary components of economic evaluation. These include: 1) changes in prices, timing, quantity, quality, forms produced or consumed, fishing or observational trips, and so on, that result from changing supply and demand conditions in the marketplace; 2) changes in revenues and operating costs for firms or individuals; 3) how a regulation is expected to affect fishing fleets and the fishery-dependent communities they support; and 4) the biological analysis that explains the response of the stock or stocks of living marine resources to the proposed regulation.[84] None of these elements specifically addresses how to consider the impacts of an action on ecosystem services.

EPA's *Guidelines for Preparing Economic Analysis*, though developed for that agency, are also used by other agencies for such issues as the treatment of uncertainty and nonmonetary information, discounting and comparing differences in the timing of benefits and costs, and other methodological considerations. The guidelines apply to NEPA analysis and any other agency activities that require economic analysis. The guidelines do not specifically address the evaluation of ecosystem services.

Though the regulatory agencies have not generally calculated the ecosystem services benefits of proposed actions in their critical habitat designations, several nonfederal analyses have attempted to calculate ecosystem services benefits from critical habitat designations.[85]

Policy Implications and Opportunities

Provisions for critical habitat designation under the ESA include requirements for the assessment of economic impacts of designations. To date, such analyses have not included an assessment of ecosystem services benefits from designation. One opportunity to broaden such analyses for critical habitat designations and other economic analyses is to include the evaluation of ecosystem services benefits. A potential tool for fostering this broadened analysis for critical habitat designations and other federal programs includes the following.

- *Updating EPA's Economic Analysis Guidance* with provisions defining ecosystem services and offering standard methodologies for identifying and quantifying such benefits.

Operational Permits (dams, utilities)

Basic Provisions and Responsibilities

Federal licensing or permitting of hydropower dams, energy transmission infrastructure, and other facilities generally requires both EISs under NEPA and measures to avoid or mitigate environmental impacts. We look briefly at the nonfederal hydropower dam licensing process to illustrate current practices and requirements related to evaluating biophysical impacts and ecosystem services.

Most nonfederal hydropower dams require licensing under the provisions of the Federal Power Act (FPA).[86] Current licensing (and relicensing) authority resides with the Federal Energy Regulatory Commission (FERC). In the licensing process, FERC balances competing costs and benefits, giving "equal consideration" to power production; impacts to fish, wildlife, and their habitat; and recreational opportunities. As part of this process, FERC must consider recommendations from state and federal fish and wildlife agencies. The FPA also authorizes the secretaries of the Interior and Commerce to prescribe mitigation measures for hydropower facilities.

The Environmental Law Institute (ELI) reports that FERC oversees licensing for more than 1,000 nonfederal hydropower projects and issued some 350 licenses (usually "subsequent" or relicenses) from 1993 to 2005,[87] with license durations of 30 to 50 years. Many projects now being reviewed for relicensing had received initial approvals prior to the passage of many of the nation's environmental statutes.

Analytical Objectives and Requirements

A number of hydropower licensing provisions pertain to mitigation requirements.[88] FPA Section 4(e) requires that:

> [I]n addition to the power and development purposes for which licenses are issued, [FERC] shall give equal consideration to the purposes of energy conservation, the protection, mitigation of damage to, and enhancement of, fish and wildlife (including related spawning grounds and habitat), the protection of recreational opportunities, and the preservation of other aspects of environmental quality.[89]

Despite the reference to "equal consideration," FERC notes that courts have held that "equal consideration" does not necessarily "mean equal treatment of developmental (e.g., power generation and irrigation) and nondevelopmental (e.g., fish and wildlife protection) values."[90] Nonetheless, to receive a license or relicense, a hydropower operator must take actions to protect, mitigate damages to, and enhance fish and wildlife and their habitat. Certain mitigation requirements pertaining to impacts on federal lands and provisions prescribed by FWS or NMFS are mandatory. However, the Energy Policy Act of 2005 provides processes through which applicants can appeal proposed mandatory conditions.[91] FPA requirements for protection, mitigation, and enhancement measures for fish and wildlife affected by the project do not directly refer to ecosystem services, though analysis of project effects on water flows, temperature, and other biophysical conditions and ecosystem components is undertaken.

Policy Implications and Opportunities

A number of statutes that affect the hydropower licensing process can result in compensatory mitigation requirements. These include, for example, Section 404 on wetlands and other provisions of the CWA and the ESA, along with the FPA. No database comprehensively tracks FPA mitigation actions or expenditures. However, in its analysis of licensing and related records from 2003 to 2006, ELI reports that FERC issued 70 EAs and EISs with some analysis of compensatory mitigation costs. ELI reports that "the annual costs of recommended compensatory measures varied dramatically from year to year, and comprised anywhere from two to 29 percent of the total cost of recommended [protection, mitigation and enhancement] measures."[92] During the 2003 to 2006 time frame, compensatory mitigation measures averaged $7 million per year in total costs for the life of a project of $210 million.[93]

In a 2010 Memorandum of Understanding (MOU) among the U.S. Department of Energy (DOE), DOI, and the Department of the Army, the agencies affirm the role of hydropower in providing renewable energy and agree to reduce "the environmental impact sometimes associated with historical hydropower development."[94] The MOU uses terms such as "environmentally sustainable," but does not refer to ecosystem services or their evaluation.

Through the licensing process, environmental impacts and mitigations are now required. This process offers opportunities to support the quantitative evaluation of ecosystem services impacts from projects and to identify mitigation opportunities that protect, enhance, or invest in ecosystem services. As in wetland mitigation and conservation banking, the mitigation provisions under the licensing process offer a potential source of funding for ecosystem services

investments and a potential source of market demand. These opportunities could be strengthened in a number of ways.

- *Updating the hydropower interagency MOU* to reference ecosystem services evaluation within the context of requirements to evaluate the environmental impacts of projects.
- *Setting mitigation funding priorities*: Developing FWS and NMFS mitigation guidance for relicensing decisions that includes consideration of ecosystem services and an emphasis on maintaining or enhancing ecosystem services outcomes to achieve more effective, better targeted mitigation efforts
- *Development by CEQ (or through a joint FWS, NMFS, and DOE agreement) of a Comparative Benefits Guidance*: The emerging interest in micro-hydropower projects presents a context in which including ecosystem services evaluation could play a significant role in understanding the comparative economic benefits from project development (new energy supplies) versus maintaining existing river/stream flows that may provide other benefits (flood control, species protection, recreation, and so on).

Land/Resource Management Planning (U.S. Forest Service, Bureau of Land Management, National Park Service, Fish and Wildlife Service, National Oceanic and Atmospheric Administration)

Basic Legal Provisions and Requirements

The federal government manages around 650 million acres of land, with most of those lands managed by BLM, the USDA Forest Service, the National Park Service, and FWS in its refuge system. Numerous statutes guide the management of these lands by federal agencies. Agency authorities, responsibilities, purposes, and goals vary. However, all of these agencies engage in land-use planning for the lands under their jurisdiction, which are generally subdivided into land units such as individual or groups of refuges, individual parks, forest planning units, and BLM planning units. In some cases, particularly for national parks, individual land units are established by acts of Congress that define the goals and allowable uses for the land.

Analytical Objectives and Requirements

For purposes of analyzing environmental conditions and project impacts, NEPA environmental reviews (through EAs and EISs) provide the primary context in which biophysical characteristics and ecosystems are assessed. Specific land-unit plans and records of decision regarding land uses are generally accompanied by NEPA documentation. The NEPA analysis largely sets the stage for whether and how agencies incorporate evaluations of ecosystem

services into their decisionmaking. However, the agency-authorizing statutes and other relevant laws, by setting forth the goals for managing particular land types or units, can affect the scope and type of NEPA analysis undertaken. As currently written, none of the land planning authorities explicitly requires an evaluation of ecosystem services, although ecosystem functioning is a goal for the management of most federal land units, especially for lands such as wildlife refuges, wilderness areas, and national parks.

Policy Implications and Opportunities

NEPA is the primary evaluative tool within the context of agency planning. However, agency land and resource management plans provide a context for identifying priorities for the management of public lands. Each agency operates under specific authorities that define land-unit priorities and purposes. Agencies, in turn, develop policies, regulations, and guidance to implement these statutory provisions. Currently, these agency policies, to varying degrees, include ecosystem functioning and land-health goals. However, they do not generally include or require an analysis of ecosystem services, ecosystem services gains or losses from different management regimes, or ecosystem services market potential.

Policies and tools to strengthen the evaluation of ecosystem services and support for ecosystem services investments by federal land managers include the following.

- *Examining Legal Authorities (and Policy Revisions) To Support Payments for Ecosystem Services:* Currently, multiuse agencies lease lands for timber harvesting, grazing, and other traditional resource uses. Several years ago, BLM attempted to create “conservation use” allotments for grazing lands that would have, in essence, enabled individuals and organizations to acquire grazing permits and “use” the land for conservation purposes. Under current law and policy, this concept has been difficult to implement. However, requiring the calculation of the ecosystem services benefits of public lands could provide a stronger basis from which to develop new policy options that support payments to agencies or land users to enhance, protect, and create ecosystem services. FWS, for example, has partnered with electric utilities to invest in tree planting on some 80,000 acres of wildlife refuges to create voluntary carbon credits. Denver’s water authority has entered into an agreement to fund fuels treatments on forestland as a means of maintaining source water supplies and preventing erosion that can adversely affect those supplies.

Ecosystem Services Quantification: Overview of Crosscutting Issues

The preceding review is intended in part as a reminder that ecological analysis and quantification is not new to the federal government. Quite the contrary: federal programs have decades of experience with such analysis, driven by statutory and regulatory requirements. Advocates of innovative ecosystem services-related federal policies can and should draw upon this experience.

Nonetheless, ecological analysis is not synonymous with ecosystem services analysis. Much more can be done to deliver policy-relevant services quantification. The current challenge is to better translate ecological outcomes affected by policy into social and economic terms. A few existing policy applications do this already (NRD assessments, for example). As a rule, however, biophysical assessment and economic assessment remain disconnected analytically and institutionally.

Other challenges arise because the production and delivery of ecosystem services cut across bureaucratic and legal authorities, geographies, and political jurisdictions. It can be difficult for a given federal program to deliver ecosystem services quantification without the close cooperation of sister programs with unique, complementary analytical strengths.

Another challenge for federal programs is to manage and conduct ecosystem services research that is applicable in policy contexts. Science that is designed—from the ground up—to be actionable in the real world changes the (natural and social) science that is conducted and the outcomes that are delivered. In our experience, a "sequential" approach to science and policy interactions—where, for example, scientists produce research and then ask policymakers to "apply it"—is ineffective. Policy-relevant science (and quantification) requires a more continuous process of interaction between policy innovators and implementers, natural scientists, and social scientists.

Ecosystem services analysis requires the integration of multiple disciplines (hydrology and ecology, for example) as well as the measurement and modeling of complex systems; yet it also must be applicable to real decision contexts and accomplished within practical time frames for decisionmaking. Inevitably, this means that programs will have to strike a balance between easier forms of analysis (which are practical but less technically rigorous) and state-of-the-art assessments. In either case, the principles below can help guide ecosystem evaluations.

Policy-Relevant Ecosystem Services Quantification

Policy-relevant natural science is science that describes the consequences of policy choices for biophysical outcomes that are meaningful to household, community, and social welfare within a context of federal, state, and local laws. There is a tremendous opportunity (and need) for federal programs to foster this kind of policy-relevant science and quantification. Payments for ecosystem services, environmental markets, and modern resource planning goals demand new kinds of analysis. The federal government is in a unique position to manage and deliver such analysis due to the sheer breadth of its scientific and technical resources (the people, facilities, and data already in place), its mandate to address policy-relevant questions rather than questions of purely academic interest, and its ability to finance and coordinate large, multidisciplinary initiatives.

