



Federal Resource Management and Ecosystem Services Guidebook

National Ecosystem Services Partnership
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Section 1—The Guidebook and Ecosystem Services in Federal Decision Making



SECTION 1

THE GUIDEBOOK, ECOSYSTEM SERVICES IN FEDERAL DECISION MAKING

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ABOUT THE GUIDEBOOK

What is the National Ecosystem Services Partnership?

What is the Federal Resource Management and Ecosystem Services Project?

Project Funding

Project Partners and Collaborators

ABOUT THE GUIDEBOOK

This guidebook is a collaborative effort and as a whole does not reflect the official position or views of any federal agency. It was created to fulfill the expressed need of federal agencies for common, credible approaches to incorporate ecosystem services concepts into natural resource management, planning, and decision making.

On May 8, 2012, the National Ecosystem Services Partnership (NESP)¹, in partnership with A Community on Ecosystem Services (ACES), coordinated a meeting of federal agencies wanting to integrate ecosystem services concepts into management and planning and to engage resource managers and planners in this process.² The participants identified multiple challenges:

- Lack of capacity and tools to identify and assess ecosystem services and incorporate them into planning and management processes;
- Institutional resistance to a new idea with still-developing methods;
- Institutional limits to cross-agency sharing and coordinated use of these methods and tools; and
- Concern about the credibility and defensibility of methods within the context of the planning process and agencies' legal authorities.

To move forward, agency representatives asked for guidance on developing an ecosystem services assessment and accounting framework and assessment and accounting methods. They also requested information about relevant tools and a mechanism to share best practices, thereby eliminating unnecessary duplications of agency efforts.

In response, the National Ecosystem Services Partnership (NESP) launched the Federal Resource Management and Ecosystem Services (FRMES) project to develop credible approaches for incorporating ecosystem services into natural resource planning and management. This effort culminated in this guidebook, which describes how these approaches can be useful for federal resource planners and managers, provides a framework and methodology to enhance the consistency of the approaches, and examines how federal agencies are exploring or applying them.

The guidebook includes

- A description of the project, its contributors, and its audience and purpose;
- A high-level overview of ecosystem services, why they may be a constructive framework for natural resource decisions, and potential challenges to this framework's adoption;
- Two papers that explain how the Federal Land Management and Policy Act of 1976³ and the National Environmental Policy Act⁴ enable or limit agencies' incorporation of ecosystem services approaches into federal research management and planning, overviews of the context in which 5 agencies are incorporating consideration of ecosystem services into resource management, and 13 descriptions of explorations or applications of an ecosystem services concept in natural resources management;
- A decision framework for incorporating consideration of ecosystem services into natural resources management.

¹ <http://nicholasinstitute.duke.edu/initiatives/national-ecosystem-services-partnership>.

² <http://nicholasinstitute.duke.edu/sites/default/files/forum-summary.pdf>.

³ <http://nicholasinstitute.duke.edu/ecosystem/publications/application-ecosystem-services-framework-blm-land-use-planning-and-integration-ecosystem>.

⁴ <http://nicholasinstitute.duke.edu/ecosystem/publications/integration-ecosystem-services-valuation-analysis-national-environmental-policy-act>.

More than 150 individuals from agencies, universities, NGOs, and think tanks participated in the FRMES project. More than 80 people contributed directly to the guidebook's contents.

In July 2015, NESP released a companion paper, "Best Practices for Integrating Ecosystem Services into Federal Decision Making," to build on the methods reviewed in the *FRMES Guidebook*.⁵ Content from this paper will be incorporated into the next round of guidebook updates.

Guidebook Users

This guidebook is primarily written for federal resource agencies that undertake land and waters planning and management. However, its framework, methods, and examples can be applied broadly—for example, to inform rulemaking and permitting decisions or large-scale restoration efforts as well as to inform natural resource management decisions by entities other than federal natural resource agencies.

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NATIONAL ECOSYSTEM SERVICES PARTNERSHIP

NESP is the National Ecosystem Services Partnership, a loose collection of public and private individuals and organizations working together to enhance cooperation within the ecosystem services community and to strengthen coordination of policy and market implementation and research at the national level.⁶ NESP is housed at the Nicholas Institute for Environmental Policy Solutions at Duke University.⁷

FEDERAL RESOURCE MANAGEMENT AND ECOSYSTEM SERVICES

The Federal Resource Management and Ecosystem Services (FRMES)⁸ project was designed as a shared learning and methods development process for ecosystem services evaluation in federal resource planning and management. The project was coordinated by the National Ecosystem Services Partnership (NESP) in collaboration with federal agencies, NGOs, academics, and others.⁹

⁵ https://nicholasinstitute.duke.edu/sites/default/files/publications/es_best_practices_fullpdf_0.pdf.

⁶ <http://nicholasinstitute.duke.edu/initiatives/national-ecosystem-services-partnership>.

⁷ <http://nicholasinstitute.duke.edu/>.

⁸ <https://nicholasinstitute.duke.edu/initiatives/national-ecosystem-services-partnership/federal-resource-management-and-ecosystem>.

⁹ <http://nicholasinstitute.duke.edu/initiatives/national-ecosystem-services-partnership>.

The project managed across-agency and cross-sector community to share ideas and build a consistent understanding and use of ecosystem services in resource management and planning processes. The result is this guidebook, which acknowledges agencies' legal authorities and mandates, and builds on decision processes and current planning and management assessment methods common across many agencies.

The project reflects the work of

- Technical working groups, which developed scientifically robust methods for ecosystem services assessments.
- Community of practice, a forum for sharing agency experiences and providing feedback on this guidebook's design and content.

The FRMES project is supported by the Gordon and Betty Moore Foundation, the National Center for Ecological Analysis and Synthesis, the National Socio-Environmental Synthesis Center (SESYNC), and the U.S. Department of Agriculture's Office of Environmental Markets. It has received in-kind support from Duke University, academics and NGOs, and partner agencies.

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Primary Funding Sources

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- Resources for the Future
- Rights and Resources Initiative
- U.S. Bureau of Land Management
- U.S. Department of Agriculture Office of Environmental Markets
- U.S. Environmental Protection Agency
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INTRODUCTION TO ECOSYSTEM SERVICES

Integrating Ecosystem Services into Federal Resource Management
Frequently Asked Questions
Is an Ecosystem Services Approach Right for My Project?

