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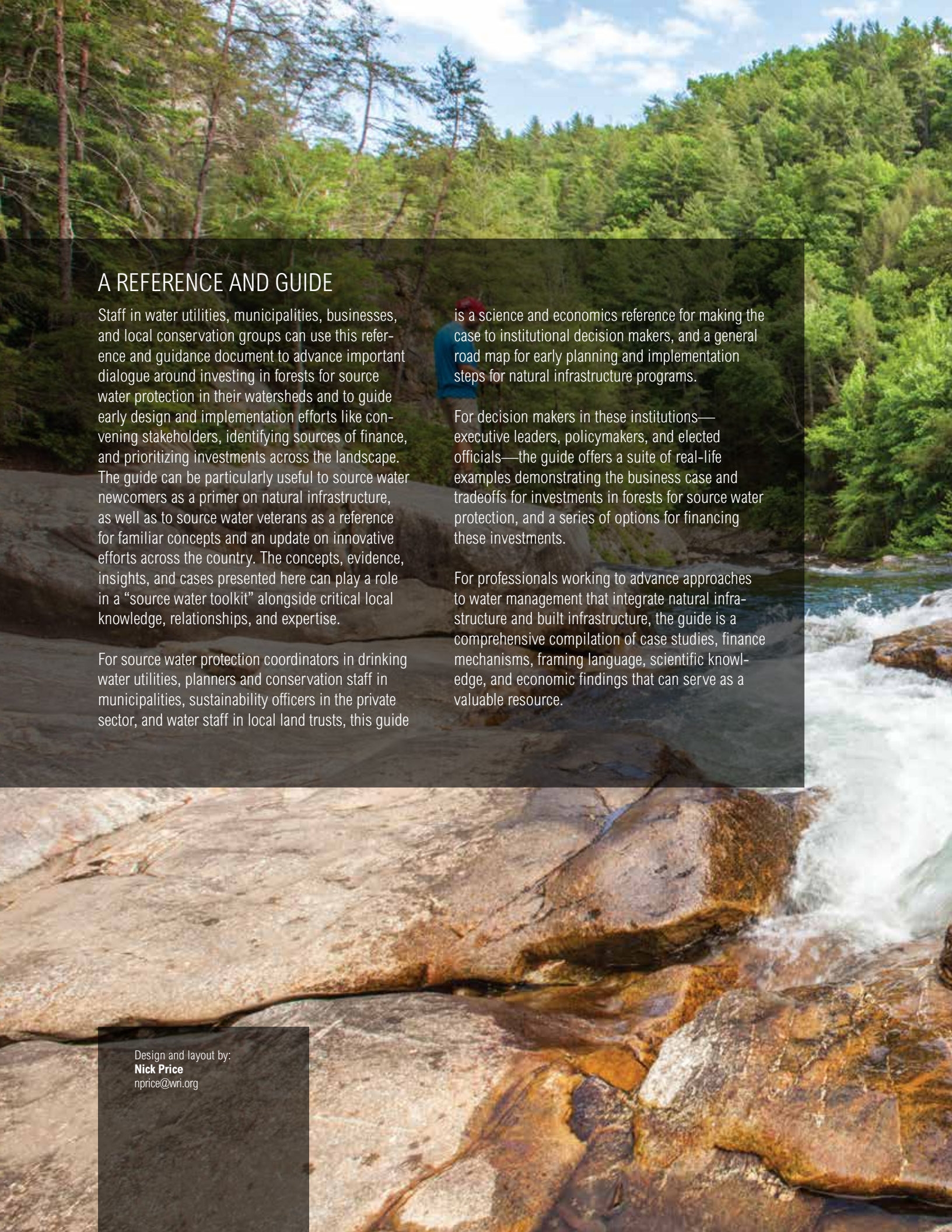
NATURAL INFRASTRUCTURE

*Investing in Forested Landscapes for
Source Water Protection in the United States*

EDITED BY TODD GARTNER, JAMES MULLIGAN, ROWAN SCHMIDT, AND JOHN GUNN

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A REFERENCE AND GUIDE

Staff in water utilities, municipalities, businesses, and local conservation groups can use this reference and guidance document to advance important dialogue around investing in forests for source water protection in their watersheds and to guide early design and implementation efforts like convening stakeholders, identifying sources of finance, and prioritizing investments across the landscape. The guide can be particularly useful to source water newcomers as a primer on natural infrastructure, as well as to source water veterans as a reference for familiar concepts and an update on innovative efforts across the country. The concepts, evidence, insights, and cases presented here can play a role in a “source water toolkit” alongside critical local knowledge, relationships, and expertise.

For source water protection coordinators in drinking water utilities, planners and conservation staff in municipalities, sustainability officers in the private sector, and water staff in local land trusts, this guide

is a science and economics reference for making the case to institutional decision makers, and a general road map for early planning and implementation steps for natural infrastructure programs.

For decision makers in these institutions—executive leaders, policymakers, and elected officials—the guide offers a suite of real-life examples demonstrating the business case and tradeoffs for investments in forests for source water protection, and a series of options for financing these investments.

For professionals working to advance approaches to water management that integrate natural infrastructure and built infrastructure, the guide is a comprehensive compilation of case studies, finance mechanisms, framing language, scientific knowledge, and economic findings that can serve as a valuable resource.

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FOREWORD

Cities and towns across the United States face a growing water crisis. Aging water infrastructure, increasing demand, continued land use change, and increasingly extreme weather events are driving the costs of water management higher. Water challenges strain public budgets, limit productive economic development, and threaten public health. Resolving this water crisis is essential for community health and wellbeing across the United States.

Harnessing the water-related services provided by forests, wetlands, floodplains, and working lands—known as “natural infrastructure”—has a major role to play in combating the water crisis, especially in a period of fiscal austerity. Investing in integrated water management strategies that combine engineered solutions with natural infrastructure can reduce costs, enhance services, and provide a suite of co-benefits for communities and the environment. This integrated approach, beginning with the protection of drinking water at its source, is the future of water management.

The World Resources Institute and its partners envision a world in which governments and businesses invest in conserving and restoring forests, wetlands, and floodplains as a key component of water management and economic development strategy. We are working to integrate natural infrastructure into day-to-day water management decisions to make this transformative vision a reality. The success of this effort ultimately relies on visionary but often unsung individuals in water utilities, businesses, and local governments.

This guide, the most comprehensive of its kind, threads together the experience and insights of over 50 authors from the front lines of source water protection efforts. It is a call to action for water utility staff and land managers alike to bring natural infrastructure into focus in their institutions, with this guide as a foundation from which businesses and municipalities can innovate in the face of a growing water crisis.



Andrew Steer
President
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EXECUTIVE SUMMARY

Natural ecosystems like forests and wetlands provide essential services to water utilities, businesses, and communities—from water flow regulation and flood control to water purification and water temperature regulation. To ensure these ecosystem functions and associated benefits continue, communities can strategically secure networks of natural lands, working landscapes, and other open spaces as “natural infrastructure.” While concrete-and-steel built infrastructure will continue to play a critical role in water storage and treatment, investing in natural infrastructure can reduce or avoid costs and enhance water services and security as part of an integrated system to cost-effectively deliver safe drinking water (Table ES-1).

Now is a critical moment facing water resource managers and beneficiaries nationwide. Much of America’s aging built infrastructure for drinking water is nearing the end of its useful life (American Society of Civil Engineers 2013). Yet funds for investment in water infrastructure are drying up in an era of fiscal austerity. As utility rates for drinking water are increasing faster than inflation and household incomes (Harris 2012), the need is clear for lower cost, integrated solutions to meet water infrastructure demands of the 21st century.

Recognizing this critical moment, water resource managers are looking to invest in ecosystems to address emerging water issues. Promising efforts across the country have secured natural infrastructure for water management objectives through a variety of means—from land acquisition, zoning ordinances, and conservation easements to catastrophic wildfire risk mitigation and payments to private landowners for best management practices. These efforts have yielded a number of valuable lessons and highlighted several challenges.

A number of barriers have impeded efforts to scale up the integration of natural infrastructure into water management nationwide. For example, many utilities, municipalities, and businesses face knowledge gaps among key constituents or even internal decision makers. These entities often lack the financial resources or technical guidance needed to champion natural infrastructure. Moreover, utilities have struggled to quantify the ecological and economic benefits of natural infrastructure, a task made more difficult by imperfect science.

Table ES-1 | **Example Natural Infrastructure Strategies & Complementary Built Infrastructure**

WATERSHED	MAJOR ISSUES	NATURAL INFRASTRUCTURE STRATEGY	COMPLEMENTARY BUILT COMPONENTS
Crooked River Watershed—Portland, Maine	Forest conversion for development and need to maintain filtration avoidance waiver	Conservation easements, land acquisition, and best management practices as a cost-avoidance strategy in a healthy watershed	Ozonation, chlorination
La Cache Poudre and Big Thompson River Watersheds—Fort Collins & Greeley, Colorado	Costly sedimentation and flood risks associated with catastrophic wildfire in forested watershed	Wildfire risk management as a cost-avoidance strategy in the face of extreme and costly disruptive events	Off-river reservoir, pre-sedimentation basin, ability to blend water from reservoir and Poudre, flocculation, sedimentation, filtration
McKenzie River Watershed—Eugene, Oregon	Loss of forested riparian buffers to residential development, and associated water quality decline and incremental increases in treatment costs	Forested riparian buffers as a cost-reduction strategy in a non-regulatory setting in a healthy watershed	Chlorination, coagulation and flocculation, sedimentation, filtration
Upper Neuse River Basin—Raleigh & Durham, North Carolina	Substantial degradation from development in heavily forested landscape leading to Clean Water Act requirements and high treatment costs; reservoir siltation against backdrop of flood and drought risk	Protection of forested riparian buffers, wetlands, and floodplains as a regulatory compliance, cost reduction, and risk mitigation strategy in a degraded watershed	Ozonation, coagulation, two-stage filtration (activated carbon and sand filters), UV, and chlorination; multiple reservoirs

Even where the case has been made, public utilities work with financial accounting standards that do not enable operations and maintenance spending on natural infrastructure as part of normal business practices, despite the clear benefits. Ultimately, however, the movement toward widespread, landscape-level investments in natural infrastructure nationwide can be successful if key decision makers in key institutions have the understanding, know-how, and tools needed to act.

In light of these challenges and opportunities, this guide is intended to be a foothold for those who can champion natural infrastructure in water utilities, local conservation groups, and private businesses, and who need a persuasive case, a road map of next steps, and overarching guidance to do so. It attempts to provide the resources, science and economics, illustrations, and guidance needed to foster meaningful dialogue with watershed decision makers and stakeholders around natural infrastruc-

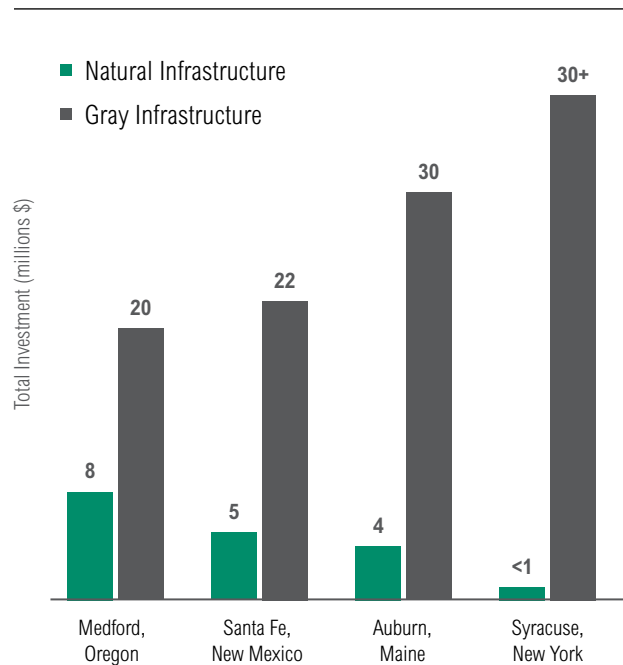
ture options, to secure adoption and commitment, and to begin early design and implementation steps on solid footing. It is the most comprehensive publication of its kind to date, pulling together the perspectives of 56 authors spanning the stakeholder groups and experts who need to be involved for natural infrastructure efforts to be successful. As such, it is a go-to reference for their colleagues across the water resource management and conservation fields, agencies at all levels of government, and academia.

Together, these authors have threaded together the evolving “story” of the forest-based natural infrastructure approach to source water protection. These take-aways from the economics and underlying science, the opportunity for the approach across the country, and lessons for program design and implementation comprise the guidance and overarching narrative of this guide.

Economics

- 1. The economic benefits can be substantial.** High source water quality and well-regulated flow can reduce the capital and variable costs of providing clean and abundant water. Numerous studies have affirmed the intuitive: High source water quality can reduce treatment costs. And across the United States, we have seen utilities with high source water quality avoid dredging and maintenance costs, and even major capital investments, by bypassing elements of the conventional treatment process. Similarly, ecosystem-regulated water flow can have substantial economic benefits by avoiding flood-related damage and maintaining water supply through dry seasons.
- 2. The financial case can be made.** The case for natural infrastructure investment has been made in several watersheds nationwide, and a methodology for “green-gray analysis” is available to compare the financial merits of integrated natural and built infrastructure alternatives (Figure ES-1).
- 3. Natural infrastructure investments are actionable despite uncertainty.** Ultimately, the strength of natural infrastructure economic analyses depends on the robustness of the underlying science. Even where detailed scientific modeling has not been conducted,

Figure ES-1 | **Example Natural & Built Options**
(millions \$)



conservative assumptions and careful sensitivity analyses can produce actionable results. However, being overly conservative about costs and benefits can also lead to underestimation of the returns of natural infrastructure.

“There are risks and costs to a program of action, but they are far less than the long-range risks and costs of comfortable inaction.”

- John F. Kennedy

Science

4. **The scientific foundation is imperfect, but robust.** The water-related functions of healthy forested landscapes are well-established; maintaining healthy, forested landscapes and implementing best practices in forestry management can be effective strategies for promoting source water quality and regulating flow. For example, forests help to anchor soil against erosion, promote infiltration and minimize overland flow, prevent nutrient delivery to streams, minimize the impact of rain-on-snow events, and maintain snow pack later into the spring. Best practices in forest management can help maintain these critical functions and mitigate the potentially negative impacts of activities such as timber harvest and road construction.
5. **Inherent variability poses challenges for quantification.** While the science is robust, there is inherent variability across and within watersheds in the magnitude of water resources impact of a given land cover change or management practice. Quantitative watershed models can help to address part of this variability. These tools are advancing in reliability and usability, and can account for a portion of the variability in natural ecosystems. While there is a growing number of applications of these models, modeling remains relatively resource-intensive and results inevitably come with some level of uncertainty.
6. **Risks and uncertainty can be managed.** Despite residual scientific uncertainty, natural infrastructure options are actionable. Given robust but imperfect science and the need to prevent the perfect from being the enemy of the good—as in all things—the dominant approach to natural infrastructure investments has been to manage uncertainty and maximize cost-effectiveness by a) prioritizing types of interventions (e.g., easements and best management practices) and the distribution of those interventions throughout the watershed, b) carefully monitoring the response of water resources throughout implementation, and c) managing investments adaptively to maximize outcomes.

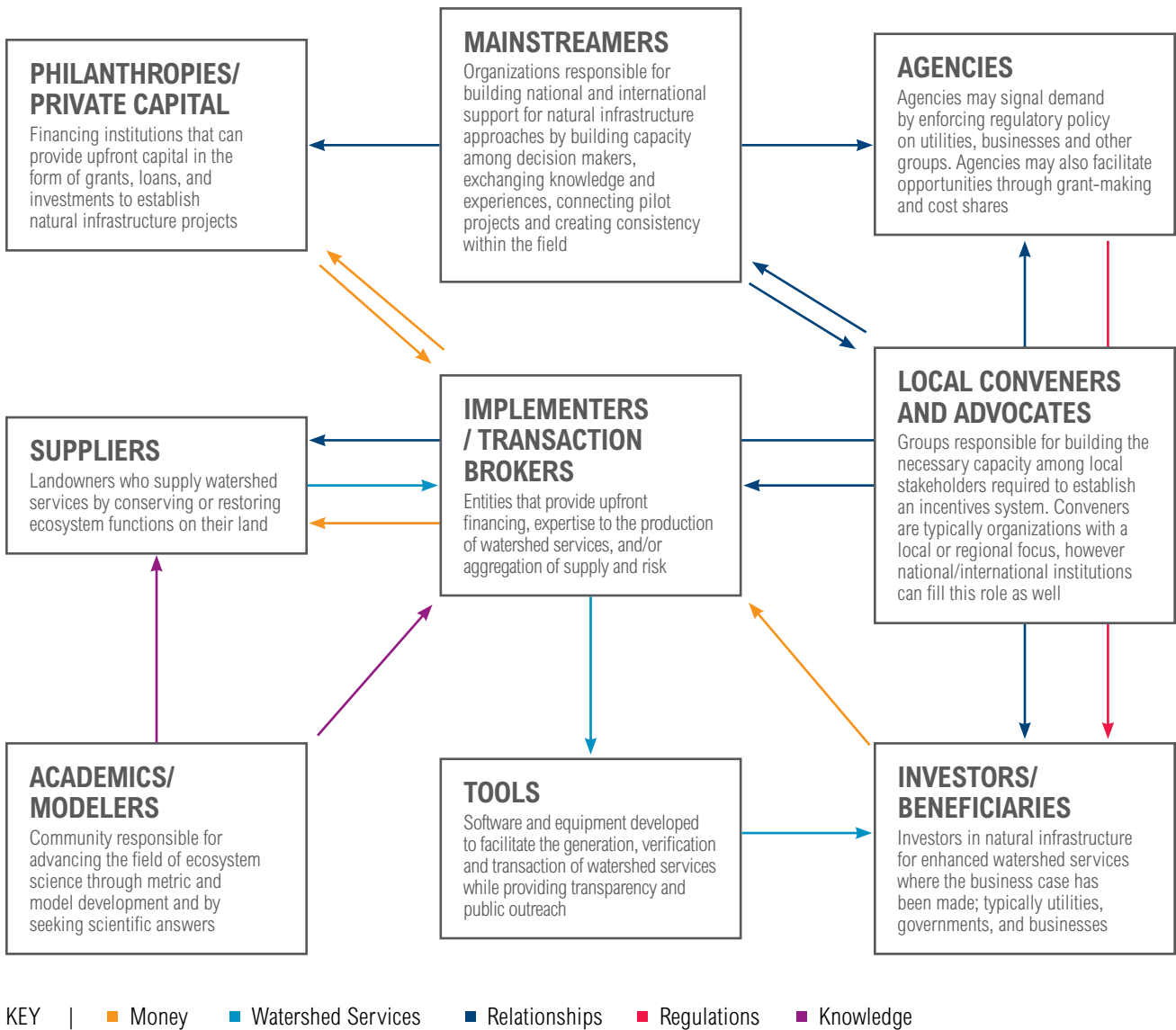
Opportunity

7. **The opportunity is widespread.** Watersheds across the United States have opportunities to integrate natural infrastructure alongside critical built infrastructure. The fundamental conditions needed for natural infrastructure to be a potentially viable solution to water needs are quite basic and found in diverse watersheds across the United States. Unfortunately, costly water management challenges are increasingly widespread in the United States. Where there is a clear connection between these challenges and ecological conditions on the landscape—for example, loss or degradation of natural ecosystems due to development, wildfire, invasive species, or unsustainable forestry—the natural infrastructure investment approach can play a role.
8. **Local decision maker participation is critical for success.** The success of the approach depends on the ability of natural infrastructure champions to make the case to local decision makers and stakeholders, and to articulate a vision of success. Early engagement efforts with decision makers should be careful to understand and take into account their priorities, preferences, and perceptions related to water delivery, source water management, and natural infrastructure.

Design & Implementation

9. **Cultivating partnerships is an important first step toward success.** In each of the successful attempts to build robust programs for investment in natural infrastructure, essential components have been collaboration among a variety of stakeholders and experts, and the emergence of champions within stakeholder groups to push the program forward. The co-benefits associated with natural infrastructure—benefits such as carbon sequestration, wildlife, and recreation—can motivate a wide range of stakeholder groups to partner with water utilities and other beneficiaries. These partnerships can be critical to success as they expand available resources, increase capacity, and provide political capital.

Figure ES-2 | The “Actor Network” in Successful Natural Infrastructure Efforts



10. Landowner participation is essential in privately owned watersheds. Landowners are highly independent, value their autonomy, and generally engage in agriculture or forestry because it is a way of life as well as an economic enterprise. In addition to the financial inducement being offered, landowners consider how the program is designed and administered as part of their participation decision.

11. Investment must be large-scale and sustained. A long list of public, private, and hybrid public/private finance mechanisms is available to get dollars on the ground to restore, enhance, protect, and manage natural infrastructure for water resources. The primary challenge is to select a finance mechanism (or combination of mechanisms) that is capable of gaining the necessary political support for adoption, while also generating sufficient funds for meaningful and sustained investment in natural infrastructure.

While there are several challenges facing the natural infrastructure approach, several forest-based water management efforts have been successfully implemented in watersheds across the United States to provide clean and abundant source water at reduced cost and with a suite of co-benefits for people and nature. These efforts and the lessons they produced are profiled in this guide.

From experience with the natural infrastructure approach, a set of “action items” are evident for both watershed stakeholders and the broader community of practitioners working to scale up the approach nationwide.

Action items for water managers, conservationists, and other stakeholders at the local watershed level

1. Assess the watershed for ecological condition and trends causing water-related issues tied to substantial current or projected costs;
2. Engage with key stakeholders and decision makers early and often to articulate a vision of success, expand capacity for program development and implementation through strategic partnerships and consultation with experts, and build on the lessons of past successes and failures;

3. Conduct necessary economic analyses to determine if natural infrastructure is the best approach and to make the case for financial investment;
4. Assess a broad array of finance mechanisms with an eye toward securing large-scale “anchor funding” as well as a broader “funder quilt” to ensure meaningful and sustained investment over the long term;
5. Prioritize investments across parcels and interventions (i.e., reforestation or forest best management practices), monitor outcomes, and adapt investments accordingly.

Action items for the broader community of practitioners

1. Actively participate in the community of experts, facilitators, consultants, and “mobilizers” seeking to scale up integration of natural infrastructure into water management strategies, in order to leverage others’ efforts;
2. Assist in securing large-scale natural infrastructure funds such as bonds by ballot measure and natural infrastructure “set-asides” like the 20 percent green infrastructure requirement in the State Revolving Funds (SRS);



3. Expand research to quantify forest-to-water connections and improve the reliability and accessibility of watershed models;
4. Improve accounting standards to enable operations and maintenance spending on natural infrastructure by public entities as part of normal business practices;
5. Build awareness among the water resource management industry, the urban planning field, ratepayers, and taxpayers of the importance of natural infrastructure as a cost-effective and beneficial element of an integrated solution to emerging water issues.

Perhaps the two most important lessons learned from natural infrastructure efforts to date are the power of individuals and the importance of partnerships. Ultimately, the most effective messengers to decision makers and stakeholders affecting natural infrastructure decisions at the local level are influential individuals within their own institutions. Behind successful natural infrastructure programs are consistently the often-unsung source water coordinators, conservation staff, and sustainability officers creating real change.

These champions can be those in positions of power, but they need not be. A source water coordinator or manager in a public utility, a risk manager in a private business, or a water program manager in a state environmental agency can have immense impact within their respective institutions—many have been creating that impact for decades. These champions lead and inspire by offering fresh ideas and creativity where precedent might otherwise win the day—and by coming to the table with the evidence base to support those ideas. They identify likely challenges within their institutions and seek external support where appropriate to overcome those challenges.

In the source water context, these champions may need to help decision makers step outside the bounds of their primary roles and grow their competencies through various learning processes. Water utilities and municipalities that have been able to innovate in the face of the internal and external challenges they face recognize that bringing the natural infrastructure approach to scale will require institutional change in combination with a concerted effort to provide external cover by raising public awareness.

At the same time, successful cases have illustrated the importance of leveraging the resources, capacity, and political capital of a wide set of partners—including those who have not traditionally partnered with water utilities. The wide range of benefits offered by natural infrastructure—not just for water but also wildlife, recreation, climate, and rural economic development—offers a salient opportunity to build new coalitions across utilities, rural landowners, conservation groups, and private businesses.

But the task is not easy. As one utility staffer put it, if this were so, we'd have been doing it at scale a long time ago. This guide can be a resource for these individual champions and their partners as they work to gain traction for investment in natural infrastructure in their watersheds.



OVERVIEW

Natural Infrastructure: An Underutilized Solution

| Todd Gartner, World Resources Institute

| James Mulligan, Green Community Ventures

Background

In the late 1990s, in the face of growing development pressures in its largely privately-owned Castkill and Delaware watersheds, New York City initiated a plan to protect its source water and avoid the cost of an \$8–\$10 billion filtration plant. Strategic investments in its 2,000-square-mile watershed were estimated to cost \$1.5 billion. This watershed program staved off the need to build a filtration plant and provided an annual \$100 million injection to the rural economy in the upper reaches of the watershed. The program provides financial incentives to forestland owners to keep forest intact and to farmers to fence off livestock, as well as payments to local contractors to install septic tanks and stormwater protection measures (Kenny 2006).

The fundamental premise of this highly cited example, and the “natural infrastructure” approach more generally (Box 1), is that healthy natural ecosystems provide essential services to water utilities, governments, and businesses—from water flow regulation and flood control to water purification and water temperature regulation. Investments in natural infrastructure can complement essential concrete-and-steel built infrastructure components as part of an integrated system for water treatment and storage. This integrated approach is commonly referred to by the U.S. Environmental Protection Agency (EPA) and the industry as the “multi-barrier approach.”

BOX 1 | KEY TERMS DEFINED

The terminology in the water resource world, including the three terms below, can often have different meaning to different actors in different contexts. Because the three terms below are critical to the content and clarity of this guide, we offer our own definitions of these terms.

Source Water Protection

Refers to the protection of water quality, quantity, timing of flows, and associated benefits at the water's source—before it reaches the intake of a drinking water system. In this guide, we are most interested in source water protection through investments in “natural infrastructure.”

Built Infrastructure

Refers to the human-engineered infrastructure for water resources such as treatment plants and dams.

Natural Infrastructure

Refers to the “strategic use of networks of natural lands, working landscapes, and other open spaces to conserve ecosystem values and functions and provide associated benefits to human populations” (Allen 2012). Forests, wetlands, riparian buffers, and other natural elements on the landscape can comprise natural infrastructure when strategically used and managed to provide services for communities, such as through land acquisition and conservation easements, low-impact development, conservation practices on agricultural and forest lands, and even beaver dams. As such, it is commonly referred to as “watershed protection,” “land conservation,” or several other more traditional terms. Natural infrastructure is also sometimes referred to as “green infrastructure”—although the latter term is also used more broadly for things such as rain gardens or even water meters and energy efficient equipment (Allen 2012).

Natural infrastructure can be secured through a variety of means. In this guide, we are primarily interested in incentive-based approaches, by which financial incentives and/or technical assistance are provided to landowners to conserve, sustainably manage, and/or restore ecosystems to provide one or more watershed-related ecosystem services. Such investments typically involve downstream beneficiaries paying upstream landowners. Use of incentives can be an efficient and viable approach to securing natural infrastructure. However, many of the successful efforts to date have used a combination of approaches, including non-incentive-based mechanisms like zoning ordinances.

A Critical Moment

Whether building on rich histories of watershed protection or creating new initiatives to address emerging threats, water resource managers and beneficiaries nationwide now face a critical moment. Much of America's aging built infrastructure for drinking water is nearing the end of its useful life (American Society of Civil Engineers 2013). Yet funds for investment in water infrastructure are drying up in an era of fiscal austerity. As utility rates for drinking water are increasing faster than both inflation and household incomes (Harris 2012), water resource managers are seeking lower cost solutions to meet water infrastructure demands of the 21st century.

These factors provide a unique window of opportunity to integrate natural infrastructure into water resource management efforts to keep costs down, enhance resilience to climate change, and provide a suite of co-benefits for the air we breathe, the places we play, the wildlife we share our landscapes with, and the climate we live in. Recognizing that an integrated approach to securing clean drinking water and other watershed services is cost-effective and common sense (Box 3), stakeholders and water utilities in a number of watersheds nationwide are looking to natural infrastructure as part of a solution to growing challenges.

Opportunity

In the forest-to-water setting, opportunities to secure and invest in natural infrastructure tend to be forested watersheds that face challenges like projected land use change, detrimental land management practices, or risk of extreme events like fire and flood. The examples in Table 1 below illustrate the importance of forests and other ecosystems to potable water providers in a variety of ecological, financial, and regulatory settings. Detailed case studies can be found in Part 3.

While the ecological, regulatory, and “built infrastructure” context is unique for each of these watersheds, they all have opportunities to capture cost savings by investing in forest-based natural infrastructure, while continuing to harness essential built infrastructure components in parallel. This type of opportunity is common for many watersheds nationwide—particularly those relied on for drinking water.

Table 1 | **Example Natural Infrastructure Strategies & Complementary Built Infrastructure**

WATERSHED	MAJOR ISSUES	NATURAL INFRASTRUCTURE STRATEGY	COMPLEMENTARY BUILT COMPONENTS
Crooked River Watershed— Portland, Maine	Forest conversion for development and need to maintain filtration avoidance waiver	Conservation easements, land acquisition, and best management practices as a cost-avoidance strategy in a healthy watershed	Ozonation, chlorination
La Cache Poudre and Big Thompson River Watersheds—Fort Collins & Greeley, Colorado	Costly sedimentation and flood risks associated with catastrophic wildfire in forested watershed	Wildfire risk management as a cost-avoidance strategy in the face of extreme and costly disruptive events	Off-river reservoir, pre-sedimentation basin, ability to blend water from reservoir and Poudre, flocculation, sedimentation, filtration
McKenzie River Watershed— Eugene, Oregon	Loss of forested riparian buffers to residential development, and associated water quality decline and incremental increases in treatment costs	Forested riparian buffers as a cost-reduction strategy in a non-regulatory setting in a healthy watershed	Chlorination, coagulation and flocculation, sedimentation, filtration
Upper Neuse River Basin— Raleigh & Durham, North Carolina	Substantial degradation from development in heavily forested landscape leading to Clean Water Act requirements and high treatment costs; reservoir siltation against backdrop of flood and drought risk	Protection of forested riparian buffers, wetlands, and floodplains as a regulatory compliance, cost reduction, and risk mitigation strategy in a degraded watershed	Ozonation, coagulation, two-stage filtration (activated carbon and sand filters), UV, and chlorination; multiple reservoirs

While concrete-and-steel built infrastructure plays a critical role in water storage and treatment, natural infrastructure can reduce or avoid costs and enhance water services and security, serving alongside necessary built infrastructure components as part of an integrated system to cost-effectively deliver safe drinking water.

BOX 2 | EXCERPT FROM SOURCE WATER PROTECTION VISION AND ROADMAP (SKLENAR & SHAM 2012)

A 2010 source water workshop identified four themes critical to advancing source water protection in the U.S.:

Raise Awareness

There is a need to raise awareness of the importance and value of source water protection. Greater awareness is needed by utilities, of the role source water protection plays in the multi-barrier approach to providing reliable, high quality water at reasonable rates; by utilities and their management, of the value of source water protection; by consumers, of the benefits and value of source water protection; and by stakeholders, of the importance of protecting drinking water sources and the priority that should be given to drinking water concerns related to source water protection.

Enhance Coordination

Programs, efforts, and regulations affecting source water protection for drinking water supplies can at times be conflicting, redundant, or lacking in focus. There is a need for enhanced coordination overall (across all relevant operational and stakeholder groups), so that source water protection efforts and programs are better integrated and work together more synergistically; and among Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) regulators, both at the state and federal levels, for more effective implementation of existing CWA regulations so that drinking water interests are more immediately and completely addressed.

Provide Support

Several water utilities interviewed that had not developed source water protection programs stated they were not sure where to begin and/or how to proceed with source water protection. It became apparent they might benefit from assistance from peers who were further along in the

process of developing a source water protection program for their own utilities. In addition, several utilities lamented the shortage of funding for their efforts as well as a shortage of funding for technical assistance positions. In these ways, there is a need for greater support. Specifically, water utilities would benefit most from support provided by experienced water industry peers, for fellow drinking water professionals trying to plan and implement source water protection programs; state and federal funding agencies, so that source water protection needs are sufficiently addressed (for high-quality water sources as well as impaired water bodies); municipal officials, who can influence public support of regulatory and financial measures to implement source water protection; and customers, through water rates.

Increase Recognition

There are issues and efforts related to source water protection that should be acknowledged more publicly. Successful efforts being made to protect sources of drinking water should be noted and praised more frequently. Such recognition benefits a water utility and its community. Alternatively, regulatory inconsistencies that hamper source water protection should also be addressed. In these ways, there should be increased recognition by the public and the drinking water community, of successful source water protection efforts made by water utilities (i.e., recognition in terms of praise and extolment); and by state and federal regulators, of the inconsistencies and shortcomings of existing regulations that should be more effectively ensuring the protection of drinking water sources (i.e., recognition in terms of awareness and acknowledgment of the need to act).

Scaling Up in the Face of Challenges

Natural infrastructure efforts face a broad set of structural challenges—from the under-pricing of water and competition with development for space on the landscape, to accounting standards that do not allow operations and maintenance spending on natural infrastructure as part of normal business

practices. While these and other challenges can be formidable, they are manageable—there are real examples of water utilities and stakeholders overcoming each of them. And despite these challenges, conditions are ripe for a major breakthrough in the practice of turning to natural landscapes to safeguard, enhance, and sustain the critical water-related services communities rely on.

The scientific foundation clearly establishes the connections between natural infrastructure investments and water resource outcomes. The business case for investing in natural infrastructure as part of a water management strategy has been consistently demonstrated, and a framework for green-gray financial analysis is available to decision makers to apply in their own watersheds. A growing network of experts is emerging to assist with program design and development, enhancing prospects for scalability and long-term success. And a growing number of success stories are offering proof-of-concept and lessons learned. Perhaps most importantly, many utilities have key staff who have been, or have the opportunity to be, transformative in addressing many of the barriers identified above. Against a backdrop of aging water infrastructure and fiscal austerity, the opportunity for natural infrastructure to play an increasingly active role as part of the solution to water challenges over the next several decades is very real.

But the movement toward widespread, landscape-level investments in natural infrastructure nationwide cannot gain real traction if key decision makers in key institutions lack the understanding, know-how, and tools needed to act (Box 2). Uncertainty can paralyze decision makers if they lack the economic analysis (Chapter 1) to understand the value of natural infrastructure, despite robust but imperfect science (Chapter 2). Natural infrastructure is likely to be seen as a “soft priority” close to the chopping block if decision makers or their constituents do not understand the urgency of emerging threats (Chapter 3) to source water. Decision makers who are ready to act may find the task overwhelming without the help of critical partnerships (Chapter 4) and a sense of potential mechanisms to finance investments (Chapter 5).

In light of these obstacles, and recognizing the power of individuals, this guide is intended to be a foothold for those who can champion natural infrastructure in water utilities, local conservation groups, and private businesses, and who need a persuasive case, a road map of next steps, and overarching guidance to begin to integrate the natural infrastructure approach into institutional decision making in their watersheds. Throughout, the guide highlights lessons learned from early natural infrastructure efforts in sections written by utility

managers, conservation practitioners, and government officials who have championed the natural infrastructure approach to water management.

Outline of the Guide

This guide includes the seven chapters in Figure 1, divided into three distinct parts: making the case, design and implementation, and case studies. Each chapter is comprised of contributions from experts and representatives from the key stakeholder groups who are championing the natural infrastructure approach to water management.