The centerpiece of policy-relevant ecosystem services quantification is the definition, measurement, and evaluation of "ecological endpoints". Ecological endpoints are a distinct subset of the larger universe of biophysical outcome measures. In general, natural systems can be thought of as collections of features, things, and qualities that interact via physical processes with other physical features, things, and qualities. Accordingly, almost anything we can measure in nature is an "outcome" of some underlying process. Ecological endpoints are a special set of biophysical outcomes—those that are meaningful and understandable to communities, businesses, households, planners, and other stakeholders.

> **Ecological Endpoints** are biophysical outcome measures that require little further biophysical translation in order to make clear their relevance to human welfare. These endpoints are the essential bridge between biophysical and economic assessment.[95]

In our experience, inadequate attention is paid by analysts (natural and social scientists) to these outcome measures. The goal of ecosystem services assessment is *linked biophysical and social/economic evaluation.* Ecological endpoints are the essential points of linkage between natural and social science. They depict biophysical outcomes that are interpretable by stakeholders and decisionmakers and that thus facilitate social interpretation and evaluation.[96] In practice, this means focusing ecosystem services research and measurement on outcomes that are comprehensible and meaningful to nonscientists. Outcomes like biotic integrity indices, chemical water quality concentrations, hydrogeomorphic classifications, and rotifer productivity are of scientific interest, but thwart social interpretation and evaluation. Based on our experience, academic, nongovernmental, and government scientists and analysts should be more actively encouraged to measure and model these kinds of accessible and applicable outcome measures.[97]

Two additional elements are necessary for policy-relevant ecosystem services quantification: first, the *interventions* or actions that trigger ecological changes and, second, the biophysical *production functions* that relate interventions to changes in ecological endpoints.

> **Actions and Interventions** describe policy and management choices—land cover conversion, restoration, protection, and resource management—that affect natural resources and that trigger subsequent biophysical changes.

The biophysical relationships between those interventions and changes in ecological endpoints are referred to as *biophysical production functions.*[98]

> **Biophysical Production Functions** are the biophysical relationships that link concrete policy choices to changes in socially meaningful biophysical outcomes—that is, ecological endpoints.

Measurement and prediction of biophysical production functions is the most important aspect of an ecosystem goods and services research strategy. The accuracy of the economic analysis of ecosystems depends entirely on our ability to measure these biophysical production functions.[99]

Consider an ecosystem payment or market policy that leads a landowner to change land cover or a land management practice. The change in land cover or the new management practice is the intervention promoted by the policy. A key issue is how to assess the effect of that intervention on the delivery of ecosystem services, as measured by one or more biophysical endpoints? A market or payment program cannot exist until the production functions that relate intervention to endpoint outcomes are measured or predictable. Once they are, ecosystem services research can enter its social and economic phase—namely, what is the value of the endpoint change triggered by the intervention?

Producing these kinds of measurements is a scientific and institutional challenge. But existing federal programs have significant (and improving) capacity to deliver analyses of ecosystem services endpoints that could support the development of ecosystem services market transactions and investments.

Part III: Payments, Incentives, Mitigation, and Markets

Analysis and some quantification of baseline environmental conditions and monitoring of changes in those conditions are prerequisites to the development of markets in ecosystem goods and services. Such quantification and monitoring are also essential for any performance-based

investment in ecosystems. But a number of policy tools and programs build upon these basic biophysical, ecosystem services, and economic evaluations.

Many federal programs and policies affect both public and private activities and incentives regarding the management of ecosystems, their components, and their functions. We array these policies within six program types. These include:

- direct payments for, or procurement of, ecosystem goods and services
- indirect incentives and disincentives
- compensatory mitigation requirements and practices
- permit offsets
- group permits or "permitting bubbles"
- cap-and-trade markets

Each of these program types, though supporting to varying degrees investment in ecosystem goods and services, reflects differences along five primary policy dimensions that affect the extent to which these programs and tools have been used to support ecosystem services protection, restoration, and enhancement: 1) demand for ecosystem services, 2) supply of ecosystem services, 3) measurement and performance, 4) distribution and fairness effects, and 5) legal authorities.

1. Demand for Ecosystem Services

How well does the policy stimulate the creation of or investment in more ecosystem goods and services? Is the policy designed to replace lost ecosystem goods and services? Or is it designed to prevent future losses?

Demand for ecosystem services conservation and restoration is constrained by an absence of regulatory standards and/or incentive programs. Mechanisms to strengthen demand could potentially include, but are not limited to, the following.

- The creation or tightening of standards for pollution and certain habitat types (grasslands, for example).
- The consistent enforcement of existing regulations.
- The alignment of federal, state, and local taxes to favor the protection of ecosystem services. For example, while farmland that is in production receives favorable tax

treatment in some states, farmland conversion to native vegetation may not receive similarly favorable treatment.

2. Supply of Ecosystem Services

Does the policy stimulate participation in the creation, restoration, and protection of ecosystem services on public and private lands? Does the policy generate new private-sector revenue sources for conservation, thereby enhancing market participation?

Some current environmental programs do not fully advance opportunities to increase the supply of ecosystem services from the private sector. Mitigation investments, for example, often occur on a project-by-project basis, limiting opportunities to focus investments more strategically. The supply of ecosystem services could potentially be enhanced in the following ways.

- Using existing mitigation programs, NRD assessments, and environmental penalties to steer funds within a particular ecosystem into a common pool for investment in priority ecosystem services protection and restoration.
- Developing credit registries to bring buyer and seller together.
- Facilitating the aggregation of ecosystem benefits.
- Clarifying program participation rules regarding baselines, additionality, and performance requirements.

3. Measurement and Performance

In implementing a particular federal resource management planning and policy tool, what are the federal responsibilities for evaluating ecosystem performance?

Some ecosystem services markets (for example, water quality–trading markets) have been impeded, in part, by an absence of metrics and accepted equivalencies. In other instances, federal regulators have required the use of specific technologies (e.g., stormwater pipes and tunnels, mechanical wastewater treatment, or specific wetland restoration techniques) rather than outcome performance goals to achieve environmental results. These technology prescriptions can increase costs to participate in mitigation banks, water quality programs, or other environmental initiatives and limit innovation. Mapping and identifying priority areas for investment is often also lacking. Options to enhance efficiency might include the following.

- *Developing outcome-based performance measures* (for example, water quality goals or other ecosystem services endpoints) where they do not currently exist and facilitating access through online tools.
- *Developing monitoring protocols and tools* to facilitate market implementation and outcome validation.
- *Integrating permitting* across programs (in water quality and water flows, for example).
- *Creating "reverse auctions"* for ecosystem services payments to attract lowest-cost environmental outcomes.

4. Distributional and Fairness Effects

What are the fiscal and revenue implications of each natural resource planning and policy tool for federal agencies, and what are the distributional effects of the tool? A number of design issues accompany ecosystem services policy development. Types of design issues include: 1) eligibility, 2) determining additionality, 3) managing risks associated with nonperformance, 4) establishing criteria for priority-setting, and 5) determining how to harmonize across governing tiers and across interrelated programs.

5. Legal Authorities

What are the policy's key statutory and regulatory underpinnings and requirements? What gaps in authorities and procedures, if any, limit effectiveness in supporting investments in and markets for ecosystem goods and services?

The following discussion provides background on a sampling of policies and programs that currently provide opportunities for further development of ecosystem services markets, payments, and planning. This discussion is driven by the same five questions as those in the previous section on quantification.

- What are the basic statutory provisions and requirements?
- How are the analyses and practices financed?
- What are the analytical practices and areas of focus in terms of biophysical evaluation, ecosystem services evaluation, and economic valuation?
- What lessons might be drawn from these payments and market-based schemes?
- How might these efforts be relevant to the development and use of actual ecosystem payments, markets, and incentive-based policies?

Direct Payments for, and Procurement of, Ecosystem Goods and Services (Farm Bill Programs)

Basic Provisions and Responsibilities

The federal government provides grants and other payments to private landowners, tribes, states, and nonprofit organizations for the protection, restoration, and enhancement of forests, grasslands, wetlands, and other ecosystem types. Most significant among these are Farm Bill conservation programs. Payments to farmers to conserve soil and maintain farmland productivity date back to the 1930s. Current-era conservation programs first emerged in the 1985 Farm Bill, with its inclusion of the Conservation Reserve Program (CRP), which provided payments to farmers to keep environmentally sensitive lands in "conservation uses" for 10 to 15 years. The CRP and a variety of new conservation programs have expanded in scope and scale over the past three decades. Key program additions included the Wetlands Reserve Program (WRP) and the Water Quality Incentives Program. Other changes occurred in the 1996 Farm Bill, which consolidated several programs and added a Farm and Ranchland Protection Program and Wildlife Habitat Incentives Program.

USDA describes Farm Bill conservation payments as falling into four categories: 1) education and technical assistance; 2) financial incentives to encourage landowners to achieve natural resource conservation objectives, including direct payments to place agricultural lands into specific conservation uses and establish permanent easements; 3) conservation support to reduce soil erosion, protect wetlands, improve water quality, and achieve other benefits; and 4) support to farmers for meeting regulatory requirements regarding air and water quality, species protection, and wetland protection.[100]

Although Farm Bill direct payment conservation programs vary in their details, generally they include "rental payments," term-limited easements, and easements consistent with state laws, with full payments or cost-share payments used to support specified conservation use. Rental payments and easements generally have timelines that vary from 5 to 30 years, depending on the program. Payments are also applied to some reimbursements for land enhancement and restoration actions. The programs also generally place limits on the maximum number of acres that can be enrolled. The majority of overall Farm Bill conservation payments have gone to farmers participating in the CRP, with participation concentrated in the Plains and the "corn belt."[101]

USDA reported in 2006 that 14 percent of rural residence farms and 24 percent of commercial farms received some conservation payments in 2004, with average payments of

$6,904 per recipient farm, comprising 16 percent of all government payments and 1 percent of gross cash income.[102]

Numerous analyses have evaluated the performance of Farm Bill conservation programs using a variety of different criteria, including, for example, the effect of these programs on: 1) farm producer behavior; 2) environmental outcomes; and 3) the protection of high-value ecosystems. These evaluations show some environmental benefits attributable to conservation payments. For example, soil erosion between 1982 and 2003 fell 43 percent, with conservation payments considered to be major contributors to erosion reduction.[103] Likewise, wetland losses to agricultural production have decreased significantly, with the WRP and CRP considered important contributors to these wetland protections. By the end of 2005, for example, the WRP had enrolled 1.8 million acres, with much of this land under long-term or permanent easements.

Despite these achievements, however, Farm Bill conservation programs have faced criticism for allocating funds in a manner that is not always closely tied to high-priority ecosystems and for evaluating results based on such basic indicators as acreage protected rather than on ecosystem functionality or ecosystem services provided. As these payment programs have evolved, their focus is increasingly on achieving measurable benefits that include achieving, for example, "the greatest wetland functions and values" on enrolled acres.[104] The CRP program now directs funding to cropland "located in a national or state CRP conservation priority area"[105] and uses an Environmental Benefits Index (EBI) to "determine what lands to accept from among all farmer offers."[106] Nonetheless, key questions remain regarding how to better harness these programs to further increase their benefits.

- How robust is the selection of priority conservation areas?
- Should the EBI include a broader set of criteria?
- Are funds always allocated based on the priority designations, or do other factors, such as equal geographic distribution, affect fund allocation?