INTEGRATING ECOSYSTEM SERVICES INTO FEDERAL RESOURCE MANAGEMENT

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“Using an ecosystem services perspective is like moving from black and white to full-spectrum color in terms of the richness of the analysis and the ability to communicate it to the public.”

— John Allen, Deschutes National Forest Supervisor

In the Pacific Northwest in the Deschutes National Forest, the U.S. Forest Service is developing a forest management plan to support several under-appreciated forest benefits such as high biodiversity (including Oregon’s largest Spotted Frog population), mushroom harvests, big game and fish habitat, local firewood gathering, and historic cultural resources. The National Oceanic and Atmospheric Administration (NOAA) is exploring how inland land and water management can be altered to help sustain commercial and recreational shellfish harvests as well as other recreational and storm protection benefits that coastal habitats provide for the Puget Sound. In the Upper Green River in Wyoming, the Bureau of Land Management (BLM) is collaborating with the U.S. Fish and Wildlife Service (USFWS) and many other organizations to develop a conservation exchange for an at-risk species, the greater sage-grouse, while also protecting water quality and riparian functions and mule-deer and sage-grouse habitat for their economic and social benefits. These and many other federal agency management efforts confront very different challenges in very different ecological and social contexts, and they all would benefit from ecosystem services analysis.

The *Federal Resource and Management of Ecosystem Services Guidebook* has been developed in partnership with federal agencies engaged in natural resource planning and management. Agencies have a growing interest in more clearly and quantitatively articulating the benefits and possible tradeoffs inherent in natural resource management decisions—and they would like to make these tradeoffs in a way that clearly communicates what matters to people. Although the guidebook was developed for these agencies, its assessment framework, methods, and examples can be applied more broadly, for example, to inform large-scale restoration efforts, infrastructure siting, rulemaking and permitting decisions, and natural resource management decisions made by states, NGOs, and the business community.

Why Do We Need to Consider Ecosystem Services in Resource Management?

Nature provides humans with many things of value. Not only the water we drink and the air we breathe, but also the crop pollination accomplished by bees, the flood protection afforded by wetlands, and the sense of

peace we might find standing in a quiet forest. To be clear, nature's benefits include environmental commodities that are consumed as well as places within which people live, recreate, and work. They even include the knowledge that other species, wilderness, and natural beauty will exist for future generations. Ecosystem services is shorthand for all of these aspects of nature that contribute to our health, wealth, and well-being. Ecosystem services analysis describes how natural resource management options affect the well-being of people, communities, and economies through their effect on ecological conditions and processes.

Because many ecosystem services are not bought and sold in the marketplace, their benefits often don't come with convenient data points like prices, inventories, or sales volumes. Lacking such common metrics makes them no less valuable—but it can lead to confusion about what they are, how important people perceive them to be, and how and to what purpose they should be managed.

Broadly speaking, measuring or assessing ecosystem services requires moving beyond ecological measures that are not explicitly linked to human benefits to make causal connections between changes in a natural system to the ecosystem services outcomes that are valued by people. (Such changes in natural systems can be caused by natural stressors or management actions.) Ecosystem services link ecological outcomes to their equally diverse social outcomes—the household, community, and business benefits and values associated with clean water, abundant species, open space, and so on.

Federal agencies are interested in incorporating ecosystem services into planning and management to more clearly link natural resource management choices to things people care about in an understandable and analytically robust manner. This task requires considering (not necessarily quantifying) all important environmental and social values, even those that might be difficult to quantify or monetize. In addition, agencies want methods that more clearly and transparently assess tradeoffs in management decisions. Relating natural resources to social and economic outcomes helps them identify options that yield the greatest benefits for stakeholders and the public at large. Analysis of the many ways natural systems affect communities allows managers to identify management options that yield multiple benefits or to clarify and resolve conflicts that arise when management options involve tradeoffs. In contrast, management that narrowly focuses on one or only a few ecological outcomes can miss important benefits or costs—to society's detriment.

Incorporating ecosystem services into resource assessments focuses attention on social outcomes—such as health, wellbeing, or economic benefits—arising from ecological systems and natural resources. Other benefits, such as the economic value, tax revenues, or jobs arising from urban, commercial, or industrial development also often bear on agency decisions. Adding ecosystem services to an assessment complements and broadens, but does not replace, analysis of these more conventional economic benefits.

Why Is Use of Ecosystem Services Accelerating?

The concept of nature's services was coined in the 1970s.¹⁰ Recognition of the connection between healthy natural systems and social and economic welfare is not new and was, for example, cited at the birth of the U.S. conservation movement 100 years ago.¹¹

Natural resource management continues to evolve, most recently with the multiple use mandate and cumulative impacts analysis. An ecosystem services approach is the next step in this progression.

The recent explosion of interest in incorporating ecosystem services into management is driven by many factors.

¹⁰ Gomez-Baggethun, E., R.D. Groot, P.L. Lomas, and C. Montes. 2010. "The History of Ecosystem Services in Economic Theory and Practice: From Early Notions to Markets and Payments Schemes." *Ecological Economics*. 69(6):1209-218. doi:10.1016/j.ecolecon.2009.11.007.

¹¹ McGee, W.J. 1909. *Proceedings of a Conference of Governors in the White House Washington, D.C. May 13-15, 1908*, edited by N.C. Blanchard, J.F. Fort, J.O Davidson, J.C Cutler, and M.F Ansel, 10-11. Washington: Government Printing Office.

Public Awareness

The public is increasingly aware of the role that population growth and economic trends play in creating resource scarcities and losses. Although public environmental concern and interest in resource management is not new, there is a growing recognition of the ways in which management of interconnected ecosystems directly affect businesses, communities, and households.

Changes in Natural and Social Sciences

Changes in the environmental science and research community have helped increase interest in incorporating ecosystem services into management decisions. Understanding and measurement of ecological systems over larger geographic and time scales continue to improve, as does understanding of natural systems in “engineered” solutions to environmental problems (e.g., green infrastructure, large-scale restoration). Cooperation between conservation planners and natural scientists has led to improved understanding of how resource management affects ecological systems. In general, natural resource data, models, and insight make the measurement and analysis of ecosystem services more practicable than in the past.