Figure 1 | **Guide Chapters**



PART 1 | Making the Case for Natural Infrastructure

Part 1 is a reference for early-stage efforts to spark decision maker and stakeholder interest and dialogue around natural infrastructure.

Chapter 1: The Business Case examines the evidence decision makers need to act. The chapter establishes connections between source water quality and costs of delivering clean and abundant drinking water, looks at a methodology and sample application for “green-gray” economic analysis, and provides examples of past natural infrastructure economic analyses and their results. The chapter substantiates the core premise that natural infrastructure can be a cost-effective component of an integrated system to provide clean drinking water.

Chapter 2: The Scientific Underpinnings reinforces the business case by laying out the ecological and hydrological connections between various natural infrastructure elements and the watershed services they produce. The chapter covers both land cover-related natural infrastructure (i.e., forests) and practices in working forests (e.g., harvest and forest road practices). Given imperfect science, the chapter offers insights into decision making in the face of uncertainty, including modeling and prioritizing parcels and practices on the landscape.

Chapter 3: Identifying Opportunity provides guidance on the ecological, economic, and regulatory factors that set the stage for natural infrastructure investments. The chapter discusses the characteristics of “hotspot” watersheds and gives a sense of their geographic distribution. The chapter also provides guidance on beginning dialogue with watershed decision makers and stakeholders on opportunities for the natural infrastructure approach to water management.

PART 2 | Design & Implementation

Part 2 provides guidance on early-stage efforts to design and implement a natural infrastructure program. It focuses on two critical elements—getting the right players to the table and identifying finance options.

Chapter 4: Players at the Table identifies the broad set of experts and stakeholders whose participation is essential for the design, adoption, and



implementation of successful natural infrastructure investment programs. The chapter then takes a close-up look at one stakeholder group in particular—landowners—including current knowledge on landowner preferences and a series of recommendations for engaging landowners in natural infrastructure programs.

Chapter 5: Natural Infrastructure Finance provides a list of available options for putting dollars on the ground for natural infrastructure. The chapter also provides a close-up look at a range of innovative finance approaches, from auctions to carbon financing.

PART 3 | Case Studies

Part 3 offers a series of case studies that illustrate past and current applications of natural infrastructure. The case studies highlight challenges, successes, and lessons learned from the perspective of utility managers, conservation practitioners, and government agency leadership.

Finally, the editors offer **concluding remarks** on the practice and future of the natural infrastructure.

BOX 3 | NATURAL INFRASTRUCTURE AND SAFE DRINKING WATER

| Jim Taft – Executive Director, Association of State Drinking Water Administrators; Co-Director, Source Water Collaborative

A strong and compelling case can be made for source water protection as an essential and cost-effective component and “first line of defense” in an integrated approach to public health protection. The “multiple barrier approach” refers to the various components in the train of providing safe drinking water to the customer—from the source (whether ground or surface water), to a water treatment facility, through a distribution system, and ultimately to the customer at the tap. Among the most important and effective strategies that can be deployed to protect sources of drinking water is investment in natural infrastructure.

Source water protection (and natural infrastructure approaches in particular) makes both good common and economic sense. This is particularly true when one considers the plethora and ever-increasing number of both man-made and naturally occurring contaminants threatening sources of drinking water. It is far more effective (and typically cheaper) to prevent or reduce sources of contaminants at their source than it is to treat them at a public water system. A recent study by EPA of drinking water source protection efforts in six communities around the country concluded that, on average, every \$1 spent on source-water protection saved an average of \$27 in water treatment costs (Winiacki 2012). Several other studies have also found that improved source water quality relates to lower treatment and chemical costs (Holmes 1988; Postel 2005; Dearmont et al. 1998; Espey et al. 1997; Forster et al. 1987; Holmes 1998; Dearmont et al. 1998; Forster and Murray 2001; Freeman et al. 2008).

A further reason for source water protection is the limitation of conventional water treatment technologies. Despite our best efforts and sophisticated treatment technologies, some contaminants are poorly treated by conventional water treatment plants or pass through untreated. While not all such contaminants pose a human health threat at the levels typically seen, others can. Further, the toxicity and carcinogenicity of some contaminants are currently poorly characterized. We simply do not know how big a problem some such contaminants are. Source water protection has an important role to play in helping water systems comply with regulated contaminant limits as well as in reducing or eliminating unregulated contaminants that can pose a public health threat when they enter finished water that is ultimately delivered to the customer. Indeed, the American Academy of Microbiology argued in a 1996 study that one of the best tools for reducing the transmission of waterborne diseases is the establishment of watershed protection programs (Ford & Colwell 1996 in Ernst 2004).

Decision makers at all levels—including state drinking water and clean water administrators—can play key roles as champions in fostering natural infrastructure investment. Their efforts in this regard can be aided by compelling case studies (similar to those situations they may face in their states), well documented and easy-to-access reference materials, and consideration of these approaches at appropriate points in the planning cycle—so that they receive the attention they are due.



Part 1

MAKING THE CASE

Chapter 1: The Business Case

● **MAKING THE CASE**

- The Business Case
- The Scientific Underpinnings
- Identifying Opportunity

▼ **DESIGN AND IMPLEMENTATION**

- Players at the Table
- Natural Infrastructure Finance

▼ **CASE STUDIES**

- Cases
- Concluding Remarks

KEY TAKE-AWAYS

1. The economic benefits for utilities and other beneficiaries can be substantial (Section 1.1). First steps should center around engaging with decision makers to identify specific cost-saving opportunities associated with the services provided by natural infrastructure.
2. The financial case can be made. Although many decision makers have acted without spending on detailed economic analyses, tools and methods are available to compare the costs and benefits of natural and built infrastructure side-by-side (Section 1.2). Determine whether such an analysis is needed to motivate action. There are several examples from other watersheds that can be used to illustrate the business case to decision makers (Section 1.3).

Introduction

Water resource professionals increasingly recognize the cost-effectiveness and broad-based value of an integrated approach to water resource management that includes investments in natural infrastructure. High source water quality is linked to several potential areas of cost savings related to built infrastructure, including reduced capital costs in the form of bypassed treatment processes like flocculation, sedimentation, membrane filtration, and activated carbon (Section 1.1); reduced dredging and other maintenance costs at water storage facilities and intakes; and reduced variable treatment costs associated with reduced need for chemical inputs (Section 1.1). In turn, carefully managed forested watersheds are linked to high source water quality (Chapter 2). These are foundational links underlying the business case for forest-based natural infrastructure for clean and abundant water.

The benefits of natural infrastructure in terms of avoided and reduced costs hold up as a general principle, but decision makers need to be able to justify investments to their constituents—be they utility board members, ratepayers, or taxpayers. Several utilities have made natural infrastructure investments based on an understanding of the direction of impact and clear indicators of cost-effectiveness—but without extensive and detailed cost-benefit analyses (see, e.g., Denver, Colorado case in Part 3). Although the return for these utilities is clear in a general sense, other utilities and businesses facing a different set of challenges may

require explicit financial analyses demonstrating the financial returns on investment. Without strong metrics to guide investments, some utilities—recognizing the value of natural infrastructure generally but unable to quantify that value—are forced to operate with a more opportunity-driven approach.

Indeed, the authors of a 2012 Water Research Foundation report noted that “before they will authorize related activities, many utility managers need to be convinced that source water protection is worth the effort and expenditures—there is not enough information on the costs and benefits of source water protection” (Sklenar and Sham 2012). For most utilities, quantifications of economic benefits and costs are not available and may be expensive to obtain. However, the tools (Section 1.2) and partners (Section 4.1) needed to pursue these metrics are increasingly available to help water utilities break the cycle of “opportunism” and adopt strategic programs needed to optimize expenditures across natural and built infrastructure.

Ultimately, the business case for natural infrastructure is a story not only of substantial potential cost savings, but also of decision making in the face of uncertainty. Even discounting direct, private benefits to account for this uncertainty, however, the often overwhelming public benefits of natural infrastructure can attract a broader “quilt” of prospective funders and tip the scales clearly in favor of pursuing an approach to water resources management that integrates both natural and built components.



Section 1.1: Source Water Quality and Drinking Water Costs

| Jade Freeman, PhD, Office of Groundwater and Drinking Water, EPA

| Rebecca Madsen, USDA Forest Service (Current Affiliation: Electric Power Research Institute)

| Kelley Hart, The Trust for Public Land

A 2008 white paper prepared jointly by EPA, USDA Forest Service, and the Trust for Public Land (Freeman et al. 2008) provided a review of the literature for empirical evidence supporting the relationships between source water quality and treatment costs, as well as original econometric analysis.

If incoming raw water quality is high, treatment plants may be able to bypass some of the processes in conventional treatment (Box 4). For example, in a dataset of 430 U.S. water utilities, Holmes (1988) found that most utilities with raw turbidity levels over 10 Nephelometric Turbidity Units (NTUs) had added a separation process, such as sedimentation or flotation (i.e., conventional versus direct filtration process—see Box 4). This indicates that there may be a sediment-related water quality threshold, at which utilities must make capital investments in conventional treatment processes. In other cases where water quality is poor, plants may need to augment conventional treatment with additional processes like membrane filtration or activated carbon (Cooperative Research Center 2003).

Water utilities may be able to avoid capital costs for treatment processes like flocculation and sedimentation (Holmes 1988), and more advanced processes like membrane filtration and activated carbon by maintaining high source water quality through natural infrastructure investments. For example, seven U.S. cities with excellent water quality have saved from \$500,000 to \$6 billion in avoided water treatment infrastructure costs (e.g., see Section 1.3).

Reduced sedimentation in source water also prevents sediment build up in reservoirs over time, thereby maintaining critical water storage capacity and reducing dredging costs. In extreme cases, sedimentation in source water can clog water intakes, posing additional repair and maintenance costs for a water utility or other water user. The Denver Water Board case in Part 3 illustrates these issues.

BOX 4 | KEY TREATMENT PROCESSES DEFINED

Conventional treatment processes include:

Coagulation/Flocculation – Removes dirt and other particles suspended in water. Coagulation destabilizes negatively charged contaminants with aluminum or iron salt. Flocculation accelerates particle collision by gentle mixing and aggregates destabilized particles into larger precipitates.

Sedimentation – Settles out heavy particles (floc). The majority of particulate matter is removed for a refined filtration stage.

Flotation – Aerates the water to float finer particles onto the surface for removal by skimming, as part of the clarification process.

Filtration – Removes even smaller particles by passing water through filters—often comprised of anthracite and sand.

Disinfection – Kills any bacteria or microorganisms in the water with chlorine or some other disinfection method.

Storage and Transport – Holds water while disinfection takes place and then delivers water.

Select nonconventional treatment processes include:

Membrane Filtration (microfiltration and ultrafiltration) – An alternative to rapid sand filtration in conventional treatment, membrane filtration features smaller pore sizes in the filter in order to remove suspended solids, turbidity, some colloids, bacteria, protozoan cysts, and viruses. The process requires additional operational considerations relative to sand filtration.

Activated Carbon – Used to absorb natural organic compounds, taste and odor compounds, and synthetic organic chemicals.

See [EPA's website](#) for a more detailed description of conventional and nonconventional treatment processes.

It is clear that poor water quality at a drinking water intake can be an indicator of high treatment costs.

In addition to large capital and maintenance cost savings related to high water quality, treatment plants with high-quality raw water may save on variable costs as well. For example, plants may need to add more chemicals like coagulants, disinfectants, and pH adjusters as water quality degrades (Dearmont et al. 1998). In an analysis of over 100 drinking water price models (directly related to cost), Espey et al. (1997) found weather to have an effect on water price, presumably through sediment and pollutant loads associated with storm flows. While surveying 24 treatment plants, managers informed Forster (2001) that chemical costs were the variable costs most affected by raw water quality.

Four economic studies investigated the effect of raw water turbidity levels on drinking water treatment costs (Forster et al. 1987 from Holmes 1988; Holmes 1998; Dearmont et al. 1998; Forster and Murray 2001). All studies reported a positive relationship between sediment or turbidity levels and drinking water treatment costs. Elasticity reported in the studies indicated that a 1 percent increase in sediment or turbidity levels would lead to a 0.07–0.30 percent increase in water treatment costs. All of the studies assumed that fixed costs such as capital investments would not vary over the short term and thus looked only at variable costs. While the studies differed in some of the variables used in the cost equations, all studies used either turbidity or sediment loading rates as an indicator of raw water quality. Another economic study determined treatment costs by using water demand and supply models (Piper 1998). The study found that incoming water quality, the volume of water treated, the population density of the service area, and the source of water supplies all significantly affected the cost per unit of water delivered.

Freeman et al. (2008) tested the relationship between source water quality and chemical treatment costs. The study found that treatment cost had a significant positive relationship with total organic carbon (TOC), and a significant negative relationship with a water quality index (comprised of turbidity, TOC, and alkalinity). In other words, higher water quality is related to lower treatment cost. These findings reinforce the intuitive—that it costs more to treat lower quality water.

However, it is difficult to create a predictive model for the cost response of changing water quality for any given treatment plant. Within the sample of 60 treatment plants in Freeman et al. 2008, there are differences in raw water sampling methods; differences in the type of water body used for source water; a rich diversity in the sequences of treatment and types of chemicals used; differences in climate, soil, and geography; and variations in the price of chemicals. In addition, water treatment plants often apply excessive treatment to their raw water. For example, some operators were seemingly not altering chemical treatment on the basis of raw water quality fluctuations, and some were systematically treating beyond required standards as a precaution. This would have the effect of dampening the potential impact of changes in source water quality on treatment costs. Moreover, it would be difficult to model changes in other variable costs like labor and part replacement due to differences in reporting and accounting procedures.

Despite these challenges, the economic literature strongly affirms the relationships between water quality at a drinking water intake and treatment costs.

Section 1.2: Green-Gray Analysis

| John Talberth, Ph.D., Erin Gray, Logan Yonnavjak, and Todd Gartner,
World Resources Institute

“Green-gray analysis” (GGA) is a type of investment analysis (cost-benefit analysis or cost-effectiveness analysis, depending on the situation) that provides a basis for considering both natural infrastructure (green) and built infrastructure (gray) alternatives. GGA is in its infancy and has yet to permeate public infrastructure investment decisions in a consistent, accessible, and robust manner. As a result, ecosystem-based options are still largely left out of investment decisions. While calculating the costs and benefits of built infrastructure is relatively straightforward, there is no formalized methodology for placing natural infrastructure costs and benefits on equal footing with built infrastructure costs and benefits. This methodological gap presents a formidable barrier to public infrastructure investment managers contemplating investment in natural rather than built infrastructure (Forest Research 2010).

Green-Gray Analysis in Action

Sebago Lake in Maine contains some of the cleanest water in the Northeastern United States. It is also the primary drinking water reservoir source for the Portland Water District (PWD), and supplies drinking water to over 200,000 people daily. PWD currently qualifies for filtration avoidance under the EPA 1989 Surface Water Treatment Rule. The rule waives public water systems from requirements to install filtration systems as long as concentrations of turbidity and either fecal or total coliform are maintained at or below regulatory baselines through land use practices upstream.

In recent years, it has become clear that upstream development, deforestation, and population growth trends may jeopardize the filtration waiver and force PWD to install a conventional filtration system—a present value cost of \$97 to \$155 million over 20 years. For example, the U.S. Forest Service determined that areas of the Sebago Lake watershed are at high risk of forest conversion from development pressure, which, coupled with unsustainable land use practices, is a major threat to water quality (Gregory et al. 2009). In response, the community is actively investigating natural infrastructure alternatives that would minimize the chance of losing the waiver and otherwise help

reduce its water treatment costs. Using the GGA methods discussed below, we completed a preliminary analysis to provide a sense of economic tradeoffs involved and to identify data gaps and parameters that would need to be addressed for a more complete analysis.

Using a cost-effectiveness analysis (CEA) framework, we compared the cost of a new filtration plant with investment in five forest-based natural infrastructure elements over the next 20 years that would mutually help retain the existing high quality waters of the Sebago Lake Watershed. These included riparian buffers, upgrades to culverts posing a significant threat to water quality due to risk of failure in severe storm events, sustainability certification of future timber harvests, reforestation in riparian zones, and conservation easements. The quantity available and costs associated with the natural infrastructure portfolio were determined through on-site consultations with stakeholders throughout the watershed, review of publically available data, and GIS analysis (see description of the Conservation Priority Index in Section 2.1).

Binary green-gray analysis can illustrate clear tradeoffs. However, the use of a filtration waiver as a “hinge point” creates complications. The political nature of decision making related to the waiver makes it not easily “modeled.” As a result, analysts are forced to make conservative assumptions about the condition of the watershed needed to maintain the waiver. However, even if the waiver is maintained over the study period, a filtration plant may eventually be required. There has been good dialogue with utility professionals around this issue. Ultimately, “permanence” is not a concept water resource managers can work with, given a changing ecological, technological, and regulatory landscape. Despite this reality, precluding the need for major capital investments over a 20–30 year period—a typical lifespan of built infrastructure before it needs substantial capital reinvestment—can be a worthwhile investment, particularly given the technological advances in built infrastructure that may occur over that period.

With these issues in mind, we conducted a preliminary analysis comparing the present value of costs and benefits for natural infrastructure and built infrastructure alternatives over a 20 year period.

Since this analysis was preliminary, it did not include detailed biophysical modeling to connect natural infrastructure elements to water quality outcomes; instead, conservative assumptions were made regarding the scale of natural infrastructure investments required. The impacts of those assumptions were then tested by running scenarios with different natural infrastructure cost and effectiveness estimates. Also note that the analysis does not consider the effect of the natural option in reducing variable treatment costs by improving source water quality, nor does it consider the range of ancillary benefits associated with the natural option. The results simply reflect the estimated costs associated with a new filtration plant relative to the natural infrastructure investments needed to avoid building that plant.

Our bottom-line finding under the expected scenario (Figure 2) is that the natural infrastructure option represents a cost savings of more than \$12 million over 20 years, even when excluding public benefits such as carbon sequestration and Atlantic salmon habitat.

Given the uncertainty associated with the lack of underlying biophysical modeling, we tested this finding by running the analysis under different assumptions regarding the efficacy of the natural infrastructure measures, and various cost estimates for initial and annual costs of the alternative investment portfolios. Under an optimistic scenario for natural infrastructure (Figure 3), the option would generate savings of \$110 million.

Under the least optimistic scenario—which assumes lower-bound cost estimates for the membrane filtration system, high use of costly conservation easements, and residual risk of waiver loss of 25 percent—the natural infrastructure option would represent as much as a 46 percent increase in costs. However, even with these pessimistic assumptions, the natural option is economically superior when the wide range of ancillary benefits is considered. Based on a combination of empirical data on the ground and calibrated non-market benefits transferred from other settings, non-market benefits from carbon sequestration¹ and Atlantic salmon habitat alone are estimated to amount to \$72 to \$125 million over a 20 year timeframe. While it is

Figure 2 | Preliminary Analysis for Portland, Maine—Baseline Scenario (\$ millions)

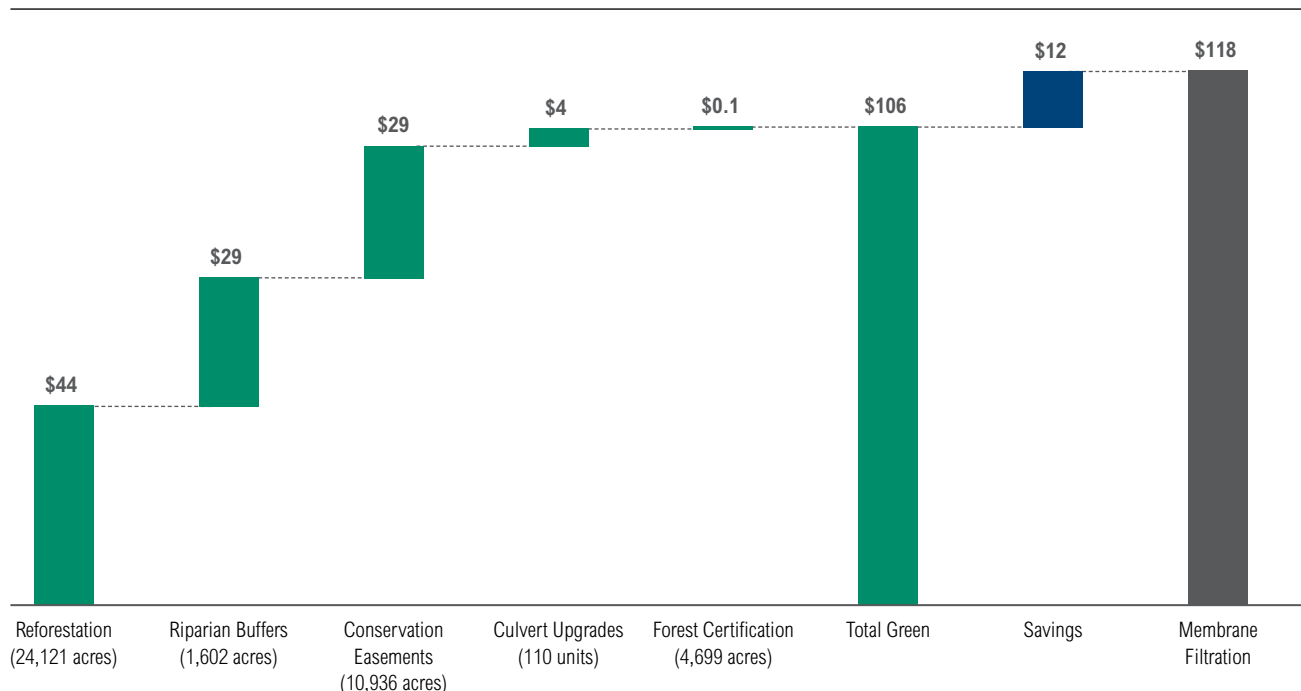
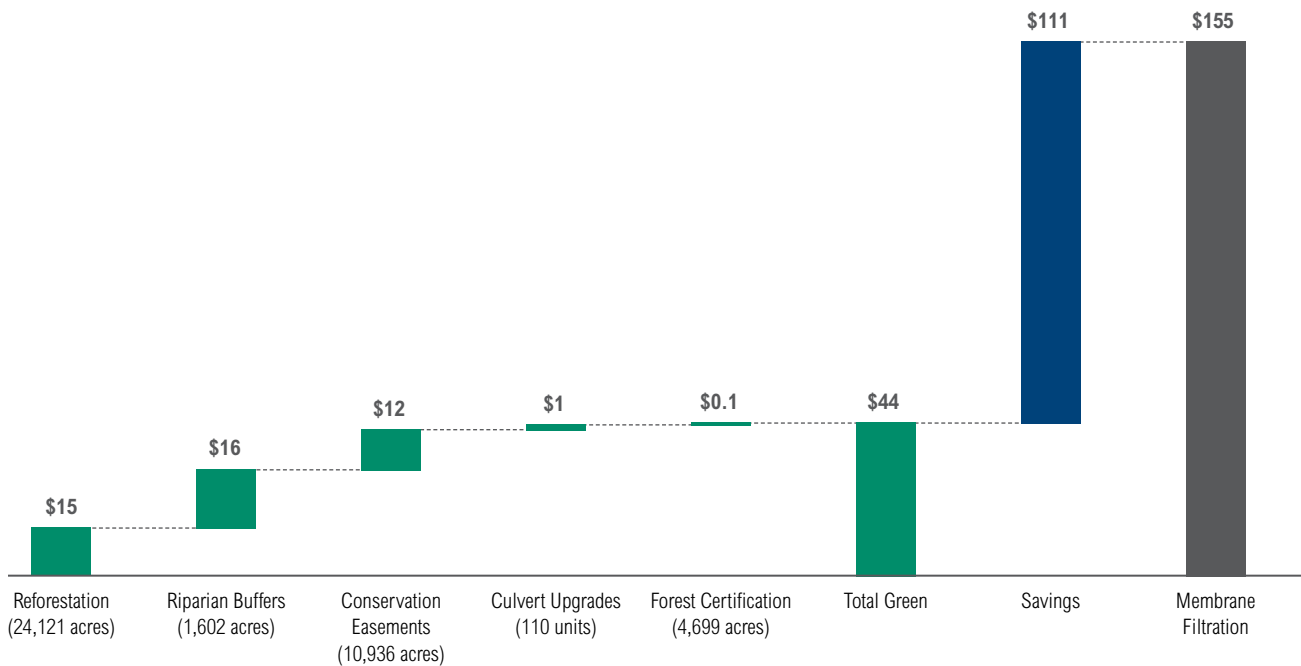


Figure 3 | Preliminary Analysis for Portland, Maine—Optimistic Scenario (\$ millions)



typically beyond the statutory authority of public utilities to raise rates for such non-water-related benefits, PWD is interested in the public benefits of its investments, and these benefits and others open the door to other potential funders such as land trusts and philanthropies.

Preliminary analyses like these can be used to determine whether a more in-depth study is warranted to pinpoint expected costs and savings. In this case, a “phase 2” analysis, drawing on biophysical modeling and addressing variable costs for PWD and potential carbon credit sales, would provide greater confidence that the prescribed natural infrastructure would stave off the need to build a filtration plant for the expected duration of time (20 years). In the meantime, PWD has committed to paying up to 25 percent of the cost of conservation easements in its watershed, while land trusts provide the remainder (Case 3 in Part 3).

Toward More Widespread and Robust Applications of GGA

Three insights emerge from our PWD case study. First, while there are certainly complexities involved, natural infrastructure investments can indeed be presented in a manner commensurate with conventional gray investments so the two can be compared dollar for dollar, apples to apples, by public investment analysts. This suggests that, once fully developed, a GGA methodology can be a standard part of infrastructure investment decisions for a wide variety of settings.

Second, to be actionable, a GGA must rely on either highly conservative assumptions or robust underlying biophysical or econometric modeling to link each natural infrastructure component in the portfolio with the outcome sought. Thus, as GGA applications proliferate, availability of robust modeling capabilities will be key if these analyses are to give full credit to the potential returns of natural infrastructure.

Common Analytical Limitations:

1. Lack of detailed biophysical modeling;
2. Need to make (conservative) assumptions; and
3. Full range of benefits not quantified.

Third, the underlying biophysical modeling may not completely resolve uncertainty associated with natural infrastructure outcomes. Thus, any GGA must place a heavy emphasis on identifying and mitigating risk and uncertainty through portfolio design (i.e., an integrated green-gray approach), analytical adjustments (i.e., modeling the risk of failure), and sensitivity analysis. Nevertheless, and as demonstrated by the PWD case study, natural infrastructure may represent a significant enough source of savings to warrant selection even under conditions of uncertainty. GGA that incorporates more accurate cost estimates and site-specific biophysical modeling will help investment analysts make a more convincing case for natural infrastructure.

A Standard GGA Methodology

The GGA conducted in Portland, Maine, serves as an example for water utilities. Indeed, stakeholders in Fort Collins, Colorado, are investing in a similar analysis for their watersheds. A replicable GGA methodology can be one important step forward for scaling up natural infrastructure investments nationwide.

Drawing on standard methods of alternative investment analysis, we can distill six key components for an effective methodology:

1. **Clearly specify the investment objective and constraints.** Although intuitive, this step is essential for getting the math right, which involves making sure all relevant economic benefit and cost variables are included in the right units and in the right place in the investment tradeoff equations.
2. **Develop portfolios that include both green and gray investments.** In each infrastructure investment situation, there may be one or more gray, and likely several green, investment options under consideration. Developing a portfolio of gray options is fairly straightforward; technologies are relatively well established and understood. There is less familiarity with green options, although the literature on the number and applicability of various natural infrastructure solutions is rapidly evolving.² In constructing green portfolios, there are several unique aspects to consider such as physical constraints (i.e., there are only so many streams where riparian buffers could be restored), the need to incorporate redundancy (i.e., replanting two acres of trees instead of one in case one burns down) and sequencing (i.e., obtaining water rights before constructing wetlands).

3. Model outcomes. This is perhaps the trickiest aspect of GGA, as noted in the case of PWD. Quantitatively establishing the relationship between the level of investment in any one natural infrastructure measure and the environmental outcomes requires careful modeling—biophysical, probabilistic, econometric, or some other approach that relates changes in ecosystem function to changes in economic services provided. In situations where there are inadequate resources for robust modeling or where there may be little scientific information to go on for the natural infrastructure components at hand, the trickiest step is documenting assumptions about biophysical relationships.

4. Quantify present value costs and benefits of individual green and gray measures. Before portfolios of green or gray options are considered, each individual measure needs to be analyzed by itself. Both green and gray options must be analyzed on a common platform so that costs and benefits can be directly compared or combined. The gray infrastructure option should serve as the baseline since in most cases GGA is undertaken to explore alternatives to some impending gray investment decision, and not vice versa. Adopting gray as the baseline requires evaluation of green options within the general analytical framework offered by standard infrastructure investment methods. The EPA provides a useful synopsis of standard “two stage” discounting to evaluate gray infrastructure investments in terms of present value costs, net present value, and cost-benefit ratio (EPA 2009). Present value costs and benefits of natural infrastructure can be modeled in precisely the same way, albeit with a few complexities.

5. Compare investment portfolios. At the heart of GGA is alternative investment analysis to compare green against gray, or different combinations of green and gray together. Once the benefits and costs of individual green or gray measures are calculated, the next step is then to compare investment portfolios. Depending on the investment objective, the

comparison is carried out by using either cost-benefit analysis (CBA) or cost effectiveness analysis (CEA). CBA is a technique used to estimate and sum up (in present value terms) the future flows of benefits and costs of policy alternatives to establish the worthiness of undertaking the stipulated activity against some set of alternatives. CEA on the other hand is a technique for identifying the least cost option for meeting a specific outcome. In either CEA or CBA, single solutions can be sought by way of optimization or the analysis can compare two or more discrete, exogenously assembled investment portfolios that can consist of green and gray measures together or green versus gray.

6. One must account for risk and uncertainty. Like built infrastructure, natural infrastructure investments can be risky and uncertain. Sources of risk include the possibility that floods, fires, insect outbreaks, extreme drought, and climate change significantly affect the function of natural infrastructure over the long run. Sources of uncertainty include poor existing data on implementation costs, speculative relationships between natural infrastructure elements and the environmental outcome sought, and lack of understanding about important land use trends, market trends, landowner behavior, or policy or regulatory changes that have bearing on the investment decision. Particularly where natural infrastructure avoids capital costs for built infrastructure elements, future changes in regulatory requirements can affect envisioned cost-effectiveness for a water utility. Risk and uncertainty can be dealt with in two fundamental ways—through project design and through project analysis. Redundancy, or having two or more natural infrastructure elements included to achieve the same outcome, is one way to reduce risk and uncertainty in the design of natural infrastructure investment portfolios. With respect to analysis, standard approaches for incorporating risk and uncertainty include sensitivity analysis, scenarios, and use of expected values.

Section 1.3: Demonstrations of the Business Case

| Rowan Schmidt, Earth Economics

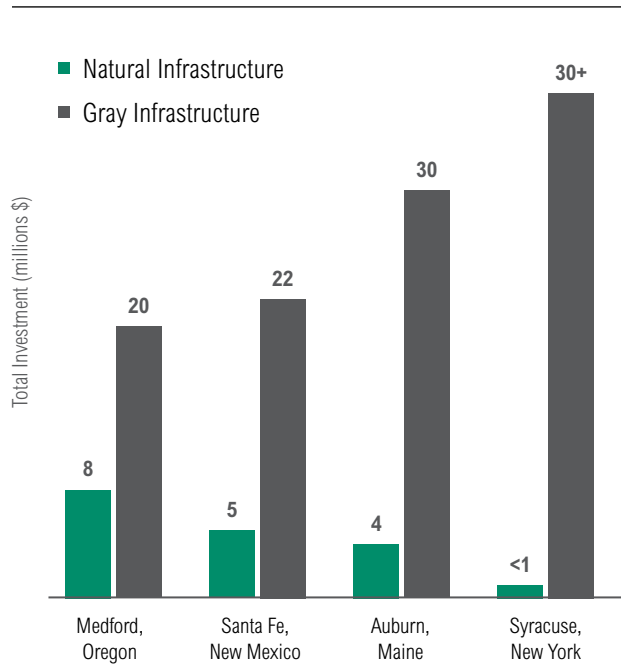
| James Mulligan, Green Community Ventures

Natural infrastructure economic analyses are increasingly common in watersheds nationwide. Two emerging themes are evident from a review of these analyses: First, natural infrastructure is often (but not always) a cost-effective option; and second, decision makers in different watersheds require different levels of decision-making support and certainty before acting—presumably due to variations in their underlying political context. Note that some of the analyses we present stray from the forest-to-drinking water context to demonstrate broader applicability of cost-effective natural infrastructure.

The series of examples presented below include both “prospective” economic analyses (cases where economic analysis contributed, or may contribute to, a utility’s decision to invest in natural infrastructure—Table 2), as well as “retrospective” economic analyses (cases where a utility’s past natural infrastructure investments were analyzed and their economic benefits calculated—Table 3). Though retrospective case studies do not show how to make the “business case” for natural infrastructure in decision making, their results are likely to be more accurate with the advantage of hindsight. Note that there is not yet an industry standard for how to present a business case for natural infrastructure. Some of the metrics presented in the examples below vary, and may have been calculated with slightly different methods. Figure 4 illustrates the costs of natural infrastructure and built infrastructure options facing some of the municipalities and utilities discussed below. See also Box 5 for a new tool to identify some of the central inputs to these types of analyses—ecosystem service values.

Note that an apples-to-apples comparison between the presented business cases is challenging for a number of reasons. They use a number of different economic methods to assess natural infrastructure, including avoided cost, replacement cost, or project benefits. Each of these methods uses different assumptions and/or proxies for measurement.

Figure 4 | **Example Natural & Built Options**
(millions \$)



For example, some natural infrastructure investments reduce or eliminate the need for an upfront capital cost, some reduce or eliminate certain operating costs for the utility, and some do not reduce costs but provide greater benefits for a given investment. The business cases also measure a range of different natural infrastructure benefits. For example, some cases focus on the water filtration benefits of natural infrastructure for drinking water, while others focus on temperature reduction benefits. Finally, the results of each analysis are also presented over inconsistent time periods, and depending on the size of a utility, the political landscape, the utility’s financial situation, and many other factors, a given investment in natural infrastructure may have different impacts.

