National Ecosystem Services Partnership

FEDERAL RESOURCE MANAGEMENT AND ECOSYSTEM SERVICES GUIDEBOOK

Federal Agency Explorations and Applications: Case 15 (National Park Service)

Determining Links to the Human Beneficiary: Report from the Air Quality and Ecosystem Services Workshop

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FEDERAL AGENCY EXPLORATIONS AND APPLICATIONS: CASE 15

National Park Service

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How to cite:
Bingham, Andrew. 2015. "Determining Links to the Human Beneficiary: Report from the Air Quality and Ecosystem Services Workshop." In *Federal Resource Management and Ecosystem Services Guidebook.* Durham: National Ecosystem Services Partnership, Duke University, www.nespguidebook.com.

FEDERAL RESOURCE MANAGEMENT AND ECOSYSTEM SERVICES

Institutional Partners

National Oceanic and Atmospheric Administration
U.S Army Corps of Engineers
U.S. Bureau of Land Management
U.S. Department of Agriculture
U.S. Department of the Interior
U.S. Environmental Protection Agency
U.S. Forest Service
U.S. Geological Survey

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The University of San Francisco

The National Center for Ecological Synthesis
The National Socio-Environmental Synthesis Center

Defenders of Wildlife
NatureServe
Resources for the Future
The Nature Conservancy

Spatial Informatics Group

Funding Sources

Primary Funding Sources

Gordon and Betty Moore Foundation
Duke University
National Center for Ecological Analysis and Synthesis
National Socio-Environmental Synthesis Center
USDA Office of Environmental Markets
And significant in-kind support from many of the institutional partners listed above

Seed Funding Sources

American Forest Foundation, Defenders of Wildlife, National Oceanic and Atmospheric Administration, Rights and Resources Initiative, Resources for the Future, U.S. Bureau of Land Management, U.S. Department of Agriculture Office of Environmental Markets, U.S. Environmental Protection Agency, U.S. Forest Service, U.S. Geological Survey

About This Document

This case is part of the Federal Resource Management and Ecosystem Services (FRMES) Guidebook created by the National Ecosystem Services Partnership (NESP). NESP, housed at the Nicholas Institute for Environmental Policy Solutions, seeks to enhance collaboration within the ecosystem services community and to strengthen coordination of policy implementation and research at the national level. The FRMES Guidebook represents a collaborative effort by federal agencies and outside experts to develop a credible and feasible approach to incorporating ecosystem services into the decision-making processes of federal agencies.

Cases are written and approved by the author(s)' agency, but they have not been peer reviewed. They describe the decision-making context within which that agency is considering or testing an ecosystem services management framework, and they present approaches or innovations that the agency is using to incorporate ecosystem services into its planning and decision-making processes. Cases informed development of the FRMES Guidebook and could be of value to others embarking on ecosystem services planning and management efforts.

To read other federal agency explorations and applications of an ecosystem services management framework, visit www.nespguidebook.com.

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Motivation

In line with its mission, the National Park Service (NPS) frequently cooperates with other natural resource management agencies and experts to improve understanding of the connection between natural systems and human well-being. The effects of air pollution on ecosystem function have been a particular focus of the NPS's Air Resources Division (ARD). Air pollution can have many different effects on ecosystems. Fertilization (also known as eutrophication) of landscapes due to excess nitrogen deposition can alter plant communities and decrease biodiversity. Excess nitrogen and sulfur can also lead to acidification of soils, lakes, and streams, leading to loss of vital nutrients and harm to aquatic species. Critical loads (the level of deposition from the atmosphere below which no adverse impacts are thought to occur according to current knowledge) have been identified for many ecosystem components around the country and are used to pinpoint areas where air pollution may be harming ecosystems.

As described in the US Environmental Protection Agency (EPA) Science Advisory Board's report *Valuing the Protection of Ecological Systems and Services*, a challenge in communicating why ecological changes matter to people is that ecological effects are often described in terms that are meaningful only to experts (EPA-SAB-09-012, May 2009). For example, critical loads are designed to provide information about when deposition causes ecosystem harm, not to determine when effects are necessarily adverse to human well-being. In order to help bridge this gap, scientists from government agencies, NGOs, universities, and the private sector participated in a workshop in February 2015. Experts in ecology, economics, natural resource management, and air pollution policy were represented, with the goal of identifying links between atmospheric deposition effects on sensitive natural resources and the ecosystem services they provide by determining specific linkages from critical loads endpoints to ecosystem services and the human beneficiaries who use them directly. While substantial information on the effects of acidification and eutrophication in aquatic and terrestrial ecosystems has been published, little work had previously been done in establishing how specific air quality effects on plants, animals, soils, algae, and water are linked to the humans who use or enjoy them. By better elucidating the effects that degraded air quality can have on nature's benefits, NPS can better integrate air quality considerations into park management and planning processes while highlighting the many benefits the average person derives from these ecosystems and the important benefits of air pollution mitigation measures.