Funding and Compensation

The 2002 Farm Bill significantly increased funding for these programs, as did the 2008 Farm Bill. The Congressional Budget Office estimated that the 2002 Farm Bill increased conservation funding by more than $17 billion over a 10-year period (2002–2011).[107] The 2002 Farm Bill increased federal funding for various NRCS programs, including CRP, from $3 billion in FY 2001 to $4.7 billion in FY 2005.

Analytical Objectives and Requirements

Some form of ecological ranking or criteria—and thus ecological evaluation—is associated with each of the Farm Bill programs. However, existing ranking and payment criteria focus almost exclusively on the characteristics of the lands receiving payment. There is relatively little assessment of how the conservation status of agricultural lands leads to the production and delivery of ecosystem changes "off-site." Off-site ecosystem services improvements are both likely and desirable. Our understanding of how CRP and other payment programs change off-site conditions—and the economic consequences—is an important area for future analysis and quantification.

The most developed ranking schemes to date are associated with WRP and CRP.[108] While ranking procedures vary, most scoring criteria relate to such factors as habitat type, hydrology, species support, operations and maintenance costs, and the likelihood of limiting factors, such as invasive species.[109] Ranking or targeting factors in current use are primarily biophysical in nature and not based on measures of the economic or social benefits of a given biophysical outcome. One exception is CRP's EBI, which includes both biophysical outcome measures (e.g., soil erosion vulnerability) and social indicators (e.g., the number of well-water users in proximity to the land). Thus, this approach, in a very limited way, targets payments based on the social value of the land's water purification function. Although a service-intensive index is not currently in use, USDA has explored the value of including additional service value indicators in its targeting of CRP lands.[110] The general principle that payments should be directed toward conservation that yields the largest environmental benefit is well established in policy discussions.[111]

In response to increased conservation funding in the 2002 Farm Bill, USDA and other federal agencies established the Conservation Effects Assessment Project (CEAP) to quantify the environmental effects of conservation practices, programs, and payments.[112] A focus of CEAP is the development of performance and accountability measures for conservation payments. CEAP produces national assessments and regional, watershed-scale assessments with an annual budget of approximately $8 million.[113]

CEAP has experienced delays in its ability to assess and report, due in part to the inherent difficulty of assembling the biophysical data needed for assessment.[114] And an up-to-date review of CEAP capabilities and products is beyond the scope of this study. However, we urge such a review, with particular attention to how CEAP analyses contribute to understanding of ecosystem services production and delivery.

In 2006, a review of CEAP concluded: "CEAP must change direction to become the coherent, science-based assessment and evaluation system policymakers, program managers, and the conservation community urgently need."[115] The review panel highlighted a need for direct monitoring of outcomes. Notably, the panel recommended that "at least 1 percent" of conservation program funds be set aside for monitoring and evaluation. Ongoing and subsequent CEAP research and assessment efforts expanded the focus on quantifying measurable effects of conservation practices, particularly at the watershed scale, through 38 watershed assessment studies.[116] A November–December 2008 report on CEAP points to continued challenges confronting efforts to quantify some ecosystem services. For example, the report notes that "efforts to quantify wetland ecosystem services to interpret conservation effects under existing or future conditions are challenged by the lack of modeling and data collection mechanisms that capture the temporal and spatial variability of wetland ecosystems."[117]

Policy Implications and Opportunities

Conservation payment programs, particularly Farm Bill programs, have received significant scrutiny from Congress, OMB, the academic community, and the conservation community. Key proposals to improve program performance have centered on: 1) consolidating programs that share common purposes and/or consolidating different payment types (rental payments, easements, incentives) into a single, multipurpose payment system; 2) better targeting programs to high-priority conservation areas to achieve ecosystem benefits; 3) developing and using better performance indicators; and 4) improving environmental returns on investment through the use of landscape-scale approaches, competitive bidding to lower the cost of conservation program contracts, and linking payments more directly to environmental performance. Consistent with these proposed areas of improvement, USDA is working to develop better performance metrics and tools for measuring the effects of different land management practices on greenhouse gas (GHG) emissions, water quality and quantity, and other indicators of ecosystem services.

Less Direct Incentives/Disincentives

Total Maximum Daily Load Requirements

Basic Provisions and Responsibilities

During the first three decades of implementation of the CWA, regulators pursued the achievement of cleaner water largely through requirements that municipal and industrial wastewater treatment facilities utilize effluent treatment technologies to achieve specified load-

reduction standards. Under the implementation of TMDL requirements, the regulatory focus shifts to water quality outcomes, with the establishment of effluent loads that can be discharged consistent with achieving those outcomes.[118] Regulators establish maximum aggregate levels of pollutant discharges and, subsequently, specify initial allocations of effluent targets (or wasteload allocations—WLAs) for different categories of dischargers, which can include both point and nonpoint pollution sources. In some instances, discharge amounts for individual pollution sources over a specific period of time are also established.

Implementation of the TMDL program confronts a number of challenges that include decisions about: 1) how to allocate effluent loads among pollution sources; 2) how to accommodate new sources within the fixed ambient water quality standard; and 3) whether and how to establish mandatory discharge levels for individual dischargers. The sum of mandatory wasteload limitations equals the "mass load cap." In some instances, although wasteloads for dischargers are established, their achievement is not mandatory for particular sources that are relatively small or difficult to track. In these cases, progress in pollution reduction is sometimes fostered through financial incentives, technical assistance, and educational outreach.

The TMDL program creates a context that is *potentially* conducive to effluent trading programs, since different dischargers face different costs to reduce their pollution loadings. In practice, the CWA's zero-discharge, antibacksliding, and other provisions pose significant barriers to water quality trading in practice.

The history of water quality–trading initiatives goes back several decades. For example, in 1996, EPA issued a "Draft Framework for Watershed-Based Trading." A variety of state-led trading experiments were initiated as a result. In 2003, EPA issued additional policy guidance to "encourage states, interstate agencies, and tribes to develop and implement water quality trading for nutrients, sediments, and other pollutants where opportunities exist to achieve water quality improvements at reduced costs."[119] Within this context, states have experimented with water trading programs or pilot studies.

These programs vary in their purpose and design, which, in turn, affects both environmental and economic outcomes. Trading programs differ in several significant ways that include the following.

- *Allowable universe of participants*: For example, some programs allow trading only between individual dischargers that face mandatory load caps. Others include exchanges between a buyer subject to a legal load limitation and a seller not subject to a cap. These latter exchanges also vary. In some cases, the discharger has the flexibility to decide

whether to purchase "credits" from an uncapped source; in other cases, a regulator decides whether a capped source of discharges must sponsor pollution reductions or "offsets" by an uncapped source.

- *Placement of responsibility for load reallocation*: In some programs, dischargers essentially hold transferable load allowances that are traded as a commodity among dischargers. In other cases, regulators "allocate effluent control responsibility in order to maintain a cap."[120]

Funding and Compensation

Though some information about TMDL trades and trading programs within individual states exists, aggregated information on the total value of these transactions has not been compiled. Nor is information available regarding the range of compensation levels by transaction or across programs.

Analytical Objectives and Requirements

Effluent trading programs pose several implementation challenges. Such programs require a means of measuring, tracking, and monitoring effluent discharges. Capped systems have the added requirement of tracking and monitoring discharges to ensure that reported discharges from all capped dischargers reflect actual discharges. The inclusion of dispersed sources of smaller discharges complicates measurement, tracking, and monitoring. Any trade requires the quantification of loads from the trading parties. Measurement alone is not sufficient, however. Since trades between capped and uncapped sources may involve somewhat different effluent composition and discharge locations, protocols for determining equivalencies are necessary. One study of effluent trading points to several policy issues, noting that: "trades involving uncapped sources are confronted with leakage, fairness issues, and baseline definition . . . in order to calculate total load reductions that occur from installing a pollution control practice or technology."[121]

The CWA requires that individual discharge sources obtain National Pollutant Discharge Elimination System (NPDES) permits for certain pollutants. EPA sets required levels of performance controls based on its designation of "best conventional" or "best economically achievable" control technology. Additional requirements may be applied if the technology standards are inadequate to achieve specified water quality standards. EPA rules "prohibit point sources [of water pollution] from ever increasing discharges once individual permit limits are established."[122] Backsliding, under some interpretations of these provisions, could prevent point

sources from engaging in trading to offset increases in discharges that might, for example, result from expanded wastewater treatment or industrial production. In effect, the provisions limit the flexibility of dischargers and regulators to reallocate wasteloads under TMDL provisions, even when such reallocations would not affect a total wasteload limit in a water body.

While the CWA directly regulates only point sources of pollution, requirements for states to establish TMDLs introduce some foundation from which trading among point and nonpoint sources of pollution can occur. The 2003 Water Quality Trading Policy and 2004 EPA *Water Quality Trading Assessment Handbook* were designed to facilitate water trading to lower compliance costs and improve water quality.[123] Through the end of 2006, EPA had sponsored 11 pilot projects to assess trading opportunities and issues in various regions.[124]

The overall use of these sorts of trading provisions has been infrequent. Since 1990, 40 water quality–trading programs have been initiated in the United States, of which 15 include production agriculture as a potential source of credits for regulated point sources of pollution. Though 40 programs had been initiated, by 2008, completed trades had occurred in only 4 of 15 programs involving farmland—2 in Minnesota, 1 in Wisconsin, and 1 in Illinois.[125] Supply- and demand-side challenges have presented barriers to actual trading. Ineffective caps on point-source dischargers and no real cap on nonpoint sources, difficulties in establishing equivalencies, various eligibility requirements, and performance uncertainty with best practices have all inhibited trades. With no regulation of farm runoff, producers need not actively seek trading partners, and returns from trading may not compensate for the increased inspection and scrutiny that may accompany trading. Broader participation in these trading programs may depend, ultimately, on enforceable requirements to reduce nonpoint discharges from agricultural practices.

Several states, through legislation or other practices, have active trading programs or have initiated state laws to encourage such trading.[126] These programs create some opportunity for urban water managers to pursue ecosystem services investments, especially efforts that link to the broader nonurban watershed and ecosystem restoration and conservation initiatives. Two examples follow.

- ***Long Island Sound, Connecticut and New York*:** Focused on improving water quality in Long Island Sound, the governors of Connecticut and New York, with EPA, adopted a basin wide plan (the Long Island Sound Comprehensive Conservation and Management Plan) to reduce nitrogen loads in the sound by 58.5 percent over 15 years. The plan set interim targets for years five and ten. In Connecticut, the plan calls for reduction in the

pollution loads in effluent at 84 municipal wastewater treatment discharge sites along with a small (10 percent) reduction from nonpoint sources. Using the TMDL framework, the state adopted waste load allocations for each point source and a total load allocation for the nonpoint sources. The plan allows for nitrogen credit trading among municipal wastewater point sources, with savings from trades estimated to reach over $200 million. Program management costs are covered through a special fund and fees for service.[127]

Several rounds of trading have occurred among wastewater dischargers in Connecticut, and the state projects it is ahead of reduction targets for nitrogen established in its TMDL requirements.

- ***Virginia, Pennsylvania, and Maryland*:** Virginia adopted a law that would enable farmers to sell water quality credits. Virginia's program sets a high performance bar, with the emphasis on achievement of water quality goals. The program explicitly excludes any credits for conversion of farms for development purposes and also excludes projects supported with public funds. These features distinguish Virginia's law from those of other states, such as Pennsylvania. Though both Pennsylvania and Virginia set best management practices for agriculture on a statewide basis, Pennsylvania's program is designed more to promote trades than to establish high environmental performance standards. Maryland also has a trading program but uses performance thresholds rather than statewide best management practices. Participants can sell credits if pollution levels fall lower than the thresholds. All of these state programs were recently initiated, so it is premature to assess them. Though some trades have occurred under Pennsylvania's program, it is unclear to date whether those trades will result in better water quality.