Table 2 | **Examples of the Business Case Made Through Prospective Economic Analysis**

LOCATION	DESCRIPTION
Clean Water Services, Tualatin River, Oregon (2006)	Niemi et al. (2006) compared the costs of reducing thermal pollution of the Tualatin River in Oregon for natural infrastructure and built infrastructure options. The study found that the built option, installing two mechanical chillers to cool water before it is discharged to a stream, would cost between \$60 and \$150 million. The natural infrastructure option, establishing riparian forests to shade water and augmenting stream flows with releases from upstream reservoirs, was estimated to cost \$6 million but came in at \$4.6 million—realizing savings of \$50.4–\$145.4 million relative to the built alternative.
Denver Water Board, Denver, Colorado (2013)	No explicit, detailed cost-benefit analysis was conducted to support the Denver Water Board’s \$16.5 million investment in fuel reduction in the National Forests that house Denver’s source water. However, the utility incurred \$26 million in costs in the aftermath of two devastating fires in 1996 and 2002 to manage post-fire sedimentation. Fire suppression costs were another \$47 million, the Forest Service has spent another \$37 million on post-fire restoration and stabilization, and private insured property losses were an additional \$38.7 million. These events and their costly aftermath provided sufficient impetus for Denver’s investments to manage against risk of future wildfires and associated sedimentation (Denver Water Board-this publication). See Part 3 for an in-depth look at this case.
Eugene Water & Electric Board, Eugene, Oregon (2012)	Riparian buffers in the McKenzie Watershed were shown by Earth Economics in 2012 to represent a value (including public benefits) of \$1,031 to \$6,713 per acre per year (Schmidt & Batker 2012). This valuation is being used to support and inform the development of an ecosystem services market within the watershed to protect and restore these sensitive areas.
City of Medford, Oregon (2012)	The City of Medford’s wastewater facility discharges into the Rogue River but exceeds maximum temperature load requirements as allowed by its Total Maximum Daily Load (TMDL). In order to meet its temperature TMDL requirements, Medford evaluated three alternatives: lagoon storage for discharge later in the year, mechanical chillers, and riparian restoration and shading. An economic analysis showed that riparian restoration was three times more cost-effective than mechanical chillers for reducing thermal loads into the river and would provide additional benefits such as wildlife habitat and water filtration. Over the next 10 years, Medford plans to engage 100 landowners through the project developer—The Freshwater Trust—to restore 30 miles of stream bank at a cost of \$8 million, saving about \$8 million compared with lagoon storage and \$12 million compared to installing mechanical chillers—as well as greenhouse gas emissions that would occur as a result of operating the chillers (Sanneman 2012). The City of Medford’s Dennis Baker reported, “We weighed our options, and water quality trading was the lowest cost option, and offered significant environmental benefits” (OACWA 2012).
New York City Department of Environmental Protection, New York (2006)	In the late 1990s, in the face of growing development pressures in its largely privately-owned Catskill-Delaware watershed, New York City initiated a plan to protect its source water and avoid the cost of a filtration plant by investing in its 2,000 square mile watershed. A filtration plant would have cost the city \$8–\$10 billion in current dollars—roughly \$6 billion to build and \$250 million annually to maintain. In contrast, the cost of securing natural infrastructure in the watershed was estimated at \$1.5 billion. The watershed program has staved off the need to build a filtration plant and provided an annual \$100 million injection to the rural economy in the upper reaches of the watershed by providing supplemental income to farmers and forestland owners, paying local contractors to install septic systems and set up stormwater protection measures, and by promoting ecotourism (Kenny 2006).
Portland Water District, Portland, Maine (2013)	In the Crooked River Watershed, the World Resources Institute estimates the Portland Water District would save an expected \$12 million—and possibly as much as \$110 million—over the next 20 years by investing in natural infrastructure alternatives to a membrane filtration plant (Talberth et al. 2013).

Table 2 | **Examples of the Business Case made through Prospective Economic Analysis (cont.)**

LOCATION	DESCRIPTION
City of Santa Fe, New Mexico (2009)	In 2009 Santa Fe completed the Santa Fe Municipal Watershed Plan, largely in recognition of the potential cleanup costs associated with a fire in their municipal drinking water watershed. The Plan provides a framework and recommendations for long-term management, outreach, and funding for the Santa Fe Municipal Watershed. Santa Fe estimated the total cost of restoring the forest to be \$4.3 million, at an average of \$200,000 annually over 20 years. This was compared with the alternative: not restoring the forest and incurring \$22 million in expenses after a 7,000 acre fire, estimated to be a 1-in-5 years event (Margolis et al. 2009).
Seattle Public Utilities, Washington (2005)	In 2005, Seattle Public Utilities (SPU) was in the planning stages for the Tolt River Levee Restoration and Habitat Preservation Project, a \$5 million levee setback to benefit threatened Chinook salmon, native fish habitat, and maintain flood protection. With the project located in the Tolt River Watershed, the source of approximately 30 percent of Seattle’s drinking water supply, SPU was interested in the full suite of ecosystem service benefits the project would achieve, and contracted with Earth Economics to identify and value the ecosystem services provided by the site in current conditions (in which the river was disconnected from the floodplain), compared with a restoration scenario. The ecosystem service benefits were estimated to range from \$134,000 to \$484,000 per year, resulting in a net present value of \$4.0 million to \$14.3 million. This analysis confirmed the project was justified based on the public benefits and value provided by ecosystem services (Batker 2005). With the help of this additional information, the senior management committee approved the project unanimously, and construction is now complete.

Key Themes

The following themes are important takeaways from these examples of the business case for natural infrastructure:

1. Natural infrastructure provides valuable services to water utilities, like sediment removal and water storage—as well as ancillary benefits like fish and wildlife habitat, increased property values, and recreational opportunities;
2. Methods of economic analysis and tools are available to calculate the value of natural infrastructure and support decision making;
3. Based on economic analysis, in many contexts natural infrastructure is found to be a more cost-effective choice than alternatives;
4. Different utilities invest in natural infrastructure based on different levels of economic analysis;
5. The scale of analysis needs to fit the problem being addressed—broad scale analysis is typically sufficient to inform priority setting (i.e., to show that natural infrastructure is a worthwhile investment), while more precise modeling/valuation is needed at the site scale (i.e., to show which specific natural infrastructure project is the best option);
6. Economic analysis is always conducted within the context of a specific social and regulatory environment and in many cases is the last decision point that “tips the balance” toward natural infrastructure, rather than the only factor;
7. Economic analysis of natural infrastructure tends to be conducted by larger utilities/agencies (greater than 100,000 customers), suggesting that smaller utilities may not have the needed capacity in general; and
8. An effective way to make the business case for natural infrastructure is to compare it with built assets that provide similar services for the utility. For example, the cost of protecting a watershed can be compared with the cost of building a filtration plant. When the ancillary benefits of natural infrastructure are also considered and valued, the business case is likely to become stronger.

Table 3 | **Examples of Retrospective Economic Analyses**

LOCATION	DESCRIPTION
<p>City of Auburn, Maine (2012)</p>	<p>The Auburn Water Department spent \$570,000 to acquire and protect 434 acres of land around Lake Auburn, part of the city's drinking water watershed. This purchase saved the utility \$30 million in capital costs, and an additional \$750,000 in annual operating costs, by maintaining water quality standards and avoiding the need for a filtration plant (Ernst 2004). The land acquisition was funded with a Drinking Water State Revolving Fund Loan. Today, Lake Auburn Watershed Protection Commission controls approximately 1,600 acres in the 9,792-acre watershed of Lake Auburn (including 80 percent of its shorelines), and the Auburn Water District and Lewiston Water Division continue to be exempt from EPA filtration requirements (LAWPC 2012).</p>
<p>Seattle Public Utilities, Washington (2000)</p>	<p>Following the Great Seattle Fire of June 6, 1889, Seattleites voted to establish Seattle Public Utilities (SPU) to provide water to the city. Seattle began acquisition of the 100,000-acre Cedar River Watershed to provide and filter the community's water. This was a radical and expensive idea at the time. By 1901 clean water was flowing, banishing cholera and typhoid. By 1909 Seattle was considered one of the healthiest cities in the United States. Today, SPU would have to pay an upfront cost of \$200 million to build a filtration plant to filter the city's water supply with annual operating and maintenance costs of \$3.6 million per year if the forest did not do this job. Of course, after a century, it would likely have been the third or fourth filtration plant to be built (Cosman et al. 2011). Seattle now invests in the Cedar Watershed through its habitat conservation plan (HCP), which commits at least \$79 million (in 1996 dollars) over the life of the HCP (Seattle Public Utilities 2000).</p>
<p>City of Syracuse, New York (2010)</p>	<p>Skaneateles Lake provides high-quality drinking water for over 200,000 residents in the City of Syracuse and the surrounding region. With increasing development pressure around the lake, Syracuse developed a watershed protection program that includes agricultural non-point source pollution control measures, open space and farmland protection, and public outreach and education. At a cost of \$10 million, the program has allowed Syracuse to maintain high drinking water quality in Skaneateles Lake and receive a filtration waiver from EPA, avoiding construction of a \$70 million filtration plant with \$7 million in annual operating costs. The nearby Town of Skaneateles has also saved approximately \$4 to 6 million in filtration costs (EPA 2010).</p>



BOX 5 | ECOSYSTEM VALUATION TOOLKIT

| Corinne Cooley, Earth Economics

In making the business case for natural infrastructure, finding reliable data on the value of benefits provided by nature is frequently both essential and a challenge. The Ecosystem Valuation Toolkit (www.esvaluation.org) includes a Researcher's Library that assists in finding these values. The Library already contains full bibliographic information for nearly 50,000 documents of relevance to ecosystem service valuation. These studies either contain ecosystem services values, or have relevance to theory, practice, and implementation of ecosystem services frameworks. Approximately 10,000 entries have been identified as containing candidate ecosystem service values, and are in process of being transcribed so that detailed ecosystem service value data are readily available for searching and viewing.

The Researcher's Library's custom transcription user interface includes hundreds of fields to fully capture data about the values of ecosystem services. These data undergo a multi-phase review process before being approved and "published" in the database for use in ecosystem service valuation.

The Ecosystem Valuation Toolkit also includes SERVES (Simple, Effective Resource for Valuing Ecosystem Services), a computational tool supporting calculation of monetary and non-monetary ecosystem service values for areas of interest using Benefit Transfer and Function Transfer. Values generated by this system are already being used by organizations such as Federal Emergency Management Agency (FEMA), The Nature Conservancy, Seattle Public Utilities, and many others. This computational tool still requires expert knowledge for proper use, but will be made available for wider use as the expert knowledge is codified into rules and validated by a panel of internal and external expert economists and ecologists.

Limitations and Take-Aways

While the above themes can be inferred from this compilation of business case analyses conducted on forest-based natural infrastructure in the United States, the business cases must also be presented with a number of caveats. First, economic and financial analysis of natural infrastructure is relatively new, so there is a lack of historical cost and benefit data from which to draw. In comparison, there is a wealth of historical cost and benefit data for built infrastructure. This increases the perceived risk (i.e., uncertainty) associated with natural infrastructure, and such projects may have to pass a higher threshold in order to be considered. Indeed, many of the analyses presented here may underestimate the value of a natural infrastructure investment both because of conservative assumptions about the benefits of natural infrastructure as well as the omission of ancillary benefits. In time, however, efforts by economists in this area of research and the benefit of hindsight will lend additional clarity to the real returns provided by natural infrastructure.

Ultimately, however, any economic analysis is limited to the accuracy of the underlying science. The science connecting natural infrastructure to water resource outcomes generally is extensive and robust. However, predicting marginal benefits is still a challenge, often leaving economists to make conservative assumptions. Even with this conservative approach, however, analyses to date have demonstrated the clear potential for cost-effectiveness of a wide range of natural infrastructure options relative to built infrastructure alternatives. Meanwhile, the science underpinning the water-related benefits of natural infrastructure investments is advancing rapidly.

Chapter 2: The Scientific Underpinnings

● MAKING THE CASE

- The Business Case
- The Scientific Underpinnings
- Identifying Opportunity

▼ DESIGN AND IMPLEMENTATION

- Players at the Table
- Natural Infrastructure Finance

▼ CASE STUDIES

- Cases
- Concluding Remarks

KEY TAKE-AWAYS

1. The scientific foundation is imperfect, but robust. The latest science establishes the connections between natural infrastructure investments and water resource outcomes (Sections 2.1 and 2.2). These basic connections serve as important context for dialogue with decision makers and stakeholders.
2. Inherent variability poses challenges for quantification of natural infrastructure benefits. Watershed models (Section 2.4) can address part of this variability, but remain relatively resource-intensive and inevitably leave some residual uncertainty.
3. Risks and uncertainty can be managed. The dominant approach to natural infrastructure investments has been to manage uncertainty and maximize cost-effectiveness by prioritizing types of interventions (e.g., easements or best management practices) (Section 2.3) and the distribution of those interventions throughout a watershed (Section 2.1), monitoring, and managing adaptively.

Introduction

Among the most important types of natural infrastructure for water in the nation's landscapes is forest. About 53 percent of the freshwater supply in the contiguous United States originates in forests (Brown et al. 2008), although forests cover only about a third of the country (Sedell 2000). Water originating in forests is widely recognized as clean compared with water coming from other sources. Watersheds with more forest cover have been shown to have higher groundwater recharge, lower stormwater runoff, and lower levels of nutrients and sediment in streams than do areas dominated by urban and agricultural uses (Brett et al. 2005, Crosbie and Chow-Fraser 1999, Matteo et al. 2006). These features of forests are particularly important for communities in the face of a changing climate (Box 6).

There has been consensus for generations that well-managed forested watersheds are “good” for water resources. To provide the confidence many would-be investors need, we must have a more precise scientific understanding of the relationships between ecological conditions in the watershed and water-related outcomes.

The science is well established on the direction of impact—that maintaining healthy, forested landscapes and implementing best practices in forestry management are highly effective strategies for promoting source water quality and regulating flow. However, there is inherent variability across and within watersheds in the magnitude of water resources impact of a given land cover change or management practice. Quantitative watershed models can help to address part of this variability. These tools are advancing in reliability and usability, and can account for a portion of the variability in natural ecosystems. Models are being used in a growing number of watersheds to estimate, with varying degrees of accuracy, the quantitative outcomes from interventions such as reforestation, forest preservation, and increasingly even specific management practices such as road decommissioning and riparian buffer practices. Still, modeling remains relatively resource-intensive and results inevitably come with some level of uncertainty.

Yet, despite residual uncertainty, natural infrastructure options are actionable. Given imperfect science and the need to prevent the perfect from being the enemy of the good—as in all things—the dominant approach to natural infrastructure investments has been to manage uncertainty and maximize cost-effectiveness by a) prioritizing types of interventions and the distribution of those interventions throughout the watershed, b) carefully monitoring the response of water resources throughout implementation, and c) managing investments adaptively to maximize outcomes. Watershed experts and conservation practitioners typically have a robust understanding of investments on the landscape that produce critical watershed services—and, where needed, basic watershed assessments can identify existing and potential sources of impairment given trends in ecological conditions. Types of investments can be ranked in terms of likely effectiveness and cost as documented in the literature, and parcels within a watershed can be prioritized in terms of the potential for conservation investments to positively impact water resources.

This chapter, a series of contributions from experts and practitioners, presents the current state of scientific literature underlying natural infrastructure, including approaches to investing in the face of residual scientific uncertainty—watershed models, targeting of specific practices, and parcel prioritization. Due to the nature of the topic, this chapter delves into a fair amount of technical detail to support the narrative laid out here.

Section 2.1: Land Cover, Water Resources, and Prioritizing Parcels

| Paul Barten and Craig Nicolson, University of Massachusetts Amherst
| Bill Van Doren, South Central Connecticut Regional Water Authority

Water quality and water flow are strongly linked to land cover in a watershed, as streams are in a state of dynamic equilibrium (see, e.g., de la Crétaz and Barten 2007) with the natural vegetation communities and disturbance regimes within their watershed. For nutrient cycling, for example, the dominant analytical framework over the past 30 years (the Vitousek-Reiners [1975] hypothesis) is based upon the concept of mass balance; that nutrient flows through an ecosystem comprise inputs (e.g., from upstream flow, aerial deposition, and weathering), some amount of internal cycling, and outputs (through decomposition/outgassing and leaching). Thus when ecosystems are aggrading biomass, generally there will be a net uptake of nutrients.

Water-Related Functions of Forests

Forests, in particular, have a number of characteristics that have been demonstrated to have a generally favorable effect on water resources:

- Forests have sturdy, long-lived roots that help to anchor soil against erosion (Beeson and Doyle 1995; Geyer et al. 2000).
- Forests have multiple layers of vegetation (Dohrenwend, R.E. 1977) and especially thick litter layers that help to slow falling rain and reduce its erosive force (Stuart and Edwards 2006).

“We kept hearing from local planners that we need metrics—it is nice to say forests are good for the environment, but we need metrics to quantify the impact and build it into decision-making processes.”

—Buck Kline, Director of Forestland Conservation,
Virginia Department of Forestry

BOX 6 | NATURAL INFRASTRUCTURE AND ADAPTATION TO CLIMATE CHANGE

| James Mulligan, Green Community Ventures

As plainly stated in the draft 2013 National Climate Assessment, “Climate change, once considered an issue for a distant future, has moved firmly into the present.” The question is no longer “is the climate changing,” but rather, “can society manage the unavoidable changes and avoid the unmanageable?” (Bierbaum et al. 2007). In the Northeast, Midwest, and Great Plains, very heavy precipitation has increased over the past century and heavy downpours have led to flooding events and accelerated erosion and exceeded the capacity of built infrastructure. The drought in western states over the last decade represents the driest conditions in 800 years (Karl et al. 2009; Schwalm et al. 2012). And in the Northwest, changes in timing of snowmelt and associated streamflow have already been observed reducing summer water supplies. In some areas, the increase in severe high temperature days in combination with dry air mass events—as well as fuel changes, successional growth, exotic invasive species, insect and disease, longer fire seasons, and more severe episodic drought—is contributing to an increase in wildfire frequency and intensity in the Intermountain West (Sexton 2013). Indeed, eleven of the twelve largest fires in modern U.S. history have occurred since 2004 (Sexton 2013).

In addition to these clear water quantity impacts, air and water temperatures, precipitation intensity, droughts, and wildfire all affect source water quality as well in the

form of increased sedimentation, nitrogen, and pollutant loads, and decreased lake mixing, reduced oxygen in bottom waters, and increased length of time pollutants remain in water bodies (National Climate Assessment 2013). These water-related climate impacts have serious implications for communities.

Given these impacts, the need is clear to maintain healthy upstream ecosystems. The ability of forests to reduce peak storm flows, maintain snowpack, and filter sediment, nutrients, and other pollutants is an essential “first line of defense” against the extreme events expected to increase in frequency and intensity as the climate changes. Given the multiple benefits associated with healthy ecosystems, natural infrastructure can represent a “no regrets” adaptation strategy for downstream communities.

At the same time, however, investors in natural infrastructure must have an understanding of how a changing climate may impact the water-related functions of targeted natural ecosystems. Impacts like changing species composition and increasing incidence of disturbances like wildfire, insects, and disease can affect the water-related function of upstream ecosystems, potentially requiring additional and ongoing management interventions.

- Multi-layered forest canopies have more interception (Brooks et al. 2003; Briggs and Smithson 1986), greater photosynthetic area, and deeper roots than other plant communities, and so promote greater evapotranspiration and thus soil water deficits (de la Crétaz and Barten 2007). The forest litter layer promotes infiltration of water into the soil and provides a barrier that slows downslope water movement (Dudley & Solton 2003). These characteristics, together with the very high infiltration rates of forest soils created by complex pore structures, minimize stormflow peaks and render overland flow and associated erosion unlikely for all but the most intense storm events.
- This subsurface flow minimizes sediment and pollutant delivery to streams and gives ample opportunity for nutrient uptake by plants and microbes in the soil (de la Crétaz and Barten 2007; Bormann and Likens 1979; Vitousek and Reiners 1975). Sediment delivery to streams contributes the majority of total suspended solids, five-day biochemical oxygen demand (BOD), total nitrogen, and total phosphorous in the nation’s waterways (Gianessi et al. 1986 from Freeman et al. 2008).

- In the Pacific Northwest, the forest canopy can minimize the impact of rain-on-snow events through interception. Additionally, as snowmelt is most sensitive to temperature and wind speeds (van Heeswijk et al. 1996), lower wind speeds beneath forest canopies reduce the contribution of snowmelt to runoff from forested areas (Marks et al. 1998).

See NRC (2008), Ice and Stednick (2004), and LaFayette (2012) for more review of current scientific understanding in the field of forest hydrology.

Moreover, there is a body of literature examining correlations between forests and downstream water quality. Freeman et al. (2008) profiles a number of these statistical findings. For example:

- In a U.S. Geological Survey (USGS) study of nutrients in undeveloped watersheds (mostly forested), Clark et al. (2000) found that forests “produced the best water quality in the country” (Wear and Greis 2002).
- In a large-scale watershed study analyzing 16 river mixed-use basins in the Northeast, Boyer et al. (2002) found that nitrogen loading decreased as the percentage of forested land increased (de la Crétaz and Barten 2007).
- In a study of Ontario watersheds, Sliva and Williams (2001) found that forested lands were important in mitigating water quality degradation (Gabor et al. 2004).
- Houlahan and Findlay (2004) found a negative correlation between stream nutrient levels and forest cover over 2000 meters upland from the stream.
- Freeman et al. (2008) found statistically significant relationships between forest land cover and indicators of water quality—affirming that land cover within a drinking water source area can be an indicator of water quality at a drinking water intake.

Water Flow Effects of Forest Conversion & Disturbance

When forest vegetation is cleared, the effects on water yield and peak flows are commensurate with the scope and scale of clearing. Cutting trees and thus reducing transpiration will cause an increase in water yield primarily during the growing season, during which transpiration would be greatest (Hornbeck et al. 1997). Reduced transpiration and interception allow soil moisture to increase, generally causing greater increases in baseflow than stormflow (Hornbeck et al. 1995). However, poorly planned logging roads can channel water more quickly to streams and cause increases in peak flows (see, e.g., Wemple and Jones 2003; NRC 2008). In the Pacific Northwest, snowmelt and runoff due to rain-on-snow events are substantially higher in cleared areas than in forested areas and can increase the potential for flooding. Higher wind speeds in cleared areas relative to beneath forest canopies can exacerbate the contribution of snowmelt to runoff (Marks et al. 1998).

Decades of paired watershed studies indicate that approximately 25 percent of basal area must be removed before noticeable increases in water yield occur (Hornbeck et al. 1995). However, persistent and substantial increases in water yield will occur if the forest is prevented from regrowing (Hibbert 1967; Hornbeck et al. 1995; Hornbeck et al. 1997). The level of increase can be related to factors such as slope and aspect (Hibbert 1967) and dominant forest type (coniferous vs. deciduous). Generally, conversion of forest to shallow-rooted plants or agricultural crops—either row crops and pasture or forage—will result in less “use” (transpiration and interception) of water and thus will increase water yield (see, e.g., Patric and Gould 1976; Verry 1986). This can be problematic for communities in flood-prone areas. However, such water yield increases are typically small and short-lived, and are less in dry years and dry areas when water is needed most by communities facing drought (Jones et al. 2009). Moreover, potential increases in water yield due to forest conversion are likely to be offset by concurrent deleterious effects such as declining water quality.

Tilling the soil for agricultural purposes both homogenizes the pore structure and can tend to form a “plow pan”—a layer of hard soil. Thus, the soil loses the elements that give forests a very high infiltration capacity—the macropores, intermixed soil particle sizes, and litter layer—and the plow pan reduces the percolation and downward movement of water through the soil profile. This increases the ratio of stormflow to baseflow (de la Crétaz and Barten 2007), which can have effects on flood frequency, stream temperature, and ultimately stream fauna. While the draining of wetlands for agricultural use is an increasingly rare practice, the cumulative alteration of wetlands for agricultural and urban land uses can affect the timing of streamflow at a magnitude greater than their size alone would indicate (O’Brien 1988).

Conversion of forests to urban land uses can also affect water flow. It is a common assumption that increases in imperviousness associated with urbanization result in an increase in the ratio of stormflow to baseflow. Impacted soil loses some of its sponge-like ability to slowly soak up and release water during storms, which can increase flooding and scouring. Impervious surfaces (e.g., roofs, driveways, and roads) increase the velocity of surface flows and scouring of the stream channel (Freeman et al. 2008). Schueler (1994; 2003) found that hydrologic functions begin to change when impervious surfaces cover a threshold of 5–10 percent—and can change dramatically above a 25 percent threshold (Braden and Johnston 2004 from Freeman et al. 2008). Walsh et al. (2005) describe the set of negative impacts from urbanization, such as increased flashiness and peak flows, as well as increased nutrients, as “urban stream syndrome” (Freeman et al. 2008).

While it is commonly assumed that urbanization can have the effect of reducing baseflow, some recent studies (Konrad and Booth 2002; Meyer 2002) have found that this expected inverse relationship may not be as clear as once thought. Brandes et al. (2005), for example, found few watersheds that exhibited a pattern of decreasing baseflow as population density and associated area of impervious surface increased. They posit that leaky sewer pipes, treated water stream discharges, ground water pumping, and concentration of storm runoff allowing infiltration at a higher rate can

interact in a complex manner to complicate the effect of urbanization on baseflow and stormflow.

In addition to conversion, increasing incidence of unnatural, catastrophic wildfire in western lands can prime a watershed for dramatic surges in peak flows. Post-fire peak flows have been documented to be up to 900 times greater than the unburned reference case for up to 15 years after a fire, when rainfall surpasses a certain threshold (Martin 2013). The USDA Forest Service expects a five-fold increase in wildfires by 2050, as a result of a series of factors including more severe episodic drought and longer fire seasons due to climate change (Sexton 2013).

Water Quality Effects of Forest Conversion & Disturbance

Sediment (Patric 1976) and nutrient yields (Ice and Binkley 2003) from forested watersheds are naturally variable. However, logging roads and increased flows can cause erosion, both from uplands and within the stream channel itself. Agricultural and urban lands have both been related to degraded water quality (Sliva and Williams 2001, Boyer et al. 2002 from Freeman et al. 2008). Relative to forestland, agricultural land can have nutrient concentrations nine times higher, and sediment discharges five times higher (Omernik 1977; Gianessi et al. 1986 from Brown and Binkley 1994).

Changes in flow pathways can occur from subsurface flow in forestland to overland flow in agricultural land resulting in increased sediment delivery to streams and water bodies. (see, e.g., Verry 1986; Sutherland et al. 2002). Long-term shifts in land use from forestland to agriculture and the concurrent changes in water yield and timing have effects on stream channel morphology that also cause erosion. Changes in biogeochemical cycling and use of agricultural inputs, while sometimes difficult to separate from the effects of urbanization, can also affect water quality (McDowell 2002; Beaulac 1982).

Conversion of forestlands to urban uses can cause short-term but significant increases in sedimentation during construction. An early paired watershed study found that sediment concentration downstream of construction sites without proper sediment control were up to 70 times the concentration of sediments downstream of forested and

agricultural lands (Wolman and Schick 1967; de la Crétaz and Barten 2007 from Freeman et al. 2008). Weiss (1995) cited sediment loads 1,000–2,000 times higher in uncontrolled construction areas relative to forests (Dissmeyer 2000 from Freeman et al. 2008).

Catastrophic wildfire can also disrupt the water quality-related functions of forest and cause massive sedimentation. In some cases, post-fire runoff can release potentially toxic “legacy sediments” into drinking water systems. To illustrate the scale of post-fire sedimentation issues, the City of Fort Collins is planning to spend \$24 million in sediment stabilization costs in the wake of its 2012 High Park fire (Gertig 2013).

The Bottom Line for Water Resources

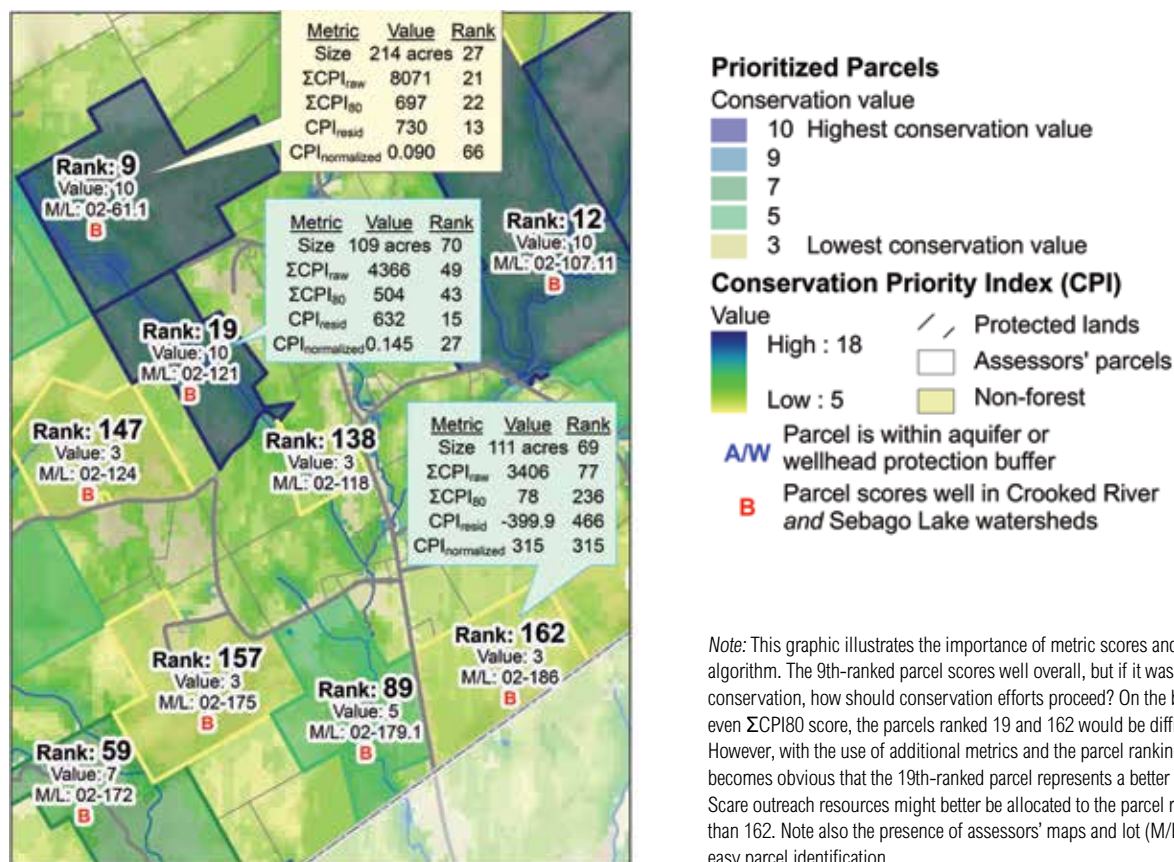
The science is clear: forests are essential for the water-related services they provide to downstream communities (Jones 2009). As forests are

converted to other land uses or are unnaturally disturbed, the benefits from forests will diminish, putting communities at risk of flood, drought, higher cost of treatment, and greater incidence of drinking water contamination. Recognizing this, in 1996, EPA amended the Safe Drinking Water Act to reflect a need for a balanced approach starting with source water protection (EPA 2007).

Prioritizing Parcels—The Conservation Priority Index

A key step in getting a natural infrastructure investment program to “investment readiness” is understanding of where conservation and restoration activities on the landscape can have the greatest impact for water resources. Parcels in a watershed can be objectively prioritized based on importance for water resources (Figure 5). Yet, all too often land conservation proceeds in an opportunistic and haphazard manner. The tool described here prioritizes watershed land parcels in terms of importance

Figure 5 | Illustration of Parcel Prioritization



Note: This graphic illustrates the importance of metric scores and the parcel ranking algorithm. The 9th-ranked parcel scores well overall, but if it was unavailable for conservation, how should conservation efforts proceed? On the basis of size and even ΣCPI_{80} score, the parcels ranked 19 and 162 would be difficult to distinguish. However, with the use of additional metrics and the parcel ranking algorithm, it becomes obvious that the 19th-ranked parcel represents a better conservation value. Scare outreach resources might better be allocated to the parcel ranked 19, rather than 162. Note also the presence of assessors' maps and lot (M/L) numbers for easy parcel identification.

Table 4 | **CPI Inputs Used for Crooked River Watershed**

LANDSCAPE CHARACTERISTIC	WHY IS IT IMPORTANT?	INCREASING IMPORTANCE			DECREASING IMPORTANCE
		3	2	1	0
Land use	Forests provides the best protection of water resources of any land cover.	Forest/wetland	—	—	All others
Distance to streams (feet)	Forests provide shade, organic matter, and woody material while they absorb nutrients and trap sediment. The “riparian forest buffer” has a major influence on streamflow and water quality.	0 to 100	100 to 200	200 to 300	> 300
Distance to ponds/wetlands (feet)		0 to 100	100 to 200	200 to 300	> 300
SOILS (1/2 WEIGHT): Depth to water table	If forests are removed more water enters the soil. If the shallow water table reaches the surface it can lead to overland flow and erosion.	shallow	intermediate	deep	—
SOILS (1/2 WEIGHT): Permeability	This is the rate at which water flows into and through soils. Poorly drained soils can lead to overland flow and erosion.	poorly drained	intermediate	well drained	—
Slope	The rate of water flow is directly related to land slope. Steep slopes also may be less stable and more prone to erosion.	steep (> 15%)	intermediate (5 – 15%)	gentle (< 5%)	—
Water – Forest – Roads	The narrow strips of forest between roads and streams are especially important for water quality protection.	yes	no	no	no

as natural infrastructure for watershed services. This prioritization enables the program administrator to direct capital (e.g., for conservation easements, riparian buffers, or other investments) most cost-effectively across the landscape.

The Conservation Priority Index (CPI) is a component of the [Watershed Forest Management Information System](#) (WFMIS; Zhang and Barten 2009). This ArcGIS extension, which intuitively and scientifically scores and ranks the importance of forestland for water supply protection, has been refined through over a decade of use. Watershed stakeholders can develop multiple metrics, totally or in part from the CPI, to generate a list of the highest-priority forested parcels and neighborhoods

in their watershed that have the greatest potential to sustain water quality through improved management, or degrade it through conversion to other uses. This allows local experts to focus their efforts on those most influential parcels, and if necessary move on to the next in a quantitative, objective, and science-based fashion.

Moreover, the weighting of the inputs to the CPI (table 4) is flexible and can be adapted to a variety of settings and needs. For example, the slope ranges can be adjusted to common thresholds (e.g., slopes over 30 percent may need special protection regardless of how common they are), or prioritized based on their frequency of occurrence (flat, low-gradient watersheds may have an extremely small

area of steep land, resulting in a downward skewing of high-priority lands if arbitrary slope categorizations are used).

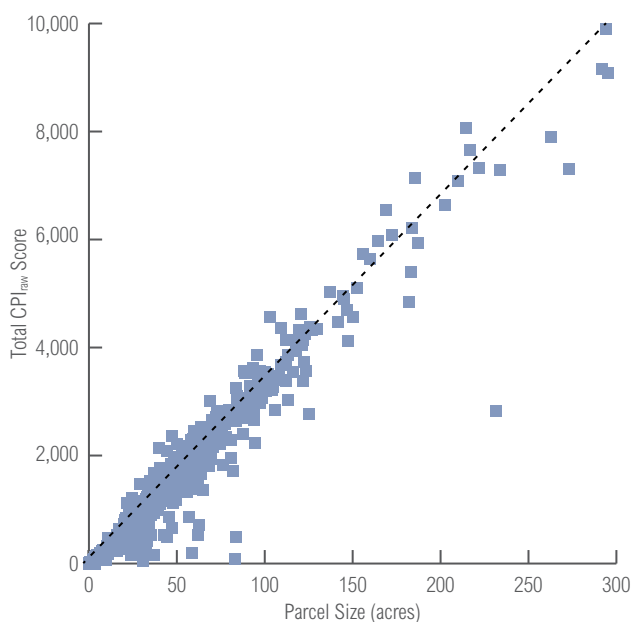
The CPI can also be useful for groundwater issues. In certain geologies, the water table is an attenuated reflection of surface elevation, and groundwater flows from areas of high elevation to low elevation. In other cases, there are regional aquifers that cross surface watershed boundaries. However, some of the same inputs to the CPI (soil permeability and land use) are especially useful in evaluating relative risk to groundwater in certain settings.

The CPI can incorporate economic and social inputs in addition to ecological inputs. The WMIS interface allows for inputs that can then be weighted and integrated into the CPI, or the user could manually add these inputs to the CPI in a simple raster-overlay process. Such inputs could include cultural, scenic, and social values developed through stakeholder consultation processes.

Development of the CPI and associated parcel prioritization is a valuable tool for directing conservation efforts. Raw data inputs are generally available free from national and state Geographic Information System (GIS) data repositories; and while the WMIS (which includes CPI) is an extension to ArcGIS—not inexpensive software—the analysis could also be performed as a raster overlay in an open-source GIS. The basic development of the CPI—acquisition and pre-processing of the GIS data and input scoring—along with validation of results, would take an intermediate GIS user up to one week to accomplish. Associated parcel and block prioritization, and collaborative integration with the goals of local cooperators (land trusts, watershed coalitions) and development of comprehensible maps might take up to another week for development and refinement. See Box 7 for additional detail on the CPI.