Another change within the research community relates to interactions between natural and social scientists. Today, their relationship is increasingly collaborative and constructive. Environmentally oriented social science within economics, like human dimensions research, is expanding. Also more sophisticated ecological knowledge is being incorporated into the social sciences as ecologists become more involved in the study of human-managed systems. This has opened the door for assessments that go beyond ecological assessments to incorporate social benefits.

Finally, research has been affected by trends in the conservation community (nongovernmental and philanthropic organizations) that emphasize conservation’s role in generating broad social benefits beyond protection of biodiversity.

This greater integration of social and natural science methods allows researchers to explore nature-society relationships in new and more accurate ways. The Millennium Ecosystem Assessment, authored by hundreds of scientists around the world under the auspices of the United Nations, played a large role in accelerating the engagement of the academic community as well as public policy makers in using an ecosystem services framework for natural resource management.

Public Policy

Recent policies and guidance at the federal level reflect a growing interest in incorporating ecosystem services to natural resource planning and management. The ecosystem services policy dialogue was sparked in part by the 1998 President’s Council of Advisors on Science and Technology (PCAST) report, “Teaming with Life: Investing in Science to Understand and Use America’s Living Capital.”¹² A decade later, the 2008 Farm Bill¹³ called for federal agencies to explore ecosystem services and their potential application in environmental markets, resulting in establishment of the U.S. Department of Agriculture (USDA) Office of Environmental Markets. Also in 2008 a new rule on wetland and stream mitigation issued by the U.S. Army Corps of Engineers and the Environmental Protection agency stated that “mitigation ... should be located where it is most likely to successfully replace lost ... services.”¹⁴ In 2010, appointees from federal agencies with natural resource jurisdictions met to explore markets and payments for ecosystem services. Since then, several events have advanced federal agencies’ consideration of ecosystem services approaches to natural resource planning and management.

- In 2011 the PCAST issued *Sustaining Environmental Capital: Protecting Society and the Economy*, a report

¹² Lane, Meredith A. 1998. *Teaming with Life: Investing in Science to Understand and Use America’s Living Capital*. President’s Committee of Advisors on Science and Technology Panel on Biodiversity and Ecosystems. <https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-teamingwithlife.pdf>.

¹³ U.S. Congress. 2008. Public Law 110-246, June 18, 2008, 122 STAT. 1651, 110th Cong.

¹⁴ U.S. Environmental Protection Agency. 2015. “Policy and Guidance: Policy and Technical Guidance Documents.” Last modified October 28. <http://www.epa.gov/cwa-404/policy-and-guidance>.

that asserts the critical importance of the environment for the economy and to societal wellbeing and that emphasizes the need for agencies to develop consistent ecosystem services valuation techniques across federal agencies.¹⁵

- The U.S. Forest Service's 2012 Planning Rule required that planning activities consider ecosystem services as part of an integrated resource management focus. The agency is moving quickly to phase in implementation of the rule.¹⁶
- In 2013, the White House Council on Environmental Quality released new principles and requirements for federal investments in water resources.¹⁷ These principles and requirements include guidance on using an ecosystem services evaluation framework for water resources projects.
- In 2015, the White House released a policy memorandum asking agencies to incorporate ecosystem services into federal decision making and calls for further guidance to be released in 2016.¹⁸ The White House also released a report that provided an ecosystem assessment of research needs for coastal green infrastructure.¹⁹
- Other agencies, including the Bureau of Land Management, Fish and Wildlife Service, U.S. Geological Survey, the U.S. Army Corps of Engineers, the Environmental Protection Agency, and the National Oceanic and Atmospheric Administration, have begun assessing and testing methods for identifying and valuing ecosystem services as they move toward applying them in decisions about natural resource management.

Federal efforts designed to link social and ecological analysis predate the initiatives described above. Although not labeled ecosystem services, natural resource damage assessments by NOAA and USFWS under the Ocean Pollution Act and the Comprehensive Environmental Response, Compensation, and Liability Act require assessment of ecological damage and associated social costs arising from oil spills and improper hazardous waste disposal.²⁰

How Can Federal Resource Agencies Benefit from Using Ecosystem Services in Management Decisions?

An ecosystem services approach to natural resource planning and management provides an analytical framework for integrating ecological, social, and management factors in a way that is both specific to the local context and reflective of the larger physical and human landscape within which planning and analysis takes place. Such an approach can identify and incorporate a broad spectrum of desired benefits. It can account for difficult-to-value benefits and incorporate them into analyses that allow robust assessment of alternatives, tradeoffs, and opportunities. Although agencies may have provided some consideration of these broader objectives and benefits in the past, an ecosystem services approach brings to the table new analytical techniques, data, and insights.

¹⁵ President's Council of Advisors on Science and Technology. 2011. *Sustaining Environmental Capital: Protecting Society and the Economy*. https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_sustaining_environmental_capital_report.pdf.

¹⁶ Department of Agriculture Forest Service, "National Forest System Land Management Planning," *Federal Register* 77(68)(2012):21162–21276, http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5362536.pdf.

¹⁷ White House Council on Environmental Quality. 2013. *Principles and Requirements for Federal Investments in Water Resources*. https://www.whitehouse.gov/sites/default/files/final_principles_and_requirements_march_2013.pdf.

¹⁸ Donovan, Shaun, C. Goldfuss, and J. Holderen. 2015. "Memorandum for Executive Departments and Agencies: Incorporating Ecosystem Services into Federal Decision Making." M-16-01. <https://www.whitehouse.gov/sites/default/files/omb/memoranda/2016/m-16-01.pdf>.

¹⁹ Committee on Environmental, Natural Resources, and Sustainability. 2015. *Ecosystem-Services Assessment: Research Needs for Coastal Green Infrastructure*. Committee on Environmental, Natural Resources, and Sustainability, National Science and Technology Council. https://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/cgies_research_agenda_final_082515.pdf.

²⁰ U.S. Environmental Protection Agency. 2015. "Superfund." Last modified December 21. <http://www.epa.gov/superfund>.

A Systemic Analysis of Management Actions

Any single resource management action typically affects multiple ecosystem services; likewise, the provision of one ecosystem service can be influenced by multiple management actions. Providing access to a stream, for example, creates opportunities for fishing and hunting but may impair the public's enjoyment of a wilderness experience. At the same time, management of the view, the clarity of the water, and the size of the trout population can affect recreational fishing benefits. A systemic approach asks resource managers to consider this interplay of cause and effect among multiple objectives and multiple management actions and to identify and articulate the implications of management for how people enjoy, use, or value the effected resources—however difficult to quantify.