Policy Implications and Opportunities

The TMDL policy's virtue lies in the fact that environmental planning and compliance are assessed on a watershed basis. Aggregate conditions, across a watershed's geography, are the focus of evaluation and quantification.[128] Inevitably—and by design—TMDL plans and water quality trading reallocate pollution controls and mitigation activities across the physical landscape. This places a burden on the regulator and analysts since the location of discharges, for ecological and hydrological reasons, affects the effectiveness of controls and their impact on the delivery of water quality to different locations in a watershed. Conventional NPDES permits avoid this quantification challenge because they are not directly concerned with the attainment of water quality goals. But as U.S. water quality regulation has evolved toward a more

performance-based approach, monitoring and modeling tools have become increasingly available to assess the consequences of control allocations or trades.

In fact, the existing portfolio of TMDL plans and water quality–trading experiments offer a rich set of lessons pertaining to the quantification of ecological impacts arising from trades. A detailed review of these quantification efforts is beyond the scope of this study, but a large technical literature is available. These analytical efforts, their successes, and their limitations offer advocates of environmental markets and payments a rich set of experiences from which to draw pertinent lessons.

Experiments with water quality trading also reveal the importance of statutory and regulatory design. One lesson to be drawn from the water quality experience is that our existing laws and regulations may prohibit (or at least inhibit) the creation of these markets.[129]

Trading is inhibited both by a lack of explicit regulatory authority and by regulatory provisions that reduce incentives to trade. First, trades cannot be used to comply with NPDES technology-based standards. This limits the scope of trading since compliance with those standards is typically the largest component of control costs. Second, in order to have credits to sell, sources must in effect "overcomply." When they do so, however, they face two regulatory risks. The CWA has antibacksliding provisions for all regulated sources of discharges to ensure that, once achieved, water quality is sustained. Overcomplying sources that return at a later date to more standard levels of compliance may run afoul of this provision.

These legal and regulatory issues constrain the supply of water quality credits (tradable pollution control responsibilities), particularly from point sources. The supply of nonpoint source pollution credits has its own issues. First, nonpoint sources cannot claim credits until their baseline environmental obligations are met. What are those obligations? They vary state-by-state and even locality-by-locality and are also a function of participation in other environmental programs (e.g., conservation payment programs already administered by USDA). Also, when nonpoint sources generate offset credits, they identify themselves as polluters and as sources of relatively cost-effective pollution reductions. There is a concern among some nonpoint sources that this will invite more direct regulation of their activities.[130]

Coastal Barrier Resources Act (FWS)

Basic Provisions and Responsibilities

The Coastal Barrier Resources Act (CBRA), enacted in 1982, designated undeveloped private coastal barrier lands and associated aquatic habitat as part of a Coastal Barrier Resources System. The CBRA specifies federal funding prohibitions in 585 system units covering some 1.3 million acres of lands and associated aquatic habitat. The act prohibits federal funding of road construction, channel dredging, and other coastal engineering projects. Federal flood insurance in these areas is permitted for structures in existence before the unit's effective date. Federal funds can be spent within system units for certain exempted activities after consultation with FWS, which oversees the implementation of the act. Such exempted activities include emergency assistance, military activities essential to national security, exploration and extraction of energy resources, and maintenance of existing federal navigation channels.

In 1990, a Coastal Barrier Improvement Act expanded the Coastal Barrier Resources System to include a category of lands referred to as "otherwise protected areas". These 271 areas, covering 1.8 million acres, include coastal areas already managed for conservation or recreation, such as national wildlife refuges, national parks and seashores, state and county parks, and land owned by private groups for conservation and recreation purposes. The only federal funding prohibition in these otherwise protected areas is for federal flood insurance.

Analytical Objectives and Requirements

While the CBRA does not specifically reference ecosystem goods and services, its focus is on protecting "undeveloped coastal barriers"—areas of high risk vulnerable to storm surges and hurricane winds that include fragile and ecologically sensitive coastal areas. The purpose of the act is to restrict development of man-made structures and people's activities associated with them to sustain natural geomorphic and ecological processes. Thus, the designation of CBRA system units requires a biophysical evaluation. While the act does not require an evaluation of ecosystem goods and services in CBRA units or an economic evaluation of these benefits, FWS has estimated an overall "savings" to American taxpayers of $1.3 billion resulting from the restriction of federal spending in these areas for roads, wastewater systems, potable water supply, and disaster relief.

A 2002 reauthorization of the act requires FWS to undertake a digital mapping project to update and produce draft digital maps on a pilot basis to facilitate identification of CBRS units and to allow for more targeted conservation initiatives and investments. The act has been

described as a market-based approach because it limits federal subsidies for coastal development and shifts development costs fully to the private sector.

Compensatory Mitigation Programs and Practices: Wetlands

Basic Provisions and Responsibilities

The CWA prohibits the discharge of dredged or fill material into waters of the United States unless a CWA Section 404 permit that authorizes such discharges is provided by the U.S. Army Corps of Engineers or an approved state. Every permitted discharge requires the avoidance or minimization of adverse impacts to wetlands and other regulated water resources. Where adverse impacts are unavoidable, the law and accompanying regulations require compensatory mitigation to replace the loss of wetland and aquatic resource functions. Compensatory mitigation pertains to the restoration, creation, enhancement, or preservation (in limited situations) of wetlands, streams, or other aquatic resources to offset unavoidable adverse impacts of the actions of the regulated entity.

Funding and Compensation

Based on data from 2000–2005, Green Banks, LLC, reports that annual market volume for wetland banking "is estimated at nearly $290 million with approximately 7,967 credits sold at a national average $36,357 per credit and over 22,800 acres protected, enhanced or restored to satisfy permit requirements."[131] Other reports estimate higher figures. For example, in its final environmental assessment prepared for the compensatory mitigation regulation promulgated in 2008, the Corps notes that "it has been estimated that the conservation and mitigation markets may now trade [at] more than $1 billion per year, and the new regulations are expected to spur a dramatic growth in the market for tradable wetlands mitigation credits."[132]

Analytical Objectives and Requirements

Implementation of Section 404 compensatory mitigation requirements, though potentially complex, involves three analytical steps. First is the assessment of the nature and extent of adverse impacts to the regulated wetland or water resource. Second is the determination by the Corps (or the state agency) of the appropriate type and amount of mitigation required. Options fall into four categories: restoration, establishment or creation, enhancement, and preservation. Each of the first three options results in a gain in wetland function, wetland acres, or both. Preservation, which does not result in a net gain of wetland acres, is used in exceptional

circumstances to protect upland or other areas deemed to contribute significantly to the ecological sustainability of a watershed.

A third determination pertains to how to accomplish the compensatory mitigation. Federal rules provide for three types of mitigation: mitigation banking, in-lieu fee mitigation, and permittee-responsible (often on-site) mitigation. EPA describes the three options as follows.[133]

- ***"Mitigation Banking***: A wetlands mitigation bank is a wetland area that has been restored, established, enhanced or preserved, which is then set aside to compensate for future conversions of wetlands for development activities. (Similar banks emerged to mitigate stream impacts as a result of Army Corps of Engineers regulations of impacts to streams in its nationwide permitting). Permittees, upon approval of regulatory agencies, can purchase credits from a mitigation bank to meet their requirements for compensatory mitigation. The value of these 'credits' is determined by quantifying the wetland functions or acres restored or created. The bank sponsor is ultimately responsible for the success of the project. Mitigation banking is performed 'off-site,' meaning it is at a location not on or immediately adjacent to the site of impacts, but within the same watershed. Federal regulations establish a flexible preference for using credits from a mitigation bank over the other compensation mechanisms."
- ***"In-Lieu Fee Mitigation****:* Mitigation that occurs when a permittee provides funds to an in-lieu-fee sponsor (a public agency or nonprofit organization). Usually, the sponsor collects funds from multiple permittees in order to pool the financial resources necessary to build and maintain the mitigation site. The in-lieu-fee- sponsor is responsible for the success of the mitigation. Like banking, in-lieu fee mitigation is also off-site, but unlike mitigation banking, it typically occurs after the permitted impacts."
- ***"Permittee-Responsible Mitigation****:* Restoration, establishment, enhancement or preservation of wetlands undertaken by a permittee to compensate for wetland impacts resulting from a specific project. The permittee performs the mitigation after the permit is issued and is ultimately responsible for implementation and success of the mitigation. Permittee-responsible mitigation may occur at the site of the permitted impacts or at an off-site location within the same watershed."

Mitigation banking under Section 404 of the CWA is among the nation's more well-developed environmental markets. In effect, mitigation banks involve the exchange of one wetland for another since permits are issued contingent on a wetland restoration, enhancement, creation, or preservation activity in one site to offset losses at another site.

Banks are created by public, private, and nonprofit organizations that enter into agreements with a regulatory agency. Banks specify the site and how it will be restored, established, enhanced, or preserved. Bank operators enter into a formal agreement with regulators. The agreement establishes liability, performance standards, management and monitoring requirements, and the terms of bank credit approval. Each bank identifies the number of "compensatory mitigation credits" available for sale and "requires the use of ecological assessment techniques to certify that those credits provide the required ecological functions."[134]

Mitigation banks first surfaced in FWS guidance in 1983 to support consolidated compensatory mitigation for impacts associated with state transportation and other agencies. However, mitigation banking received broader recognition after the release of several reports that critiqued on-site and single-project, off-site compensatory mitigation as ineffective. To address these concerns, EPA and the Corps issued interim banking guidance in 1993 with the goal of enhancing monitoring, long-term stewardship, and the clear transfer of liability from the permittee to the banker to ensure mitigation success.

Three other developments further encouraged the use of mitigation banks. The 1998 federal Transportation Equity Act for the 21st Century identified banking as the preferred compensatory mitigation alternative for federally funded transportation projects. Nearly a decade later, the WRDA of 2007 also identified mitigation banking as the preferred means of offsetting unavoidable wetland impacts associated with Corps civil works. Specifically, the act states that, "in carrying out a water resources project that involves wetlands mitigation and that has impacts that occur within the service area of a mitigation bank, the Secretary, where appropriate, shall first consider the use of the mitigation bank if the bank contains sufficient available credits to offset the impact."[135] Third, in 2008, EPA and the Corps issued updated regulations governing compensatory mitigation. The regulations establish a preference for the use of compensatory mitigation when appropriate credits are available. Rich Mogensen, past president of the National Mitigation Banking Association, has estimated that the new rule could "promote a tripling in the size of the U.S. wetland mitigation banking sector from roughly 500 banks [in 2008] to 1,500 within the next three-to-five-years."[136]

With these policy tools, the use of mitigation banks increased nearly 400 percent between 1992 and 2001, with 219 approved banks in place covering some 139,000 acres and another 95 under review.[137] By 2005, the Corps estimated that there were 450 approved mitigation banks (of which 59 had sold out of credits) and another 198 banks in the proposed stage.

Policy Implications and Opportunities

Currently, "replacement of lost social value is not a regulatory requirement."[138] A general "no net loss" goal for the program is generally interpreted in acreage terms, though agencies are increasingly emphasizing "no net loss" of functional capacity. The growing emphasis on wetland functions rather than simply on acres lost and gained provides an important precursor to evaluating and quantifying ecosystem services and applying a goal of "preservation of service value."[139] Moreover, Section 404(b)(1) guidelines provide regulatory authority to consider ecosystem services benefits of wetlands, such as water purification. To date, however, loss of service value is not generally evaluated.