The CPI was used in the Crooked River Watershed, upstream of Sebago Lake in Maine. In this context, the tool not only helped to prioritize investments, but also helped the World Resources Institute to target outreach activities associated with the preliminary economic analysis described in Section 1.2. The CPI was also applied by Snohomish County, Washington, in 2012 to Snohomish Basin

Figure 6 | Illustration of Parcel Prioritization



as part of an effort to assess the viability of using payment-based mechanisms to encourage private landowners to protect forest cover on their properties and address issues related to stream flow, channel stability, and aquatic habitat. The CPI and the Washington State Department of Ecology Watershed Characterization (WC) were used to prioritize 268 subbasins within the Snohomish River watershed and the CPI was used to prioritize 288 parcels within a pilot subbasin. HSPF hydrologic modeling (see Section 2.4) was performed in the pilot subbasin to evaluate how forest cover retention of high-priority parcels affects stream flows and its processes. The developed methodology will support future efforts in the protection of working forests and ecosystem services across the Puget Sound region (Gi-Choul 2013, pers. comm.).

While the CPI does not estimate quantitative water resource outcomes, overall it represents a very modest investment in return for a means of directing scarce time and resources to the forestland most influential in the provision of clean water.

BOX 7 | THE CPI MODEL

The CPI is incorporated into the WFMS, but the analysis can also be completed independent of the extension as a raster overlay process. Due to weighting and scoring rules, any 30 m cell of forest or forested wetland could receive a CPI score (called CPI_{raw}) between 5 and 18. On the low end, a parcel would receive 3 points for forest, ½ point for a deep water table, ½ point for being well drained, and 1 point for a gentle slope (if >300 feet from a water feature, no points are allotted for “proximity”). On the high end, only a small number of grid cells will be forest land with steep slopes, immediately adjacent to streams, with silt or clay soils that are frequently saturated, and would yield a score of 18 (Table 4). Once the CPI_{raw} score is assigned, the 80th percentile and higher (top 20 percent) are extracted for further analysis in an index called CPI_{80} .

The GIS was used to calculate the sum of CPI_{raw} and CPI_{80} from all grid cells within each parcel to create parcel-level metrics called ΣCPI_{raw} and ΣCPI_{80} . Figure 6 shows the strong statistical relationship between the area of the parcel and total CPI score. More importantly, it shows that because of differences in their location, soil properties, and terrain features, some parcels at any given size are clearly more important for water supply protection. Losing forest on high-scoring parcels to development would be the most damaging to streamflow and water quality. These two parcel-level metrics were combined with two other metrics—the residual from the relationship in Figure 6 (CPI_{resid}), and the area of the parcel in the watershed—and parcels were ranked in descending order by their score for each metric. Across the Crooked River watershed the parcels ranking in the top 5 percent for multiple metrics received the highest score. The next priority was assigned to the parcels scoring in the top 15 percent, and so on as in Figure 7. The owners of the highest-ranking parcels are identified for initial outreach and conservation efforts, to ensure that scarce resources are focused on parcels with the greatest contribution to water supply protection (Figure 5).

When GIS tax parcel data are not available, or if additional analysis is warranted, roads, town boundaries, or water district or common well-head boundaries can be used to subdivide the watershed into neighborhoods to guide the outreach process. This creates groups of potential ownerships within which landowners often communicate with each other. The sum of CPI_{80} cells within these neighborhoods was calculated (the highest-quality forest land is identified), and then the Integrated Climate and Land Use Scenarios (ICLUS) data were used to identify neighborhoods with greater development pressure. In this manner, neighborhoods with the most valuable forest resource, under the most pressure for development, were identified. Local conservation experts can leverage existing contacts within these neighborhoods using place-based conservation efforts to better focus efforts and resources.

Needed data for the CPI include:

- Watershed boundary shapefile from the USDA Natural Resource Conservation Service (USDA NRCS) Watershed Boundary Dataset (WBD).
- Slope (derived from elevation) from the USGS Seamless Data Warehouse at 30 m resolution.
- Land use/land cover from the 2001 National Land Cover Database (NLCD)—more recent data now available.
- Hydrography (linear: streams, rivers) from the USGS (2009) (National Hydrography Dataset [NHD] high-resolution—1:24,000 scale); used to represent linear and areal surface water features. Note: the NHD may under-represent lower-order streams (see, e.g., Brooks and Colburn, 2011), and the tradeoffs between regional consistency (of national datasets) and potentially more accurate local datasets should be weighed carefully.
- Hydrography (areal: lakes, ponds, wetlands) from a combination of the NHD and the National Wetland Inventory (NWI; U.S. Fish and Wildlife Service, 2009) to ensure a complete representation of surface water bodies.
- Roads (a principal source of sediment) from a combination of three Maine-specific GIS roads datasets to ensure as complete a representation of roads as possible. In multi-state analyses, TIGER/Line data available from the U.S. Census Bureau would be a logical choice to ensure consistency and alignment.
- Soils from a combination of large scale ($\pm 1:24,000$) NRCS SSURGO data with coarser scale (1:100,000) STATSGO where necessary for complete soils coverage. Data were incorporated into the WFMS through NRCS’s Soil Data Viewer (SDV, 2008), a free program that simplifies the process of summarizing the necessary soil characteristics, permeability, and depth to water table.
- Parcel data and conserved lands from Maine-specific GIS data. Without these data, the analysis is limited to prioritizing broad regions or “blocks” coinciding with likely ownerships (bounded by roads and town lines). Data were manually reviewed to identify “non-parcels” such as roads and water bodies, a potentially time-consuming process. Because of economies of scale associated with working with the owners of larger parcels, only parcels greater than 20 acres were considered.
- Projections of future housing density (e.g., projected housing density in 2050 minus actual density in 2000) from the EPA for its ICLUS program (2009).

Note that the accuracy of the CPI relies on the accuracy of underlying data. Though the accuracy of needed data files has improved in recent years—and that trend is likely to continue—results should be ground-truthed before investments are made.

Section 2.2: Forest Practices and Water Resources

| Jodi Schoenen, Portland State University
| Nikola Smith, USDA Forest Service

The manner in which forests are managed can have a significant impact on ecosystem function and valued benefits. This section shares basic principles of watershed function from a forest management perspective.

Forestry Best Management Practices

Watershed function can be enhanced or degraded by timber harvesting and other management practices that impact the hydrologic regime, fish and wildlife communities, and vegetation (Hornbeck and Reinhard 1964, Corbett et al. 1978, Martin and Hornbeck 1994, Alexander et al. 2007). Forestry activities can impact downstream water quality

through biomass removal, soil compaction, and forest roads. The former two typically have a short-term effect, while forest roads can have a major and more permanent effect—accounting for up to 90 percent of all the sediment produced in forestlands, for example (Beasley and Granillo 1988; Marion and Ursic 1993; and Blackburn et al. 1990 from Azevedo et al. 2005.; Grace 2002). Overall, research indicates that effective implementation of forestry best management practices (BMPs)—e.g., maintaining forested buffers on streams and designing stream crossings and forest roads to minimize sedimentation from storm events—can reduce water quality impacts from 80 to more than 99 percent (Ice et al. 2004). For example, forested riparian buffers normally retain 80 percent of sediments that might otherwise be delivered to streams (de la Crétaz and Barten 2007).

Watershed structure and function includes not only the regulation of water quality, quantity, and timing of flow, but also maintenance of productivity and health of terrestrial and aquatic ecosystems (Hornbeck and Kochenderfer 2004). The literature strongly supports that structure and function is promoted through adoption of forest practices that maintain adequate infiltration within the system, minimize conversion of forest land to other land uses, and minimize inputs to streams and rivers through establishment of riparian buffers and forest road best management practices (Ice and Schilling 2012).

Best management practices are typically prescribed by the state and vary across jurisdictions based on ecological context as well as political factors. Generally, prescribed practices relate to design and maintenance of forest roads and stream crossings, maintenance of riparian buffers, application of chemicals relative to streams, and harvest and road activities on unstable slopes. In some states, prescribed BMPs are voluntary, while in other states they are required by state law—however, implementation rates across all states are typically high (i.e., greater than 80 percent). While BMPs have been found to be generally effective at the local scale, regardless of jurisdictional differences in prescriptions (Ice and Schilling 2013), little research has investigated the effectiveness of the current suite of BMPs from a cumulative effects standpoint (Jones et al. 2009). In some watersheds, stakeholders are investigating the merit of providing incentives to

BOX 8 | UNDERSTANDING BIOPHYSICAL CONDITIONS THROUGH WATERSHED ASSESSMENTS

Land managers and practitioners can conduct site-specific watershed assessments that (1) address how climate, soil type, vegetation conditions, geology, and topography affect water movement on the landscape, and (2) identify existing or potential sources of impairment to water quality such as runoff from roads, unstable slopes, and development pressure—including geographic locations of those threats. In some cases, the scale of these factors and relevant ecological processes may cross land ownership boundaries. For example, the cities of Fort Collins and Greeley, Colorado, face a suite of drivers of source water quality degradation across a variety of landownership types—from catastrophic wildfire and forest roads on both public and private forestland to livestock feeding operations on private ranchland. A collaborative, landscape-scale approach to watershed analysis can improve understanding of the system and potential management actions needed to sustain it. Given that many land managers, municipalities, and conservation organizations are charged with sustaining intact, resilient forests that provide a range of benefits to people, it is useful to apply an integrated approach that addresses water quality and supply as well as fire and flood risk reduction, aquatic habitat restoration, recreation, and other values (Schmidt and Batker 2012).

BOX 9 | MODELING FORESTRY MANAGEMENT PRACTICES

| Charles Governali, World Resources Institute

Recent developments in the modeling field have broadened the possibilities for modeling the benefits of specific forestry management practices. For example:

- The Agricultural Policy/Environmental eXtender (APEX) model (Williams et al. 2000, and see Gassman et al. 2009) is a small-watershed-scale model with strong BMP modeling abilities (Borah et al. 2006) and recent improvements for forestry applications (Saleh et al. 2004, Azevedo et al. 2005), allowing assessment of the impact of specific forestry practices.
- A platform called SWAPP has been created to integrate APEX with a broader watershed model (SWAT) in order to offer a large-watershed-scale modeling system with spatially explicit processes and strong performance in BMP analysis (Saleh 2004).
- The Water Erosion Prediction Project (WEPP) is another small-watershed-scale model (USDA-ARS National Soil Erosion Research Laboratory 1995, and see Flanagan et al. 2012), which has undergone development specifically for modeling forest roads and their watershed impacts (Elliot et al. 1999). WEPP has been hybridized with a broader watershed model (HSPF) to provide a more comprehensive modeling system that that can be used for large-scale projects (Imhoff et al. 2010).

SAMPLE FORESTRY BMPS ADDRESSED BY WATERSHED MODELS OR VIA HYBRID MODELING SYSTEMS*

BMP CATEGORY	SPECIFIC BMP FOCUS	MODELING OPTIONS	SOURCES
General / Spatial Planning	Spatial arrangement of various LULC types, especially in relation to the channel network	APEX, WEPP	Gassman et al. 2009; Flanagan et al. 2012
SMZs	Forested buffers (general)	APEX, HSPF (crude)	e.g., Azevedo et al. 2005, Saleh et al. 2004; Shoemaker et al. 2005, and e.g., Liu and Tong 2011.
Forest Roads	Road slope, siting, and density (general)	APEX (crude), WEPP	e.g., Saleh et al. 2004; Elliot 2004
	Road surfacing	WEPP	Elliot and Foltz 2001
	Drainage systems (incl. fillslope erosion/deposition)	WEPP	Elliot et al. 1999
Timber Harvesting / Stand Mgmt	Harvesting (general)	APEX, [GWLF & SWAT (crude)*]	e.g., Saleh et al. 2004, Azevedo et al. 2005; Dissmeyer and Foster 1984
	Thinning	APEX+HARVEST	e.g., Azevedo et al. 2005
Revegetation / Stabilization	Mechanical site preparation	APEX, [GWLF & SWAT (crude)**]	Gassman et al. 2009, e.g., Saleh et al. 2004; Dissmeyer and Foster 1984
	Herbicide application	APEX	e.g., Wang et al. 2007
	Burn operations	APEX	e.g., Saleh et al. 2004
	Vegetation regrowth (general)	APEX, SWAT, WEPP	Saleh et al. 2004; Gassman et al. 2007; e.g., Dun et al. 2009

Notes: *Not intended to be an exhaustive listing of BMPs or modeling options for any given BMP; **Possible via manual manipulation of LULC-type parameters in their erosion module using values outlined in a guide to forest erosion prediction by Dissmeyer and Foster (1984). See Section 2.4 for more information on watershed modeling.

High-level Strategies Underlying Forest Practices:

1. Maintain adequate infiltration within the system;
2. Minimize conversion of forest land to other land uses; and
3. Minimize inputs to streams and rivers through riparian buffers and forest road BMPs.

landowners to implement more stringent practices than are prescribed by the state (i.e., wider riparian buffers or more restrictive practices on unstable slopes). Box 8 discusses the watershed assessment approach to identifying potential natural infrastructure interventions, and Box 10 discusses the importance of coordinating natural infrastructure efforts across the site-, region-, and landscape-level scales within a watershed.

Complexity and Uncertainty

The effectiveness of a particular forest practice is influenced by a variety of factors, including soil type, geology, fire, weather patterns, species composition, and management history, among others

(Black 2004). Complexity at the landscape level is a significant research challenge and limits the ability to quantify hydrologic function in relation to specific management practices (Hassan et al. 2005). This challenge is compounded with attempts to develop long-term cumulative effects or combined effects of multiple disturbances over space and time (Hornbeck and Kochenderfer 2004).

In other words, while the principles of forest hydrologic responses are well-established (Jones et al. 2009) and the direction of impact is clear, precise predictions of the magnitude of benefits resulting from management practices are challenging (Hassan et al. 2005, Ice et al. 2004, Hornbeck & Kochenderfer 2004, Jackson et al. 2004). While studies of basic processes at research station scales over short time periods are fundamental to the interpretation of results from experimental watersheds in a particular region, there remain considerable research gaps for producing models that are useful to policy advocates of market approaches to ecosystem services (Hassan et al. 2005).

Still, models have been successfully applied to approximate the impact of a variety of forest management practices on water resources in a quantitative fashion (e.g., La Marche and Lettenmaier 2001, Saleh et al. 2004, Azevedo et al. 2005, Liu and Tong 2011). See Box 9 and Section 2.4 for more detail on watershed models.

Where do we go from here?

Forested systems are complex and must be managed according to their unique characteristics. Still, the principles described above can be applied within the context of that complexity and uncertainty. While it is challenging to transfer research findings across landscapes, the scientific literature in this area of research is extensive and resoundingly supports the general effectiveness of best management practices for safeguarding the water resources benefits of forests. Understanding the relative costs and effectiveness of various practices and the importance of specific parcels within a watershed can help practitioners to target natural infrastructure investments efficiently.

BOX 10 | A SEAMLESS QUILT OF NATURAL INFRASTRUCTURE

| William L. Allen III, The Conservation Fund

First coined in the mainstream by President Bill Clinton's Council on Sustainable Development in 1999, the term "green infrastructure" (or natural infrastructure, as referred to in this guide) is salient to many because it represents the foundational importance of the environment to the continuance and growth of a community. Since the term resonates with constituents across multiple disciplines, we must ensure it does not become meaningless through excessive breadth or malleability. Commonly accepted definitions emphasize the interconnected network concept and are mostly differentiated by the scale at which natural infrastructure planning is implemented. What is ultimately needed is a seamless quilt of planning and implementation across scales and jurisdictional boundaries. Toward that end, an operational framework with three scales—landscape, region, and site—can be used to guide natural infrastructure implementation.

Landscape-scale natural infrastructure is based on the principle that landscape attributes should be the basis for land-use planning. Natural infrastructure network design, springing from landscape ecology and conservation biology, exemplifies that principle. Natural infrastructure network design consists of a system of core areas, corridors, and hubs that provide essential habitat to endangered and threatened species and connect with broader natural functions and processes at the ecosystem scale. Core areas contain functioning natural ecosystems and provide habitats for native plants and animals that meet a minimum size threshold based on landscape conditions. Hubs are aggregations of core areas, other habitat, and other natural land that support native species, and serve as an interface between ecological areas,

working landscapes, and the built environment. Corridors are linear landscape features that allow for wildlife movement between core areas. As a guide to natural infrastructure network design, practitioners reference habitat preferences of umbrella and keystone species. Umbrella species are those whose habitat needs overlap with those of other species, while keystone species are those with a critical role in ecosystem function, such as pollinators or top predators. At the landscape scale, implementation focuses on land acquisition and adaptive land management by public and private landowners to preserve critical habitats as well as ecosystem processes and functions. An example of landscape-scale implementation is America's Longleaf Initiative, which focuses on restoration of functional, viable longleaf ecosystems for ecological, social, and economic benefits.

Region-scale natural infrastructure bridges landscape and site-scale and is often implemented within recognized jurisdictions to inform strategic, regional land-use and transportation plans and ensure land conservation.

Site-scale natural infrastructure is usually categorized under low-impact development and urban-scale watershed protection. While site-scale implementation can serve landscape-scale functions, it can often stand on its own merits in terms of site-scale natural infrastructure benefits, with economic savings over traditional, built infrastructure.

Best-practiced natural infrastructure attempts to connect and coordinate planning and implementation across all three scales—landscape, region, and site.

Section 2.3: Prioritizing Forest Management Practices

| Ethel Wilkerson and John Gunn, Manomet Center for Conservation Sciences (Current Affiliation: Spatial Informatics Group – Natural Assets Laboratory)

There are several examples across the United States and around the world of informed decision making based on evidence that supports the direction of impact (positive or negative) and indicators of cost-effectiveness. Adaptive management can then be used to adjust investments based on monitoring results. In this section, we demonstrate how five forestry BMPs can be ranked based on benefits to clean water, aquatic habitat, and associated ecosystem services, as well as estimates of the financial costs of applying these practices on forestland. The practices

evaluated are: (1) use of temporary bridges on skid trails;³ (2) road and stream crossing monitoring and maintenance on an annual basis and periodic larger repairs for 15 years post-construction; (3) installation of appropriately sized culverts to ensure proper function under projected flow conditions; (4) creation of a harvest plan and implementation of on-the-ground planning and communications; and (5) establishment of low-impact riparian management zones. These are the types of practices included alongside reforestation and easements in the green-gray analysis conducted for Portland, Maine (Section 1.2). The results presented here are specific to North-eastern U.S. forests, although the general approach has broader relevance.

Table 5 | **Summary of Practice Costs and Benefits of Improved Forest Management Practices**

PRACTICE	REDUCE SEDIMENT	PROTECT AQUATIC HABITAT	PROTECT OTHER ECOSYSTEM BENEFITS	ASSOCIATED COSTS
Temporary bridges on skid trails	HIGH	HIGH	HIGH	LOW \$4,500 or \$75/harvest
Road and stream crossing monitoring, maintenance on annual basis, and periodic larger repairs for 15 years post-construction	HIGH	HIGH	HIGH	MODERATE \$9,400/15yrs or \$627/yr
Installation of culverts properly sized for projected flow conditions	HIGH	HIGH	HIGH	MODERATE to HIGH ^a 25–141 percent increase in materials cost
Harvest plan and on-the-ground planning and communications	HIGH	HIGH	HIGH	MODERATE \$1,300/harvest
Low-impact riparian management zones ^b				
75ft, 40 percent timber volume removal	HIGH	MODERATE	MODERATE	MODERATE \$231/acre of RMZ
75ft, no timber volume removal	HIGH	MODERATE	MODERATE	HIGH \$584/acre of RMZ
150ft, 40 percent timber volume removal	HIGH	HIGH	HIGH	HIGH \$692/acre of RMZ
150ft, no timber volume removal	HIGH	HIGH	HIGH	HIGH \$1,152/acre of RMZ

^a Cost category varies by width of culvert

^b Cost estimates were adapted from LeDoux and Wilkerson (2006)

The Approach

Environmental benefits can be evaluated based on the effectiveness of a practice to: (1) prevent or reduce sediment flow to water bodies; (2) prevent or reduce the degradation of aquatic habitat (e.g., stream temperature regimes, supplies of coarse woody debris to stream channels, and populations of macroinvertebrates, periphyton, and fish); and (3) protect or enhance other ecosystem benefits (e.g., terrestrial habitat, landscape-level biodiversity, timber management, recreational access, or recreational fisheries). With a scientific literature review, practices can be scored (low, moderate, high) based on authors' confidence that the practice can prevent or reduce negative impacts or enhance ancillary benefits.

Determining the costs of timber harvesting and land management activities is extremely complex and can be highly variable depending on local conditions. Instead of attempting a comprehensive and potentially inaccurate cost estimate for each practice, the study focused on estimating the portion of the cost associated with the practice that was additional or incremental to "business as usual" management strategies. Costs considered include those associated with planning (design, engineering, and pre-harvest prep work), implementation (materials, labor, and other costs associated with applying the practice on the ground), monitoring and ongoing costs (post-harvest activities including follow-up visits, regular monitoring, and routine maintenance), and lost landowner revenue (lost timber value, short- or long-term reductions in the allowable harvest volumes, or other lost opportunity costs). Cost estimates were derived from quotes for materials and labor, computer modeling of operation and stumpage costs, and an expert panel of forests. Scoring criteria and cost estimates are detailed in Wilkerson and Gunn (2012).

Results

The cost and benefit evaluations for each practice are summarized in Table 5 above.

- Temporary bridges on skid trails emerged as an affordable and highly effective way to maintain clean water and aquatic habitat and related ecosystem benefits. Federal and state agencies promote adoption of this practice through



free 'loaner' bridges and cost-share grants. Supplementing existing programs or providing additional funds to individual landowners or contractors should be a priority for any payment for watershed services program.

- Funding a road and stream crossing monitoring and maintenance over the long-term, and installing appropriately sized culverts scored high in protecting aquatic resources but with moderate to high costs to landowners. If incentive funding and potential buyers are limited (as is typically the case), natural infrastructure investment programs should prioritize forest parcels that play a significant role in the protection of clean water. Characteristics of these parcels may include: proximity to water bodies and wetlands, steep topography, poorly drained and wet, sensitive, soils and location between road networks and water bodies. The Conservation Priority Index (Section 2.1) is an example of a GIS tool that provides a framework to identify parcels with high value in terms of protection of clean water.

- Harvest planning and on-the-ground planning and communications scored high in protecting water resources but with moderate costs to the landowners. Professional foresters and loggers provide valuable knowledge and skills that benefit not only the protection of clean water but also the long-term value of land and timber resources. Involving professional foresters and logging contractors is critical to the success of any financial incentives program.
- Establishing low-impact riparian management zones (RMZs) that prevent or restrict harvesting activities near water bodies was shown to be a moderately to highly effective strategy to protect aquatic resources. Both the benefits and costs of this practice increased with the width of the RMZ. This analysis found that partial harvesting within RMZs can provide the benefits to the water resource while allowing landowners to realize some of the financial benefits of the timber resources contained within these areas. Any incentive program should permit management within RMZs with acknowledgement that careful planning and harvest design may be more critical to protecting water resources than specified buffer widths.

Summary

Applying forestry practices that protect or enhance aquatic resources represents a cost to the landowner and exact benefits are often difficult to quantify. Therefore, an efficient natural infrastructure investment program should prioritize practices across the landscape based on costs and approximate expected benefits. The cost and benefits rankings provided here for common forest management practices can serve as guidance for that purpose in Northeastern forests, while the general approach can serve as a model to be replicated in other forest types.

Section 2.4: Watershed Modeling

| Charles Governali, World Resources Institute
| James Mulligan, Green Community Ventures

Predictive watershed models draw on current scientific knowledge of the relationships between various ecological factors and water resources to approximate quantitative impacts from various natural infrastructure interventions through multiple simulations. Once validated and calibrated to different watershed conditions, these models can greatly advance our ability to make quantitative predictions about the impact of natural infrastructure on water resources in a particular watershed. While the majority of cases of watershed investment have not relied on detailed watershed modeling, the field is advancing and can improve the basis for decision making. See Box 11 for sample applications of watershed models.

Watershed modeling currently offers relevant, credible, reasonably accessible, and useful tools for making quantitative predictions in a wide variety of regions and watershed conditions, on the annual to multi-decadal timescale relevant to investment decisions. Existing models are well developed for predicting the impacts of land cover change on water quality, quantity, timing, and distribution within watersheds. Existing models can also serve to predict the individual and cumulative impacts of various management practices across watersheds, especially for agricultural and urban BMPs, and increasingly for forestry BMPs.

General Limitations of Modeling

On the whole, the application of quantitative watershed modeling to natural infrastructure investment decisions faces the following limitations:

1. First and foremost, even excellent models cannot explain some proportion of the variation in water quantity and quality measures. Optimistically, the best models often do not capture 20–40 percent of variation⁴ for annual predictions (performance tends to improve for multi-annual to multi-decadal predictions);

2. Substantial resources in the form of both expertise and personnel hours are still required to rigorously apply the most useful modeling systems—on the upper end, typically a multi-person team for a multi-month period in order to achieve high quality implementation from scoping to secondary analyses (see, e.g., Shoemaker et al. 2005);
3. Extensive data are required, including field monitoring data to calibrate models to local conditions, to achieve the highest-quality performance, although reasonable performance can be achieved without calibration;
4. While models have the technical capacity to function in decision-making contexts, support for such non-academic (non-research-oriented) applications⁵ is sometimes poorly developed, and organized support for forest management applications of existing models is largely absent; and
5. Hybrid modeling systems⁶ that allow for the best multi-scale, comprehensive watershed analyses still need to be mainstreamed (i.e., applied and critiqued by non-developers in a wide variety of regions and contexts); and
6. While methods for conducting uncertainty analyses abound and are well developed, there is not a standardized set of analysis tools built in to modeling systems or even applied in modeling studies across the board (see Pappenberger and Beven 2006).

While assessing the impacts of land cover change is a widespread function of watershed models, strong modeling capabilities for forest management practices are restricted to a small number of modeling systems—and much development has been relatively recent. There is a large need for more widespread testing of these capabilities, development of a more substantial body of support literature, and enhancements to the structure of modeling software programs to facilitate those approaches and analyses best suited to forest management applications. Another significant limitation of some of the most used and tested models, in the context of natural infrastructure investment applications, is the lack of spatial explicitness in the representation of the land

BOX 11 | SAMPLE WATERSHED MODEL APPLICATIONS

The potential value of watershed modeling to guide natural infrastructure investments is well illustrated by several examples from the literature. A few are described here:

- Cerucci and Conrad (2003) used the Soil and Water Assessment Tool (SWAT) and the Riparian Ecosystem Management Model (REMM) to determine optimal riparian buffer configurations to minimize pollution in south central New York's 37 km² Town Brook watershed. They determined the marginal utility of buffer widths and the most affordable parcels in which to establish riparian buffers.
- Azevedo et al. (2005) used a modified version of APEX and the HARVEST landscape model in east Texas to assess the impacts of specific, SFI forestry practices (limitation of harvest unit size, a "green-up interval," and streamside management zones) on water and sediment yields, in comparison to a reference scenario without implementation of these practices. They estimated absolute differences between scenarios at different spatial scales and were able to identify riparian management zones as the practice primarily responsible for the differences.
- Pai et al. (2011) used SWAT in a 1,960 km² northwestern Arkansas watershed for spatial prioritization of subwatersheds for targeting management efforts. Prioritization was based on quantitative estimates (supported by model validation statistics) of sediment, total P, and nitrate concentrations for the 28 subwatersheds. GIS analysis showed that "the resulting priority subwatersheds comprised only 24 percent of the total area of the watershed but contributed 49 percent of sediments, 33 percent of TP, and 27 percent of NO₃-N annual average loadings." These results were supported by spatial correlations between priority subwatersheds and land cover characteristics that are expected risk factors.

cover pattern and small-scale features like forest roads. This shortcoming translates into an inability to physically represent BMPs that address the location of different land uses (and their associated pollutant sources) relative to each other and the stream network (e.g., siting of log landings).

Table 6 | Major Differences Across the HSPF, SWAT, and GWLF Models

	HSPF	SWAT	GWLF
Pollutant Transport / Fate Processes	Highly detailed	Highly detailed—somewhat less so than HSPF (see, e.g., Radcliffe and Lin 2006)	Only simple loading functions (i.e., no representation of fate of pollutants after leaving source areas; Shoemaker et al. 2005, Borah et al. 2006)
High-Profile Uses	EPA's Chesapeake Bay Program (HSPF; EPA 2010)	USDA's Conservation Effects Assessment Project (CEAP 2007, Mausbach and Dedrick 2004)	State-level TMDL work in Illinois, Virginia, and Pennsylvania (Borah et al. 2006)
Data Inputs	Requires extensive local data inputs (i.e., streamflow and water quality monitoring data) for calibration before use (Borah et al. 2006)	Can be run uncalibrated with only publicly available data (Haith et al. 1992)	Can be run uncalibrated with only publicly available data (Neitsch et al. 2011); demands fewest data inputs of the three
User Support	Well-developed interface, GIS-platform, and supporting literature for implementation ¹⁰	Well-developed interface, GIS-platform, and supporting literature for implementation ¹¹	Well-developed interface, GIS-platform, and supporting literature for implementation; ¹² however, lags behind in terms of available support

However, as discussed in Section 2.2 (Box 9), the field has recently developed new models that address some of the limitations of earlier models—including lack of spatial explicitness and modeling of forest management practices. These models tend to be less broadly applicable to natural infrastructure applications on their own, but can be integrated with the more comprehensive models to produce “hybridized models” with broader capabilities.

While there are many high quality watershed models, we profile three representative models with natural infrastructure investment applications: the Generalized Watershed Loading Function (GWLF; Haith and Shoemaker 1987), the Soil and Water Assessment Tool (SWAT; Arnold et al. 1998), and the Hydrological Simulation Program—FORTRAN (HSPF; Barnwell and Johanson 1981). These models offer a number of qualities⁷ that are important for natural infrastructure applications. All three perform well in predicting water quantity and common quality measures (e.g., total N, P, and sediment loads) at watershed outlets at annual to multi-annual time scales, when applied well.⁸

However, GWLF, SWAT, and HSPF are each best suited to quite different natural infrastructure contexts because of fundamental differences in modeling system structure and function. They vary in terms of complexity, input requirements, output spatial and temporal scale, accuracy, built-in uncertainty analysis tools, and institutional support for implementation. It is important to carefully select the best model for a given context and set of objectives. Reviews such as Shoemaker et al. (2005), Borah et al. (2006), and Moriasi et al. (2012) can provide valuable comparative information to aid model selection. Table 6 above highlights some important differences. See the Resources Section in the Appendix for additional information on these models, and discussions of more recent model hybridization and using model outputs as inputs to economic analysis. See also Box 12 for a discussion of a user friendly modeling interface developed in Virginia to serve as the basis for payments to landowners.

Even the best watershed modeling systems still face shortcomings, including resource demands and accuracy limitations. However, when coupled with uncertainty analysis,⁹ quantitative model

BOX 12 | InFOREST

| Buck Kline, Director of Forestland Conservation, VA Department of Forestry

To provide metrics to support natural infrastructure decision making, the Virginia Department of Forestry developed a web-based application known as [InFOREST](#).

InFOREST is a user-friendly interface that enables the user to input watershed scenarios, which are then run on a model housed on a Virginia Tech server. The interface currently draws on the GWLF model—discussed in more detail in Section 2.4 above. However, InFOREST is “plug-and-play”—that is, if a case is made for a better model, that model can be plugged into InFOREST. The GWLF model does not capture efficiencies gained from forestry practices (e.g., implementation of BMPs), and is not spatially explicit (i.e., the model does not incorporate where a given parcel is situated within the larger watershed). All acres of a given land cover are statistically assigned the same nutrient and sediment loading values based on the extent and type of land cover found in the watershed of project area.

InFOREST allows the user to estimate both baseline conditions and changes from baseline under a variety of scenarios for both water quality (nutrients and sedimentation) and carbon sequestration. The tool will add models for air quality and biodiversity in 2013. The user can run the tool for water quality at either the watershed level or the project level. At the watershed level, the user could input a scenario such as conversion of 1000 acres from forest to impervious surface, and the model will produce statistically discovered changes in nutrient loading and sedimentation in the watershed from baseline conditions. At the project level, the user can input a scenario such as reforestation of 200 acres of steep grade marginal pasture, and the model will produce the “delta” in terms of nutrient loading and sedimentation.

To date, InFOREST has been used to produce the data necessary to make payments to forest landowners for the water quality benefits their lands produce. The tool has also been used to identify the most impaired

watersheds—in terms of forestry land cover, nutrient loading, and sedimentation—to tailor rental payments to landowners to attract more participation in those impaired watersheds.

One of InFOREST’s recent applications has been for a payment for watershed services (PWS) program in Albemarle County, Virginia. The Rivanna River watershed is about 60 percent forested. The watershed benefits immensely from having its headwaters located within Shenandoah National Park, and mountainous terrain on private lands bordering the park has limited development there. But further downstream, development has accelerated substantially—particularly as the river approaches the City of Charlottesville.

A stakeholder advisory committee was organized and quickly realized that prioritization and targeting was needed to identify potential participating landowners, heavily impaired subwatersheds, and the forest management practices that provided the most environmental lift. This was important for two reasons: First, to most efficiently spend the limited conservation dollars available, and second, to more successfully build the business model for water utilities that demonstrates natural infrastructure is a necessary and important complement to built infrastructure.

InFOREST provided the metrics for identifying how forest cover reduced sediment and nutrient loading. This enabled the team to prioritize critical subwatersheds and set landowner payments. Payments to landowners to date have been grant-supported. However, there has been keen interest among utilities in the region in how watershed work can maintain or lower treatment costs. While those downstream water utilities that benefit from forest conservation have yet to offer up dollars themselves, an important dialogue has been started, in part with the help of InFOREST.

predictions offer a major improvement over proxy-based and other non-computational techniques for estimating returns on natural infrastructure investments. While many of the active natural infrastructure programs nationwide have not hinged on the availability of such quantitative predictions, an improved understanding of expected financial returns on investment may be critical to appeal to a broader set of water beneficiaries.

Modeling Outputs as Inputs to Economic Analysis

Overall, while limitations remain, recent progress and ongoing work in model system expansion and hybridization promise even greater applicability of watershed modeling for natural infrastructure investment decisions. While natural infrastructure economic analyses are often forced to make (conservative) assumptions about the water resources impact of a given natural infrastructure investment based on literature syntheses and proxies (see, for example, the Sebago Lake watershed green-gray analysis by Talberth et al. discussed in Section 1.2), detailed watershed modeling can produce quantitative predictions that can serve as inputs to those economic analyses.

For example, the Natural Capital Project’s Resource Investment Optimization System (RIOS) tool (still in development), is being explicitly designed to integrate natural infrastructure scoping analysis (siting and alternative investment portfolios), biophysical modeling of returns on natural infrastructure investments, and economic analysis of implementation costs and returns. RIOS will be able to incorporate biophysical outputs from multiple models (including SWAT), but will include in-house watershed modeling already in existence—components of the Integrated Valuation of Environmental Services and Tradeoffs (InVEST) toolbox¹³ (Tallis et al. 2011, Vogl et al. 2012, and Vogl, pers. comm.). Quantitative modeling with some of InVEST’s modules (for various ecosystem services) has already been applied to aid land management decision making on multiple continents (Natural Capital Project 2012). The workflow that RIOS formalizes has already been used without a quantitative model in scoping and establishment of “water fund” projects in Latin America (Vogl and Tallis 2012, Vogl, pers. comm.).