Incorporating ecosystem services into planning can improve efficiency, reveal tradeoffs, demonstrate win-win conservation solutions, and avoid mistakes that arise from management of a resource or specific ecosystem service in isolation. Without systematic identification and consideration of the connections between management and ecosystem services, some impacts (positive or negative) will be left out of the decision-making process. Unaccounted for, or externalized, costs and benefits can lead to poor decisions. This situation is most common when resources managed by an agency affect services not directly managed by that agency. By clarifying how all benefits—and any potential tradeoffs—effected by management choices have been considered by the agency, an ecosystem services approach may help generate support for agency actions and reduce conflict and litigation.

Under a traditional “plan and mitigate” approach to resource management, agencies propose management actions for individual resources or services and mitigation actions for negative impacts to that resource or service that would result from the selected management action. Incorporating ecosystem services into planning can provide managers with a framework that “balances all outcomes” insofar as is possible within agency mandates and regulatory constraints. Without changing existing mandates or regulations, this shift in thinking can result in management plans that address (and improve) a wide range of outcomes. (For an example of how the ecosystem services can change the decision process, see agency example 4, “Sustaining Ecosystem Services across Public and Private Lands: The Cool Soda All Lands Restoration Proposal.”²¹)

Even when agencies’ legal and regulatory missions constrain their focus to relatively narrow objectives (e.g., endangered species), a more comprehensive ecosystem services approach can be helpful. As an example, if biodiversity or habitat restoration is a project’s overriding goal, incorporation of a broader suite of ecosystem services in planning may identify co-benefits (or costs) relevant to public support, conflict resolution, or jurisdictional disputes.

Expanding the scope of outcomes to include additional ecosystem services during a planning exercise may not change a manager’s assessment of which management alternative is best. Incorporating ecosystem services into decision making does not replace an agency’s existing priorities—but it does provide additional information about how best to meet existing priorities while also addressing other objectives. (For an exploration of how co-benefits may be considered in project planning, see agency example 5, “Incorporating Consideration of Ecosystem Services into Plans for the Great Dismal Swamp National Wildlife Refuge.”)

More Formal Integration of What Is Important to People

Ideally, integrating ecosystem services into planning is part of an inclusive, collaborative process involving people and communities throughout the decision-making process, incorporating their input regarding what they value and the benefits they would enjoy from a given management option. Collaborative engagement can align with existing agency processes, such as impact scoping under the National Environmental Policy Act. By incorporating engagement at the outset of the process, before any management actions are proposed, additional benefits or desired outcomes can surface that might not emerge in a public involvement process wherein stakeholders respond to a specific proposed outcome or action. The 2012 Forest Service Planning

²¹ Smith, N. 2014. “Sustaining Ecosystem Services across Public and Private Lands: The Cool Soda All Lands Restoration Proposal.” In *Federal Resource Management and Ecosystem Services Guidebook*. Durham: National Ecosystem Services Partnership, Duke University, www.nespguidebook.com.)

Rule encourages this type of early engagement both to elicit the public's needs and values and to inform the selection of management objectives.²² Early elicitation of public values to help define the management objectives and services of interest can, in turn, lead to more formal ecosystem services assessments and valuations and eventually result in better communication of benefits and tradeoffs to stakeholders and the broader public.

Use of ecosystem services language reinforces agency efforts to describe the impacts of management actions using metrics and terms that are relevant to the public. For example, a project aimed at removing invasive species could be described not only in terms of number of acres treated, but in terms of an expected increase in bird sightings or other species' abundance, or in terms of reductions in risks of catastrophic wildfires. This approach can help stakeholders and the public better understand the implications of implementing one set of management actions over another.

Explicitly incorporating preferences, priorities, or values in comparisons of the ecosystem service outcomes or benefits of management allows alternatives to be compared on the basis of their social outcomes (how they will affect people). Social preferences for ecosystem service benefits can be incorporated into tradeoff analysis, resulting in a transparent evaluation of options in terms of both these outcomes and the public's ranking or valuation of them. These methods may also lead to the expression of ecosystem services benefits in monetary terms, which can help managers convey to the public, Congress, communities, and businesses the very real economic and social value of the resources being protected and managed.

Analysis of who is providing services, who is gaining services or losing them, or who is bearing greater or lesser risk can be useful for understanding whether management decisions are equitable across communities affected by resource management. Equity concerns are a common source of controversy in public lands resource management. A landscape analysis of services and beneficiaries can increase the transparency of distributional effects. Although some may view it as an invitation to greater controversy, this transparency can also clarify which ecosystem services can be provided over time and across the landscape with minimal tradeoffs. Even when it reveals distributional conflicts, more transparent measures of ecosystem service benefits can reveal options that reduce perceived inequities.

Important Questions about Using Ecosystem Services in Management

How do ecosystem services concepts complement ecosystem-based and landscape-scale planning?

For historic, political, and administrative reasons, U.S. natural resource management tends to be agency-, media-, and place-specific. But because most ecological systems are linked across broad geographic scales, the impacts of management decisions do not stop at a fence line or political boundary, and the biophysical factors that create benefits (and thus social outcomes) may be geographically far removed from the people affected. In this way, all federal lands and waters are connected to entities outside their boundaries. An ecosystem services approach can be used to consider how the flow of services to and from federal lands and waters is changed by management choices.

Systemic analysis of the ecosystem services effects of resource management decisions can help managers identify potential partners by understanding

1. who benefits from or is adversely affected by the agency's management outside the boundaries of the management area;
2. which outside parties affect the management options and priorities for natural resources within the management area; and
3. what outside activities or conditions may complement, substitute for, or detract from federal agency contributions to an ecosystem service.

²² Department of Agriculture Forest Service, "National Forest System Land Management Planning," *Federal Register* 77(68)(2012):21162–21276, http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5362536.pdf.

Incorporating ecosystem services into assessments can complement efforts to evaluate the impact of large-scale threats, such as drought, nutrient enrichment of waters, habitat fragmentation, air pollution, and invasive species, and develop strategies to deal with them. Also, by understanding the implications of resource management activities on the ecological benefits important to people, particularly those benefits arising for people outside a management area's boundaries, managers can "leverage" their management actions or funding sources to address bigger challenges and provide more benefits than would be possible when working alone. This reasoning is part of the impetus for the USDA's new "all-lands" approach to resource management, BLM's eco-regional assessments, the Department of the Interior's creation of landscape conservation cooperatives, the U.S. Army Corps's watershed informed budgeting, and NOAA's Integrated Ecosystem Assessment and Habitat Blueprint programs.