Even for function-based assessments, agencies apply varying evaluation methods. A 1992 report on 46 banks showed 20 banks using functional assessment, with the remainder using acreage-based compensation ratios.[140] More recent critiques of
Corps compensation evaluations continue to point to inconsistent evaluation practices and failure to assess lost functions; evaluation of lost services derived from lost functions is rarely mentioned.[141]

Though the use of wetland mitigation banks has expanded significantly over the past 15 years, several implementation practices limit their full potential. Both WRDA and the 2008 EPA and Corps guidance on mitigation banking state a preference for mitigation banks over in-lieu or permittee compensatory mitigations. In practice, however, decisions on the mode of compensatory mitigation are determined largely at the Corps district offices. In-lieu fees, which can be directed for use in specific projects, provide a potential funding source for various Corps project priorities associated with wetland protection. Mitigation banking, by contrast, directs compensatory funds to preexisting (generally nonfederal) wetland banks that may have no nexus to Corps projects.

Another challenge with mitigation banks is their potential to redistribute ecosystem services from one location to another. For example, in Florida, wetland mitigation banking may have stripped wetlands from coastal, densely populated areas and relocated them to rural inland areas. Such distributional effects, thus, need careful consideration in the design of mitigation banks.[142]

Nonetheless, over the past decade, around 30–50 mitigation banks have been approved annually, with the total now over 600. Although 34 states have at least 1 mitigation bank, most are located in 10 states that include California, Colorado, Texas, and North Carolina, as well as some Great Lakes states and northeastern states.[143]

Based on USDA analysis, there is likely some significant untapped potential for agricultural lands to supply wetland mitigation banks.[144] Some 60 percent of mitigation counties "have agricultural lands that were once wetlands."[145] USDA analysis shows the costs of maintaining wetlands on agricultural lands to be significantly lower than the costs of creating wetland mitigation banks outside the farmland context. For example, WRP wetland restoration costs average $73 to $525 per acre, with a high of $2,500 per acre. According to USDA, restoration costs of wetland mitigation banks generally exceed $5,000 per acre, with costs reaching as high as $125,000 per acre. Some of this difference may result from regulatory requirements associated with mitigation banks and not required in WRP restoration. Although USDA did not analyze the reasons for the cost differential, the large difference suggests some prospect for the cost-effective use of farmlands as wetland mitigation banks.

The first farmland mitigation bank was approved in 2004. The bank, located in the Otter Slough Conservation Area in Missouri, resulted in the transformation of once productive, high-quality farmland back into wetland marshes and hardwood forests of tupelo and cypress.

Compensatory Mitigation Programs and Practices: Conservation Banking

Basic Provisions and Responsibilities

Conservation banks, first used in California in 1995, refer to parcels of land protected and managed to conserve listed species under the ESA. They can be established on local, state, tribal, and (in some cases) federal land, but may not be established on lands previously dedicated to or managed for the protection of biological resources. The natural resource values that protect the species are sold as "credits" to land users seeking to satisfy legal requirements for offsetting the adverse effects of their actions on listed species. Conservation banks have been developed under the authorities of Section 7 (conservation measures) and Section 10 (mitigation measures).

To provide greater consistency in the use of conservation banks, FWS published guidance in 2003. Landowners establishing a conservation bank work with FWS to develop a Conservation Banking Agreement. Landowners must grant conservation easements to a third party, develop a management plan for the conservation bank lands, and invest funds (generally in an endowment) for monitoring and long-term land management.

An estimated 133 conservation banks currently protect over 100,000 acres that benefit nearly over 90 listed species. Banks range in size from just 25 acres to 27,000 acres. The Vierra Bank in California, for example, protects 333 acres that provide 35 vernal pool credits, while the Agua Fria Multi-Species Conservation Bank, also in California, provides 3,200 acres of

rangeland habitat to protect San Joaquin kit fox and other species.[146] Banks can sell credits for multiple species.

The use of conservation banks is extremely modest given the numbers of listed species, their geographic spread, and ESA regulatory requirements associated with listed species. Moreover, The Nature Conservancy and ELI note that these requirements will likely affect several major land-use developments over the next several decades. They note that "new or expanded transmission corridors will affect habitats extending beyond the footprint of the right-of-way. In the Mountain West, over 100,000 additional oil and gas wells with a footprint of roughly 2 million acres are anticipated over the next 20 years. Other infrastructure investments are also increasing . . . ."[147]

Funding and Compensation

Tallies for the total payments spent on conservation credits are not available. However, data on some individual banks indicate that credits have sold for as little as $55 and as much as $100,000.

Analytical Objectives and Responsibilities

Because conservation banks serve as mitigation offsets for actions that adversely affect species listed under the ESA, key analytical issues in their establishment include how to define enforceable credits; delineate the number of credits available for allocation; and determine the trading ratio. Challenges in these determinations include uncertainties regarding long-term species survival and how to address potential catastrophic events, vandalism, or other illegal land uses that could undermine the conservation value of the conservation bank.

Policy Implications and Opportunities

Though conservation banks emerged in 1995 in California, nationwide they have been used for less than a decade. In theory, the ESA provides a demand-side "driver" as those facing species protection requirements look for ways to meet their obligations cost-effectively. Several issues have limited their use to date, however.

One issue is that of transaction costs on the part of would-be conservation bank "suppliers." Entering into agreements with FWS requires site-by-site development of relevant baseline information and calculations of available credits. Banking implementation measures that increase consistency and transparency in the calculation and monitoring of benefits could reduce transaction costs.

Others have pointed to requirements for permanent easements, suggesting that provisions for short-term land conservation contracts and short-term mitigation credits could address broader market needs, as would an expansion of banking opportunities to public lands, public land managing agencies, and public land users. Allowing banks to enter into short-term contracts with owners of suitable habitat could provide opportunities for interim mitigation actions or provide some land-use flexibility in the event of an eventual full recovery of a species, for example. Further exploration of these concepts for their legal, economic, and environmental feasibility would be a first step to identifying ways to expand conservation bank supply and demand.

A third issue is how to use species conservation banks as a platform on which to build "full-service" or multiple-benefits banking. FWS conservation banking guidance supports state involvement in the creation and oversight of banks, which provides an opportunity to use banks to provide mitigation for other state regulatory requirements through their strategic location.[148]

Emissions Trading

Emissions trading policies are those that establish overall emissions limits (for example, for air pollutants and effluent) within a defined geographic area or for a specified set of emissions sources. Individual emissions sources within these parameters can then buy and sell "credits" for emissions reductions, while achieving the overall regulatory limits on emissions or effluent loads. Trading programs include four main types—offsets, bubbles, banking, and netting. Here we discuss offsets and bubbles, drawing on examples from both air quality and water quality programs.

Permit Offsets

Permit offsets refer to transactions in which environmental restoration or pollution abatement in one place is used to compensate for environmental impacts of pollution elsewhere. Wetland mitigation and endangered species mitigation are, essentially, types of offset programs. See the discussion on Wetland Mitigation and Conservation Banking for examples of offset programs with particular relevance to ecosystem services analysis and investments.

Group Permits/Permit Bubbles

Basic Provisions and Responsibilities: The concept of permit bubbles first received regulatory traction three decades ago under a bubble policy established in 1979 by EPA under the Clean Air Act, which was also adopted by 32 states. In 1984, the U.S. Supreme Court affirmed the authority of EPA and state air pollution control agencies to apply bubble concepts to

meet the requirements of the Clean Air Act. Pursuant to that decision, EPA finalized its bubble rule in 1986. In effect, the policy enabled emissions sources to meet emissions standards by aggregating multiple individual emissions points within a facility (or multiple facilities of the same or different firms within the same air quality attainment area), treating them as a single emissions limit and determining where and how to achieve emissions abatement within the overall bubble. These bubbles must be approved as revisions to State Implementation Plans (SIPs), which has discouraged their use. Prior to the 1986 final rule, EPA had approved 50 source-specific bubbles, which were estimated to have saved at least $300 million over more conventional compliance costs and possibly as much as $800 million.[149]

Analytical Objectives and Requirements: At their inception, the use of bubbles was intended as a tool to support flexibility among regulated entities in how to achieve air quality goals, allowing them to identify and implement the lowest-cost compliance options. Though the bubble policy under the Clean Air Act gained early traction, several challenges accompany implementation of the bubble concept. First, gaps in data and data analysis on the effects of a bubble on actual air or water standards persist. Second, debates continue about the definition of what constitutes a "source" and how to treat new emissions sources. Third, negotiation and transaction costs for enforcing trades in emissions permits among different regulated entities (rather than within a single firm) can reduce perceived benefits of entering into trades under a bubble concept.

Policy Implications and Opportunities: As the concept of ecosystem services has gained traction, permit bubbles, particularly in the context of water quality, provide a potential tool for supporting ecosystem services payments. The bubble concept has been adapted to water quality activities; although EPA does not have a specific bubble policy for water quality, the agency has approved the clustering or grouping of permits for wastewater, stormwater, and other related facilities. Permit clustering is a predicate to enabling investments in ecosystem services as a means of meeting permit water quality requirements.

Examples: The most notable example of this clustering is that of the Tualatin Basin, in Oregon. Permits at four wastewater treatment plants expired in 2000. Rather than renew each permit and, separately, seek a required stormwater permit, the local water agency used a clustering approach, bundling into a single permitting action the renewals of all four wastewater treatment permits and the stormwater permit. Rather than investing $60 million in expensive refrigeration systems, the water agency worked with the adjacent farming community to plant shade trees along 35 miles of riverbank to cool water temperatures to required standards for $6 million, a tenth the cost of the mechanical cooling equipment.

In the Menominee Watershed in Wisconsin, a "clustering" concept is also being pursued. With multiple stormwater districts within and among six watersheds in the Milwaukee metropolitan region, successful stormwater management in any one district is linked to others. Eleven participants collaborated to establish a "group" permit that covers eight entities. The Milwaukee Metropolitan Stormwater District provides overall monitoring.

Cap-and-Trade Markets

In cap-and-trade programs, a legislature or regulatory agency establishes a limit or "cap" on the amount of pollution or other environmental degradation that is permitted to occur in a geographic area or for a regulated industry and then allows firms, nonprofit organizations, or others to generate, purchase, and trade credits to meet the cap. The most developed cap-and-trade program in the United States was developed through the Clean Air Act amendments of 1990 for sulfur dioxide.

Over the past decade, however, cap-and-trade programs have emerged to address GHG emissions. International carbon markets are extensive, but they have not generally been "significant in terms of their impact on land management, particularly in the United States."[150] Several municipalities and states have created regional compliance markets. Through the Regional Greenhouse Gas Initiative, the first mandatory, cap-and-trade effort in the United States targeting GHG emissions, 10 Northeast and Mid-Atlantic states have set a cap and agreed to reduce GHG emissions from the power industry by 10 percent by 2018. California's Global Warming Solutions Act (AB-32) is the first statewide program to cap all GHG emissions from major industries. Many other regional (and international) cap-and-trade initiatives to reduce GHG emissions have also been promulgated.

Most U.S. carbon market programs are, however, voluntary activities that include, for example, the Chicago Climate Exchange and a more disaggregated over-the-counter market. Other voluntary transactions are not driven by an emissions cap or by trade in a formal exchange.