Chapter 3: Identifying Opportunity and Beginning the Conversation

MAKING THE CASE

- The Business Case
- The Scientific Underpinnings
- Identifying Opportunity

DESIGN AND IMPLEMENTATION

- Players at the Table
- Natural Infrastructure Finance

CASE STUDIES

- Cases
- Concluding Remarks

KEY TAKE-AWAYS

1. Forests are critical for the provision of clean, timely, and plentiful water. They are the source for 53 percent of the freshwater supply in the contiguous United States.
2. The opportunity for natural infrastructure is widespread. The fundamental conditions for the approach to be viable are quite basic and found in diverse watersheds across the country—healthy and degraded, privately owned and public. Assess the watershed for ecological trends causing water-related issues tied to substantial current or projected costs (Section 3.1).

Local decision maker participation is critical for success. Engage with key stakeholders and decision makers early and often to articulate a vision of success. Tailor engagement to the knowledge base and major priorities and preferences of decision makers (Section 3.2).

Introduction

Natural infrastructure programs should begin at square one with broad scoping of opportunity and early efforts to spark dialogue among key decision makers and stakeholders. The opportunity is widespread for natural infrastructure to play a cost-effective role as part of a solution set for a wide range of water-related challenges. The fundamental conditions needed for natural infrastructure to be potentially viable are found in watersheds across the country.

While the approach can be an exciting new initiative for many stakeholders, a few basic conditions must be in place in order to drive meaningful investments from water beneficiaries. It is critical that early program partners—ideally with assistance from conservation practitioners and experts—realistically assess the likelihood of success and long-term sustainability. Section 3.1 can help to guide initial thinking on this important first step.

If prospects for a viable program appear to be real, the next and often difficult step is to foster dialogue with decision makers and stakeholders. Early engagement efforts with decision makers should be careful to account for their priorities, preferences, and perceptions related to water delivery, source water management, and natural infrastructure. Section 3.2 offers some insights into the priorities and preferences of water utility managers and associated guidance for beginning conversations around approaches to water management that integrate both natural and built infrastructure components.

Section 3.1: “Hotspot” Watersheds—Identifying Opportunity

| James Mulligan, Green Community Ventures

Every watershed is different. Yet, in one way or another, everyone benefits from the services provided by natural infrastructure. Natural ecosystems provide businesses and communities—often represented by public water utilities—with a wide range of services in the form of flood control, flow regulation, reduced sedimentation of reservoirs, and enhanced water quality. Major water-related issues vary from watershed to watershed based on political, regulatory, economic, and ecological factors—but the landscape plays a consistently critical role.

While natural infrastructure plays a consistently critical role in the provisioning of critical water-related services, some watersheds have combinations of characteristics that make them particularly ripe for substantial natural infrastructure investments. These watersheds are “hotspots.” They offer salient opportunities to enhance water security and reduce costs relative to built alternatives.

This section is intended to serve as broad guidance for identifying watersheds ripe for natural infrastructure investment. The characteristics of these hotspot watersheds relate not only to ecological conditions and trends across the natural landscape, but also the economic, regulatory, and political factors at play in a watershed.

Foundational Elements

The following foundational elements make a watershed a hotspot for natural infrastructure investment:

- 1. One or more clearly identified current or projected water-related issue(s).** These issues can be purely economic—such as water quality degradation that threatens increased costs for drinking water treatment or other industrial processes. Or they can relate more directly to water security—for example, issues related to flood or drought risk like property damage, water supply shortages, a need to expand services due to a growing population, and/or loss of reservoir storage capacity due to sedimentation. These issues can also be tied to regulatory drivers, like impending loss of a filtration avoidance waiver under the Safe Drinking Water Act, or non-compliance with the Clean Water Act or other regulations (Box 13). To-date, action has typically occurred at substantial scale only where regulatory or cost drivers are imminent and substantial; however, there is a strong case for more proactive investment in natural infrastructure as part of an integrated approach to water resources management.
- 2. Substantial economic value associated with identified water-related issues.** For substantial investments to mobilize—and be worthwhile economically—there also needs to be real economic value tied to current or emerging water-related issues in a watershed.

BOX 13 | OVERVIEW OF LEGAL & REGULATORY FRAMEWORKS & DRIVERS

| Katherine Garvey, Vermont Law School

The regulatory framework that governs water resources is critical for sound natural infrastructure investment decisions for two reasons:

First, traditional “command and control” regulations provide the baseline for what is already being protected under federal, state, and local laws. For example, many municipalities require setbacks and buffers between certain types of development and streams. Natural infrastructure investments should provide “additionality”—that is, an impact over and above the business as usual scenario, which typically includes what is required by law.

Second, many of the regulations governing water resources take a flexible approach and allow the regulated community (including water utilities and others) to use natural infrastructure to achieve compliance in ways that reduce cost and may achieve greater environmental benefits than are possible under a traditional regulatory approach. Where the regulations allow for this flexibility, natural infrastructure approaches can be a cost-effective alternative or complementary strategy to built infrastructure in achieving compliance.

The principal provisions of federal law that govern water quality are the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA). They are administered by the U.S. Environmental Protection Agency, which delegates significant regulatory authority to the states.

Safe Drinking Water Act (SDWA)

Under the federal SDWA, all drinking water taken from surface water sources must be filtered to remove microbial contaminants. Maximum Contaminant Levels (MCLs) are set by EPA to determine the amount of a substance that is allowed in public water systems. Typical contaminants include arsenic, chlorine and E. coli.

Source water protection is voluntary and implemented at the local level without additional federal mandate or funding support. However, as a strategy to meet the MCL standard, protecting raw water in streams, rivers, lakes, and aquifers can yield long-term savings on water treatment and capital investment (Mehan et al. 2009).

In 2002, EPA promulgated the Long Term 1 Enhanced Surface Water Treatment Rule. This Rule strengthened the filtration requirements for “all public water systems that use surface water or ground water under the direct influence of surface water...and serve fewer than 10,000 persons.” EPA may waive this requirement for water suppliers if they can demonstrate that they have an effective watershed control program and that their water meets strict quality standards. Water systems with filtration waivers have a strong incentive to invest in upstream natural infrastructure in order to maintain those waivers, since protecting water at the source is often more cost-effective than installing expensive filtration technology. As discussed earlier in this guide, source water protection can also help to reduce variable treatment costs.

There needs to be sizeable “willingness to pay” in the watershed to resolve or avoid the critical water-related issue at hand. Here, we refer to willingness to pay in a strict economic sense.

In some cases, for example where investments are made to meet regulatory requirements, the buyer may not be truly “willing.” Sizeable willingness to pay is typically found in watersheds that serve major beneficiaries—for example, public utilities and their ratepayers in urban centers or industrial entities that rely on abundant clean water, such as manufacturers, agricultural producers, and hydropower plants. It can also be found in watersheds that receive regulated inputs from large point-

sources, which may find it cost-effective to meet regulatory requirements through investments in natural infrastructure.

- 3. A clear connection between the water-related issue(s) and ecological conditions on the landscape.** Ecological conditions in hotspot watersheds include current or projected degradation or outright loss of ecosystems, typically due to development pressures, agriculture, or industrial forestry (including legacy impacts). In Virginia, for example, an ecosystem services workgroup spawned in 2007 in response to net annual loss of 20,000–30,000 acres of forest land to

BOX 13 | OVERVIEW OF LEGAL & REGULATORY FRAMEWORKS & DRIVERS (CONT.)

| Katherine Garvey, Vermont Law School

Clean Water Act

Section 402 of the CWA allows states, with EPA approval, to establish procedures for permitting point-source effluent discharges. Under § 303 of the Act, approved states must establish water quality standards (WQS) under the National Pollution Discharge Elimination System (NPDES). When an NPDES permit has been issued, waterbodies are monitored to determine whether the state WQS are being met. If monitoring indicates that the water quality does not meet WQS then that waterbody is considered impaired and is included on the state's "list of threatened and impaired waters" maintained under § 303(d)—"the 303(d) list." Once a waterbody is on the 303(d) list, the state is required to establish Total Maximum Daily Loads (TMDLs)—the amount of specific pollutants that the waterbody can receive and still meet WQS. Pollutants are capped based on the carrying capacity of a particular body of water, plus a margin of safety. TMDLs are not self-implementing; in order to comply with TMDL standards, states and local governments must develop a Continuing Planning Process which contains the TMDLs for pollutants and provisions for "adequate implementation, including schedules of compliance, for revised or new water quality standards."

Achieving compliance with TMDLs under the Clean Water Act has often meant costly technological improvements to facilities that discharge pollutants, such as wastewater treatment plants. One way to reduce the cost of implementing TMDLs is through water quality trading. Voluntary trading programs allow those sources with high pollution control costs to purchase equal or greater pollution reductions from sources with lower abatement costs—either other point sources or non-point sources (e.g., forest, farm, or ranch owners). Credits

for pollutant reduction within a trading program must achieve greater environmental benefits than those under existing regulatory programs. About 100 point sources have participated in water quality trading—about 80 percent of which have been point source to point source trades (Willamette Partnership 2012). The Willamette Partnership, with contributions from the Pinchot Institute for Conservation and the World Resources Institute, has developed an in-depth water quality trading guidance publication, titled "In It Together: A How-To Reference for Building Point-Nonpoint Water Quality Trading Programs."

State Law

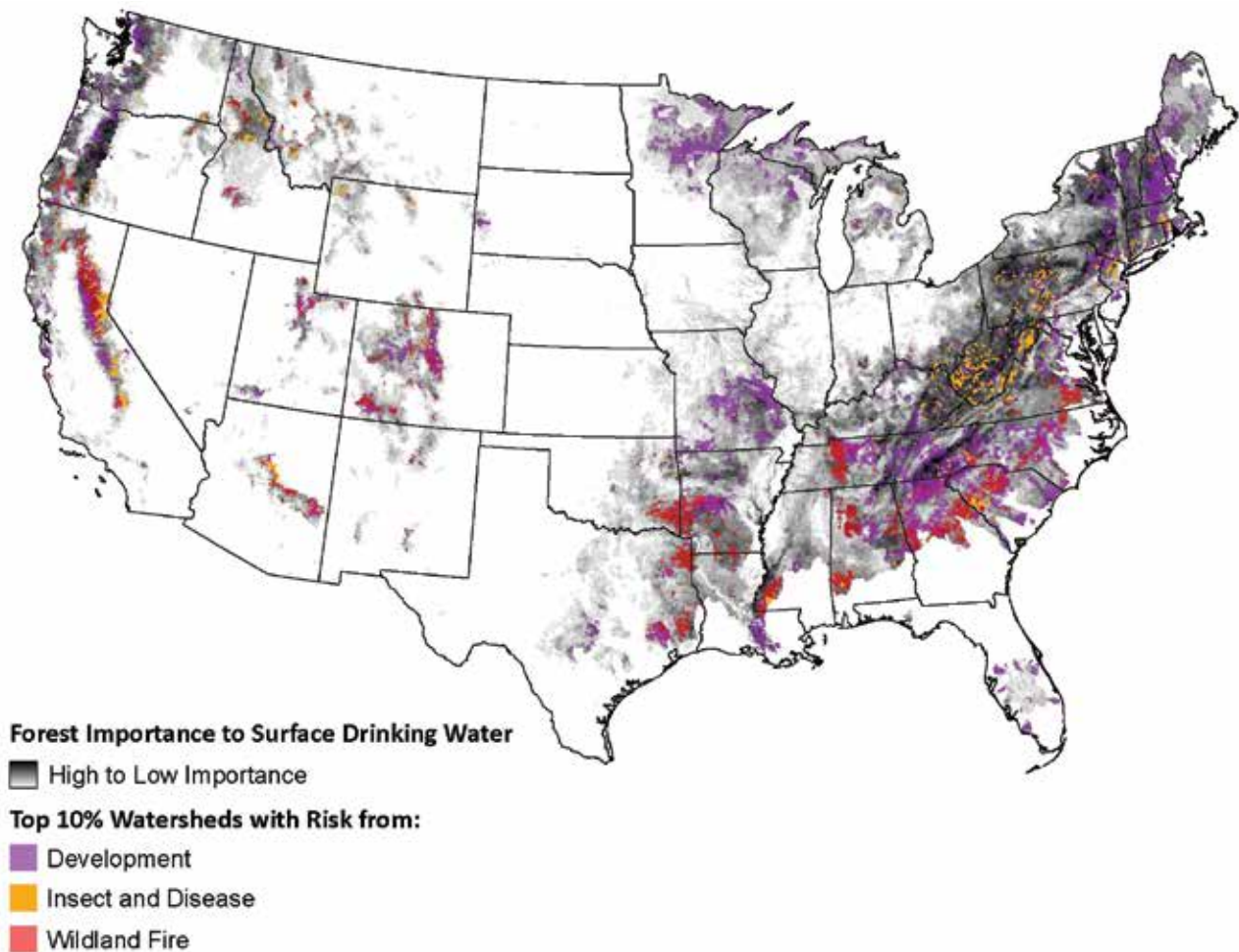
In addition to groundwater protection, states have other regulations that protect water quality. These range from best management requirements for practices on working lands to very specific land use restrictions. Some states have land use acts of statewide application that regulate major development in ways that have an impact on water quality. In all states, state law enables municipalities through zoning to regulate development and use along waterways and within flood zones. Many municipalities require setbacks and buffers between certain types of development and streams. Some municipalities are required to regulate along waterways under state law.

These requirements set a regulatory baseline for land uses that affect water quality. Investing in natural infrastructure above and beyond this regulatory baseline (e.g., expanded riparian buffers or conservation easements on high-impact lands without development restrictions) can often be a cost-effective means to manage water quality, quantity, and flow.

development. However, a wide range of factors can be at play. In Colorado, for example, pine beetle infestation and fire suppression has increased risk of wildfire, which in turn threatens catastrophic sedimentation in Denver's reservoirs. Additionally, watersheds that have already weathered a period of development without experiencing substantial degradation of watershed services may find that remaining natural infrastructure is inadequate to handle future impacts related to climate change.

The elements described above can be found in many different degraded and healthy watersheds in both public and private ownership across the country. In privately owned watersheds, conversion of forest for development represents a clear and common threat to water resources. For utilities that benefit from public ownership of their watersheds—either by the utility itself or by another public landowner such as the local municipality, or state or federal agencies like the USDA Forest Service—major threats to drinking water are typically less clear.

Figure 7 | **Forest Importance to Surface Drinking Water and Watersheds with High Risk (Top 10 percent)**



Source: USDA Forest Service Forests to Faucets.

However, ongoing protection and management efforts are likely needed to improve and maintain the watershed as natural infrastructure.

For example, Portland, Oregon, works hand-in-hand with the USDA Forest Service to manage the Bull Run Watershed for the primary purpose of providing clean drinking water. The watershed does not face threats of private development as a result of wise decisions long ago—it has been protected as a water supply source since the 1890s, and has no private homes, farms, or businesses. The management unit prohibits commercial timber harvest as well as all forms of recreation. Excluding the vast majority of common pollutant sources has helped Portland keep its raw water very clean and thereby significantly reduce the treatment costs necessary to

protect public health. Portland’s watershed protection program emphasizes avoidance and prevention, such as monitoring for invasive plant species, mapping slopes vulnerable to landslides, and maintaining roads. Portland also provides supervised tours so that both adults and school children can see and learn about the watershed resources behind the locked gates.

Zeroing in on Forest-to-Faucet Hotspots

In this guide, we are primarily concerned with watersheds where ecological conditions of concern are forest-related. Recent work by the USDA Forest Service helps to guide our focus in this regard.

The USDA Forest Service’s Forest to Faucet project (Box 15) modeled and mapped the continental United

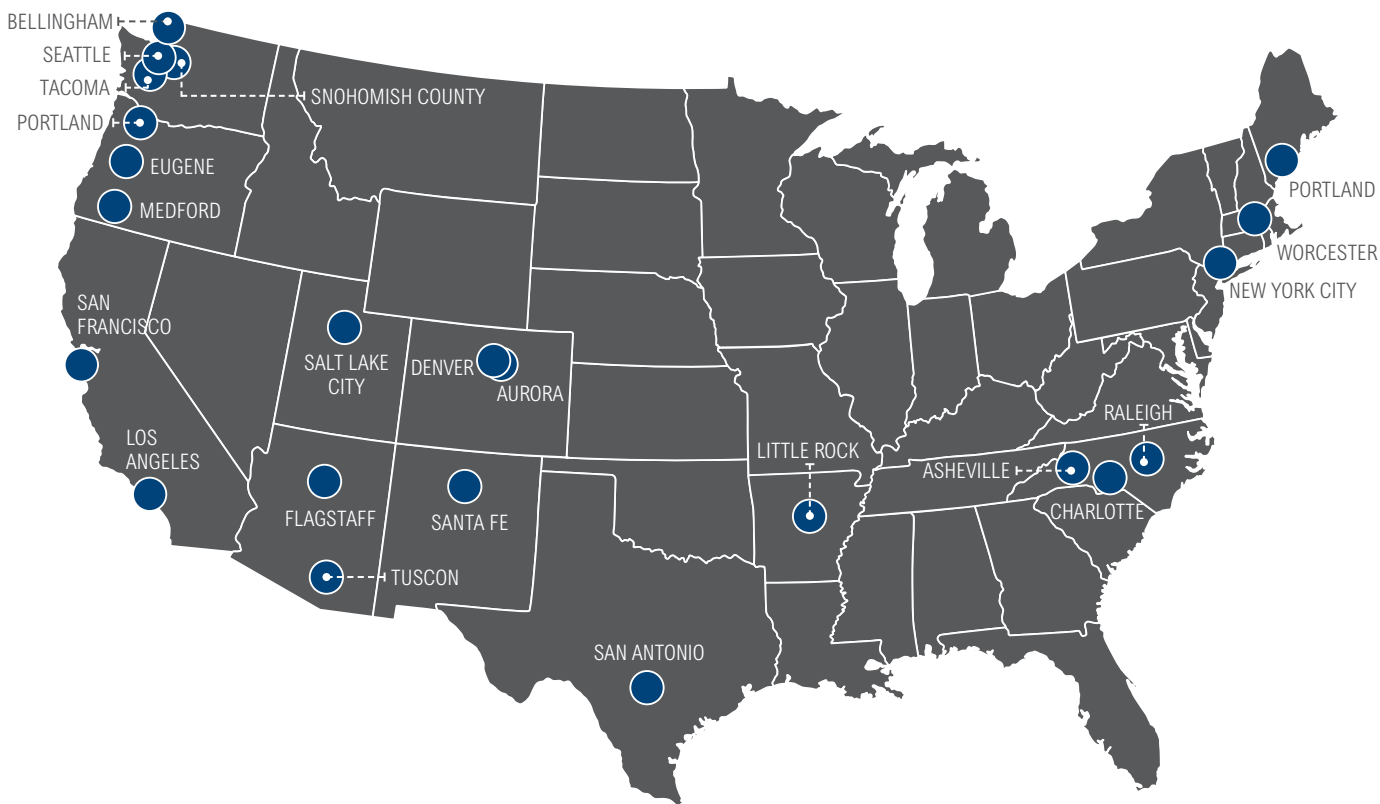
States forest land areas most important to surface drinking water supplies against watersheds with the highest risk (top 10 percent) due to development, insects and disease, and wildfire. The areas of overlap between these two variables (Figure 7) give a high-level sense of where the ecological and economic conditions for natural infrastructure investment may be most ripe. Further investigation of these watersheds may be needed to confirm feasibility of the natural infrastructure approach and there are likely to be opportunities outside of the areas identified here (particularly for non-forest-based natural infrastructure).

Beneficiaries in many watersheds nationwide have already recognized the role natural infrastructure can play as part of the solution to the critical water issues they face. Figure 8 below shows a sample of those major cities that have invested in forest-based natural infrastructure. In addition, Ernst (2004) provides several salient examples of watershed protection in smaller counties and towns.

Private Businesses as Potential Investors in Natural Infrastructure

Domestically, it is most often the municipality or public utility that makes the investment on behalf of taxpayers or ratepayers. However, a wide range of private industries are heavily reliant on a steadily available supply of clean water. As water scarcity emerges as one of the defining challenges of the 21st century, private companies and investors are realizing that there are many ways a company's water use can pose significant risk to its bottom line. Dwindling or variable water supplies can bring manufacturing to a halt. Deteriorating water quality can lead to higher capital and operating treatment costs. Changes in regulation can expose polluting industries to fines and sanctions. Additionally, a company's reputation can be damaged by unsustainable water use, leading to a decline in sales and revenues. Further complicating the issue, exposure to water risk in all of its forms varies significantly from region to region and across sectors.

Figure 8 | Sample of Cities that Have Invested in Forest-Based Natural Infrastructure



BOX 14 | BIG SKY BREWING COMPANY & WATER RESTORATION CERTIFICATES

| Chris Corbin, Lotic Water

Private-sector companies stand to benefit from participation in water resource initiatives—whether to manage real water-related risks (direct or indirect) or to strengthen the communities where their employees live and play. For some companies, participation in these initiatives is philanthropic. For others, it is a business strategy to manage increasing costs and brand risks in the face of projected water resource degradation.

Big Sky Brewing Company first opened its doors in Missoula, Montana, in 1995. Since its beginnings, Big Sky Brewing Company has grown to Montana's largest brewer and the 37th largest craft brewery in the United States. The company is known for brands like Moose Drool, having as much fun as possible, and a dedication to giving back. As a brewery that prides itself on recreation, Big Sky Brewing Company also possesses a hunting, fishing, and recreation conservation ethic with history of supporting the natural resources that define its home in Montana and its beer. This starts with water.

Written on the side of every can of MOOSE DROOL is the company's slogan: "WE MAKE WATER FUN." This mantra hails from a culture that embraces the free-flowing rivers that define Montana and the obvious importance of water. The brewery brews and packages over 44,000 barrels of beer a year—using over 1.3 million gallons of water. The water used at the brewery's Missoula home originates in the plentiful and healthy Missoula Aquifer. Although water is abundant at this location, other critical water resources in the state are not so fortunate. The state is home to over 4,000 miles of dewatered streams—most of which lack sufficient flows for trout, or run completely dry due to irrigation withdrawals. To a company that brews a beer called Trout Slayer, employs a workforce with a fly rod in almost every garage, and realizes a cold beer is a fitting end to a Montana fishing day—this is a problem.

The Bonneville Environmental Foundation (BEF) released Water Restoration Certificates in the Summer of 2009 as an effective way for businesses to take responsibility for

their water consumption by returning an amount of water equal to what they have used back to the environment. The specific details of the transaction include an instream flow lease that is credited as a Water Restoration Certificate and marketable to any individual or company interested in restoring their water footprint. In essence, one Water Restoration Certificate represents 1,000 gallons of water restored to a critically dewatered river or stream. Through this program, Big Sky Brewing Company has taken strides to restore all of the water that goes into the company's beer back into a dewatered Montana stream.

Prickly Pear Creek flows from the Elkhorn Mountains north to the Helena Valley, past the small town of East Helena, continuing through agricultural farmlands, pastures, and small rural subdivisions upon entering Lake Helena. The Creek is home to a variety of fish species. Sadly, however, decades of timber harvest, mining, and water withdrawal have taken a heavy toll on Prickly Pear Creek. Legacy mining impacts have contaminated ground water in places, and the creek is chronically dewatered due to over-allocation of surface water rights. As a result, EPA has listed Prickly Pear Creek as not meeting a number of federal environmental standards, and the creek goes dry in most years.

Water Restoration Certificates purchased from BEF have restored more than 4 million gallons of water instream for a three year period (2010–2012) in Montana's critically dewatered Prickly Pear Creek—allowing the creek to maintain connectivity through the irrigation season for the first time in many years. All BEF restoration projects are certified by the National Fish and Wildlife Foundation to ensure that water is returned at a time and place that will produce real environmental benefits.

For Big Sky, investing in Water Restoration Certificates is an opportunity to lead, producing a measurable benefit where it is needed most and in a way that aligns with the brewery's brand. Since its original investment, six other breweries have joined this worthy cause.

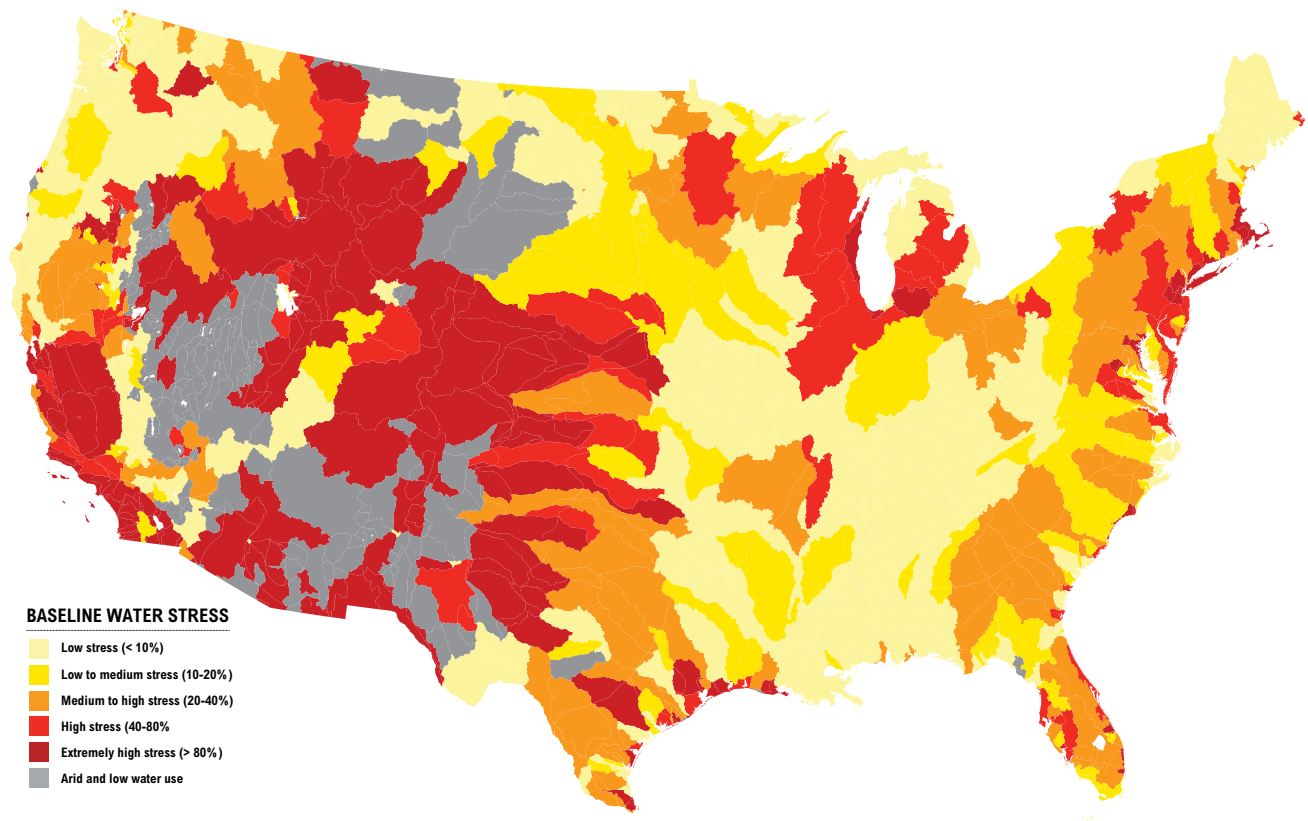
Consider the toll taken on the U.S. agricultural economy in 2012 in what the National Oceanic and Atmospheric Administration (NOAA) has called the country's most extensive drought in more than 50 years. U.S. crop yields were steadily reduced across the 29 states in the affected area, impacting a wide range of suppliers, consumers, communities, and others. In 2011, the Texas drought resulted in \$5.2 billion in agricultural losses, driving Gap clothing company to cut its profit forecast by 22 percent because of higher cotton costs. And Kraft, Sara Lee, and Nestle all announced plans to raise prices in the wake of droughts and floods. Events like these—which are projected to become increasingly common should climate change continue unabated—provide a sharp reminder of how heavily communities and global economies rely on water.

Water is a critical component in many industries—not just agriculture and those that directly rely on agriculture like food and clothing. The beverage, energy, and manufacturing industries, for example, are all heavily reliant on water—and many businesses are susceptible to damage from flood.

Quantity matters, but so does quality. Water quality can be directly important to manufacturing processes or products like bottled water, and it can also affect the cost of water.

Across the country and worldwide, we are beginning to see the impacts of water risk reflected in companies' investment choices. Companies such as MillerCoors, PepsiCo, Coca-Cola, Ford Motor Company, IBM, Intel Corp., and many others have

Figure 9 | **Aqueduct--Measuring, Mapping, and Understanding Water Risks**



Source: WRI 2013.

BOX 15 | FOREST TO FAUCET PROJECT

| Emily Weidner, USDA Forest Service

Forests and drinking water

Forests play a critical role in providing drinking water in the US. Forests capture, store, and slowly release precipitation, in addition to trapping and transforming chemicals, nutrients, and sediments from rain or adjacent runoff. This refills underground aquifers, cools and cleanses water, slows storm runoff, reduces flooding, and sustains watershed stability and resilience, among many other benefits.

Restoring, conserving, and sustainably managing forests has been a key strategy for maintaining drinking water quality. But with approximately 78 percent of the continental U.S. within a surface drinking water watershed, and a third of the nation's land area as forests, there is a lot of land to protect, conserve, restore, and maintain. Conservation professionals dedicated to watershed-based efforts to protect and maintain drinking water quality are therefore challenged to identify those key land areas most important for surface drinking water. These areas are high-impact targets for conservation and sustainable management. Note, however, that while interventions to protect source water in these areas may be critical, it is also important to manage forest land for multiple ecosystem benefits.

The Forests to Faucets Project

Expanding on the earlier Forests, Water, People report (Barnes et al. 2009), the Forests to Faucets project hones in on forest and non-forest areas most important for surface drinking water by creating a watershed index that incorporates three components:

1. The number of surface drinking water consumers of each intake (stream location where water is withdrawn),
2. Surface water flow direction and distance of each sub-watershed to the intake, and
3. Water supply (precipitation minus evapotranspiration—model and data from Brown et al. 2008).

This approach highlights the importance of not only those areas directly surrounding surface drinking water intakes, but also those upstream areas that contribute to water quality at the intakes. The results of the first analysis step show high index values (indicating high importance for surface drinking water) in much of the east due to high population densities and high reliance on surface rather than groundwater. There are other clusters of high values throughout the west—those of note include the Colorado Front Range, Sierra Range, and the Cascade Range.

By incorporating data on land use type and forest ownership in the second step of the analysis, we can see the role forests (private, public, and protected areas) play in protecting the areas most important for surface drinking water quality. In other words, these Step 2 results show the forest areas where people are most dependent for their surface drinking water. The third step of the analysis focuses in even further to identify forested areas most important for surface drinking water that are also highly threatened by insects and disease, development, and wildland fire.

Overlaying these “hotspot” areas elicits interesting patterns, and this can start to paint the broad brushstrokes picture of not only where the hotspots are for forest management, restoration, and conservation for surface drinking water, but also what types of challenges and strategies may be most relevant for different areas. For example, distinct patterning occurs in the Sierra Range where we see, from west to east, bands of hotspots of development, fire, and then insects and disease.

This project also sets the groundwork for identifying watersheds where a water-centered natural infrastructure project may be an option for financing conservation and management on forest lands. The Forests to Faucets data on a broad scale identify areas that supply surface drinking water, have consumer demand for this water, and are facing significant threats that could be minimized through a payment designated for forest management or protection—all important criteria for successful natural infrastructure initiatives. As such, these hotspots can be used to determine good candidates for projects.

all made efforts to reduce water-related risk. For example, Mondi's South African forest plantations and processing plants depend on healthy watersheds and riparian zones. Mondi has taken a leading role in promoting the awareness, improved management, rehabilitation, and protection of wetlands in order to secure its license to operate as well as provide benefits to the local community. Coca-Cola, meanwhile, joined forces with the World Wildlife Fund to improve the water quality of the upper reaches of the Yangtze River in China—one of the world's top ten most threatened rivers. One result has been a united recommendation to the Chinese government on the implementation of pollution regulations. Coca-Cola operates 39 bottling plants in China. See Box 14 for a domestic example featuring Big Sky Brewing Company.

WRI's Aqueduct program identifies, measures, and maps the key indicators that drive water risk with an unprecedented level of detail. [Aqueduct's maps](#) and the underlying water information database are designed to:

- 1. Help companies and investors understand the strategic importance of reducing their exposure to water risk in high stress areas.** Aqueduct can help users identify and disclose potential sources of water risk in their operations and supply chains, and prioritize areas to implement risk mitigation solutions.
- 2. Encourage public sector leaders to collaborate with domestic, agricultural, and industrial water users** to achieve more equitable, efficient, and sustainable water resources management in water-stressed basins.
- 3. Highlight trends and opportunities for innovative solution providers,** informing the next generation of water management technologies, techniques, and policies.

Section 3.2: Initiating Dialogue in Water Utilities¹⁴

| John Tynan, Sustainnovate, LLC (Current Affiliation: Central Arkansas Water; formerly on Board of Greenville Water System)

The U.S. Endowment for Forestry & Communities (the U.S. Endowment) contracted with Sustainnovate, LLC to collect the perspectives of water utility professionals throughout the country on source water protection. Sustainnovate conducted over 50 interviews and reviewed similar past efforts, including the 2010 AWWA Source Water Protection Survey (a poll of 127 large utilities), A 2011 Education Survey by The Rocky Mountain Section of the AWWA (200 utility member respondents), and A Conversation with Utility Managers (100 interviews with utility managers in 2009). The results of the effort indicate key internal and external challenges, priorities, and preferences related to natural infrastructure, and a corresponding set of guidelines for water utility staff and others seeking to start meaningful dialogue around integrating natural infrastructure into water management strategies. Box 16 details lessons learned for conservation practitioners.

Challenges

Three major challenges face natural infrastructure champions in water utilities: resource constraints, lack of public understanding, and lack of access to the quantitative business case for natural infrastructure strategies.

Water utility managers resoundingly highlight limited time and resources for utilities to participate in planning as a challenge to source water protection efforts. The scarce resources that utilities have, from their own revenues or from a state agency, are typically quickly consumed by regulatory requirements, leaving few resources for voluntary programs regardless of the benefit. Many utilities do not prioritize implementation of source water protection plans because there are few or no regulatory requirements to do so. Source water professionals have found success in the face of constrained resources by bringing something to the table—such as grant funding and partnerships that leverage the utilities' expertise and capacity. Focusing on these opportunities early and often can provide a jumpstart for source water professionals seeking to advance the natural infrastructure conversation with key decision makers and stakeholders in their watersheds. While a wide variety of available finance mechanisms is available to support natural

infrastructure investments (Chapter 5), at minimum, proponents should recognize the impact that real and perceived funding constraints may have on forward progress.

Compounding resource issues is lack of public understanding of the real value of water. This is a critical challenge for the ability of utilities to raise rates for source water protection efforts (to avoid larger rate increases in the future). Several effective ratepayer communication strategies (see, e.g., Box 23) are available and should be part of early conversations around natural infrastructure.

Finally, while general awareness of the importance of upstream ecosystems for water utilities is advancing, source water professionals and other champions of natural infrastructure must still make the case to decision makers in their institutions and to the public. Without access to reliable quantitative analysis demonstrating the business case, those charged with protecting source water are limited to qualitative arguments for landscape investments. According to one source water protection manager, “I have been pushing the qualitative ‘prevention is better than remediation’ case and have ridden that argument pretty far over the past 14 years. But I would be eager to be able to make the case quantitatively.” The field of analysis focused on the financial case for natural infrastructure is relatively new and rigorous watershed-specific economic analyses are rarely available unless pursued by the utility. Earlier chapters have focused on making the scientific and business case for natural infrastructure and can be used in presentations and memos to gain traction for dialogue.

Priorities

Water utility managers frequently cite the central importance of four issues when considering any new program:

- Avoided regulation and/or increased regulatory compliance,
- Cost reduction,
- Reduced risk and uncertainty, and
- Long-term and short-term economic development.