Decision Context

The EPA is charged with setting National Ambient Air Quality Standards (NAAQS) for several pollutants, including NOx and SOx. A primary standard is set for the purpose of protecting human health from direct effects of a pollutant, while a secondary standard is set to protect public welfare derived from components of nature such as soils, water, crops, vegetation, and wildlife, as well as to address their economic values. During the review process, EPA evaluates the science since the last review of the standards, generally every five years, to determine the level at which the standard should be set. Products from the workshop may be useful during this review process and may help inform the risk assessment with regard to the links between critical loads and public welfare. The linking of a change to a biological indicator via an ecological production function directly to human beneficiaries can provide important indications of the many ways humans depend on the natural world for their well-being and how appropriate air quality standards are crucial for ensuring those benefits.

Links between atmospheric deposition and ecosystem services developed during the workshop can also inform public and private land managers about how excess nitrogen and sulfur can affect those who use

and depend on the landscapes they manage. For example, a result of this workshop was the identification of a chain whereby nitrogen deposition above a critical load can alter phytoplankton communities in lakes and streams. This then causes declines in small fish and macroinvertebrates, which results in decreased piscivorous wildlife such as large fish and birds. Eleven separate human beneficiaries were identified who use this final ecosystem good, including anglers, resource-dependent businesses, and people who care about wildlife for its existence value. Illustrating the chain from atmospheric pollution to human beneficiaries can help build grassroots support for better controls on excess nitrogen emissions and inform which mitigation strategies could help the most beneficiaries. This information could then be integrated within planning and adaptation frameworks at both the park and agency level.

Location

The ecosystems covered in this workshop included any natural landscape that is adversely affected by nitrogen or sulfur deposition, including both aquatic and terrestrial ecosystems. A majority of NPS units exceed a critical load for at least one indicator, and many parks, such as Rocky Mountain National Park and Shenandoah National Park, are experiencing significant adverse effects from nitrogen and/or sulfur deposition. A critical load must have been identified in the scientific literature for a given ecosystem to have been considered in this workshop, but most ecosystems in the contiguous United States have had at least one critical load determined for a component of the ecosystem. Critical loads used as starting points varied in scale, from a single species such as balsam fir, to ecosystem-wide indicators such as changes to herbaceous cover in western coastal sage scrub. Because an objective of the workshop was to identify as many chains as possible linking critical loads to social benefits, groups were encouraged to explore any nitrogen- or sulfur-based critical load published in the scientific literature for any region of the lower 48 states.

Key Players, Existing Resources, and Organizational Capacity

The workshop was organized and run through a collaboration of the National Park Service, the U.S. Forest Service, the Environmental Protection Agency, and the Research Coordination Network on Reactive Nitrogen. In addition, experts with backgrounds in ecology and air pollution, economics, air quality policy, and natural resource management from the federal government, universities, nonprofits, and private consultancies played important roles. The National Science Foundation Research Coordination Network on Reactive Nitrogen in the Environment (under award DEB-1049744) sponsored the workshop.

The Final Ecosystem Goods and Services Classification System (FEGS-CS), developed by the EPA, was selected to identify the ecosystem services and beneficiaries affected by exceedance of critical loads. The FEGS-CS framework provided an existing resource that has been vetted and peer reviewed. It was also a desirable framework because it "provides simple guidelines for identifying ecosystem services" and is designed to reduce or eliminate many of the stumbling blocks encountered when using an ecosystem services framework, such as double counting. The straightforwardness of the system made it easier for participants with less experience using ecosystem services to get up to speed, an important consideration for getting the most production out of a short workshop.

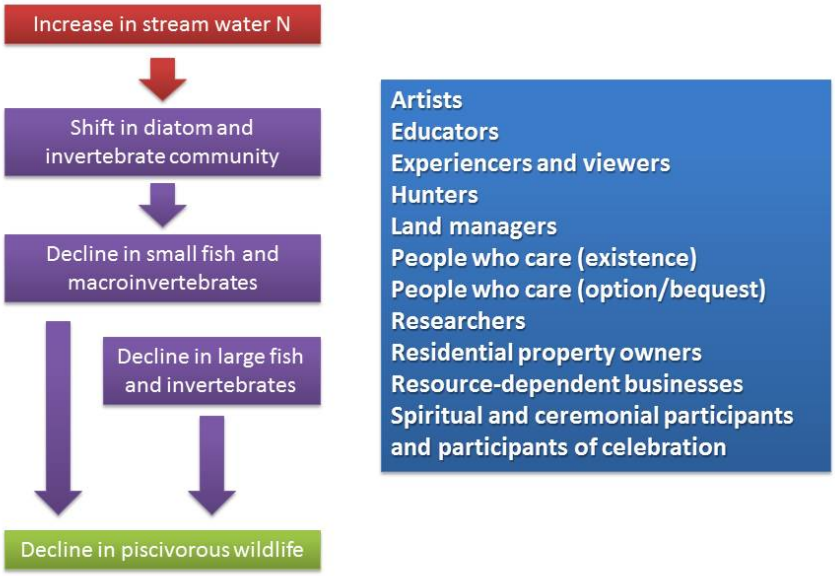
Alone, none of the organizing groups possessed the expertise and capacity to fulfill the workshop's goals of linking atmospheric deposition and critical loads to ecosystem services and human beneficiaries. The

collaboration between groups with ecological and economic expertise was crucial to the success of the workshop; indeed it was designed so that each work group had a mix of the two.