Agencies may find it more cost-effective to achieve management objectives by providing incentives (e.g., payments) for private landowners or nearby municipalities to undertake conservation efforts rather than implementing additional management actions on agency lands or waters. Incorporating ecosystem services into assessments can assess the potential ability of partners to support management objectives and opportunities to incentivize their participation. Under the proposed Green River Conservation Exchange, for example, the Bureau of Land Management and other interested parties have agreed to contribute funds toward conservation actions undertaken by federal, state, local, and private parties to benefit greater sage-grouse habitat (see agency example 8), "An Ecosystem Services Approach to Sage-Grouse Conservation: Upper Green River Conservation Exchange Program."²³

In the context of constrained budgets, implementing ecosystem service approaches can shift debate over program costs to a discussion of program benefits and help justify changes in program funding and budget allocations. It may also provide support for engaging external beneficiaries (individuals, businesses, and state and local agencies) in incentive/cost-sharing programs or partnerships to improve ecosystem services provision. For example, hunting permits, grazing permits, and park entrance fees have been around for decades. The USFS Forests to Faucets project illustrates a new take on this idea: Denver Water has invested in the USFS's Rocky Mountain Region forest thinning and watershed protection projects in recognition that they benefit Denver Water's downstream drinking water reservoirs.²⁴

Does the shift to an ecosystem services approach favor nature's more utilitarian benefits over intrinsic values, such as species' existence value?

An ecosystem services approach is human-oriented by design in that it seeks to relate ecosystem features to the wellbeing of people. This orientation can lead to a false impression that utilitarian benefits arising, for example, from water consumption, timber harvests, energy extraction, recreational resources, and commercial fisheries are the focus. Ecosystem services include less tangible, more intrinsic, and equally important benefits associated with things like species' existence, wilderness, beauty, and the value to future generations of preserving those things. Because these matter to people and their well-being, they are benefits provided by ecosystems—they are ecosystem services.

Does a dollar value need to be placed on all services?

Use of assessment of ecosystem services in assessments and decision making does not require a monetary assessment. Ecosystem services approaches can and often do describe social and economic outcomes without giving them monetary value. For example, the value can be described in terms of health outcomes, such as number of hospitalizations from smoke-induced respiratory distress. Analysis can also produce quantitative, but non-monetary, indicators tied closely to benefits, such as the number of households whose drinking water is protected from groundwater depletion or contamination. Important insight can also come from narrative explorations of ecosystem services outcomes that provide general information about which ecosystem services are most important to affected communities or which management actions are likely to

²³ Reed, A., and L. Scarlett. 2014. "An Ecosystem Services Approach to Sage-Grouse Conservation: Upper Green River Conservation Exchange Program." In *Federal Resource Management and Ecosystem Services Guidebook*. Durham: National Ecosystem Services Partnership, Duke University, www.nespguidebook.com.

²⁴ U.S. Department of Agriculture Forest Service. 2012. "Forest to Faucets." Last Modified February 15. http://www.fs.fed.us/ecosystemservices/FS_Efforts/forests2faucets.shtml.

increase or decrease the provision of ecosystem services. However, such narrative descriptions are insufficient on their own for a robust assessment.²⁵ Regardless of whether monetary, non-monetary, or other well-defined ecological or social measures are used, use of ecosystem services in assessments provides information to help decision makers and the public understand and compare different ecosystem services and different management, project, or planning options and to make tradeoffs among them.

Do resource agencies need to change their management to prioritize whatever local stakeholders value most?

Incorporating ecosystem services into management decision processes neither preempts an agency's existing mandates and decision-making discretion nor requires that a specific decision be reached. Rather, it provides additional information on how best to meet existing priorities (and perhaps provide other benefits at the same time), thereby supporting informed decisionmaking.

What are the potential challenges of implementing an ecosystem services approach to management?

Incorporating ecosystem services into assessments and management decisions poses a number of challenges. One relates to confusions that can arise due to terminology. For example, the term ecosystem services is interpreted in various ways. Some resource managers, policy makers, and researchers think of ecosystem services as the biophysical processes (such as nutrient cycling, wave attenuation, climate regulation) that give rise to social benefits. Some think of ecosystem services as the goods or commodities (such as cubic-feet of water, duck populations, or acres of wilderness) arising from biophysical processes that benefit us. Others define ecosystem services as the benefits themselves (such as the recreational value of a forest, the commercial value of a fish population, or health improvements associated with environmental amenities). Coming to a common understanding and use of terms is a challenge that will need to be addressed for those conducting assessments. This guidebook provides a starting place for developing consistent terminology that will likely evolve with use.

Discussion of ecosystem services with the public need not rely on technical terminology. In fact, successful public engagement often will feature intuitive, commonly used, and concrete language about specific resources—language such as “abundant fish populations,” “water suitable for swimming,” “natural views,” or “reduced flood risks.”

Although narrative descriptions of a wide range of services and management actions is possible, they are insufficient for formal analysis and quantitative approaches can be limited by significant data and modeling gaps.²⁶ One potential gap is a lack of models that link management actions to specific ecological and biological changes, though more and more of these models are becoming available. Monitoring data currently collected for regulatory or more purely ecological purposes often does not match the data needed for ecosystem services—that is, data that facilitates the linkage of ecological and social outcomes. Furthermore, federal guidelines can make it difficult for agencies to get approval to conduct social surveys, limiting the agencies' capacity to quantify the demand for and the value of many services. Finally, despite hundreds of economic valuation and other social benefit studies, huge gaps remain in our knowledge of social benefits. Although existing studies of values and social benefits can be generalized, their “transferability” to other sites may be limited or impossible when resource and social conditions at these other sites are quite different from those at the study site.

²⁵ L. Olander, R.J. Johnson, H. Tallis, J. Kagan, L. Maguire, S. Polasky, D. Urban, J. Boyd, L. Wainger, and M. Palmer, *Best Practices for Integrating Ecosystem Services into Federal Decision Making* (Durham: National Ecosystem Services Partnership, Duke University), accessed January 27, 2016, <https://nicholasinstitute.duke.edu/ecosystem/publications/best-practices-integrating-ecosystem-services-federal-decision-making/>.