As discussed throughout this guide, investments in natural infrastructure can serve a major role in addressing each of these issues. Framing natural infrastructure in terms of these issues can help build traction for meaningful internal dialogue among decision makers.

Preferences

Water utility managers have articulated clear preferences for various program design elements. Emphasizing these elements early in the process may help to facilitate dialogue. First and foremost, natural infrastructure efforts must clearly demonstrate results. Managers and governing boards must see some benefit from their investment within reasonable timeframes. While this requirement is likely to be a challenge where natural processes are slow to produce measurable changes and where the benefit in question is the prevention of water quality degradation or flooding, for example, a program design that includes robust validation, monitoring, verification, and adaptive management may resonate with decision makers.

Additionally, utility managers frequently suggest that forest-based efforts must be a component of an integrated approach to water treatment, rather than an attempt to eliminate it. Early dialogue should emphasize integrating forest preservation into treatment optimization processes. Similarly, the researchers behind the 2010 AWWA survey noted that source water protection efforts should be aligned with other top utility priorities rather than serve as a stand-alone program.

Partnerships

A consistent theme in the natural infrastructure field of practice is the importance of partnerships. While some utilities historically may not have considered working with land trusts or other “conservation” organizations, these partnerships are critical for bringing needed capacity and resources to the table to execute successful source water protection efforts that focus on natural infrastructure. When questioned about community partnerships, utility staff often note logical connections with local watershed organizations. Water conservation and efficiency in particular are identified as initial areas of collaboration between utilities and local groups. These local watershed groups (especially those with existing efficiency partnerships with utilities) may serve as

BOX 16 | FOR CONSERVATION PRACTITIONERS—ENGAGING UTILITIES

The primary recommendation from the U.S. Endowment's 2011 convening work with a group of conservation, water utility, forestry, and government leaders was that natural infrastructure advocates must engage the water utility industry as an early partner in any project. Sustainnovate's interviews with water utility managers and review of past utility surveys yielded the following recommendations related to engaging water utilities:

1. Facilitate peer-to-peer dialogue in workshops and conferences—utility managers rely most heavily on their peers for new programs and ideas, often through informal dialogue;
2. Align framing with issues utilities care about: cost reduction, regulatory compliance and certainty, and economic development;
3. Tailor efforts to the local context;
4. Secure funding for utility participation in planning efforts;
5. Encourage partnerships;
6. Integrate efforts into a larger treatment optimization scheme;
7. Educate the public and water utilities on the need for short-term rate increases to avoid long-term costs; and
8. Clearly demonstrate results and make utility payments contingent on achievement of benchmarks.

Engagement efforts should also recognize differences in knowledge base, existing platforms for education, and major issues of concern:

- In the Northeast, there is clear recognition of the linkage between forest preservation and improved water quality. Framing efforts should focus on improved stream flow and reduced energy costs. Efforts in the Northeast should also build upon the multitude of existing partnerships, including AWWA sustainability committees.
- In the Midwest, a vast majority of utilities in the Midwest obtain their water from groundwater or the Great Lakes. Consequently, the best opportunity for natural infrastructure relates to connections between improved forest management and groundwater protection. Midwest utility associations have had good success in engaging and educating utilities through webinars.
- In the Northwest, watershed councils are existing collaborations that should be engaged to promote natural infrastructure efforts. Framing efforts should focus on natural infrastructure as a healthy alternative to traditional chemical treatment. The Eugene Water and Electric Board is an emerging regional leader in source water protection, and supporting and publicizing their efforts would provide strategic outreach opportunities.
- In the Southeast, education and outreach is needed both to utility managers and the general public. Many southeast utilities rely on state or federal agencies to provide source water protection, believing that their treatment begins at their intake.
- In the West, framing efforts should focus on natural infrastructure as a strategy to ensure sustainable water supplies for regional growth. Existing utility collaborations can be leveraged to engage a wide variety of large and small utilities. Also, association newsletters can be an effective Western tool to reach a wide-range of utility managers about natural infrastructure efforts.

an effective “bridge” between forest landowners and water utilities. However, less than half of large utilities have reportedly engaged stakeholders in their efforts, despite recognition of the importance of collaboration with stakeholders for source water protection efforts (AWWA 2010). Building these partnerships and highlighting the doors they open related to funding or capacity may be a successful strategy for initiating dialogue around natural infrastructure.

Take-Aways

There is often a broad set of decision makers whose active engagement or tacit support is required for

natural infrastructure efforts to be successful—and whose technical backgrounds may not include source water protection and natural infrastructure. These can include budget managers and finance officers, lead engineers, environmental compliance directors, utility executives, board members, municipal officials, and major rate payers. While it would be folly not to recognize the unique perceptions, preferences, and backgrounds these decision makers may carry with them, there are a number of common themes identified here that should be carefully considered when working to foster dialogue.



Part 2

DESIGN AND IMPLEMENTATION

The first part of this guide focused on key elements of securing adoption of an integrated natural and built infrastructure approach—the business case, underlying science, and opportunity. Once decision makers and stakeholders in a watershed have adopted the approach, the next task is to design and implement an investment program.

Natural infrastructure investment programs have several components that can “make or break” the credibility, scalability, and long-term success of the program. These components include:

1. Stakeholder engagement;
2. Quantification Tools and Metrics—the measures or proxies of watershed services that serve as the basis of payment;
3. Protocols—the “rules of the game” for buyers, sellers, and third parties (e.g., landowner eligibility, service areas, and additionality requirements);
4. Risk-management tools such as private finance and insurance;

5. Software, online platforms, and other technological tools to facilitate investment;
6. Finance mechanisms; and
7. Ongoing monitoring, adaptive management, and documentation of performance

The extent and complexity of design elements will depend in part on the scope and scale of the natural infrastructure program. For example, markets for watershed services—such as nutrient trading programs with multiple buyers and multiple sellers—tend to require robust “program infrastructure” like protocols for validation and verification of reductions, broker arrangements, and technological platforms for trading and tracking credits. These components are necessary to assure buyers, regulators, and other stakeholders that the program is achieving its objectives. Some of these components—for instance, broker arrangements and online platforms—also keep transaction costs down, improving the viability of the market, and allowing it to reach meaningful scale.



Chapter 4: The Players at the Table

● MAKING THE CASE

- The Business Case
- The Scientific Underpinnings
- Identifying Opportunity

▼ DESIGN AND IMPLEMENTATION

- Players at the Table
- Natural Infrastructure Finance

▼ CASE STUDIES

- Cases
- Concluding Remarks

On the other end of the scale, a one-time direct payment (e.g., for conservation easements) by a single, large buyer such as a water utility to small group of large landowners may succeed with a much simpler framework. The clear exception is when the transaction is geared to achieve regulatory compliance for the buyer, in which case more extensive validation, monitoring, verification, and rules for adaptive management may be required.

In Part 2, we hone in on early-stage design components—bringing the right stakeholders and experts to the table and scoping the broad parameters of promising finance mechanisms. The remaining components should be designed in close collaboration with stakeholders and ideally with heavy engagement from experts who specialize in metrics, protocols, technological platforms, and validation and verification.

KEY TAKE-AWAYS

1. Cultivating partnerships is a critical first step toward successful implementation. Partnerships can expand funding, capacity, expertise, and political capital for natural infrastructure efforts (Section 4.1). Seek out key partners, build durable stakeholder commitment, articulate a vision of success and related goals, and build on the lessons of past successes and failures.
2. Landowner participation is essential in privately owned watersheds. Landowners are highly independent, value their autonomy, and generally engage in agriculture or forestry because it is a way of life as well as an economic enterprise. In addition to the financial inducement being offered, landowners consider how the program is designed and administered as part of their participation decision (Sections 4.2 and 4.3).

Introduction

This chapter begins with a look at the roles needed for a natural infrastructure investment program to be successful—including stakeholders who need to say “yes” and experts who supply critical input for the design and implementation of successful programs.

Then, we offer a close-up look at one stakeholder group in particular—landowners. Harnessing sufficient supply of natural infrastructure in privately owned watersheds requires an effective landowner engagement strategy and a program design to entice and enlist landowners as suppliers. It is often assumed that if adequate financial incentives can be provided, landowners, as economically rational actors, can be counted on to provide the necessary supply of natural infrastructure. While financial incentives are increasingly a core mechanism of incentive-based natural infrastructure programs, understanding and trust among landowners are also essential. Programs must be designed to meet landowner interests (which typically extend well beyond financial interests) and minimize landowner transaction costs.

We offer a picture of current knowledge on landowner preferences pertaining to the design of a natural infrastructure program and landowner willingness to engage, and a suite of recommendations for engaging landowners as suppliers of natural infrastructure.

Section 4.1: Stakeholders and Experts in Successful Natural Infrastructure Programs

| Todd Gartner and Josh Rego, World Resources Institute
| Bobby Cochran and Carrie Sanneman, Willamette Partnership

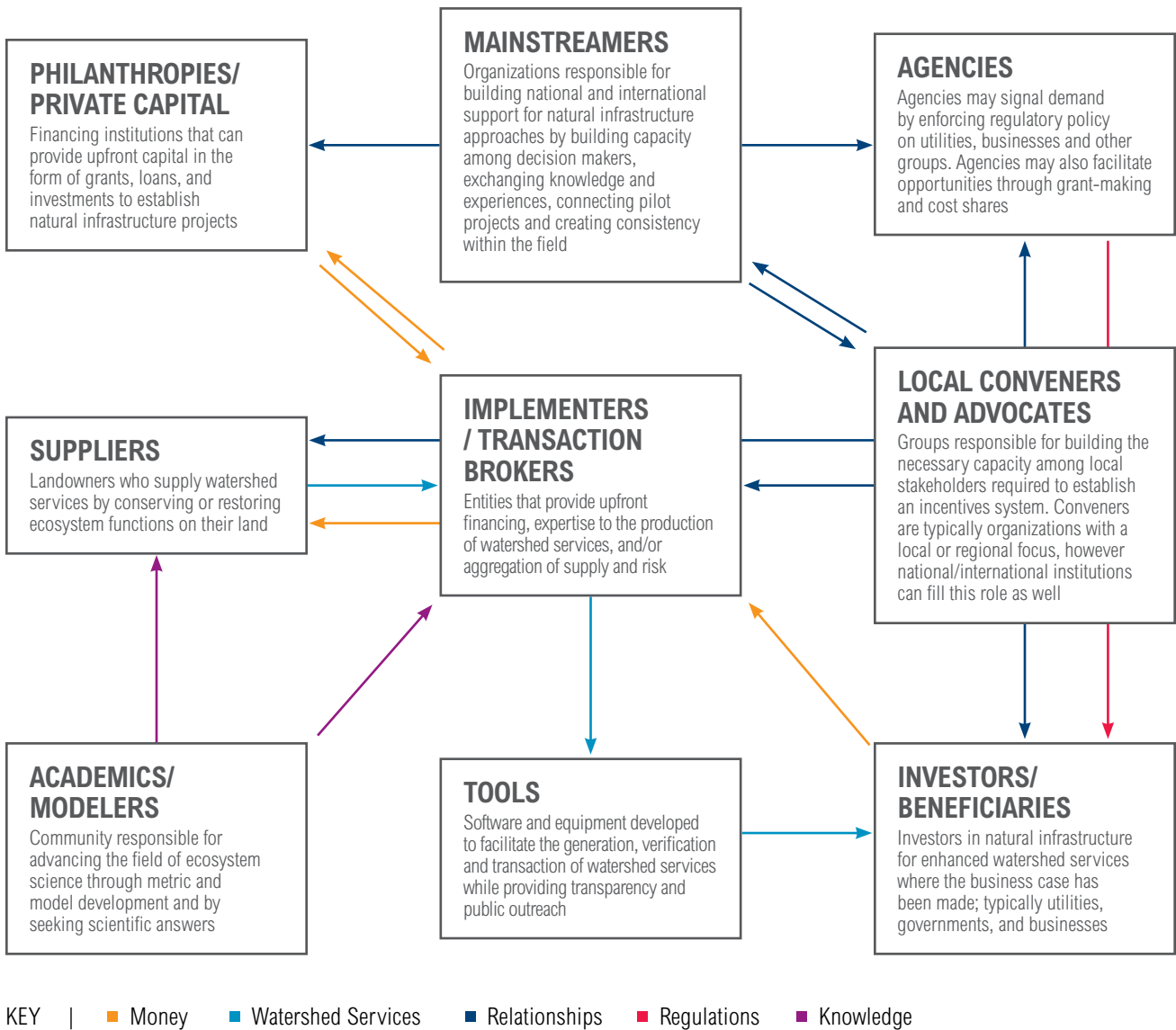
In each successful attempt to build robust investment in natural infrastructure, an essential component has been collaboration among a variety of stakeholders and experts (Figure 10) and the emergence of champions within stakeholder groups to push the program forward.

New York City worked with upstate stakeholders for seven years before brokering a deal to preserve and enhance the Catskills watershed. In Eugene, Oregon, the water utility carefully expanded its capacity to develop a payment scheme to maintain riparian buffers by partnering with a range of stakeholders with diverse missions. Portland, Maine, recognizing that neither the Portland Water District nor the state’s Drinking Water Program have the tools or authority to manage land use and development—short of buying land—sought out allies with common interests in clean water and land uses that help generate clean water. And in each of these efforts, champions emerged to recruit stakeholders, facilitate collaborative efforts, leverage their respective capabilities, and drive efforts toward fruition for natural infrastructure investments.

In addition to those actors who have a real stake (e.g., beneficiaries of watershed services, landowners who supply those services, regulatory agencies



Figure 10 | The “Actor Network” in Successful Natural Infrastructure Efforts



responsible for ensuring compliance, and the suite of organizations whose core missions and interests are affected by natural infrastructure investment), there is an increasingly clear need for a broad and advanced set of expertise to properly implement a natural infrastructure investment program. Ecologists and hydrologists, market-based conservation experts, policy experts, third-party verifiers, and

model and tool developers all bring important expertise and capacity to a program.

The stakeholders and experts critical to the establishment and operation of a successful natural infrastructure investment programs can be divided into ten groups. These groups, the roles they play, and their incentives for participation are discussed here.

BOX 17 | USDA NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

| Bruce Wight, USDA NRCS (Retired)

The 2008 Farm Bill included a new section in the Conservation Title called “Environmental Services Markets.” In it, Congress expressed a broad vision for how America’s landowners—farmers, forestland owners and ranchers—can participate in these new emerging markets for conservation on private lands. This has resulted in much discussion in and outside USDA and NRCS to gain an understanding of the claims by advocates of market-based incentives and credit trading programs as well as the criticisms from skeptics. NRCS continues to explore its role in environmental markets. NRCS has provided basic information about environmental markets to our field office staff to help answer landowner questions. This includes releasing the [Natural Resources Credit Trading Reference](#).

The NRCS [Conservation Technical Assistance Program](#) provides a wide range of services to support voluntary planning, conservation design, and implementation to improve environmental outcomes. The breadth of local and community knowledge that NRCS personnel have could contribute significantly to the success of environmental credit trading programs by explaining the programs and their potential benefits and pitfalls to participants. In order for NRCS staff to help answer landowner questions, they will need additional training about each emerging environmental market proposal.

The NRCS offers a variety of [Conservation Financial Assistance Programs](#) to aid landowners with implementing conservation on their lands. The question often comes up about landowners selling environmental services that resulted from conservation practices applied through these financial assistance programs. USDA policy has explicitly stated that all returns to agricultural producers from the sale of environmental credits generated by the adoption of conservation practices, whether or not they are paid for in total or part by USDA conservation programs, accrue to them solely. NRCS retains the authority to ensure that operation and maintenance requirements for USDA funded improvements are met. Where activities required under an agreement to produce environmental credits may affect land covered under a USDA program contract, participants are encouraged to request a compatibility assessment from NRCS.

In NRCS’s efforts to define its role in ecosystem services, the agency’s past requests for proposals for the [Conservation Innovation Grants Program](#) have included market-based incentives and credit trading programs. A number of grants have been funded to explore different methods. For example, the American Forest Foundation and the U.S. Endowment for Forests and Communities received grants to develop an innovative, self-sustaining, and replicable market-based model that facilitates transactions between ecosystem services buyers and sellers to protect and enhance watershed services. These grants concluded in 2012 and their final reports will provide valuable information about what worked and did not work in several watershed efforts to enhance water quality through a market approach.

As ecosystem service markets develop in the future, NRCS will continue to better define the agency’s role. For example, with the water quality trading opportunities that the above innovation grants are analyzing, NRCS staffs could potentially provide support by:

- Explaining the benefits and costs of participating in these markets to potential participants, along with other available incentives as a part of the conservation planning process;
- Becoming familiar with technical standards and documentation requirements that, in the future, may be incorporated in the conservation plan baseline information and potential quantification of impacts of each alternative; and
- Developing tools for measuring baseline information and the potential effect(s) of alternatives that could be used for credits.

NRCS looks forward to working with farmers, ranchers, and forest owners and those ecosystem service market developers in solving some of our nation’s most critical environmental issues through these new markets.

Investors/Beneficiaries

Investors are typically water resource beneficiaries with a clear interest in natural infrastructure investments that produce the critical watershed services they rely on. Beneficiaries can be water utilities (representing ratepayers), private businesses, or government agencies (representing taxpayers). These entities invest in natural infrastructure through an implementer or directly with landowners, and are the primary source of ongoing investment in that infrastructure. Investments are made to secure cost reductions or cost avoidance over traditional solutions, and/or to secure public relations benefits associated with watershed investment. Funding for investment typically comes from internal budgets and rate structures for water resource protection, regulatory compliance, or corporate social responsibility. These investments can often be matched with external funding sources.

Suppliers

Suppliers are the landowners who supply watershed services by conserving or restoring ecosystem functions on their land. They enter into paid agreements with either an implementer or directly with a utility, land trust, commercial firm, or agency with the intent of implementing some form of natural infrastructure to generate critical watershed services. Participation in natural infrastructure programs can provide supplemental income streams to these largely rural landowners, helping to preserve working lands and rural livelihoods. Participation can also require changes in land management practices or restrictions on land use like conservation easements. Sections 4.2 and 4.3 discuss private landowners as sellers in more detail. Public landowners can also provide supply. For example, Part 3 details a partnership between the Denver Water Board and the USDA Forest Service, which manages Denver's headwaters.

Local Conveners & Advocates

Local Conveners & Advocates are typically non-profit organizations that serve as the face of an initiative on the ground. They champion natural infrastructure locally by leveraging long-term relationships and region-specific expertise. Local Conveners raise the local profile of natural infrastructure initiatives, convene stakeholders, highlight successes, and “connect the dots.” They also lead initiatives long after the first wave of grant funding. These actors are critical “glue”

for natural infrastructure programs and the constellation of actors involved. For these actors, mobilizing investment in natural infrastructure from beneficiaries can be a strategic means to leverage their traditional resources in support of their mission, which may include objectives like ecosystem conservation, economic development, rural livelihoods, or water resource protection.

Agencies

Agencies are responsible for enforcing compliance with environmental statutes like the Safe Drinking Water Act, the Clean Water Act, and others. Natural infrastructure initiatives can represent opportunities for regulated entities to achieve compliance more cost-effectively. Where a natural infrastructure initiative is intended to achieve regulatory compliance, the regulating agency needs to be at the table to ensure the investments will “fit the bill.”

Agencies can also seek to facilitate investments in natural infrastructure as part of their mission—whether to promote water resource protection, clean and safe drinking water, or the economic viability of rural livelihoods. For example, the USDA NRCS (Box 17), various programs within the EPA (Box 18) and USDA Forest Service, and state and county forest, water, and health programs (Boxes 19 and 20) all seek to facilitate natural infrastructure investments. These entities can provide critical financial and technical support, and connect stakeholders to other important actors. They have also engaged in research, tools development, and policy formation activities to support natural infrastructure investments. For these agencies, the integration of natural infrastructure into water management efforts can be an effective means to advance their objectives and mission.

Implementers/Transaction Brokers

Intermediary organizations—whether the local conceiver or another entity—can serve as critical implementers in a natural infrastructure program. They can provide upfront funds to establish agreements with local landowners, aggregate dispersed and disparate landowners into a single supplier block, and serve as the hands-on implementer of natural infrastructure investments. The implementer role is critical as investors like public water utilities, well versed in the installation and maintenance of built infrastructure, often

BOX 18 | ENVIRONMENTAL PROTECTION AGENCY (EPA)

| Kira Jacobs, EPA Region 1

Protecting drinking water sources usually requires the combined efforts of many partners such as public water systems, communities, resource managers, and the public.

EPA supports a “multi-barrier” approach to protecting public water supplies. This approach includes technical and managerial barriers that help prevent contamination at the source, enhance treatment, and ensure a safe supply of drinking water for consumers. One of the most important tools to achieve this is protecting the land around the water supply. EPA recommends that land trusts, community groups, or others should work cooperatively with local water suppliers to identify properties that qualify for funding or offer their expertise in negotiating acquisitions from willing sellers. Such partnerships can complement the ongoing work of organizations to preserve parts of a watershed or ground water area for other purposes.

Although the drinking water industry does not commonly use the term payment for watershed services, it has long been recognized that purchased land or conservation easements can serve as a protection zone near the drinking water source. Source water protection and multi-barrier approaches to water treatment have been practiced for more than a century by many of our nation’s surface water suppliers. Although the land conservation movement of the 21st century has provided the drinking water supply industry with some clever terminology, these practices have been voluntarily exercised by water suppliers for generations.

EPA Region 1 is currently working with water suppliers in the New England region to promote the importance of protecting water supplies through sustainable land management. Specifically, the City of Manchester, New Hampshire’s water supplier (Manchester Water Works) and EPA Region 1 have partnered to establish a forum for helping New England surface water suppliers address the myriad challenges they face.

Many New England water supplies began acquiring fee ownership of raw land throughout their watersheds as an early method of water treatment. Protecting the source

through maintenance of a forested buffer around lakes, rivers, streams, and wetlands is still a priority to many water suppliers.

The land management of these properties comes with many costs and many challenges. Unfortunately, growing populations and demand for recreation near urban areas have caused additional pressure on the land around surface water supplies. Many of these properties are in close proximity to urban areas where the drinking water is distributed.

These challenges of land management are dealt with in a variety of ways and have their shares of successes and failures. A committee of surface water suppliers from each New England state was formed to discuss these processes for watershed management. The committee is identified as the New England Watershed MANagers (NEWMAN) Collaborative. The NEWMAN Collaborative consists of representatives from 15 New England surface water systems from six states. These utilities collectively provide water for 4 million people.

The Collaborative is working to address the specific challenges faced by surface water suppliers and what assistance can be provided to other utilities. The specific topics being addressed by the collaborative are forestry, recreational access, land management, and land acquisition. The water utilities have expressed a need to benchmark themselves with their peers to better educate their customers and the water boards that manage them. As a result, the Collaborative has decided to develop a NEWMAN Directory. This directory will be a resource guide for surface water supply watershed managers in New England. It will also provide both aggregate data on the four issues identified above. Lastly, it will provide a tool to enable water suppliers to seek out water systems with similar characteristics to their own to assist in researching management options. The directory will be the results of a survey of all New England surface water suppliers. The directory will summarize information received from all participating New England surface water suppliers.

BOX 19 | STATE DRINKING WATER PROGRAMS

| Andy Tolman, Maine CDC Drinking Water Program

Working at the state level, Maine's Drinking Water Program (Maine DWP) works to remove barriers to coalition building, and to facilitate the incorporation of natural infrastructure into local planning and development. We use small grants and loans to encourage water systems to work with local communities and conservation groups to help maintain and restore working forests and well-managed agriculture in their source protection areas. We also actively participate in allied efforts that foster natural infrastructure, like the Kennebec Woodland Partnership and Forest Works.

Public water systems in Maine and the Maine DWP (and its predecessors) have engaged in source protection through the maintenance of healthy watersheds and well-managed aquifers for the last century, at least. For most of that time, water systems either purchased land or worked with legislative bodies to restrict activities around their sources. With a few notable exceptions—like Bangor, which has a small watershed that it has been able to acquire in its entirety—most systems need partners and some level of voluntary cooperation to provide sustainable and affordable water.

Maine had a dozen systems with filtration waivers resulting from strong watershed protection. Nine systems still maintain waivers, and two that have installed filtration still depend on watershed protection to minimize their treatment (both use microfiltration, which requires very low turbidity). For several of these systems, as well as many systems with filtration, continued collaboration with groups in a large watershed is the most cost-effective way to deliver safe and secure drinking water.

In 2003, the DWP and the public water systems completed risk assessments for their water sources. We found that the biggest risk to safe and secure drinking water is future development near water sources. As Maine's population dispersed from town centers to the country in the last thirty years, much of that development encroached on

water supply areas. Neither water systems nor the DWP have the tools or authority to manage land use and development, short of buying land.

Once the assessment results sank in, we increased our efforts to find allies who could help us and water systems ensure safe and secure drinking water for future generations. We looked for entities with common interests in clean water and in land uses that help generate clean water. Issues like compact development, forest fragmentation, and quality of place resonate with entities that have historically not worked with water systems. Similarly, few water systems would historically have considered working with land trusts and other "conservation" organizations. Developing alliances like this is a long process, and almost a decade later, we are still working on it.

Since source protection is a voluntary, incentive-based program, much of our state-level work is focused on finding partners with resources and common cause with water systems. We have used the national Source Water Collaborative (SWC) as a tool to engage local affiliates of national groups. For example, the State Farm Service Agency, an SWC member, connected DWP with the USDA NRCS. Our EPA regional contact (active in SWC), was key to uncovering synergies with NRCS. This national perspective helps local affiliates to move forward.

Working with EPA Region I, we have been able to engage other federal agencies at the state and local level in work involving sustainable forestry. The USDA Forest Service and NRCS—and their state and county partners—have found drinking water protection to be a good motivation to advance sustainable forestry. The DWP serves as a "bridge" between water system needs and priorities and nationally-driven programs. Similarly, local districts have landowner relationships that help to make progress on the ground.

lack the capacity and expertise to directly implement natural infrastructure projects. In addition, in some setups the implementers are also responsible should the arrangement fail. In this way, implementers can aggregate risk, helping to facilitate participation by risk-averse investors or landowners. Implementers typically generate revenue through “sale” of the watershed services generated. Some secure upfront financing from private lenders.

Philanthropies/Private Capital

Philanthropic organizations and even private lenders can play a critical role by providing upfront capital to establish natural infrastructure projects. Philanthropies have a particularly important role to play in the scoping and design stages, while private lenders more typically provide capital for implementation. These institutions provide capital in the form of grants, loans, and investments.

Mainstreamers

Mainstreamers are typically non-profit organizations that promote the natural infrastructure approach as a viable policy and operational complement to built infrastructure. They raise the profile and mainstream the approach and provide access to regional and national-level organizations. They also connect disparate efforts to create consistencies, scale efforts, and achieve institutionalization. Mainstreamers typically operate with grant funding and philanthropic donations. Ultimately their involvement relates to their core mission. Examples include the World Resources Institute, Earth Economics, The Conservation Fund, The Nature Conservancy, The Trust for Public Land, Forest Trends, and sometimes academics.

Academics & Modelers

Academics and modelers (for-profit or non-profit) create the quantification methods for the investment program. In coordination with stakeholders, quantification method developers provide the scientific link, models (Section 2.4), and credibility between conservation practices, conditions, and watershed services outcomes. These entities typically charge fees for services offered, or in some cases operate with grant funding for academic purposes. For academics, quantification tool development for natural infrastructure investment is an opportunity to put research into action.

“Partnerships are critical. Effective source water protection typically requires a collaborative effort among a variety of stakeholders—at federal, state, and local levels—as well as a shared recognition of the value of the resource needing protection. No one agency or organization has all of the authorities it needs to make on-the-ground progress in protecting sources of drinking water, including with innovative approaches like natural infrastructure.”

-Jim Taft, ASDWA

BOX 20 | STATE FORESTRY AGENCIES

| Craig Partridge, Washington State Department of Natural Resources

The Washington State Department of Natural Resources (DNR) is exploring payment for watershed services (PWS) as a form of financial incentives to help retain working forest lands at risk of conversion to non-forest uses. DNR's current focus is facilitating a transaction demonstration project in the forested Puget Sound basin, to test whether current demand drivers and seller interest, along with available stakeholder and institutional support, is sufficient to generate one or more real transactions involving water utilities as buyers. The intent is to use this test as a deliberate learning opportunity aimed at broader application of the PWS concept. The specific PWS transaction most likely to be concluded involves a mid-sized city water department, using city authorization and capital funding to acquire less-than-fee property interests in rural, rural-residential, and resource lands within a new wellfield protection zone above a drinking water aquifer. The demonstration project is helping to focus and implement the city's acquisition strategy.

DNR's involvement in this initiative is based on several factors: 1) Widely acknowledged risk of accelerated conversion of working forest land to non-forest land uses in suburbanizing areas of the Puget Sound watershed; 2) Recognition, among stakeholders of Washington State's rigorous forest practices regulatory program (administered by DNR), that additional increments of resource protection aimed at biodiversity conservation are more likely to be achieved in a timely way through incentive tools than by additional regulations; and 3) Legislative direction to DNR to explore forest landowner incentive mechanisms with a focus on ecosystem service market opportunities. DNR has been coordinating stakeholder discussions of transactional incentives for forest landowners based on carbon storage, watershed services, and biodiversity conservation.

DNR's specific role in the PWS demonstration project, as the state forestry agency, has been to help organize interested organizations in two pilot watersheds, in order to create a potential market opportunity for large and small private commercial forest landowners. DNR has reached out to water utilities as potential buyers of watershed services, facilitated connections between local watershed groups and regional and national PWS experts, and facilitated the convening of large multi-interest gatherings in partnership with the Northwest Environmental Forum at the University of Washington's College of the Environment. In addition, DNR applied for and received a National Estuary Program grant, which is being used to provide analytical services, including metric development and economic analysis, for the watershed pilots. DNR is also helping to coordinate local watershed groups' project-related interactions with other state and federal agencies, such as the state drinking water agency.

Washington DNR has a broad mission, including managing over five million acres of state-owned trust lands, aquatic lands, and natural areas, regulating forest practices, protecting forest lands from loss due to catastrophic wildfire, and providing technical services to forest landowners. Working with partners to retain working forest lands at risk of conversion is a core element of the agency's five-year strategic plan. Information about the PWS demonstration project can be found at: http://www.dnr.wa.gov/ResearchScience/Topics/ForestResearch/Pages/forest_watershed_service_markets.aspx.

Tool Developers

In large-scale programs, infrastructure developers create the software, online platforms, and other tools used to facilitate investments in natural infrastructure. Examples include the [Markit Registry](#) and the Willamette Partnership's [Ecosystem Crediting Platform](#). These tools help with calculation, tracking,

verification, and monitoring of natural infrastructure investments over time while providing transparency and public outreach. Much of the early infrastructure has been developed with the support federal grant programs such as [USDA Conservation Innovation Grants](#). Technology developers typically charge fees for services and products offered.

Protocol Developers

In large-scale natural infrastructure programs—particularly those that function as a market with the trading of “credits”—protocols are needed to establish the “rules of the game,” in consultation with stakeholders. These rules outline the specific operations of a natural infrastructure initiative (landowner eligibility, service areas, additionality, etc.). Protocol developers ensure the natural infrastructure investment process is science-based, credible, transparent, and verifiable—and secure the commitment of all major stakeholders. Increasingly, protocols are being modified and adapted to local context as opposed to being created from scratch each time. Protocol developers typically charge fees for services offered, or in some cases are partners on a larger grant to establish a natural infrastructure program. Many of these organizations are interested in providing consistency to efforts across geographies, which is critical for the institutionalization of integrated natural and built infrastructure approaches to water management.

Market Administrators

In programs that function like a market, administrators are important to conduct market operations. They assist in the training of verifiers, document retention, third party validation and verification of natural infrastructure, and updating of protocols. In credit-based programs, administrators also ensure credit registration either “in-house” or through a third party. The administrator role requires continuous stakeholder engagement and facilitation. Market administrators typically charge fees for services offered, or in some cases are partners on a larger grant to establish a natural infrastructure program. These entities also operate in pursuit of place-based missions advanced by well-functioning natural infrastructure programs.

Section 4.2: Engaging Landowners

| Michael G. Sorice, Department of Forest Resources & Environmental Conservation, Virginia Tech

Critical to successfully securing the desired supply of watershed services is achieving a sufficient level of private landowner participation. Natural infrastructure programs can incentivize participation either through financial subsidies or through the creation of a market for watershed services. In addition to the inducement being offered, landowners

consider how the conservation program is designed and administered as part of their participation decision (Sorice et al. 2011). That is, private landowner participation is a function of the both social and economic costs of obtaining the subsidy or participating in a market.

This leads to questions about how to design conservation programs that achieve sufficient landowner participation to benefit the entire watershed. Financial incentives by themselves do generate participation, but perhaps not at the critical levels necessary for successful landscape-scale conservation outcomes. Further, incentives may have hidden costs (Sandel 2012). For example, the supply of the desired behavior often ends when the incentive is no longer available. Under certain conditions, such as when people are motivated by ethical, altruistic, or civic considerations, financial incentives can actually undermine an effort to build participation. Consequently, it is worthwhile to consider factors other than financial inducements that influence landowner decisions.

Landowners are highly independent, value their autonomy, and generally engage in agriculture or forestry because it is a way of life as well as an economic enterprise. Incentive programs can impose additional costs on landowners when, for example, they are administered in a way that is perceived by the landowner as controlling. In a survey examining potential participation in an incentive-based conservation program for at-risk species (Sorice et al. 2013), about one third of private landowners surveyed were predicted to participate in a program that had a long-term commitment and a moderate financial incentive, but that gave landowners no say in land management decision making. Predicted participation increased to about 60 percent when a high financial incentive was offered, and increased further to about 80 percent with a high financial incentive and a program structure that allowed landowners to share in land management decisions.

Increasing the desirability of conservation programs can be achieved by focusing on program structure and on the process used to create the program. First, providing landowners with a program that contains options and allows landowners some flexibility are ways to make them feel less like they are being controlled (DeCaro and Stokes 2008).

Further recognizing and valuing the local knowledge of landowners, respecting their sense of pride, and providing positive feedback on their progress is important to recognizing landowners' competence. Programs that are able to create a sense of community—a sense that landowners are part of a larger group of like-minded landowners—may increase a landowner's desire to join the group and adhere to the formal and informal rules of the group (Van Vugt 2009).

Second, changing the process by which an incentive program is created may lead to enhanced participation (Brown 2009). In contrast to the top-down approach where the organization or agency creates the program and then deploys it into the community, a landowner-centered approach recognizes both the social and the ecological complexity inherent in a region by creating programs that are customized to the needs of the landowners in an area. The organization enters communities to understand the landowners themselves, identify constraints and opportunities that are specific to the group of landowners, uncover needs they may not even know they have, and test new ideas. Solutions constructed from the bottom up, with direct landowner involvement, lead to greater buy-in. Landowners in the area may feel that the program is designed by them and therefore feel more vested in the program's success. The program puts the landowner first, leveraging local expertise, and thus is more likely to be structured and delivered in a way that supports landowners' basic needs for competence and autonomy.

Creating a market to induce private landowners to supply watershed services can certainly be successful. However, the reasons landowners engage in some markets and not others may be related to noneconomic factors. Designing programs that support landowner autonomy, that recognize expertise, and that create a sense of community can lead to market-based incentive programs that provide a sustained supply of watershed services.

Section 4.3: Recommendations for Landowner Engagement

| Daniel Cantor, Colm Fay, Matthew Harrison, Emily Levine, and Chris Zwicke, University of Michigan School of Natural Resources and Environment

This section highlights findings from an examination of landowner engagement in the Sebago Lake watershed in Maine. Recommendations are based on a systematic review of existing incentive programs and the literature on landowner preferences, as well as interviews with natural infrastructure program administrators throughout the United States and stakeholders in Southeast Maine. The full report can be found here: <http://hdl.handle.net/2027.42/90874>.