Of particular note for land-based investments in ecosystem services protection, enhancement, and restoration are the prospects of generating GHG reduction credits by sequestering carbon from tree-planting, avoided deforestation, and, possibly, wetland creation and enhancement. Among federal agencies, several carbon sequestration "trades" have occurred, including the following.[151]

- FWS developed a terrestrial carbon sequestration program, which is now a key part of the FWS effort to restore the Lower Mississippi River Valley. Working with more than two

dozen energy companies, several nonprofit organizations, and others, FWS has added 40,000 acres of restored habitat to its refuge system and restored more than 80,000 acres to native habitats. With its partners, FWS has planted more than 22 million trees that are estimated to capture more than 33 million tons of carbon over the next 90-plus years.[152]

- In another carbon storage project, Ducks Unlimited (DU) established a carbon credit program and has purchased carbon credits on more than 26,000 acres of private land secured through perpetual easements. DU provides a one-time incentive payment to landowners who enroll in the project. Credits are then conveyed to DU, which sells them in the market.

Clean Air Act—Air Quality Credits and Trees: In September 2004, EPA issued a new guidance, *Incorporating Emerging and Voluntary Measures in a State Implementation Plan*, that sets forth how emerging and voluntary measures may be incorporated into state air quality plans. Two circumstances reinforced the significance and timeliness of the guidance: 1) under new ozone standards, many additional urban areas became nonattainment areas that must meet the new standards, generally by 2010 (though Los Angeles has until 2021 to meet the standard) and 2) existing strategies to achieve ozone standards may be insufficient, in some locations, to ensure compliance with the standard.

The new guidance describes emerging measures as those that may not have the same high level of certainty as traditional measures, in terms of quantifying emissions reductions, yet may be included in SIPs for air quality if the measures build upon best available science to document results that justify their inclusion. Tree planting and the expansion of tree canopy are among the actions that may qualify as emerging or voluntary measures.

The emerging (untested) measures may account for not more than 6 percent of total incremental additional emissions reductions necessary for the attainment of air quality standards. According to the USDA Forest Service, EPA "may approve measures into a SIP in excess of 6 percent where a clear and convincing justification is made by the State as to why a higher limit should apply."[153]

This Clean Air Act guidance on emerging and voluntary measures can guide cities seeking to expand their urban forests and tree canopy to work with nontraditional partners, such as electric utilities, air quality districts, and others to incorporate tree planting into their air quality strategies and to support investment in urban forests. Including tree planting in air quality strategies will not substitute for traditional emissions reduction measures, but tree planting may provide cost-effective opportunities to reduce emissions, particularly in areas in which extensive

investment in more traditional pollution controls has occurred but ozone standards still have not been met.

Use of the tool is not simple, as calculating benefits and meeting regulatory requirements require much more than simply establishing tree canopy goals. The inclusion of tree planting and maintenance in an air quality strategy requires clear metrics, transparency, demonstration of permanence, and other program characteristics. For example, the Sacramento Metropolitan Air Quality Management District has teamed with the Center for Urban Forest Research and the Sacramento Tree Foundation to examine the feasibility of using trees to clean the air. Preliminary estimates for Sacramento, which is among the 10 areas in the nation with the highest ozone pollution, show the potential for urban forest strategies to "help meet air quality goals, achieving as much as 8% of the required reductions in VOCs [volatile organic compounds] and 1.1% of the required reductions in NOX [nitrogen oxides] depending on the scenario."[154]

Loan Programs: Clean Water Act and Safe Drinking Water Act

Basic Provisions and Responsibilities

EPA manages grant and loan programs under the CWA and the Safe Drinking Water Act that can support ecosystem services investments to protect water supplies, though these grants have only infrequently been used for these purposes.[155] These include the Clean Water State Revolving Fund (SRF, Section 212), which offers loans for water quality improvements that have generally funded wastewater treatment infrastructure. However, these funds (more than $1 billion, combined with another $4.7 billion in state monies) can be used to implement nonpoint source management plans and develop and implement estuary plans. Just 5 percent of projects target nonpoint source pollution mitigation. Under the Safe Drinking Water Act, SRF loans (pegged in 2003 at $787 million in grants and $1.3 billion in loans) help fund public water system infrastructure. A third of these monies can be used for investment in water source protection, which includes land acquisition. Of this amount, 15 percent can support voluntary and incentive-based measures. A review of these grants and loans concludes that "since the act's inception, only $2.7 million in assistance has been used by systems to protect less than 2,000 acres of land under the set asides."[156]

Policy Implications and Opportunities

Though these revolving fund loans could be used for ecosystem services investments, primarily through land acquisition or easements, their infrequent use for these purposes is, in part, attributable to the enormous backlog of infrastructure needs such that cities tend to steer

money toward repairs and replacement of critical infrastructure. At least one state, attributing a high value to source water protection, provides incentives to use a portion of these loan funds for source water protection, particularly where such investments can demonstrate significant cost-effectiveness in achieving water supply, water quality, and water management goals.

Two examples in which states have used the land protection provisions of these loans and grants follow.

- *Ohio Water Restoration Sponsorship Program***.** Ohio's program provides significant loan rate reductions for wastewater treatment projects if the recipient uses a portion of the savings to invest in watershed protection and restoration directly or contributes to a land trust, park district, or other watershed protection effort.[157]
- *New Jersey Green Acres Program***.** The state adjusted its criteria to allocate funds under the Clean Water SRF to give three times the weight to projects with a water supply protection benefit through land protections.

Part IV: Summary and Recommendations

Strategic Considerations and Policy Priorities

Many federal tools provide the foundations for strengthening ecosystem services information and markets. Because current potentially supportive laws, policies, and funding programs are extensive, targeted action to promote greater quantification and investment in ecosystem services would benefit from a strategic approach.

The sheer breadth of existing federal capabilities and potential policy innovations presents challenges of its own. Federal policy innovators need a focused strategy, based on what can be learned from the programs and policies described in this report.

Issues to consider in developing a strategic approach include the following.

1) Evaluating the Scope and Focus of Policy Development

A strategic approach to ecosystem services policy development should first address the practical questions regarding scope. For example, should the strategy center on a handful of specific policy problems, such as water quality and coastal protection, or a few policy tools, such as NEPA planning and Farm Bill conservation measures?

In assessing strategic policy options, four criteria are important.

- *Relevance*: Does the policy initiative address a compelling public concern, such as the need for more cost-effective infrastructure and regulatory compliance, more cost-effective hazards mitigation, or new revenue streams to support priority goals such as farmland protection?
- *Ease of replication*: Can the policy be implemented in multiple locations (for example, on many public land units) using common tools and templates that help reduce implementation transaction costs?
- *Reach*: Will the policy potentially affect decisions across multiple programs and agencies and at different geographic scales?
- *Feasibility*: What are the points of resistance to implementation? Is there broad potential constituent support—for example, from farmers, counties, coastal communities, or others?

Applying these criteria, several policy options and areas of focus have significant potential.

- Completion of revisions to the Principles and Standards for Federal Investment in Water Resources that shape water resource project decisions, including specific guidance on requirements for using an ecosystem services framework for project evaluation. A fuller accounting for the environmental benefits and ecosystem services effects of water resources projects is likely to bring greater attention to nonstructural (green) water projects across the nation.
- Issuance of an executive order instructing agencies to evaluate the effects of their programs and policies on ecosystem services and to examine ways to incorporate consideration of ecosystem services into program guidance and project assessments. Such an executive order could stimulate changes to Coastal Zone Management planning, RIA, FERC licensing mitigation practices, land-use planning processes for federal agencies, wetland mitigation and conservation banking programs, and other federal activities. The benefit of an executive order is its potential for a cross-governmental focus while allowing for tailored agency responses based on the particular statutory authorities and circumstances of each agency.
- Further improving Farm Bill conservation programs to target high-priority ecosystem services protection, enhance performance indicators, and increase environmental returns on investment.

2) Addressing Measurement and Coordination Issues

The ecosystem services policy literature and case studies point to several recurring gaps that limit the potential for the development of markets in ecosystem services and constrain effectiveness in terms of ecosystem services outcomes. Specifically, many ecosystem services activities, policies, and initiatives remain focused on a single benefit stream and provide neither a framework for generating integrated, multifunctional benefits nor tools to support such integration. Despite advances in evaluation tools, many endeavors to invest in ecosystem services still lack measures, metrics, and protocols for evaluating benefits or assessing strategic opportunities in a policy setting. Few policy tools and practices exist to protect benefits at a landscape scale and across jurisdictional boundaries, including international boundaries.

The development of federal guidance on ecosystem services measurements and monitoring could enhance consistency, including common practices for addressing issues such as multiple benefits, additionality, permanence, transparency, and other policy considerations associated with investment in ecosystem services markets. As directed by Section 2709 of the 2008 Farm Bill, USDA, though the Office of Environmental Markets, is developing technical guidelines for quantifying, reporting, registering, and verifying the environmental benefits produced by land management activities in order to facilitate landowner participation in emerging environmental markets.

In addition to general guidance on ecosystem services measurement, CEQ's NEPA policy guidance and regulations offer another potential platform within which to provide general direction for the inclusion of ecosystem services when evaluating the impacts of federal actions. Areas of particular focus might include definitions pertaining to cumulative effects, as well as off-site mitigation. Such guidance could influence the practices of all federal agencies and stimulate investments in and attention to ecosystem services.

3) Identifying Low Transaction-Cost Opportunities

Among the drivers for investing in ecosystem services are potential cost savings for basic community services, lower costs for regulatory compliance, and mitigation of economic losses associated with natural hazards. Investment in ecosystem services can substitute for traditional built infrastructure, such as levees or water filtration systems, often providing the same services at lower cost. Similarly, investments in tree planting, wetland and floodplain restoration, or other natural systems and components can help regulated entities cost-effectively comply with environmental performance requirements, Meeting infrastructure and regulatory requirements potentially offer some of the most feasible, near-term opportunities for augmenting ecosystem services investments and markets.

Situations that give rise to ecosystem services opportunities fall into three basic categories or "policy centers of gravity" that affect the likely transaction costs of policy implementation. These include decision contexts with the following features.

- *A preexisting public goal (e.g., an established water quality standard), in which the policy challenge is one of incorporating ecosystem services investments as a seriously considered investment choice to meet the standard/goal*. For example, a water quality standard might be achieved through building a mechanical water filtration plant or by investing in watershed protection. This situation parallels that faced by New York City when it opted to invest in watershed conservation to filter water coming into the city. In this instance, the decision calculus is primarily one of assessing the relative capital and operating costs of ecosystem services versus "gray" infrastructure, which involves engineering, land acquisition, and other cost assessments coupled with performance comparisons of the two approaches. There is no need to "value" the water quality benefit, since the pursuit of that benefit is a fixed policy requirement.
- *Competing values and no pre-set or fixed goal (as in a water quality standard) but trade-offs between ecosystem services investments and traditional infrastructure and management options are relatively small, where the ecosystem services investment comes close to being a "win–win" situation*. Local planning that considers measures to promote permeable surfaces and tree canopy may fall into this category. There are costs associated with investing in permeable rather than impermeable surfaces, but the difference is either minimal or even favorable for permeable surfaces; at the same time, permeable surfaces generate significant additional benefits not produced by impermeable surfaces. This type of decision, like the first example, may be one in which a "rule" favoring ecosystem services can be applied without engaging in the high costs of generating detailed scientific and economic assessments. Such opportunities may exist in the context of federal facilities management and some infrastructure.
- *Competing economic values and potentially high trade-offs, with the policy challenge being one of evaluating the costs and benefits of protecting ecosystems to maintain a set of ecosystem benefits versus the costs and benefits associated with developing those lands, waters, and resources*. For example, China's evaluation of the economic benefits of logging in a particular watershed versus the imputed benefits of maintaining forest cover to protect and regulate water flows reflects this type of decision category and involves some fairly complex assumptions and calculations. While it is possible to

undertake these trade-off calculations in some circumstances, three constraints present policy challenges: 1) the transaction costs to generate this kind of information and analysis can be extremely high; 2) unlike some other issues (tradable permit schemes for, say sulfur dioxide), often ecosystem services calculations will not be readily transferable from one context to another, meaning that the calculations for credits, trades, and other payments may require high-cost calculations in each individual circumstance; 3) it is possible that some comparisons of ecosystem services values against economic development alternatives will not yield results favorable to ecosystem services protection; this raises the question of whether that calculation—or a basic values decision favoring protection for noneconomic reasons—should drive decisions.