²⁶ L. Olander, R.J. Johnson, H. Tallis, J. Kagan, L. Maguire, S. Polasky, D. Urban, J. Boyd, L. Wainger, and M. Palmer, *Best Practices for Integrating Ecosystem Services into Federal Decision Making* (Durham: National Ecosystem Services Partnership, Duke University), accessed January 27, 2016, <https://nicholasinstitute.duke.edu/ecosystem/publications/best-practices-integrating-ecosystem-services-federal-decision-making/>.

The use of new methods raises concerns over insufficient in-house technical capacity: social scientists, in particular, remain relatively rare within environmental agencies. Incorporating ecosystem services into management and decision making does not require new analytical methods in all cases. Indeed, useful information can be gained from relatively non-technical activities, such as stakeholder engagement and linkage of management actions to prioritized benefits (i.e., desired outcomes). These activities may not be too different from the work an agency already does. Prior knowledge and reports generated under past decision-making efforts will frequently be the foundation for developing an understanding of ecosystem services. More technically challenging methods that use models to reveal the impacts of management on the production of services or to conduct formal tradeoff or cost-benefit analysis using monetary valuation (with non-market valuation) or non-monetary decision analysis are likely to require significant time and expertise. Use of these methods may require additional personnel or the use of outside consultants. Consultants are often used when any cost-benefit analysis or other economic analysis is required. Ecosystem services can similarly be incorporated into other analysis like cumulative effects analysis or risk assessments.²⁷ If ecosystem services are to be included in these analyses, federal managers need to ensure that external experts can integrate those services into the analyses using credible data and methods.

Some managers are concerned that using ecosystem services in management and decision making will entail significant effort but have only minimal effect on decisions and outcomes. In a climate of constrained funding and limited ability to increase organizational capacity, an ecosystem services (or any) approach must clearly demonstrate its value. Ideally, early testing and application will provide a wide variety of cases that can be evaluated to demonstrate when and where the approach provides the most value. Experience using new methods will help agencies learn to balance complexity and costs with its value to decision makers and the public.

Finally, because ecosystem services by design captures a wide suite of ecological and social effects, it will tend to identify ways that a given agency or jurisdiction's management decisions will affect resources managed or protected by other institutions. The analysis itself will often require the collaboration of experts from multiple agencies and may reveal the importance of coordination with a range of stakeholders. This coordination can be viewed as a desirable byproduct of ecosystem services analysis, but it also poses challenges to the institutions involved.

Important References

Millennium Ecosystem Assessment

Released in 2005, this report represents the work of more than 1,360 experts worldwide.²⁸ It examines the state of the world's ecosystems and ecosystem services, evaluating, summarizing, interpreting, and communicating information regarding ecosystem change and human wellbeing and the scientific basis for action needed to enhance the conservation and sustainable use of ecosystems.

PCAST Executive Report—Sustaining Environmental Capital: Protecting Society and the Economy

This 2011 executive report from the President's Council of Advisors on Science and Technology (PCAST) Working Group on Biodiversity Preservation and Ecosystem Sustainability addresses the needs and opportunities of governments—especially the U.S. federal government—to more effectively protect environmental capital and ecosystem services.²⁹ PCAST's recommendations involve a three-pronged effort: making better use of existing knowledge, supporting the generation of essential new knowledge, and expanding the use of informatics.

²⁷ W. Munns, A. Rea, G. Suter, L. Martin, L. Blake-Hedges, C. Davis, G. Ferreira, S. Jordan, M. Mahoney, M. Barron, "Ecosystem Services as Assessment Endpoints for Ecological Risk Assessment," Integrated Environmental Assessment and Management, DOI 10.1002/ieam.1707.

²⁸ Millennium Ecosystem Assessment. 2005. "Millennium Ecosystem Assessment." Last accessed January 29, 2015. <http://www.unep.org/maweb/en/index.aspx>.

²⁹ President's Council of Advisors on Science and Technology. 2011. *Sustaining Environmental Capital: Protecting Society and the Economy*. https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_sustaining_environmental_capital_report.pdf.

Sustainability for the Nation: Resource Connection and Governance Linkages

This 2013 report by the National Research Council highlights high-priority areas for governance linkages that can support decisions better aligned with sustainability objectives.³⁰

Best Practices for Integrating Ecosystem Services into Federal Decision Making

In 2015, NESP brought together a number of acknowledged academic experts to build upon the methods outlined in the FRMES guidebook and identify best practices. The resulting report outlines recommendations for best practices specific to ecosystem services assessment methods.³¹

Ecosystem Services and Resource Management: Institutional Issues, Challenges, and Opportunities in the Public Sector

This study by Lynn Scarlett and James Boyd published in *Ecological Economics* in 2015 describes existing federal policies that permit or promote ecosystem services analysis, management, investments, and markets.³²

Nature as Capital PNAS 100th Anniversary Special Feature

These articles are part of the special series of PNAS 100th anniversary articles to commemorate the exceptional research published in PNAS over the last century and to promote exceptional science looking to the century ahead.³³

Principles to Guide Assessments of Ecosystem Service Value

This 2014 document arose from the Ecosystem Services Valuation Workshop held July 8–9, 2013, at Portland State University, an event sponsored by Portland State University's Institute for Sustainable Solutions, the Cascadia Ecosystem Services Partnership, and Defenders of Wildlife.³⁴ The collaboratively developed guiding principles address use of ecosystem services in natural resource decisions.

³⁰ Committee on Sustainability Linkages in the Federal Government. 2013. "Sustainability for the Nations." Science and Technology for Sustainability Program; Policy and Global Affairs; National Research Council. doi: 10.17226/13471. <http://www.nap.edu/catalog/13471/sustainability-for-the-nation-resource-connection-and-governance-linkages>.

³¹ L. Olander, R.J. Johnson, H. Tallis, J. Kagan, L. Maguire, S. Polasky, D. Urban, J. Boyd, L. Wainger, and M. Palmer, *Best Practices for Integrating Ecosystem Services into Federal Decision Making* (Durham: National Ecosystem Services Partnership, Duke University), accessed January 27, 2016, <https://nicholasinstitute.duke.edu/ecosystem/publications/best-practices-integrating-ecosystem-services-federal-decision-making/>.