Analysis

Experts were split into four groups according to their expertise, with each group including at least one economist. The groups were assembled based on broad effects of nitrogen and sulfur deposition on ecosystems: aquatic and terrestrial eutrophication (fertilization) and aquatic and terrestrial acidification. Starting with critical loads data for biological indicators from peer-reviewed literature, each group worked through the ecological effects of exceedance of a critical load. They identified as many ecological links as necessary until the final product produced by nature and directly used by humans—the Final Ecosystem Goods and Service (FEGS)—was identified. These ecosystem response links are known as the ecological production function and represent the supply side of ecosystem services. The groups theorized as many chains as possible, entering each into a preformatted spreadsheet. A key task in this section was the identification of a "strength of science" score for each link of a chain to express the confidence in the scientific backing for an ecological linkage. For example, the terrestrial eutrophication team started with an identified critical load for the sagebrush-steppe ecosystem. Exceedance of this critical load has been shown to result in increased invasive grass cover. The group then brainstormed a chain (consisting of the critical load, the ecological production function, and the beneficiary) whereby this change in cover leads to an increased grass-to-forb ratio, which could in turn lead to decreased forage quality. Decreased forage quality could then lead to a shift in wildlife composition, with the FEGS being wildlife. From this FEGS, all possible beneficiaries that could be affected were identified, such as hunters or experiencers and viewers. Over all of the groups combined, 1045 unique chains were identified, with 66 unique FEGS and 26 separate beneficiaries. The report identified areas for possible follow-up work, such as further elucidation of chains with high strength of science scores where the ecological relationships are well documented. Additional work could also better quantify each link of the ecological production function using empirical data or focus on the demand (beneficiary) side of the equation, with the end goal in some cases being an economic valuation.

Figure 1. Example of chain linking critical load for changes in stream water nitrogen to decline in piscivorous wildlife and identifying parties potentially affected by loss of that wildlife



Implications

Often people perceive that air pollution affects only "unimportant" facets of an ecosystem such as phytoplankton or grass cover. But the participants in this workshop demonstrated how these seemingly benign changes can reverberate through an ecosystem until they affect human welfare in important ways. The sheer number of FEGS and beneficiaries affected shows the significant impacts that damage to ecosystems from air pollution can have on social and economic benefits. This includes those used directly by the beneficiary such as fish in the case of anglers, as well as nonuse services such as intrinsic or spiritual values. Brainstorming and diagramming links between changes in biological indicators and FEGS also served to identify chains where more analysis will have the greatest payoff, such as strong chains with one weak link or chains having many important beneficiaries. In addition, better knowledge of links between biological indicators and beneficiaries can inform and improve NPS management decisions and research priorities by highlighting vital hotspots of ecosystem provision that are degraded by air pollution.

This analysis may also be used by the EPA in the setting of a NOx and SOx secondary air quality standard. The identification of linkages between nitrogen deposition, with its effects on natural resources and ecosystems, and effects on human welfare was an important product of this workshop. The identification of so many chains and beneficiaries that are affected demonstrates the adverse effects this pollution can have on the public welfare and may help "inform the science and risk assessments with regard to the relationships between critical loads, and effects on ecosystem services." This will help provide a public welfare context for the costs of nitrogen and sulfur pollution on the environment.

A final workshop report has been published by NPS, and a series of journal articles are planned. Now that chains and beneficiaries have been identified, it is envisioned that next steps could involve valuation by economists of these degraded ecosystem services. The insights gained from this workshop will also allow ARD to raise awareness of the less well-known ways in which air pollution affects park ecosystems, those who enjoy them, and those who depend on the benefits they produce. Through a better understanding of the links from air pollution effects on ecosystems to effects on human well-being, NPS can better recognize all of the implications of degraded air quality, more strongly influence efforts for air pollution mitigation, and better protect the resources it manages.

Acknowledgments

The author would like to thank Maura Flight of Industrial Economics, Incorporated, for her valuable support and assistance in the development of this case study, as well as NESP and Katie Locklier, who also provided helpful guidance and input.

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 2005, 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, the 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 this century's most pressing environmental problems.

For more information about the
Federal Resources Management and Ecosystem Services Guidebook,
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