4) Investing in Pilot Projects to Learn and Build Communities of Practice

Another goal of a strategic assessment should be the selection of pilot studies explicitly designed to be policy experiments. Pilots will have greatest lasting value when they are used to identify both successes and opportunities on the one hand and failures and barriers on the other. Mirroring our earlier recommendation, these pilots should feature an experimental design to do the following.

- Identify legal, regulatory, and administrative barriers to policy innovation.
- Identify objective performance and accountability measures.
- Quantitatively relate the association among trades, payments, planning rules, or regulations to biophysical outcomes that are socially meaningful and comprehensible to nontechnical audiences.
- Identify the beneficiaries of produced and delivered ecosystem services.
- Just because ecosystem services are valuable doesn't mean that one will be willing to pay for them as long as one can receive those services at no cost. Accordingly, clearly identify sources of demand for ecosystem services and associated funding sources or legal/regulatory drivers.
- Identify the suppliers of ecosystem services and assess the inducements necessary to stimulate greater supply. In the case of private sector suppliers, these inducements will tend to be financial. Public sector trustees and managers will be driven more by institutional and statutory requirements.

It is very difficult, particularly in the long run, to argue with the idea of ecosystem services-based policy innovations. After all, it is hard to argue that natural systems and resources are not valuable to our economy and broader well-being. U.S. environmental policy already broadly acknowledges the importance of resource conservation. An even broader principle reflected in our laws and institutions is that wealth—in any form—is to be protected and enhanced. These two fundamental strands of our public policy come together under the "ecosystem services" label. What are federal trustees, managers, or regulators doing to protect and enhance that wealth?

In practice, the answers to that question will challenge federal policy innovators. The challenge is surmountable. We have argued that institutional creativity and a deeper commitment to policy-relevant science and performance measurement are the keys to unlocking those innovations.

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[1] "Co-Evolution: Re-engineering Human Networks, Rebuilding Natural Systems," Michael Gallis & Associates, et al., sponsored by USDA Forest Service, p.12.

[2] Ibid.

[3] Spencer Rogers, et al., "Beach Nourishment for Hurricane Protection: North Carolina Project Performance in Hurricanes Dennis and Floyd," North Carolina Sea Grant, presented at National Beach Preservation Conference, Maui, Hawaii, Aug. 7–10, 2000, p. 3.

[4] EPA, "Final Report: Harnessing the Hydrologic Disturbance Regime: Sustaining Multiple Benefits in Large River Floodplains in the Pacific Northwest," National Center for Environmental Research project, Grant number x3832205, May 1, 2005–April 30, 2008.

[5] The economic literature on ecosystem valuation is extensive. Examples of this literature include: James Boyd and Alan Krupnick, The Definition and Choice of Environmental Commodities for Nonmarket Valuation, Resources for the Future, DP-09-35, 2009; James Boyd and Lisa Wainger, "Landscape Indicators of Ecosystem Service Benefits," 84 *American Journal of Agricultural Economics,* 2002; A. Myrick Freeman, *The Measurement of Environmental and Resource Values: Theory and Methods,* Washington, DC, Resources for the Future, 1993; Raymond M. Kopp and V. Kerry Smith (eds.), *Valuing Natural Assets*, Washington, DC: Resources for the Future, 1995; James Boyd, *The Nonmarket Benefits of Nature: What Should Be Counted in Green GDP?* Discussion Paper, Washington, DC Resources for the Future, 2006.

[6] There is a large scientific literature on ecosystem services. Useful resources include EPA's Ecosystem Services Research Program website (http://www.epa.gov/ecology/products.htm) with links to numerous resources. Several relevant journals are *Proceedings of the National Academy of Sciences*, *Ecological Applications*, *Frontiers in Ecology and the Environment*, and *Ecology and Society*.

[7] Section 107 of the act establishes NRD liability and authorizes federal trustees to recover damages for assessing and correcting natural resource injuries (42 USC. 9607(f)(1)). Section 1002 of the act establishes liability for "injury to, destruction of, loss of, or loss of use of natural resources" (33 USC. 2702(b)(2)(A)). The National Marine Sanctuaries Act uses the same definition of natural resource damages as OPA (16 USC. 1432). Section 1443 establishes liability and authorizes civil actions to pursue cost recovery.

[8] See OPA 33 USC section 2701(20); CERCLA 42 USC Section 9601(16); and 15 CFR 990.52. "Potential categories of injury include, but are not limited to, adverse changes in: survival, growth, and reproduction; health, physiology, and biological condition; behavior; community composition; ecological processes and functions; physical and chemical habitat quality or structure; and public services."

[9] CERCLA Section 101(16) and OPA Section 1001(20).

[10] Qualifying resources are "resources the government substantially regulates, manages, or controls;" see *Ohio* v. *United States Department of the Interior*, 880 F.2d 432 (DC Cir. 1989), at 460–461.

[11] CERCLA Section 101(6); OPA Section 1001(5), Section 1002(b)(2).

[12] 15 CFR 990.53.

[13] Daniel Smith, "Status and Trends of CERCLA-Related Natural Resource Damage Assessments," American Bar Association Newsletter Archive, Section of Environment, Energy, and Resources: Superfund and Hazardous Waste Committee, Vol. 4 (3), May 2003.

[14] Ibid.

[15] Ibid.

[16] Daniel Smith, "Status and Trends of CERCLA-Related Natural Resource Damage Assessments," American Bar Association Newsletter Archive, Section of Environment, Energy, and Resources: Superfund and Hazardous Waste Committee, Vol. 4 (3), May 2003.

[17] The Departments of Agriculture, Defense, and Energy can also be trustees (40 CFR Section 300.600).

[18] 15 CFR 990 (NOAA regulations); 43 CFR 11 (DOI regulations).

[19] This does not imply that recoveries are easily calculated through reference to an objective, unambiguous schedule of damages.

[20] 61 FR 20609, 1986.

[21] CERCLA Section 301(c)(2)(A–B); OPA, 33 USC 2706(d). Type A assessment procedures are used for small incidents with limited duration and cost.

[22] Compensable value includes "all of the public economic values associated with an injured resource, including use values and nonuse values such as option, existence, and bequest values" (56 FR 19760, April 29, 1991).

[23] 56 FR 19759, 1991.

[24] Difficulties are not related to "financial" or "economic" issues alone. The physical determination of injury also poses technical challenges.

[25] See 15 CFR 990 (NOAA rules for OPA damages) and 43 CFR 11 (DOI rules for CERCLA damages).

[26] 15 CFR 990.25. "Trustees may settle claims for natural resource damages . . . at any time, provided that the settlement is adequate in the judgment of the trustees to satisfy the goal of OPA and is fair, reasonable, and in the public interest, with particular consideration of the adequacy of the settlement to restore, replace, rehabilitate, or acquire the equivalent of the injured resources and services."

[27] 73 CFR 57259, October 2, 2008.

[28] 43 CFR 11.83(c).

[29] 43 CFR 11.82(d).

[30] 15 CFR 990.10.

[31] See Rebecca Renner, "Calculating the Cost of Natural Resource Damage," *Environmental Science and Technology* 32:3, 1998, p. 86.

[32] The private sector generally prefers restoration cost to monetization, largely because of the former's greater predictability.

[33] Testimony of David M. Kennedy, Office of Response and Restoration, NOAA, before a joint House hearing, Subcommittees on Coast Guard and Maritime Transportation and Water Resources and Environment, March 24, 1999 (available at: www.ogc.doc.gov/ogc/legreg/testimon/106f/kennedy0324.htm)

[34] 15 CFR 990.53(d)(3)(ii).

[35] 43 CFR 11.83.

[36] Report of the NOAA Panel on Contingent Valuation, January 11, 1999. (Panelists included Kenneth Arrow, Robert Solow, Paul R. Portney, Edward E. Leamer, Roy Radner, and Howard Schuman.)

[37] *Federal Register* Vol. 58, No. 10, 4610.

[38] Department of the Interior, Natural Resource Damages Restoration Office, ADD.

[39] Congressional Research Service, CRS Report IB10133, Water Resources Development Act (WRDA): Army Corps of Engineers Authorization Issues in the 109th Congress, March 22, 2005.

[40] CRS Report RL32064 Army Corps of Engineers Water Resources Activities: Authorization and Appropriations Updated December 19, 2006.

[41] The P&G refers to a document prepared by the Water Resources Council pursuant to § 103 of the Water Resources Planning Act (42 U.S.C. § 1962a-2), entitled "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies," March 10, 1983.

[42] See Evaluation of Environmental Investments Procedures: Interim Overview Manual, U.S. Army Corps of Engineers, IWR Report 96-R-18, June 1996.

[43] See Ecosystem Restoration in the Civil Works Program (EC 1105-2-210), 1995.

[44] Ibid., p. 40.

[45] See U.S. House of Representatives, Committee on Transportation and Infrastructure, Hearing on "The Water Resources Development Act of 2007: A Review of Implementation in Its Third Year," March 2, 2010.

[46] A draft of the first two sections of this document, the P&G was released for public comment in November 2009 and simultaneously submitted to the National Academy of Sciences (NAS) for review.

[47] Press release available at: www.whitehouse.gov/administration/eop/ceq/initiatives/PandG

[48] 16 U.S.C.1450 et seq.

[49] 16 U.S.C. Sec. 1455 (d) (8) and (9).

[50] Section 307(c)(1)(A).

[51] 15 CFR 930.11(g).

[52] J.B. Ruhl, et al., *Law and Policy of Ecosystem Services*, Island Press, Washington, DC, 2007, p. 145.

[53] See www.dep.state.fl.us/legal/rules/beach/62b-33/62b-33_FAC.pdf.

[54] Ibid.

[55] Mississippi Draft 2011–2015 Assessment & Strategy, CZMA Section 309, p. 7

[56] 16 U.S.C. Sec. 1455 (d) (8) and (9)

[57] 42 U.S.C. Section 4321.

[58] Section 4332 (2)(B).

[59] Bureau of Land Management, Offsite Mitigation, EMS Transmission, September 30, 2008.

[60] Ibid.

[61] Ibid.

[62] Ibid.

[63] Robert Fischman, "The EPA's NEPA Duties and Ecosystem Services," 20 *Stanford Environmental Law Journal* 497, May 2001.

[64] CEQ NEPA Regulations, 40 CFR parts 1500–1508, available at www.nepa.gov.

[65] Ibid.

[66] Fischman, pp. 507–508.

[67] U.S. Environmental Protection Agency, 1999, "Consideration of Cumulative Impacts in EPA Review of NEPA Documents."

[68] CEQ NEPA Regulations, 40 CFR parts 1500–1508, available at www.nepa.gov.

[69] Fischman, p. 514.

[70] Ibid.

[71] Ibid.

[72] Fischman, p. 531.

[73] To clarify, this is a three-part continuum: ecosystem characteristics describe biophysical attributes; ecosystem functions describe biophysical processes—filtration and storm surge friction of coastal wetlands; and these functions then translate into services such as water quality for communities, hurricane protection, or impact abatement.