³² Scarlett, Lynn and James Boyd. 2015. "Ecosystem Services and Resource Management: Institutional Issues, Challenges, and Opportunities in the Public Sector." *Ecological Economics* 115:3-10. doi:10.1016/j.ecolecon.2013.09.013. <http://www.sciencedirect.com/science/article/pii/S0921800913002991>.

³³ National Academy of Sciences. 2015. "Nature as Capital PNAS 100th Anniversary Special Feature." In *Proceedings of the National Academy of Sciences of the United States* 112(24), 7348-7425. Washington, D.C. <http://onlinedigeditions.com/publication/?i=269508>.

³⁴ Ervin et al. 2014. "*Principles to a Guide Assessments of Ecosystem Service Values*." Principles to Guide Assessments of Ecosystem Service Values, first revised edition. Portland, Oregon: Cascadia Ecosystem Services Partnership, Institute for Sustainable Solutions, Portland State University. http://www.pdx.edu/sustainability/sites/www.pdx.edu.sustainability/files/Principles%20to%20Guide%20Assessments%20of%20Ecosystem%20Service%20Values_first%20revised%20edition%202014.pdf.

FREQUENTLY ASKED QUESTIONS

How are ecosystem services-based planning and multiple-use planning different?

An ecosystem services approach to planning has much in common with multiple-use forest and rangeland management, but the two are not equivalent. Multiple-use planning emerged from the Multiple Use Sustained Yield Act of 1960, which authorized the U.S. Forest Service (USFS) to sustainably develop and manage the national forests' renewable resources (timber, range, water, recreation, and wildlife) and from the Federal Land Policy and Management Act of 1976, which established a similar multiple-use mandate for the Bureau of Land Management (BLM). Ecosystem services planning is authorized and encouraged through various rules and guidance documents, including the 2012 USFS Planning Rule, the 2011 President's Council of Advisors on Science and Technology (PCAST) report Sustaining Environmental Capital, and the 2013 Principles and Requirements for Federal Investments in Water Resources. But no federal law currently mandates implementation of ecosystem services planning.

Multiple-use planning tends to focus on the production of marketable commodities like timber and direct uses of public lands like recreation. The ecosystem services approach (1) considers services and economic impacts beyond those specifically identified in the acts noted above and considers benefits that arise outside the boundaries of the management area; (2) emphasizes engagement with many stakeholders, including not only local communities, but also the broader public affected by services provided or supported by public lands; and (3) focuses directly on how the public values and benefits from these services.

Examination of the application of multiple-use planning in the Forest Service helps clarify how it differs from an ecosystem services-based planning approach. The act creating the agency called for it to provide for the management of forests for timber products but also to protect watersheds for people. Deeply embedded in the agency's mission is the idea that a wide range of resources as well as the impact of their management on society must be considered in planning. Early on, multiple-use processes within the Forest Service often focused on commodity outcomes, like board feet of timber sold or recreation visitor days. As such, the social outcomes tended to be driven by markets and production of services that could be consumed or used. Over the years, as "ecosystem management" and then "ecological restoration" became the overarching approach for planning and management, the agency began to shift its focus from producing goods and commodities to maintaining the health of land to restore water quality, reduce fire risk, provide scenic beauty for the public, and the like. This gradual shift has made the "reach" to an ecosystem services approach much more attainable. Today, the major changes an ecosystem services approach brings are (1) the extent of the services considered beyond commodities (e.g., carbon sequestration, pollination, flood control), (2) stakeholder input in the selection of services rather than public consideration of agency-selected alternatives, and (3) the degree to which both social and economic factors are directly tied to these services.

How is an ecosystem services approach to planning different from a cumulative impacts assessment?

As of 1987, Council on Environmental Quality regulations require analysis of cumulative environmental impacts for projects subject to the National Environmental Policy Act (NEPA). The goal of the requirement is to allow decisionmakers to better understand the totality of potential impacts to a resource over time and space, so as to avoid environmental "death by a thousand cuts." As a matter of principle, the requirement shares one of the core goals of an ecosystem services approach: the desire to capture a wide variety of ecological impacts and do so over geographic scales that are both ecologically and socially important. Although cumulative impacts assessments and an ecosystem services approach to planning share some characteristics and are not mutually exclusive, there are important differences between the two.

To begin with, an ecosystem services analysis is integrated throughout every step of a planning process, including development of alternatives, and can be applied outside the NEPA process (e.g., for high-level planning, sometimes informally referred to as "pre-NEPA" planning). Cumulative impact assessments are

generally conducted only during NEPA analyses to evaluate impacts of already-developed alternatives. Additionally, while cumulative impact assessments examine impacts to the human environment, which can in theory include many of the same services that an ecosystem services analysis would, cumulative impact assessments typically focus on more traditional and tangible environmental impacts, such as archeological resources or water quality. Like environmental impacts, ecosystem services is another type of outcome or impact that can be assessed in various analyses. A cumulative effects analysis can consider effects on ecosystem services in addition to environmental impacts. Similarly other analyses, like cost-benefit analyses that consider other implications of a decision like the social welfare trade-offs and co-benefits provided by an action or policy, can also incorporate services.

How is an ecosystem services approach to planning different from ecosystem-based management?

An ecosystem services approach to planning can aid in implementing ecosystem-based management and other holistic or integrated approaches to management.

An ecosystem is a geographically specified system of organisms (including humans), the environment, and the processes that control the system's dynamics. Ecosystem-based management uses a long-term, integrated approach to study and manage the resources of an entire ecosystem. This approach considers different management scenarios' balance of conflicting uses and cumulative impacts—including the impacts from and the benefits to humans—the ecosystem services. For instance, ecosystem-based aquatic resources management may consider multiple factors such as pollution, coastal development, harvest pressure, predator/prey and other ecological interactions, and watershed management. Ecosystem-based forestry management might consider factors such as endangered species protection, biodiversity, cultural resources, recreation, predator/prey and other ecological interactions, and watershed management.

How do climate adaptation and risk management intersect with an ecosystem services approach to planning and management?

An assessment of ecosystem services should be based on an analysis of natural resource status and trends. Information in status and trends assessments on the impacts of climate change on the risks of natural hazards, for example, would allow consideration of climate adaptation strategies. An assessment that considers ecosystem services would likely consider how management choices will affect the risks of natural hazards and disturbances like flooding, fire, and heat waves on people and the things people care about.