Scaling up natural infrastructure investment programs will take more than the simple replication of successful models. Landowners have complex and varied reasons for owning land and for engaging in conservation practices. Combining an understanding of these varied reasons with outreach and engagement strategies that encourage the adoption of innovations will enable natural infrastructure program managers to make the right investments with the right participants at the right time. The recommendations below are based on an extensive review of existing literature and interviews with individuals from conservation organizations, state forestry and water quality agencies, and managers of natural infrastructure incentive programs from across the US. These recommendations provide a broad framework, emphasizing social and institutional factors, to help program managers accelerate landowner engagement and, ultimately, participation in natural infrastructure programs.

Recommendations

The recommendations below are categorized in terms of Landowner Segmentation, Targeting and Positioning, Scheme Attributes and Administration, and Outreach Channels and Tactics. Further description of and support for these recommendations can be found in the full report.

1. Landowner Segmentation: trends and implications of landowner demographics, values, attitudes, interests, and land management behavior
 - a. Gather watershed-specific data. Because landowner characteristics vary significantly both within and across watersheds, assessing the motivations and attitudes of landowners in the specific watershed(s) of concern can yield more actionable segmentation insights than relying on proxy data from national or regional studies.
 - b. Segment landowners based on generational characteristics. Variables such as landowner age and method of land acquisition (e.g., inheritance vs. purchase) can be indicative of future changes in landowner characteristics, land use decision making, and parcelization pressures that will influence the transfer of land from current owners over the next 20 years.
 - c. Identify early adopters with a high propensity to engage and contribute. Landowners who have higher incomes and education, awareness of conservation practices, or prior participation in conservation programs, are more likely to participate in natural infrastructure programs.
 2. Targeting and Positioning: prioritizing and messaging to landowner segments
 - a. Build landowner awareness, interest, and participation in distinct stages. The factors that pique landowner interest in natural infrastructure programs often differ from those that convince them to participate. A three-stage messaging approach can create an escalating level of commitment to watershed protection: i) raising awareness through general education; ii) communicating wider program benefits to generate interest; and iii) co-creating key program features to encourage participation.
 3. Program Attributes and Administration: landowner preferences regarding major aspects of a natural infrastructure program
 - a. Offer a portfolio of incentive types or a flexible menu of options to expand participation. Landowner preferences vary. A combination of incentive types (e.g., technical and educational assistance alongside financial payments) or choice of options (e.g., conservation easement vs. term easement) can engage a broader group of landowners and lead to more efficient investments in the desired behavior change.
 - b. Administer the program via an intermediary organization to mitigate mistrust. Federal government and regulatory agencies may in some cases be mistrusted by landowners. Having an intermediary organization with pre-existing local relationships administer the natural infrastructure program can provide a layer of insulation for landowners even when governmental entities are still involved as funders.
- b. Bring landowners together with the watershed service buyer to discuss program design. Rather than a perfunctory stakeholder engagement process, early and ongoing dialogue between landowners and the 'buyer' of the desired conservation outcomes can enhance trust and uncover opportunities for integrative solutions.
 - c. Prioritize influential landowners, not just parcels that have biophysical importance. While some watershed parcels are important from a biophysical perspective, natural infrastructure program priorities should also take into account the social influence of individual landowners within the community. Particularly during the pilot phase of a program, enrolling influential landowners who are willing to champion the program among their peers can be more critical to the long-term success of the program than making the largest short-term environmental impact.



Regardless, explicit statements in program literature about who is allowed access to the land and for what reasons can alleviate concerns about government restrictions and scrutiny.

- c. Consider creating a dedicated stand-alone institution if critical mass is needed. When a specific threshold of enrolled land is needed to preclude a major investment in built infrastructure, a dedicated stand-alone institution can be more effective than a loose partnership in coordinating the interactions of the many partners and landowners.
- d. Create streamlined application processes and eligibility criteria to reduce transaction costs. In particular, programs that decouple the application process and eligibility criteria from existing federal incentive programs can reduce two significant barriers to entry for landowners: time and cost.

- 4. Outreach Channels and Tactics: means and methods for reaching and recruiting landowners in a natural infrastructure program
 - a. Identify quick wins by sourcing participants through partners landowners trust. Asking partner organizations, such as conservation or levy districts, for the names of influential landowners, or landowners already engaged in conservation programs, can be one of the most efficient ways to identify likely participants in a natural infrastructure program.
 - b. Supplement with broad outreach tactics, then tailor the message later. Initial outreach should be generalized: holding informational workshops, attending fairs, and producing educational material drives interest in conservation practices and raises awareness of environmental issues among landowners. Customized messaging should wait until after individuals have demonstrated interest.
 - c. Experiment with encouraging landowner-to-landowner referrals. Peer-to-peer referrals are one of the most powerful mechanisms for expanding participation in natural infrastructure programs, but most programs have not formally encouraged or compensated landowners for these referrals. Whether such interventions impact referral effectiveness should be empirically tested as part of a pilot.
 - d. Provide tools that enable peer-to-peer influence. An online platform that engages landowners in sharing their successes and creates two-way dialogue will help outreach to both resident landowners and the growing absentee landowner population. However, such tools may not be suitable to every demographic.

These strategies are critical to obtaining broad-based landowner trust and participation, which in turn is an essential element of the broader stakeholder engagement and collaborative processes needed for natural infrastructure efforts to be successful.

Chapter 5: Natural Infrastructure Finance

● MAKING THE CASE

- The Business Case
- The Scientific Underpinnings
- Identifying Opportunity

▼ DESIGN AND IMPLEMENTATION

- Players at the Table
- Natural Infrastructure Finance

▼ CASE STUDIES

- Cases
- Concluding Remarks

KEY TAKE-AWAYS

1. Investment in natural infrastructure must be large-scale and sustained to be meaningful. A long list of finance mechanisms is available to get dollars on the ground (Section 5.1). Assess options with an eye toward securing “anchor funding” as well as a broader “funder quilt.” Consider both political viability and fundraising potential in your watershed.
2. Accounting standards are a major challenge to financing natural infrastructure with traditional mechanisms. Stay apprised of efforts to modify standards to incorporate “natural capital” (Section 5.2).

Introduction

Finance mechanisms for built infrastructure are relatively well established for utilities. Rates have traditionally funded operating costs, and municipal bonds have provided finance for large capital expenses like treatment plants. However, when these financing mechanisms were conceived over 100 years ago, they were geared toward the production of pipes, dams, and other built infrastructure that was in short supply at that time. While a handful of utilities today are able to make substantial and deliberate investments in natural infrastructure through their operating and capital budgets, many utilities rely on opportunistic funding sources like grants. As utilities increasingly identify the economic benefits of natural infrastructure, there is a need to harness robust finance mechanisms for these investments, and on a meaningful scale. This chapter describes both existing and emerging finance mechanisms for natural infrastructure, and identifies opportunities for utilities, government agencies, non-profits, and others to drive greater investment toward natural infrastructure, provided the economic case is made.

A long list of public, private, and hybrid public/private finance mechanisms are available to get dollars on the ground to restore, enhance, protect, and manage natural infrastructure for water resources (see Box 22 for resources related to the U.S. South). Some of these mechanisms are creative revenue generators, while others are creative means to channel existing funds toward natural infrastructure—and some are both. Available finance mechanisms can vary considerably in terms of effectiveness in raising meaningful funds and in how those funds are directed toward high-impact natural infrastructure investments. Mechanisms also vary in terms of the distribution of the financial burden, perceived equity, and political palatability.

The choice of finance mechanism is intimately related to the political factors at play in a watershed. Economic analyses can show a “willingness to pay” in a strict economic sense for the services provided by natural infrastructure, and can identify beneficiaries of those services. But the question of who should pay remains a political one. For example, should the burden fall on ratepayers, or taxpayers, or just the major beneficiaries? How should the cost of large-scale investments be distributed

BOX 21 | SECURING LONG-TERM FINANCING

| Sarah Lynch, Director for Agriculture,
World Wildlife Fund

Many natural infrastructure programs begin with grant funding for program scoping and design. To ensure an impact, however, a more sustainable source of financing must be secured. Early-stage efforts can be used to demonstrate viability and return on investment to potential long-term funders.

In the Everglades, for example, a six year pilot to establish payments to cattle ranchers to provide either water retention or nutrient removal services began with a USDA Conservation Innovation Grant. In 2011, the initiative successfully culminated in the South Florida Water Management District (SFWMD)—the Florida agency responsible for improving water quality, maintaining flood control and water supply, and restoring the Everglades—becoming the buyer of these watershed services. In the first solicitation, the SFWMD entered into eight contracts for water retention services. This represents a roughly \$7 million investment for securing on average 4,800 acre-feet of water retention per year over the ten year life of the contract. A second solicitation was released in the summer of 2012. The program will be funded jointly through taxes imposed by the SFWMD and appropriations made by the Florida state legislature, ensuring the commitment and resources to scale the program over time.

Key factors of success included a collaborative approach that tapped the expertise of ranchers, environmental groups, state and federal agencies, and research scientists; the early identification and inclusion of an intended “buyer” of the watershed services in program development efforts; and the experience and “ground-truthing” afforded by working through regulatory, construction, operations and maintenance, and documentation issues on eight pilot projects before bringing the program to scale.

More information on the initiative can be found at <http://www.fresp.org/>.

between generations? Regardless of who benefits, whose responsibility is source water protection? What about the beneficiaries of ancillary services of natural infrastructure, such as carbon sequestration, air quality, biodiversity, and recreation? Or other water-related benefits like flood control that come in tandem with source water protection?

Ultimately, while the role of water utilities and the ratepayers they represent is critical, utilities in some cases may be unable to provide the full funding needed to secure natural infrastructure. One water resource professional noted, “Our utility’s charter, mission, funding mechanisms, and history all serve to question why ratepayer funds should be directed to anything beyond our core services. We are asked this question almost daily and until we have a way of including inherent values that come with natural infrastructure—e.g., air quality, habitat, and increased property values—we will forge an uphill climb. As I’m fond of saying, if this were easy, we’d all have been doing it long ago.” Given statutory restrictions on the use of ratepayer funds, it is often critical to develop a funder “quilt” (Ernst 2004) that includes finance mechanisms that leverage beneficiaries of major ancillary benefits to watershed protection—for example, states and municipalities, land trusts, and hunting and recreation associations.

The primary challenge is to select a suite of finance mechanisms that are capable of gaining the necessary political support for adoption, while also generating sufficient funds for meaningful and sustained investment in natural infrastructure over the long term (Box 21). Some water utilities have successfully adopted rate increases or user surcharges to finance natural infrastructure, in part with the assistance of effective ratepayer communication tools, but this is generally done with much caution. The City of Santa Fe, for example, is considering just a small increase, and only after the program and its public communication efforts have had about five years to convince its ratepayers of the need. Other utilities have, for now, drawn on existing funds already earmarked for source water protection in order to avoid raising rates—or to wait for a more politically opportune time to do so. Still others, like Phoenix, Arizona, and Ashland, Oregon, limit user contributions to voluntary opt-in programs (Carpe Diem West 2010). Stakeholders

BOX 22 | CONSERVATION INCENTIVES IN THE U.S. SOUTH

The World Resources Institute created a series of issue briefs that explore incentives for ensuring that southern U.S. forests continue to supply the ecosystem services that people depend upon, including water, timber, recreation, and other benefits. The issue briefs cover a variety of incentives, markets, and practices, with focuses on easements, forest carbon offsets, property tax incentives, and public ballot measures.

The series can be found at:
<http://www.seesouthernforests.org/issue-brief>

in other watersheds have successfully appealed to private business interests to secure financing for natural infrastructure. Many more watersheds have relied on politically non-contentious, voluntary donations through more traditional channels.

This chapter provides a broad overview of available finance mechanisms, and close-up looks at several efforts in particular, detailing the advantages and challenges. Watershed stakeholders across the country can use the information here to begin to scope finance options that are right for their watersheds.

Section 5.1: Overview of Finance Mechanisms

| Katherine Garvey, Vermont Law School
| James Mulligan, Green Community Ventures
| Rowan Schmidt, Earth Economics

In the United States, investments in natural infrastructure typically take one or more of three forms: land acquisitions, conservation easements, or enhanced land management practices.

Land Acquisitions

Purchasing land outright is an effective means to permanently secure the watershed services that land provides. However, it is typically costly. Consequently, easements and payments for restoration and management have emerged as lower-cost strategies to secure natural infrastructure within a watershed.

Easements

A conservation easement creates a legally enforceable land preservation agreement between a landowner and a government agency or land trust. The easement outlines specific restrictions on land use, typically barring development and commercial or industrial uses. As such, easements can be used both to protect ecosystems and to protect farms, ranches, and the rural way of life. However, unlike with land acquisitions, the landowner retains title to the property. As a result, conservation easements can be substantially less costly than acquisitions while achieving similar conservation outcomes. Additionally, easements are sometimes donated, and those donations are tax-deductible (land can be acquired outright by donation as well, with similar tax benefits for the donor). Furthermore, in some states easement donors can sell their tax credits on the secondary market—a feature that allows even low-income donors to reap the full benefits of the tax deduction. On the other hand, negotiating easements with landowners can be exceedingly difficult and time-intensive given the opportunity costs and other considerations involved for landowners.

Land Management Activities

Many utilities and municipalities own land that provides critical watershed services like drinking water filtration. For example, the City of Seattle, Washington, began acquiring Cedar River Watershed in the late 19th century, and now owns 90,000 acres. The city regularly invests in management activities on its own land (e.g., logging road removal) to maintain watershed services.

In other cases, land is owned privately or by another government agency, but the utility (or other beneficiary) would like to encourage the use of land management practices that are beneficial for water resources—such as restoration and maintenance of riparian buffers and wetlands, or implementation of forestry best management practices (BMPs). While easements can be a viable solution that allows landowners to retain property title, they can substantially and permanently encumber land and, among other things, reduce the land's market value. In some cases, landowners may be unwilling to enter into such permanent agreements. Consequently, shorter term arrangements have emerged where landowners receive payments as compensation for various land

Table 7 | Summary of Natural Infrastructure Finance Mechanisms

FINANCE MECHANISM	TYPICAL REVENUE ALLOCATION			TYPICAL USER OF FINANCE MECHANISM	POTENTIAL SCALE OF INVESTMENT
	LAND ACQUISITION	EASEMENTS	LAND MANAGEMENT ACTIVITIES		
Direct Investment by Governments and Utilities					
Rates	X	X	X	Utility	Med
Municipal bonds (revenue-backed)	X	X		Utility	High
Municipal bonds (general obligation)	X	X	X	Government	High
Rates surcharges	X	X	X	Utility	Med
Earmarked Proceeds	X	X	X	Government	Low-High
Development impact fees	X	X	X	Government	Low
Reverse auction	X	X	X	Government	Low
State revolving funds	X	X	X	Utility	Med
Farm bill programs			X	Government	Med
Water Infrastructure Finance and Innovation Authority	TBD	TBD	TBD	Utility	High
Private investment capital		X	X	Utility, Government	Low
Indirect Investment by Governments and Utilities					
Property tax incentives			X	Government	Med
Voluntary Donations by Individuals and the Private Sector					
Voluntary surcharge	X	X	X	Private sector, NGO, Utility	Low
Online crowdsource platforms	X	X	X	NGO	Low
Auction	X	X	X	NGO	Low-Med
Corporate sponsorship	X	X	X	Utility	Low
Market-based Mechanisms					
Nutrient trading		No additional revenue		Government, NGO	Med
Mitigation banking		No additional revenue		Government	Low-Med
Tradable development rights		No additional revenue		Government	Med
Forest banking		No additional revenue		Private sector	Low
Carbon market	X	X	X	Utility, Government, NGO	Low-Med
Certification and labeling programs			X	Private sector, Government	Low

management activities. These payments typically provide compensation for the costs and lost revenue associated with the management activities, plus a return. The supplemental revenue stream to the landowner not only secures management activities, it can also help ensure the profitability of the current land use (e.g., working forest).

Acquisitions, easements, or land management activities can be funded through a variety of channels (Figure 11): direct investment by governments or water utilities; indirect investment through policies like property tax incentives; voluntary donations by individuals, corporations, or philanthropies; or payments through market-based trading schemes, often motivated by regulatory requirements on private businesses.

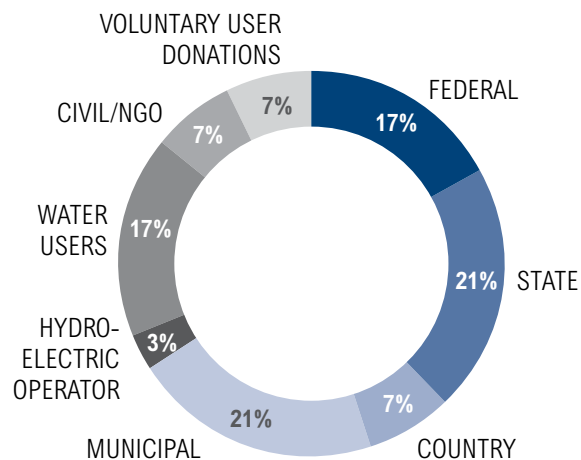
With each of these channels of funding, the specific finance mechanism can vary (see Table 7 for a summary). For municipal governments, natural infrastructure investments are most often funded using earmarked proceeds, development impact fees, and bonds. While many utilities have some portion of their budget dedicated to source water protection, existing budget capacity is generally supplemented with additional funding mechanisms. Utilities can turn to rate increases in the form of user surcharges, or invest in some kinds of natural infrastructure (such as conservation easements) with revenue bond proceeds.¹⁵ Both governments and utilities can leverage investments with funding from Farm Bill programs, turn to state revolving funds for low-interest loans or to private investment capital for upfront finance, and use reverse auctions to find competitive bids from “sellers.” Finally, efforts to raise voluntary donations can employ a variety of strategies, including voluntary surcharges, auctions, and online crowdsourcing platforms. These efforts can also be assisted with government policies like property tax incentives.

Direct Investment by Governments and Utilities

To protect watershed services, the government or local utilities can make direct payments on behalf of taxpayers or ratepayers. Funds for these payments can be raised through bonds, rate or tax increases, or from existing government or utility budgets.

Rate Increases or Surcharges are the prices assigned by a utility for providing services, such

Figure 11 | **Watershed Investors by Sector - Bilateral and Fund Arrangements, United States**



Source: Bennett et al. 2012.

as drinking water, or stormwater management. Rate structures can vary, but most drinking water rates contain a base rate, a volumetric rate (based on usage), or some combination of the two. Rates are the primary funding mechanism for utilities to recover the cost of providing services to users. This typically includes constructing and operating built drinking water infrastructure like pipes, dams, pump stations, and treatment facilities, as well as covering staff, rent, debt service, and other costs. Many utilities dedicate some portion of their rates to source water protection and natural infrastructure. A notable example, the City of Portland, Oregon, committed approximately \$93 million of investment into the Bull Run Watershed’s health over the next 50 years to meet the goals of its HCP (Portland Water Bureau 2008).¹⁶

Rate surcharges are fees on water utility ratepayers, either on the basis of water usage or with a fixed fee per customer. In Raleigh, North Carolina, for example, users pay one penny per hundred gallons of water used. The surcharge raises \$1.8 million annually for investments in the upstream natural infrastructure that protects water quality in the city’s reservoirs (Riechers 2012).

FINANCE CASE 1 | USER SURCHARGES

| Joanna Kraft and Rowan Schmidt, Earth Economics

As the primary source of revenue for water utilities, water rates have traditionally included a single base rate, or volumetric charges. Some utilities now include user surcharges in their rates structures to create more dependable revenue streams for their investments in natural infrastructure. User surcharges are also a convenient means to communicate the value and magnitude of the utility's investments in natural infrastructure to ratepayers and other stakeholders.

The City of Bellingham, Washington, is one utility that includes such user surcharges. In 2001, Bellingham's municipal utility implemented a system of "watershed rates" to fund land acquisition and preservation measures in the Lake Whatcom Watershed, the source of Bellingham's drinking water. Activities funded by the rates include identification, cleanup, long-term maintenance, and restoration of utility-owned land. The watershed rates are also used as a communication tool, to help ratepayers understand the role of natural systems in filtering pollutants and distributing nutrients more cost effectively than traditional built infrastructure.

The watershed rate for unmetered customers is \$12 per month. The watershed rate for metered customers is the sum of a \$5 per month base rate plus a volume rate of 64 cents per 100 cubic feet of water used. The base and volume rate total for metered customers is expected to be analogous to the fixed rate for unmetered customers. Rates are all increased by 50 percent for customers outside the City. Before it was implemented, the fee structure and Acquisition Program went through a public process, including a public hearing before City Council.

The fee has received little opposition from ratepayers and a recent fee increase passed unanimously in the City Council. According to Clare Fogelsong, Environment Resources Manager for the City of Bellingham, this success has been thanks to "...proactive communication with our ratepayers, to make it clear that protecting source water is protecting the community. In the long run it is cheaper to protect our source water now, rather than pay for problems in the future."

User fees for natural infrastructure finance have also been implemented in Little Rock, Arkansas; Santa Fe, New Mexico; Denver, Colorado; San Antonio, Texas; and Salt Lake City, Utah. Additionally, Eugene, Oregon, is considering instituting a user surcharge in future years to fund natural infrastructure programs (The Institute for Natural Resources 2012). Average fees per household per month are typically around fifty cents—a dollar and fifty cents in the case of Salt Lake City. The U.S. Endowment and Earth Economics developed a Watershed Protection Database¹⁷ with a growing list of utilities known to be using rates surcharges to fund natural infrastructure investments.

Straight rate increases and user surcharges can be a difficult political decision for the boards of public water utilities—particularly against a familiar backdrop of already-increasing rates in many watersheds to deal with rising regulatory costs and deteriorating built infrastructure. However, even small surcharges or rate increases can raise substantial funds, depending on the ratepayer base. Box 23 discusses a tool to communicate this dynamic to ratepayers. Finance Case 1 describes the user surcharges that a drinking water utility in Washington State has implemented for watershed protection.

Municipal Bonds are a relatively low-cost mechanism for utilities and state and local governments to borrow money for capital expenses. In general, the term "Municipal Bonds" refers to either "Revenue Bonds," which are secured by a utility's future rate revenues, or "General Obligation Bonds," which are backed by the full faith and credit of a government and its future tax revenue.¹⁸

Revenue bonds have traditionally been issued by utilities to finance large capital expenditures, such as treatment plants and water delivery infrastructure. In contrast, day-to-day operating costs of a utility, including debt service on municipal bonds, are typically funded by rate revenues. Revenue bonds can be used for natural infrastructure to the extent that utilities can include natural infrastructure projects on their capital budgets (or "capitalize" them). The advantage of capitalization is the ability to borrow money for (usually significant) natural infrastructure investments upfront through the municipal bond market, and pay off the loan over time, which is how utilities finance major built infrastructure projects.

For example, some utilities consider riparian easements to be “intangible” capital assets, so they are able to capitalize the land indirectly. However, beyond easements, justifying natural infrastructure on a capital budget remains difficult under current accounting standards (Section 5.2).

General Obligation Bonds have traditionally been used to fund public projects such as bridges, airports, and schools. Each year, many communities also propose and vote on bond measures for natural infrastructure like parks, open spaces and watershed protection. During elections in November 2012, 57 bond measures were proposed to fund parks and land conservation, and 81 percent of these were approved, raising approximately “...\$767 million to support the protection of water quality, new parks and natural areas, and working farms and ranches” (Trust for Public Land 2012). Among the bond measures, Polk County, Iowa, passed an \$18 million bond for the protection of watersheds, wildlife habitat, and natural areas. The Trust for Public Land tracks conservation bond measures through its Land Vote database, available at www.landvote.org.

Ballot measures have been effectively used in the past to secure large-scale bond financing for natural infrastructure. Voters in 23 states have approved 65 of 78 state conservation finance measures on the ballot since 1988—an 83 percent success rate. Together, the approved measures will generate more than \$28 billion for parks, trails, and the protection of natural areas, farmland, and water resources. For example, in November 2012, Maine voters approved a \$5 million bond to support the Land for Maine Future program. Voters in Maine have approved five such bond measures since 1999 to secure public access to natural areas for recreation, to conserve important habitats and watersheds, to preserve Maine’s farming traditions, and to protect the state’s natural infrastructure (Wendy Muzzy, pers. comm. June 13, 2013). In 2009, voters in New Jersey approved a measure to authorize a bond issue for \$400 million to fund a variety of open space, water supply and floodplain protection, and farmland preservation initiatives. The open spaces initiative Green Acres has leveraged public and private groups to protect almost 640,000 acres of open space to date (New Jersey Department of Environmental Protection 2013).

BOX 23 | RATEPAYER COMMUNICATION TOOL: DASHBOARD FOR REVENUE GENERATION

| Jeff Hughes, Environmental Finance Center,
University of North Carolina

The University of North Carolina Environmental Finance Center (EFC) is providing project assistance to the Conservation Trust for North Carolina in its work on the Upper Neuse Clean Water Initiative (UNCWI) through a grant provided by the U.S. Endowment for Forestry & Communities. UNCWI seeks to protect upstream lands as critical nature infrastructure for the long-term health of drinking water supplies in the basin—from groundwater to streams to reservoirs. This initiative is profiled more fully as a case study in Part 3.

A major goal of UNCWI is to establish funding streams from water resource programs within the local municipalities. Toward this end, the EFC is working with UNCWI to build a funding scenario model for the entire Upper Neuse River Basin, including Raleigh. The “[Dashboard for Capacity for Watershed Protection Investment](#)” (beta) is an interactive tool designed for water utility managers and other water resource managers to use in considering options for generating local funds for watershed protection. The tool is populated with data on the number of ratepayers (residential and commercial), the base rate, and the volumetric rate for various fees such as water, wastewater, and stormwater. The dashboard allows the user to use a “slider” to study the impact of incremental additions to the base or volumetric rates and see how much revenue can be generated for watershed protection. It also includes other watershed funding scenarios based on property tax bills instead of the utility bill. The model shows funds generated by these options can be used as a match for grants that require a cost-share. Alternatively, the funds can be used to amortize a loan, since the tool demonstrates to lenders how the funds will be generated for loan repayment.

In the instance of Raleigh, the Dashboard demonstrated that a penny per hundred gallons would generate approximately \$1.8M per year for natural infrastructure. The Dashboard goes on to show how the increased fee will affect the average bill for residential and commercial consumers. In the Raleigh example, average residential users will pay an extra \$0.40 per month, and representative commercial users will pay an extra \$2.46 per month. This information helped to make the case for Raleigh’s decision to shift to supporting UNCWI with a dedicated bill surcharge rather than a less reliable impact fee. The model was also used by neighboring Durham to support a similar but more modest utility watershed contribution program. In both cases, the model demonstrated how a small increase to the water bill could generate meaningful revenues for natural infrastructure.

Earmarked Proceeds are funds set aside to support direct payments for a particular purpose. Voters and legislators can designate a certain percentage of revenues to be dedicated for a particular project. Conservation license plates, a donation on a state income tax form, and dedicated portions of fees from hunting permits or licenses are common examples of earmarked funds for conservation projects. For example, Maine residents pay a \$20 upfront fee and a \$15 annual renewal fee for a specially marked conservation license plate. Of the \$20, \$8.40 is dedicated to the Maine Bureau of Parks & Lands, \$5.60 to the Maine Department of Inland Fisheries and Wildlife (MDIFW), and the remaining \$6 to the Maine Bureau of Motor Vehicles. Funds generated for MDIFW are used in part to protect riparian habitats and large blocks of forest and grasslands—natural infrastructure with substantial benefits for water resources. These funds are also used to secure match from various federal programs. Between program inception in 1995 and 2005, the license plates have generated an average of almost \$490,000 for MDIFW annually (State of Maine 2004).

Development impact fees are one-time charges applied to new developments. Their goal is typically to raise revenue for the construction or expansion of capital facilities located outside the boundaries of the new development that benefit the new development. Impact fees are assessed and dedicated principally for the provision of additional water and sewer systems, roads, schools, and libraries, but can be used for conservation and have been used in this manner in the past (James et al. 1991). For example, the Commonwealth of Pennsylvania in 2012 created an impact fee on natural gas wells drilled in the state. The fee generated more than \$204 million in 2012 alone, of which roughly \$25 million has been earmarked for conservation initiatives including watershed restoration and protection (Elliot 2013).

Reverse auctions are auctions in which the roles of buyers and sellers are reversed. Sellers bid for business, and prices typically decrease over time. A reverse auction is typically used in a market with multiple sellers and one buyer. In the case of watershed services, for example, landowners might bid to supply environmental outcomes at the lowest cost, and bids can be structured in terms of the environmental outcome such as cost per pound

of phosphorous removed (Selman et al. 2007). A benefit of reverse auctions to governments and utilities (or any large buyer) is that sellers self-identify and compete for investments. The World Resources Institute, the Pennsylvania Environmental Council, and other partners demonstrated the reverse auction phosphorous removal projects on farms in the Conestoga watershed. Supported by WRI's NutrientNet modeling tool, which estimated parcel-specific phosphorus runoff reduction potential associated with various changes in practices, the reverse auction in 2006 funded seven projects for an estimated 80,787 pounds of phosphorus reduction at a total cost of \$292,635 (Selman et al. 2007).

State Revolving Funds. Clean Water State Revolving Funds (CWSRF) have provided more than \$5 billion annually in recent years for water quality protection projects, including nonpoint source pollution control and watershed and estuary management. These funds provide low-interest loans for these projects (over 30,000 loans to date, worth over \$89 billion; EPA 2012). In 2006, for example, The Conservation Fund borrowed \$25 million from the California CWSRF to help finance the acquisition of approximately 16,000 acres of redwood forest in Mendocino, California (Allen 2013). The Drinking Water State Revolving Fund is similar, but focused on making funds available to drinking water systems to finance (typically built) infrastructure improvements.¹⁹ See Box 24.

An analysis by the Trust for Public Land found low demand for land conservation using CWSRF, primarily due to lack of awareness, a preference for grant money, a burdensome application process, mismatches with the “culture” of a particular state’s program, and other context-specific challenges (Stangel 2013).

Farm Bill Programs. A number of Farm Bill conservation programs, such as the Conservation Reserve Program or the Environmental Quality Incentive Program, provide technical and financial resources to landowners for restoration and conservation of farms, ranches, forests, and wetlands. These programs can be leveraged by utilities for natural infrastructure investments (USDA NRCS 2012). For example, under the Farm Bill’s Cooperative Conservation Partnership Initiative (CCPI), entities including state and local units of govern-

ment with a history of working cooperatively with producers can enter into multi-year agreements with NRCS to help enhance conservation outcomes on agricultural lands and private nonindustrial forest lands. The program leverages resources of various Federal government programs to implement natural resource conservation practices.²⁰ See Box 24.

A Water Infrastructure Finance and Innovation Authority (WIFIA) is an emerging topic of discussion gaining traction in the water industry. Modeled on the successful Transportation Infrastructure Finance and Innovation Authority, a WIFIA would be a federal entity capable of providing loans to utilities and government agencies to finance water infrastructure projects. Potential advantages of a WIFIA include the ability to lend money for large projects above the capacity of State Revolving Funds. Because the loans would be secured at Treasury rates, the cost of borrowing is likely to be much lower compared with borrowing on the municipal bond market (about \$32 million in savings for a \$100 million loan over 30 years—assuming a 5.4 percent rate for municipal bonds and a 4.04 percent rate for a WIFIA loan). It is not yet clear what percentage of a typical WIFIA loan would be available for natural infrastructure, but it may provide a substantial finance mechanism in the future. Legislation for WIFIA was introduced to the U.S. Congress in November 2012 and again in February 2013 with the support of the American Water Works Association, Association of Metropolitan Water Agencies and the Water Environment Federation (AWWA 2012). The draft legislation would provide loans generally \$20 million or larger and would encourage the use of natural infrastructure.²¹ However, it is unclear whether Congress would remove funding for the state revolving funds in order to fund WIFIA. Such a possibility has led to some level of controversy surrounding the WIFIA proposal, and its legislative prospects remain unclear.

Private Investment Capital. Mobilizing public funds for a large-scale natural infrastructure investment program can be politically difficult, as discussed above. Moreover, utilities and municipalities often prefer to pay for outcomes, rather than risk failure of conservation investments to produce needed benefits for water resources. To address these issues, private investment capital can be used

BOX 24 | LEVERAGING REVOLVING FUNDS AND FARM BILL PROGRAMS

| Jim Taft, Executive Director, Association of State Drinking Water Administrators; Co-Chair, Source Water Collaborative

From a practical standpoint, it is important to consider how existing resources can be leveraged and brought to bear on this challenge. Both the Clean Water and Safe Drinking Water SRFs have featured a requirement that 20 percent of the funds be used for green infrastructure from fiscal year 2009 through 2012—reflecting a recognition by Congress of the importance and value of environmentally sound approaches. However, the green component of the Safe Drinking Water SRF has primarily been used for procuring energy efficient equipment (e.g., pumps), putting in place water metering to promote water conservation for communities without meters, and leak reduction—rather than conserving the natural ecosystems that regulate and filter water.

The green infrastructure portion of the Clean Water SRF has been used in a variety of ways that protect drinking water quality and quantity. These have included a variety of innovative projects, such as on-site stormwater collection and treatment systems as well reclaimed water treatment facilities to preserve scarce water resources. The Conservation Title of the Farm Bill also provides a number of programs, incentives, and sources of funding for various best management practices that can prevent nutrients, herbicides, pesticides, and microbiological pollutants from contaminating sources of drinking water. These include the Water Quality Incentives Program and the Conservation Innovation Grants program. There is also a variety of other federal, state, and local sources of funding that can be used.

to finance upfront conservation investments and absorb some of the risk. While this mechanism is not a form of direct expenditure by governments or utilities, it can be used to facilitate these direct expenditures by fronting the cost and absorbing risk.

In the Pacific Northwest, The Freshwater Trust employs this innovative model. The non-profit organization raises private capital, uses the capital to “lease” land from landowners and plant riparian trees, and then sells in-stream temperature reductions to wastewater facilities that face regulatory

FINANCE CASE 2 | NATURAL INFRASTRUCTURE AUCTION

| Mary Russ, Executive Director, White River Partnership

In 2010, the White River Partnership (WRP) and its partners piloted a natural infrastructure auction (termed a “Landscape Auction”) in Vermont’s White River Watershed to help conserve ecological, historical, and social values that are provided from privately owned agricultural and forest lands.

At a natural infrastructure auction, individuals, groups, and businesses make a bid for the natural infrastructure offered—ranging from simple items like riparian restoration activities to more complex aggregates of ecosystem services such as the water retention capacity of forests, the protection of land-based carbon sinks, the conservation of habitat for fish or wildlife, or the restoration of degraded natural areas such as wetlands. These funds are then used to enter into contracts with agricultural and forest landowners to retain those particular natural infrastructure elements for at least ten years.

At the “White River Landscape Auction,” held on August 14, 2010, nine private landowners, the Green Mountain National Forest, and the WRP offered projects. The auction raised \$20,000 for a diverse set of 30 projects, ranging from \$25 to \$7,500 each. “Community bids”—the pooling of resources from a group of individuals in order to “adopt” a natural infrastructure element collectively—were effective at engaging individuals with small giving capacities.

For example, community bids organized prior to the live auction event by the White River Partnership and Vermont Law School raised \$4,500 and \$2,400, respectively.