[74] See, for example, Katherine Hawkins, "Economic Valuation of Ecosystem Services," University of Minnesota, October 2003, pp. 17–21, for a summary of numerous studies.

[75] Executive Order 12866, "Regulatory Planning and Review," September 30, 1993.

[76] See for example, U.S. EPA, Guidelines for Preparing Economic Analyses, EPA 240-R-00-003, September 2000.

[77] U.S. EPA, Valuing the Protection of Ecological Systems and Services, Report of the EPA Science Advisory Board, EPA-SAB-09-012, May 2009, p. 18.

[78] Ibid., p. 19 "In conducting benefit assessments, EPA has an incentive to use valuation methods that have been accepted by OMB in the past. This may create a bias toward the status quo and a disincentive to explore innovative approaches, both when monetizing values using economic valuation and when quantifying or characterizing values

that are not monetized. The committee recognizes the importance of consistency in the methods used for valuation, but also sees limitations from relying solely on previously accepted methods when innovative or expanded approaches might also be considered."

[79] 16 U.S.C. Section 1553 (b)(2).

[80] Pamela Baldwin, "Designation of Critical Habitat under the Endangered Species Act," CRS Report to Congress, April 11, 2005.

[81] Timm Kroeger and Frank Casey, "Economic Impacts of Designating Critical Habitat under the U.S. Endangered Species Act: Case Study of the Canada Lynx," *Human Dimensions of Wildlife*, 11: 437–453, 2006.

[82] FWS, *Draft economic analysis of critical habitat designation for the Bull Trout*, March 18, 2004.

[83] NMFS, Guidelines for Economic Reviews of National Marine Fisheries Service Regulatory Actions, March 2007.

[84] Ibid., pp. 6–7.

[85] See, for example, Timm Kroeger and Frank Casey, "Economic Impacts of Designating Critical Habitat under the U.S. Endangered Species Act: Case Study of the Canada Lynx," *Human Dimensions of Wildlife*, 11: 437–453, 2006.

[86] 16 U.S.C. 791-828c as amended; Chapter 285, June 10, 1920; 41 Stat. 1063.

[87] Environmental Law Institute, "Mitigation of Impacts to Fish and Wildlife Habitat: Estimating Costs and Identifying Opportunities," October 2007, p. 85.

[88] See Sections 4(e), 10(j), and Section 18 of the Federal Power Act.

[89] 16 U.S.C. Section 797(e).

[90] Environmental Law Institute, op cit., p. 86.

[91] Energy Policy Act of 2005, Pub. L. 109-58, see Section 241, 19 Stat. 594 (2005) (amending Section 10 (e), 18).

[92] Environmental Law Institute, op. cit., p. 93.

[93] Ibid.

[94] Memorandum of Understanding for Hydropower among the Department of Energy, Department of the Interior, and the Department of the Army, May 25, 2010.

[95] The term "endpoint" is used in many ways and refers generically to any modeled or measured outcome of a process, function, or relationship. We use the term more narrowly, to draw attention to the need for biophysical outcome measures that facilitate social evaluation.

[96] See Boyd, 2007; Boyd and Banzhaf, 2007; Boyd, 2006; Banzhaf and Boyd, 2005.

[97] Boyd and Krupnick, 2009.

[98] U.S. EPA, 2009; Daily and Matson, 2008; Boyd, 2007.

[99] "Biophysical production functions" as defined here are related to, but not synonymous with, the concepts of "ecological function or process" as understood within ecology. "Ecological function or process" is the broader concept, applicable to any relationship between biota or between biota and physical features. "Biophysical production functions" are a subset of those relationships, those that relate policy actions or choices to endpoint changes.

[100] USDA, "Conservation and the Environment," June 2006, Farm Bill Theme Papers, pp. 3–4.

[101] Ibid., p.8.

[102] Ibid., p. 11.

[103] Ibid., p. 13.

[104] USDA, Natural Resource Conservation Service, Wetlands Reserve Program, program update, June 18, 2010 at http://www.nrcs.usda.gov/programs/wrp/.

[105] USDA, Farm Service Agency, "Conservation Programs," Conservation Reserve Program, at http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp.

[106] Marc Ribaudo, et al., "The Use of Markets To Increase Private Investment in Environmental Stewardship," USDA, September 2008, p. 40.

[107] USDA, "Conservation and the Environment," June 2006, Farm Bill Theme Papers, pp. 5–6.

[108] Heimlich et al., Wetlands and Agriculture: Private Interests and Public Benefits, USDA, Agricultural Economic Report no. 765, 1998.

[109] See, e.g., Natural Resources Conservation Service, USDA, Wetland Reserve Program (WRP) Ranking Forms, Oregon Bulletin no. OR300-2001-1, Attachment 3, 2000.

[110] Peter Feather et al., Economic Valuation of Environmental Benefits and the Targeting of Conservation Programs: The Case of the CRP, USDA, Agricultural Economic Report no. 778, 1999.

[111] National Governors Association, Private Lands, Public Benefits: Principles for Advancing Working Lands Conservation, 2001 at 6: "Government-supported working lands conservation programs should demonstrate that they produce valuable and measurable 'environmental goods' or 'conservation commodities.'"

[112] Duriancik, Lisa, et al., The First Five Years of the Conservation Effects Assessment Project, *Journal of Soil and Water Conservation*, Nov/Dec 2008, vol. 63, no. 6.

[113] Congressional Research Service, Soil and Water Conservation: An Overview, RL33556, May 6, 2008.

[114] Congressional Research Service, Agricultural Conservation Issues in the 111th Congress, Megan Stubbs, 7-5700, R40692, July 7, 2009.

[115] Soil and Water Conservation Society, Final Report from the Blue Ribbon Panel Conducting an External Review of the U.S. Department of Agriculture Conservation Effects Assessment Project, Ankeny, IA: Soil and Water Conservation Society, 2006.

[116] Lisa F. Duriancik, et al., "The First Five Years of the Conservation Effects Assessment Project," *Journal of Soil and Water Conservation* 63(6), Nov./Dec. 2008, pp. 185A–197A.

[117] Ibid., p. 192A.

[118] Kurt Stephenson, Len Shabman, and Jim Boyd, "Taxonomy of Effluent Trading Programs: Concepts and Applications of TMDLs," in TMDLs: Approaches and Challenges, Tamim Younos, ed., PennPress, 2005.

[119] U.S. EPA, *Water Quality Trading Policy*, January 13, 2003 (available at http://www.epa.gov/owow/watershed/trading/finalpolicy2003.pdf)

[120] Stephenson, Shabman, and Boyd, op.cit., p. 258.

[121] Ibid., p. 259.

[122] Ibid., p. 264.

[123] See EPA, *Water Quality Trading Handbook: Can Water Quality Trading Advance Your Watershed's Goal?*, November 2004, Washington, DC, National Service Center for Environmental Publications. Other useful discussions of water trading include the World Resources Institute issue brief, "Water Quality Trading Programs: An International Overview," March 2009 (Washington, DC: World Resources Institute). See also, EPA Water

Quality Trading Evaluation: Final Report, October 2008 (Washington, DC: EPA, available at http://www.epa.gov/evaluate.

[124] EPA, *Water Quality Trading Handbook.*

[125] Marc Ribaudo, et al., *The Use of Markets To Increase Private Investment in Environmental Stewardship*, (Washington, DC: U.S. Department of Agriculture), 2008.

[126] See World Resources Institute, "Water Quality Trading Programs: An International Overview," March 2009.

[127] See Nitrogen Control Program for Long Island Sound at: http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325572&depNav_GID=1635

[128] For example, in 2000, the Water Environment Research Foundation issued a series of detailed technical reports on the status of water trading pilots across the country. (Water Environment Research Foundation, Phosphorus Credit Trading in the Cherry Creek Basin: An Innovative Approach to Achieving Water Quality Benefits, 97-IRM-5A, 2000 is an example from this series.)

[129] Recent court cases have thrown the legality of offsets and trading into question. See Jeremy Jungreis, Impaired Waters and Permitting: Implications of the Pinto Creek Case, *The Water Report*, December 15, 2007, pp. 17–23.

[130] See Joseph Kramer, Lessons from the Trading Pilots: Applications for Wisconsin Water Quality Trading Policy, Fox-Wolf Watershed Alliance, Appleton WI, 2003. Also see Dennis and Peter Kuch, Will Nutrient Credit Trading Ever Work? An Assessment of Supply & Demand Problems & Institutional Obstacles, 33 *Envtl. L. Rep.* 10352 (2003). ("Some farmers also believe that engaging in such trading poses additional risks to them by establishing justification for the government to reduce or eliminate 'green payments' and by requiring that someone establish the effectiveness of on-farm nutrient management practices that could later be required by law," 10362.)

[131] Ecosystem Marketplace, www.ecosystemmarketplace.com/.

[132] U.S. Army Corps of Engineers, Final Environmental Assessment, Finding of No Significant Impact, and Regulatory Analysis for the Compensatory Mitigation Regulation, 2007.

[133] EPA, *Wetlands Compensatory Mitigation*, Fact Sheet, derived from *Compensatory Mitigation for Losses of Aquatic Resources*, 40 CFR Part 230 Subpart J and 33 CFR Part 332.

[134] EPA, Mitigation Banking Factsheet, at: http://www.epa.gov/owow/wetlands/facts/fact16.html .

[135] WRDA 2007, Section 2036.

[136] Alice Kenney, Ecosystem Marketplace 2008, reported by Green Banks LLC at www.greenbanksllc.com/market (accessed January 8, 2011).

[137] Jessica Wilkinson and Jared Thompson, "2005 Status Report on Compensatory Mitigation in the United States," (Washington, D.C.: Environmental Law Institute), April 2006.

[138] James Boyd and Lisa Wainger, "Measuring Ecosystem Service Benefits: The Use of Landscape Analysis To Evaluate Environmental Trades and Compensation," Discussion Paper (Washington, D.C.: Resources for the Future), April 2003.

[139] Ibid.

[140] Environmental Law Institute and Water Resources Institute, National Wetland Mitigation Banking Study, U.S. Army Corps of Engineers, Institute for Water Resources, IWR Rep. 94-WMB-2, 1994.

[141] Boyd and Wainger, p. 10.

[142] Ibid.

[143] Ibid., pp. 44–47.

[144] Ribaudo, et al., op cit.

[145] Ibid.

[146] DOI, Office of Policy Analysis, "ESA Facts and Figures," October 2005, p. 7.

[147] Jessica Wilkinson, et al., "The Next Generation of Mitigation: Linking Current and Future Mitigation Programs with State Wildlife Action Plans and Other State and Regional Plans," The Nature Conservancy and Environmental Law Institute, August 4, 2009.

[148] Michael Bean, et al., "Design of U.S. Habitat Banking Systems to Support the Conservation of Wildlife Habitat and At-risk Species," Environmental Law Institute, February 2008, p. 2.

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[151] The discussion in this section is drawn from: Lynn Scarlett, "Green Clean and Dollar Smart" (New York: Environmental Defense Fund), 2010.

[152] U.S. Fish and Wildlife Service, "Terrestrial Carbon Sequestration," available at http://www.fws.gov/southeast/carbon/pdf/FWSTerrestrailCarbonFactSheet-partnerships.pdf

[153] USDA Forest Service, "Strategic Tree Planting," p. 4.

[154] USDA Forest Service, "Trees and the Clean Air Act," p. 2.

[155] Caryn Ernst, "Protecting the Source" (Washington, DC: Trust for Public Lands), 2004.

[156] Ibid., p. 10

[157] Ibid., p. 42.