How would an ecosystem services approach to management affect a project's conservation goals?

An ecosystem services management approach should augment—not replace—conservation objectives. When biodiversity conservation is the overriding goal of a project, an ecosystem services analysis can identify potential co-benefits relevant to other management objectives or to local communities or site visitors. Such information can be used to target conservation investments to yield the greatest social benefit or promote additional investment in conservation. Ecosystem services management can also help identify unintended consequences—ecological or social—that could be considered during project planning. Other advantages to an ecosystem services approach to management include improved engagement and communication with stakeholders and potential partners.

Isn't it true that with an ecosystem services approach to management, the only aspects of nature that will be managed are those with some utilitarian value?

Ecosystem services can include any aspect of nature that is considered valuable or important. Utilitarian and commercial goals are important, but so, too, is humans' desire for less tangible things: beauty, wilderness,

cultural heritage, a sense of place, and maintaining these benefits for future generations. An ecosystem services approach to management seeks to reveal, communicate, evaluate, and manage these often less tangible benefits in the public interest. Ideally, an ecosystem services assessment will identify all significant ecosystem services and evaluate the effect of management on this full suite of services throughout the decision-making process.

Does using an ecosystem services approach to management mean that a dollar value must be put on everything?

Using ecosystem services in decision making does not require a monetary assessment of ecosystem services. Using ecosystem services does require consideration of the social outcomes caused by changes to ecological systems, but those outcomes need not be monetized. For example, the value can be described in terms of health outcomes, such as the number of households protected from groundwater contamination. Decisionmakers can also gain important insight from more qualitative analyses that provide general information about which ecosystem services are most important to affected communities or which management actions likely to increase or decrease the provision of a particular ecosystem service. Regardless of the methods used, an ecosystem services framework can provide a tool for comparing options (e.g., management alternatives, project options, future scenarios) and considering tradeoffs among ecosystem services for each option—a useful tool for resource managers. Monetary valuation of outcomes can be helpful in analysis of tradeoffs, as it puts everything in common and easily understood units, but it is not a requirement.

Does an ecosystem services approach to management require resource agencies to change their management to prioritize whatever local stakeholders value most?

An ecosystem services approach to management neither preempts an agency's existing mandates and decision-making discretion nor requires that a specific decision be reached. What it does is provide additional information on how best to meet existing priorities (and perhaps provide other benefits at the same time), thereby supporting more informed decision-making.

How can the usefulness or value of adopting an ecosystem services approach to management be evaluated?

Agencies can reap many benefits from implementing an ecosystem services approach. Ultimately, though, the test of whether an ecosystem services approach to planning is worth taking hinges on (1) whether it leads to a change in decisions or a clearer illumination of the tradeoffs; (2) whether it results in an environmental and social benefit; and (3) whether it improves stakeholder engagement and public support for agency actions while aiding in conflict resolution. Answering these questions is an important next step and one that will require researchers to move beyond developing case studies to undertaking structured policy analyses and program evaluations.³⁵

³⁵ P.J. Ferraro, and S.K. Pattanayak, "Money for Nothing? A Call for Empirical Evaluation of Biodiversity Conservation Investments," *PLOS Biology* 4(4)(2006): e105, doi:10.1371/journal.pbio.0040105, <http://www.plosbiology.org/article/info%3Adoi%2F10.1371%2Fjournal.pbio.0040105>.

IS AN ECOSYSTEM SERVICES APPROACH RIGHT FOR MY PROJECT?

An ecosystem services approach to management can produce a holistic understanding of natural systems and can foster stakeholder relationships and support, resulting in improved decisions. Such an approach could be helpful in the following contexts:

- Management areas with natural assets of interest to engaged nearby communities, or those that have natural assets with national or global significance;
- Projects in which different groups of stakeholders may have conflicting priorities for resource management or in which there is a history of contentious resource management decisions;
- Management options that generate significant benefits or costs that fall outside the traditional management focus or physical boundaries of the management area;
- Management decisions that involve tradeoffs among ecosystem services; or
- Decisions that call for social or economic comparison of natural resource impacts or benefits across project alternatives.

An ecosystem services approach will not always be necessary or appropriate, particularly in the following contexts:

- Projects in isolated locations that have little human use, biodiversity, or cultural value; and
- Projects with no feasible alternative management actions.

Here are a few questions to ask when deciding whether to take an ecosystem services approach to a project management or planning effort:

- What ecosystem services might be important to the agency, the public, and stakeholders?
- Would these services already be considered in the agency's traditional planning process?
- Might considering additional ecosystem services or beneficiaries resolve or reduce management or legal conflicts?
- Does identification of these ecosystem service benefits create opportunities to leverage the actions of partners?
- Would translating ecological outcomes into socially relevant outcomes be helpful in resolving conflicts or misunderstandings between the agency and stakeholders?
- Could the inclusion of ecosystem services in planning lead to a different choice of projects, sites, or management actions?

See this guidebook's agency examples for insight into how the USFS, FWS, BLM, NOAA, EPA, and NPS have approached these questions.

See the guidebook's Methods Overview for insights into the range of methods that could be applied.

About the National Ecosystem Services Partnership

The National Ecosystem Services Partnership (NESP) engages both public and private individuals and organizations to enhance collaboration within the ecosystem services community and to strengthen coordination of policy and market implementation and research at the national level. The partnership is an initiative of Duke University's Nicholas Institute for Environmental Policy Solutions and was developed with support from the U.S. Environmental Protection Agency and with donations of expertise and time from many public and private institutions. The partnership is led by Lydia Olander, director of the Ecosystem Services Program at the Nicholas Institute, and draws on the expertise of federal agency staff, academics, NGO leaders, and ecosystem services management practitioners.

About the Nicholas Institute for Environmental Policy Solutions

Established in 2015, the Nicholas Institute for Environmental Policy Solutions at Duke University improves environmental policymaking worldwide through objective, fact-based research in the areas of climate change, economics of limiting carbon pollution, emerging environmental markets, oceans governance and coastal management, and freshwater management. The Nicholas Institute is part of Duke University and its wider community of world-class scholars. This unique resource allows the Nicholas Institute's team of economists, scientists, lawyers, and policy experts not only to deliver timely, credible analyses to a wide variety of decision makers, but also to convene decision makers to reach a shared understanding of the century's most pressing environmental problems.

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