Lessons Learned

- Adequate time, funding, and organizational capacity are needed to develop and administer the auction. This project was challenged by a short turnaround period (about seven months) and project funds did not include dollars for WRP staff.
- Auction items must be priced to match the capacity of attending buyers and should be linked to a compelling story and watershed health.
- Demand is critical. The auction model is geared to tap into a large non-profit partner’s established fundraising network with corporations and major individual donors. In contrast, the WRP’s fundraising network consists of local individuals and businesses with limited giving capacities. Larger Vermont and New Hampshire-based businesses participated in the auction, but primarily supported it through in-kind donations.

requirements. The water utility pays directly for the outcome of interest. The Freshwater Trust both covers upfront financing and absorbs all of the risk—and is compensated accordingly.²²

Indirect Investment by Governments and Utilities

Governments can incentivize natural infrastructure through the tax code. While these policies are not direct expenditures, some of them come at a cost in the form of lost tax revenue (commonly referred to as “tax expenditures”). Others, such as taxes on sale for development, can be revenue generators.

Property Tax Incentives. In addition to tax deductions for conservation easements, states use property tax laws to give special treatment to landowners who keep their land undeveloped. These

laws tax undeveloped land at its current use, rather than its potential highest and best use. For example in Maine, “permanently protected open space,” and “forever wild open space,” garner additional 30 percent and 70 percent property tax reductions, respectively (36 M.R.S.A. § 1106-A (2)). Other incentives include taxes on land sale proceeds intended to deter sale for development, and the use of the federal New Market Tax Credit Program to finance protection of environmentally sensitive lands (Levitt 2005).²³

Voluntary Donations by Individuals and the Private Sector

Voluntary donations are politically non-contentious. However, the approach can also struggle to raise sufficient funds for meaningful natural

infrastructure investments. Increasingly innovative approaches to soliciting voluntary donations have emerged in recent years. Among them are natural infrastructure auctions and online “crowdsource” platforms. These approaches are detailed as finance cases below.

When the financing of a conservation project depends on voluntary contributions, the financing is typically achieved through diverse sources of support. Donors may include individuals, foundations, businesses, and corporate interests. Businesses and corporate interests that depend on watershed services to be profitable may make “donations” for natural infrastructure in order to manage their water-related risks.

Voluntary donations are often influenced by state assistance, whether through tax relief or direct support through grants. For example, in Marlboro, Vermont, the Hogback Mountain Conservation Association raised over \$900,000 in private donations from individuals and foundations to conserve 600 acres on Hogback Mountain. These donations were matched by \$450,000 in state and federal funds from a Vermont Watershed Grant, and a \$50,000 appropriation from the Town of Marlboro (Hogback Mountain Conservation Association 2008).

A voluntary surcharge is a small fee that a business adds to a customer’s bill. The fee is given to a dedicated non-profit. The customer has the option to decline the charge voluntarily (Clark 2007). A voluntary surcharge program both generates income and can be an effective vehicle for conservation awareness. The primary disadvantage is the effort needed to set up the program. Most effective voluntary surcharge programs tend to be in popular tourist destinations and have been led by at least one prominent businessperson capable of selling the program to others (Clark 2007). Since both the adoption of the voluntary surcharge by businesses and its payment by customers are voluntary, this mechanism tends to be politically non-contentious; however, its fundraising capacity is limited. For example, 1% for the Tetons—a local chapter of 1% for the Planet—collects funds raised from 80 participating businesses that place a 1 percent voluntary surcharge on their customers. The program raised \$327,000 over its first three years for 27 different environmental sustainability projects

(One Percent for the Tetons n.d.). This amount is fairly small relative to investment needs for typical, robust natural infrastructure programs.

Auctions. Whereas a reverse auction is used in a market with one large buyer, the standard auction mechanism can be used to aid conservation groups and landowners in attracting funding from multiple donors. The auction functions as a broker between conservation groups, landowners, and financiers, creating a financial link between those who take care of the landscape and those who enjoy it. Auctions are specifically tailored to place-based needs and scales by focusing on geographic locale regions, areas, or communities where “buyers” have specific interests. And they have educational and community cohesiveness benefits by connecting local citizens directly with the often difficult to grasp concept of ecosystem services. Auctions been tried in Vermont and in the Netherlands with success, although funds raised to date with this mechanism are typically small relative to needs for natural infrastructure. See Finance Case 2.

Online Crowdsourcing Platforms are online websites that enable individuals and others to browse profiles of natural infrastructure projects and make direct “investments” (typically donations) in projects of their choosing. The mechanism can streamline fundraising efforts focused on voluntary donations and access prospective donors who may not typically give to traditional land trusts or other organizations that typically spearhead ecosystem conservation efforts. Crowdsourcing platforms have been enormously effective in financing creative projects (e.g., kickstarter.com) and international microfinance projects (e.g., kiva.org). See Finance Case 3.

Corporate Sponsorship may be an option when local businesses would like to associate their brand with the utility’s stewardship or realize their product depends on investing in the local environment. The Eugene Water and Electric Board in Oregon is exploring partnerships with local breweries in Eugene to create a “sustainable beer” label. By paying a percentage of their revenue into the utility’s watershed protection fund, the breweries can position themselves as socially and environmentally responsible businesses, which may in turn attract more customers or justify a premium price (The Institute of Natural Resources 2012).

FINANCE CASE 3 | ONLINE CROWDSOURCE PLATFORM

| Wayne Barstad, Dartmouth College

Clean Water Future is an online marketplace designed to “crowdsource” investments (donations) in projects proposed by local forest landowners to protect and enhance natural services. For landowners and non-profit organizations, the tool is an alternative fundraising opportunity, independent of foundations, state and federal agencies, and other traditional funding streams. For site visitors, on the other hand, Clean Water Future is a place to learn about on-the-ground conservation efforts and to make direct investments in services such as clean water, flood protection, habitat, and recreation.

Clean Water Future recruits and posts a variety of specific water-related conservation projects on its website. Projects are sponsored and implemented by non-profit conservation organizations working with the landowners in question. The management strategies implemented by landowners, with the assistance of these organizations, enhance natural services that benefit others. Site visitors can read about the projects and see the remaining funds each project needs to be implemented.

This type of funding platform encourages creativity in the submission of projects from sponsors with diverse needs and conservation perspectives. Unlike traditional grants, this funding source allows for quick, direct feedback on the merits of a proposed project among the funder audience. And the platform may be effective in reaching those would-be donors who prefer to give to specific projects (and put their names on those projects through social media) than to an environmental organization through more traditional avenues. At least one listed project in the site’s first six months brought new donors and new members to a project sponsor organization.

Building an effective visitor base takes time and effort. Google Analytics shows that the site had 2,804 visits from 1,756 people in the site’s first six months since launch in 2011. During this time, Clean Water Future posted 14 projects with a combined cost of \$87,609. Approximately \$22,000 in investments has been made through the site, with the Conservation Innovation Grant contributing an additional \$11,000 in match as an incentive. These early investment rates would need to improve over time to justify estimated annual operating costs (\$80,000–\$120,000). Earned income from fees on projects would be low during the first year, gradually increasing year-by-year and in time covering expenses. On-site advertising revenue would improve cash flow; however, we have not looked into this avenue of income.

Our intention was to reach investors far beyond the areas tapped by the local non-profit conservation organizations. However, the preponderance of investments in the first six months came from the local base. Initially we intended to market through web links from other sites, word-of-mouth, and press releases. However, these avenues have not been sufficient.

In addition to the tax credit incentive for donating to a non-profit organization, we tested various rewards to incentivize investments. The marketing team created several rewards to investors and tried them out on the website. Although the effect is still unclear, the use of tangible gifts or rewards has been successful in other crowdsourcing sites such as Kickstarter.com. Other sites use the loan model (investors get their money back). Ultimately, while Clean Water Future offers many of the benefits of an online crowdsourcing platform, it is still an avenue for donations.

Market-Based Mechanisms

We use the term “market-based mechanisms” here to broadly refer to those mechanisms that leverage economic markets in one way or another for conservation. Some of these mechanisms are quasi-markets created for a conservation purpose—for example, to enable regulated entities to achieve regulatory compliance (for example, under the Clean Water Act or Endangered Species Act) more cost-effectively by purchasing “credits” or “offsets”

that represent a conservation action of interest. Other mechanisms carve conservation funding out of existing markets (e.g., forest certification to secure premium prices for sustainable timber within existing timber markets).

Nutrient trading, for example, allows one player to meet nutrient reduction requirements by acquiring nutrient reduction credits from another player within the same watershed. Credits are generated

when a player reduces nutrient loadings to a greater extent than is required.²⁴ These programs are typically developed to comply with TMDLs under the Clean Water Act. Credit “producers” can be non-point sources—that is, forests, farms, or ranches that produce credits by undertaking conservation actions (various forms of natural infrastructure) in order to reduce nutrient runoff. In Chesapeake Bay, for example, wastewater treatment plants can meet the pollution limits of their operating permits by purchasing credits from farmers who employ land management practices to enhance water quality. These transactions provide financing to landowners to implement those conservation practices for natural infrastructure.²⁵ In this way, nutrient trading can generate substantial funds for investment in natural infrastructure.

Mitigation banking is another market-based mechanism whereby natural infrastructure is protected through sale of credits to polluters or developers by those who have undertaken a conservation action to offset the impact (e.g., loss of wetland or habitat), and ideally provide a net conservation benefit. An example is wetland mitigation banking, or banking for threatened or endangered species (referred to as “conservation banking”). There is a large body of literature on the mitigation banking approach. For example, [The Conservation Fund](#), [EPA](#), and the [National Mitigation Banking Association](#) each have websites dedicated to the subject.

Tradable (or Transferable) Development Rights (TDR) allows property owners who want to increase development rights on their land to pay for that right in a trade with a property owner who agrees not to develop land somewhere else. A typical case is the rural landowner who sells his or her right to develop (by creating an easement) to an urban developer who would like to increase the square footage, height, or number of units beyond that allowed by zoning restrictions. The TDR program in King County in Washington State, for example, has protected over 141,392 acres of rural and resource lands since the year 2000 (King County 2012). The benefit of TDR is to channel development away from the more healthy rural areas of a watershed to the already urbanized portions of the watershed, thereby protecting source waters.²⁶ Note that TDR programs can only be successful where there is a true scarcity of development rights.

FINANCE CASE 4 | CALIFORNIA'S EMISSIONS TRADING PROGRAM

| Christoph Weissbart and Rowan Schmidt,
Earth Economics

The Global Warming Solutions Act of 2006 (AB 32) sets the State of California's 2020 emissions reductions goals into law, and directs the California Air Resources Board (ARB) to take a number of measures toward this end. One of the state's key programs for achieving its emissions reductions goals is the Greenhouse Gas Cap-and-Trade program, to be implemented in several phases, beginning in 2013. The Cap-and-Trade program will be the world's second largest carbon market, and it creates a real finance opportunity for many water utility natural infrastructure projects across the United States.

The Compliance Offset Program and Natural Infrastructure Finance Opportunities

Utilities that plan to undertake restoration projects may be eligible to enroll in the Compliance Offset Program, which would enable them to sell “offset credits” to regulated emitters (such as cement factories) that are not able to meet their emissions cap through other requirements. One ARB offset credit represents the equivalent of one metric ton of carbon dioxide sequestered or not emitted. Up to eight percent of an emitter's compliance obligation can be met through offsets, and only projects in the United States that belong to an ARB-approved “compliance offset protocol” can apply for offsets.

Currently, four compliance offset protocols have been released, of which two are relevant to water utility natural infrastructure projects: U.S. Forestry and Urban Forestry. These protocols define requirements for creating carbon offsets through tree-planting programs, and provide guidelines for how to create and sell offsets, including eligibility rules, methods for quantifying GHG removal, and offset reporting procedures. Due to a predicted shortfall in offset credits in future years, regulators are also considering the inclusion of a protocol that would reward utilities and governments able to verify “avoided deforestation” (London Green Financial 2012).

Even at a price of just \$10, carbon offsets represent a \$4.6 billion market, creating a significant opportunity for natural infrastructure finance (Evolution Markets 2010). In early 2013, allowances sold for \$13.62. As the market develops, the State of California expects offset credits to sell for around \$21 (Environmental Defense Fund 2012).

More information on California's Compliance Offset Program is available at <http://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm>.

FINANCE CASE 5 | CLEAR WATER CARBON FUND—CARBON FINANCE FOR CLEAN WATER

| Ethel Wilkerson and John Gunn, Manomet Center for Conservation Sciences

The joint carbon-water model is also in use in the Northeast, where the Manomet Center for Conservation Sciences has developed the Clear Water Carbon Fund (CWCF)—an innovative, market-based program designed to bring together community partners to restore forests along riverbanks. CWCF plants trees on behalf of individuals and businesses that seek to protect their local water resources and mitigate carbon emissions. CWCF utilizes the concept of a voluntary carbon offset market to increase the capacity of existing community-based organizations to protect clean water. Manomet successfully piloted this program in two watersheds in Maine and Vermont in 2011.

The CWCF allows individuals and businesses to invest in reforestation of stream and river banks. These trees (1) protect and maintain clean water and wildlife habitat, (2) sequester carbon over time, and (3) help sustain natural resources that are the foundation of local economies and communities. In 2011, CWCF raised enough funds to plant nearly 2 acres of trees within riparian areas in Maine's Sebago Lake and Vermont's White River watersheds. As these 600+ native trees grow, they will absorb and store over 200,000 pounds (90 metric tons) of carbon from the atmosphere, keep water clean, create wildlife habitat, and help maintain the quality of life and economic health of local communities.

The slogan for the CWCF is: "Plant trees. Protect water. Buy local." This simple statement summarizes the multiple benefits of the CWCF. Over a 40-year period, each tree planted removes 330 pounds of carbon from the atmosphere and provides verifiable benefits to clean water and wildlife habitat. Making a contribution to the CWCF allows customers to take action on reducing their carbon emissions to fight climate change and at the same time invest funds in their community to help protect clean water and wildlife habitat.

The key problem the CWCF strives to solve is lack of sufficient resources of community and watershed groups to keep water clean and fight climate change locally. The

CWCF was developed to bring resources to community-based watershed groups, increase their capacity to plant trees along riverbanks to restore riparian areas, and engage a greater range of businesses and community members on water quality issues. The CWCF is focused on restoring riparian areas because the science shows a clear link between forested riparian areas and the maintenance of clean water. The benefits that healthy riparian areas can provide are wide-ranging, including clean and safe drinking water, habitat for fish and wildlife, and recreational opportunities that are critical for a community's economy and quality of life.

The CWCF also has a goal of supporting community-based watershed stewardship. The CWCF partners with local groups that have direct experience working with local stakeholders to promote and implement watershed enhancement projects in their communities. The "sale" of trees to businesses and individuals who are interested in reducing their carbon footprint provides a new funding stream for water quality protection projects and allows local organizations to engage a much broader audience than their traditional donor base.

CWCF has been successful in soliciting on-line contributions by many individuals. This strategy has been effective during gift-giving seasons where individuals can make contribution as "gifts" for others. However, this is a labor-intensive approach and only will be viable as a complement to an approach that engages local institutions or businesses. The costs of the program are high at a small scale of operation (e.g., planting fewer than 10 acres per year), which presents a challenge for self-sufficiency if the donations are to cover overhead and operating costs. The program is currently supplemented by external grant funding to these expenses. Third party verification of carbon offsets generated by the program is also prohibitively expensive at a small scale. Until the program gets to sufficient scale, "second-party" monitoring and transparency will need to be sufficient to convey confidence to the donors that the plantings represent additional carbon stored on the landscape.

Forest banking is another form of banking to finance watershed services. Often, forestry operations suffer from the burden of irregular cash flow. To minimize this burden and allow for successful preservation of sustainable forestry options, landowners may deposit land in a forest bank. The collective harvest of all participating landowners allows each landowner to receive a dividend each year instead of once every 10–20 years (Gilges 2000).

Carbon markets also provide market-based opportunities for natural infrastructure financing. Forest-based natural infrastructure in particular provides not only water resource benefits, but also carbon storage benefits. Selling carbon credits generated from forested watershed conservation efforts can be an excellent leverage opportunity. See Finance Cases 4 and 5.

Certification and labeling programs are market-based mechanisms to finance natural infrastructure. These programs leverage consumer preference for sustainable goods (and willingness to pay more for these goods). The increased demand or premium price paid in markets for products like sus-

tainable timber provides incentives for landowners to use sustainable practices—and compensation to do so.

At the time of publication, the World Resources Institute is investigating the extent to which one such certification standard—the Sustainable Forestry Initiative (SFI) Standard—promotes verifiable implementation of forestry practices that provide critical watershed services for downstream users. The research examines:

1. The effectiveness and related documentation of SFI certification in promoting implementation of forestry practices in accordance with state law and BMPs for water quality;
2. The extent to which state law and BMPs adequately address water quality; and
3. The effectiveness and related documentation of SFI certification in promoting implementation of forestry practices that go above and beyond state law and BMPs for water quality.



Section 5.2: Accounting Standards and their Implications for Finance

| David Cosman, Rowan Schmidt, Jennifer Harrison-Cox, and David Batker, Earth Economics

This section details a critical finance roadblock faced by public water utilities—accounting standards that do not treat natural infrastructure as a capital asset for the water supply and other critical services it provides. As we discuss, several public utilities have created the Watershed Economics Workgroup to address this roadblock.

In 1889, the City of Seattle established a public drinking water system (now called Seattle Public Utilities or SPU) and began acquisition of the forested Cedar River Watershed to provide and filter the community's water. This was a radical and expensive idea at the time. Had the City's leaders required a threshold rate of return on investment, it would likely never have justified this unusual project. However, the city's goal was not to maximize "net present value," but to provide safe and reliable drinking water for the people of Seattle for the foreseeable future. Today, Seattle owns, protects, and manages the entire 90,000-acre Cedar Watershed for drinking water.

Seattle's investment proved to be worthwhile. Today, SPU would have to pay an upfront cost of \$200 million to build a filtration plant to filter the city's water supply with annual operating and maintenance costs of \$3.6 million per year if the forest did not do this job (Batker et al. 2010). Of course, after a century it would likely have been the third or fourth filtration plant to be built. Protection of the Cedar Watershed will continue to play an important role in avoiding the need for a filtration plant, along with other factors such as EPA regulations.

The SPU case study illustrates three important points:

1. Natural infrastructure tends to provide benefits over a very long period of time (centuries or longer), whereas manmade capital provides benefits in the near term (years to decades).
2. Natural infrastructure appreciates in value over a long period of time due, in part, to increased scarcity, whereas built capital depreciates relatively rapidly.



3. Investments in natural infrastructure with the goal of sustainability can be far better investments over the long term than investments with shorter, but less sustainable benefit flows.

The value of the forested Cedar River watershed for SPU and the City of Seattle is clear.

The Accounting Gap Dilemma

From both an economic and ecological standpoint, however, a fundamental dilemma is faced by SPU, New York City, and other watershed-filtered water utilities in the form of an accounting omission. The accounting standards to which SPU must adhere are set by the Governmental Accounting Standards Board (GASB), responsible for state and local government standards in the United States. The problem is that the watershed, which provides and protects the purity of the water supply, is intuitively one of the utility's greatest assets, yet it does not register as an economic asset in the utility's financial books beyond the historical cost of acquiring the land. Facilities, pipes, vehicles, buildings, roads, computers, copy machines, fences, and pencils all count as assets. If SPU had to install a \$200 million filtration plant, it would count as an asset on their

books. The value of the forested watershed that meets the same filtration need does not count.

Why is this a problem? Consider one big advantage of a valued capital asset: you can invest in it. If SPU needed to construct a filtration plant, they could borrow money through the issue of municipal bonds, invest in the plant, and pay back the loans. In addition, since a filtration plant is an acknowledged capital asset, a sufficient budget for maintenance and operations is justified. Thus, one problem with not recognizing the watershed as an economic asset is that the utility cannot have a capital improvement project to accomplish needed maintenance and restoration. That is, it cannot borrow money against that asset to pay for improvements. In addition, because the utility's largest asset—the watershed—is not measured as an economic asset beyond the (relatively low) historical cost of the raw land plus the timber value of the trees, the operations and management budget does not have the same financial justification and therefore risks being inadequate.

A couple of interesting ironies of current accounting practice are worth mentioning. First, if a watershed becomes polluted, clean-up costs must be immediately recognized as an expense and recorded as a liability on the utility's financial statements, and the GASB provides clear guidance on how to account for these costs. However, simply having a pristine watershed is not shown on the statements beyond the (typically) very low historical costs of purchasing the watershed. Second, if an old logging road in the watershed needs to be decommissioned to prevent sediment and runoff from entering the reservoir and degrading water quality, the utility's assets will take a write-down. The road is counted as an asset because it was originally an "improvement" to the watershed, although in reality it is an economic liability.

The mission of water utilities is to manage renewable natural resources. Proper management and security of water supply is not only vital for providing clean, safe drinking water: It affects the utility's bottom line and prospects of continuing to borrow money for general capital improvement. A recent analysis by Ceres and Water Asset Management concluded that many water and power utilities in water-stressed regions, which rely on a predictable water supply

to repay their debts on the municipal bond market, may in the future find it more expensive to borrow money, if water scarcity risks should ever be reflected in the pricing or disclosure of the bonds they issue (Leurig 2010). The utilities that best protect their natural infrastructure and secure sustainable water supplies may have a distinct advantage.

Healthy watersheds can also reduce a utility's exposure to risk. Following the devastation of Hurricane Sandy along the East Coast in November 2012, for example, it was noted that while much of New York City's public infrastructure was crippled, "...in most cases drinking water quality is not one of [the problems]." Boil orders were in place for many other communities due to contamination of groundwater supplies, but New Yorkers could continue to drink straight from the tap, thanks to ample reservoirs in the Catskills Watershed "...located away from the city that are not groundwater based" (Appleton et al. 2012).

Implications for Natural Infrastructure Finance

Updated accounting standards will better equip utilities and other agencies to understand the full spectrum of built and natural infrastructure investment options at their disposal for source water protection and could enable substantially increased financing for natural infrastructure. New accounting frameworks will support existing finance mechanisms for natural infrastructure, described in Section 5.1, and will open up new streams of revenue. Examples of impacts may include:

- 1. Municipal bonds.** When natural infrastructure is reflected in utility financial statements, municipal bond ratings agencies and bond investors will begin to perceive its importance for providing utility services and supporting the utility's future revenue streams (i.e., used to repay bonds), as well as managing risk from events like hurricanes and drought. Thus, utilities that make significant investments in natural infrastructure may be in a position to improve their bond rating and lower their cost of borrowing. Over the lifetime of a large 30-year bond, even a small difference in interest rate can translate to millions of dollars in savings.

- 2. Rates.** Currently some utilities dedicate a portion of their rates to natural infrastructure, often in the form of a rates surcharge, as described in Section 5.1. Allowing utilities to reflect the value of their natural infrastructure investments in their financial statements (i.e., as capital assets) may justify widespread adoption of new rates structures, which include a natural infrastructure component, creating a robust funding stream for natural infrastructure investments. Water rates are also a convenient means of educating rate payers and policy makers on the magnitude and importance of a utility’s natural infrastructure investments.
- 3. Asset management and budgeting.** Recognizing natural infrastructure as a capital asset would support utilities in developing more integrated asset management approaches, where both natural and built infrastructure are considered an integral part of the utility’s overall system. Also, including natural infrastructure in a utility’s capital budget (often called a “Capital Improvement Program”) ensures it is assigned a sufficient ongoing operations and maintenance budget. To better understand this dynamic, Duke University and Earth Economics are leading a research project with three utilities to develop hypothetical frameworks for including natural infrastructure on financial statements, and evaluate the impact of this inclusion on each utility’s overall capital investment plans and priorities.

Finding Solutions and Taking Action

GASB accounting rules could be broadened from their sole focus on historical cost accounting and manmade assets. Because accounting rules have been developed for built capital, which depreciates, they are historical-cost-based—meaning the value of the watershed is the original amount paid for the land (in the case of SPU, most acquisitions were made in the 1800s and early 1900s). Modifying these rules for ecological assets would enable a water utility to adequately account for investing in its greatest asset: the watershed itself.

Alternatively, the value of the ecosystem services delivered by the watershed could, for example, be estimated by considering how the functions of the watershed would be replaced to provide clean

water by other means. This estimation can take into account the construction and maintenance costs of filtration plants, plus the costs of obtaining water from another source, such as desalinization or groundwater pumping.

However, while it is clear that our accounting and economic measures could do a better job of capturing the value of natural capital, a number of technical and institutional challenges remain. For example, methods for valuation of natural infrastructure are still developing, and must deal with the many complexities of ecosystems. GASB would likely be unwilling to set a standard in an area that does not have a clear consensus. Also, the concept of “value” is not the same in economics and accounting, as the disciplines have developed for different purposes. In the case of government accounting, assets are generally recorded at their historical cost value. At the same time, accountants recognize the need to provide transparent, accurate, and up-to-date information on the state of an agency’s cash and non-cash assets. This has led to the introduction of concepts such as depreciation.

Several public water utilities from the United States and Canada—including New York, San Francisco, Seattle, Tacoma, Portland, Vancouver, BC, and Victoria, BC—have embarked on a path to explore and articulate the need for updated accounting rules that include natural capital. A forum, the Watershed Economics Workgroup, has been formed with the mission to propose and justify changes to GASB rules, examine rate structures, review asset management plans, and identify funding mechanisms for watershed management activities. This information should also help water customers understand the value that their watershed’s ecosystem services bring to the local and regional economy. These utilities are sharing case studies and best practices and creating an informed and action-oriented agenda to evaluate and, where necessary, upgrade outdated economic tools.

Provided the GASB does consider new accounting standards for natural infrastructure, any rule change would take a number of years to become implemented. However, a utility or agency can take a number of immediate steps to support this process and shape the development of new funding mechanisms for natural infrastructure:

1. **Join the Discussion.** Contact Earth Economics and stay abreast of developments in funding mechanisms for utilities, as well as valuation methods and GASB standards for natural infrastructure.
2. **Endorse Earth Economics’ technical inquiry,** which encourages GASB to undertake a formal exploration of natural infrastructure accounting. This effort brings together water utilities and local governments with an interest in adding natural infrastructure accounting to the GASB research agenda. The technical inquiry is available for download on Earth Economics’ website.²⁸
3. **Educate users of financial reports (policymakers, ratepayers, investors and auditors)** about the value of natural infrastructure assets and investments. A lot of useful information can be included in the sections of a utility’s financial reports that are unaudited or less strictly audited. For example:
 - a. In the Transmittal Letter of a utility’s financial report, language can be included about the natural resources and natural infrastructure a utility depends upon for providing services. San Francisco took this step in their 2011 Comprehensive Annual Financial Report. A template based on this language is available here:
 - b. Quantify the value of natural infrastructure in the supplementary section of financial reports. Earth Economics is currently working alongside Duke University and three partner utilities to pilot test accounting methods for natural infrastructure with the goal of eventually developing industry standards and informing the GASB’s process. More information on this project is available at the [Water Environment Research Foundation \(WERF\)](#).²⁹
4. **Use water rates to communicate and invest in natural infrastructure.** Rates structures can be modified to break out a “natural capital” component, showing customers what proportion of their rates are being invested back into the utility’s watersheds. A number of utilities have already implemented separate rates for natural infrastructure, sometimes called “Watershed Rates” or “Watershed Protection Fees.” In 2012 the U.S. Endowment for Forestry and Communities and Earth Economics created a “watershed database” and accompanying factsheet with more information on these rates structures, shown in Table 8 below.
5. **Stay up to date** through the new source water coordinator—Tracy Mehan—a position jointly funded by AWWA and the U.S. Endowment for Forestry & Communities.



Table 8 | **Summary of Utility Watershed Management Programs in the U.S.**

PROGRAM NAME (LOCATION)	NUMBER OF USERS	FEE AMOUNT	AVERAGE FEE PER HOUSEHOLD	% OF AVERAGE BILL	RATE DESIGN
Aurora Water (Aurora, CO)	300,000	No fee. Included in city budget.	N/A	N/A	N/A
Bull Run Watershed Habitat Conservation Plan (Portland, OR)	900,000	No fee. Included in city and USFS budget.	N/A	N/A	N/A
Cedar River Watershed Habitat Conservation Plan (Seattle, WA)	1,400,000	No fee. Part of utility budget.	N/A	N/A	N/A
Central Arkansas Water Watershed Management Program (Little Rock, AK)	400,000	\$0.45 per month per 5/8" or 3/4" equivalent meter.	\$0.45 per month	+1.1%	Fixed Fee
Common Waters Partnership (Upper Delaware Watershed)	15,000,000	Pending.	N/A	N/A	N/A
Conserve to Enhance (Tuscon, AZ)	535,000	No fee. Voluntary checkbox on bill.	N/A	N/A	N/A
Crooked River/ Portland Water District Payment for Ecosystem Services (Portland, ME)	200,000	No fee. Grant funded.	N/A	N/A	N/A
Forest to Faucets (Denver, CO)	1,300,000	\$0.04 per 1,000 gallons.	\$0.33 per bill	+1%	Volumetric Rate
Green River Watershed Management Plan (Tacoma, WA)	300,000	No fee. Included in Tacoma Water budget.	N/A	N/A	N/A
Lake Whatcom Watershed Land Acquisition and Preservation Program (Bellingham, WA)	88,000	\$5 per month + \$0.64 per CCF	N/A	N/A	Base rate + volumetric rate
McKenzie Watershed Drinking Water Source Protection Plan (Eugene, OR)	200,000	To be determined.	N/A	N/A	N/A
Salt Lake City Watershed Management Plan (Salt Lake City, UT)	400,000	\$1.50 per meter per month.	\$1.50 per month.	+3.75%	Fixed Fee
San Antonio Source Water Protection Program (San Antonio, TX)	1,300,000	1/8-cent sales tax over five years (2005 - 2010).	N/A	N/A	N/A
Upper Neuse Clean Water Initiative (Raleigh, NC)	600,000	\$0.0748 per CCF.	\$0.40 per month	+1%	Volumetric Rate
Water Source Protection Program (Santa Fe, NM)	32,000	\$0.13 per 1,000 gallons per month.	\$0.65 per month	+1.6%	Volumetric Rate
Watershed and Environmental Improvement Program (San Francisco, CA)	2,500,000	No fee. Included in San Francisco PUC budget.	N/A	N/A	N/A
Watershed Management (Los Angeles, CA)	666,000	Included in Los Angeles DWP budget.	N/A	N/A	N/A

Table 8 | **Summary of Utility Watershed Management Programs in the U.S. (cont.)**

PROGRAM NAME (LOCATION)	SEPARATE FEE ON BILL?	REVENUE GENERATION	YEAR OF INTRODUCTION	HOW WAS THE PROGRAM ADOPTED
Aurora Water (Aurora, CO)	N	\$500,000 over two years	2011	City Council
Bull Run Watershed Habitat Conservation Plan (Portland, OR)	N	\$500,000 per year	2007	Congress (1996 Bull Run Management Act)
Cedar River Watershed Habitat Conservation Plan (Seattle, WA)	N	> \$50m over 20 years	N/A	City Council
Central Arkansas Water Watershed Management Program (Little Rock, AK)	Y	\$1m (approx) per year	2009	Utility Board of Commissioners
Common Waters Partnership (Upper Delaware Watershed)	N/A	N/A	Pending	Common Waters Fund
Conserve to Enhance (Tuscon, AZ)	N/A	N/A	2012	Non-profit
Crooked River/ Portland Water District Payment for Ecosystem Services (Portland, ME)	N/A	N/A	2009	Manomet Center for Conservation Sciences
Forest to Faucets (Denver, CO)	N/A	\$3.3m per year over 5 years	2012-2013	Utility and USFS partnership
Green River Watershed Management Plan (Tacoma, WA)	N	N/A	2006	Utility
Lake Whatcom Watershed Land Acquisition and Preservation Program (Bellingham, WA)	Y	\$25.3m since 2001	2001	City Council
McKenzie Watershed Drinking Water Source Protection Plan (Eugene, OR)	N	\$200,000 - \$250,000 per year	2013	Utility
Salt Lake City Watershed Management Plan (Salt Lake City, UT)	N	\$1.5m per year	1988	City Council
San Antonio Source Water Protection Program (San Antonio, TX)	N	\$45m (2005), \$90m cap (2010)	2005, 2010	Voters
Upper Neuse Clean Water Initiative (Raleigh, NC)	Y	\$1.8m per year	2011	City Council
Water Source Protection Program (Santa Fe, NM)	N	\$200,000 per year	N/A	City Council
Watershed and Environmental Improvement Program (San Francisco, CA)	N	\$50m over 10 years	2005	Utility
Watershed Management (Los Angeles, CA)	N	N/A	N/A	Utility and City Council

Source: Earth Economics & U.S. Endowment 2012." and go to references section for my comment there on addition



Part 3

CASE STUDIES

Introduction

● **MAKING THE CASE**

- The Business Case
- The Scientific Underpinnings
- Identifying Opportunity

▼ **DESIGN AND IMPLEMENTATION**

- Players at the Table
- Natural Infrastructure Finance

▼ **CASE STUDIES**

- Cases
- Concluding Remarks

In previous sections, we examined factors affecting adoption of the natural infrastructure approach—the business case, underlying science, and distribution of opportunity—and two components essential to early stage design and implementation efforts (players and finance mechanisms). Part 3 offers a look at natural infrastructure investment efforts in six states across the country. Five are forest-based efforts for drinking water in Maine, Oregon, North Carolina, Colorado, and Washington.

An additional case is presented—a natural stream corridor stormwater control program on Staten Island, New York. These six cases were chosen from the long list of active natural infrastructure projects nationwide to illustrate the flexibility of the approach to cost-effectively provide a variety of services across geographic, ecological, and political contexts.

These cases also bring several common themes to light. They highlight the importance of well-rounded partnerships, a foundational understanding of how natural infrastructure elements relate to the water resources issues of the watershed, the critical role played by champions, the need to communicate effectively with ratepayers, and the challenge of justifying natural infrastructure investments in internal budgeting processes.

These cases were written by the people who played key roles in the development and implementation of natural infrastructure programs in their watersheds—including staff in water utilities and their partners in conservation organization and universities. In addition to illustrating key themes, the cases are intended to stimulate further communication and networking among current and would-be champions around natural infrastructure. Table 9 below provides a birds-eye view of a sample of other source water protection programs across the United States.

Table 9 | **A Sample of Active Source Water Protection Programs, United States**

NAME	LOCATION	TOTAL INVESTMENTS	ACRES PROTECTED	FUNDING SOURCE
Carroll County	GA	\$11,840,455	1,876	Voter-approved sales tax increase
Catskills (New York City)	NY	\$1,500,000,000	1,262,076	City, state, and federal funds
Cedar River and Tolt River Watersheds (Seattle)	WA	\$82,000,000	100,498	Habitat Conservation Plan budget, utility budget
Conservation Reserve Enhancement Program (Tulsa)	OK	\$234,515	5,809	City, state, and federal funds
Edwards Aquifer (San Antonio)	TX	\$128,000,000	96,989	Voter-approved sales tax increase
Lambert Creek (Saint Paul)	MN	-	-	State and federal grants
Minnesota Clean Water Fund (Statewide)	MN	\$201,960,000	-	Voter-approved sales tax increase
Mountain Island Lake (Charlotte-Mecklenburg County)	NC	\$35,000,000	6,005	State and county government grants, foundation support, bond issue, dedicated fee on water bills
National Forest System Lands, Rocky Mountain Region (Denver)	CO	\$16,500,000	33,001	Water bill increase; Funds matched by US Forest Service
Nonpoint Source Implementation Grants	National	\$3,416,000,000	-	Federal funds
Quabbin-Wachusett (Metro Boston)	MA	\$130,846,485	73,526	State budget allocations, bond funds, ratepayer fees
Salt Lake City	UT	-	23,969	Water user fees
San Francisco	CA	\$50,000,000	-	Bond funds and operating budget allocation

Source: Bennett et al. 2012.

Case 1: Denver Water—Wildfire Risk Management for Source Water

| Denver Water

CASE AT A GLANCE

Players & Stakeholders: Public utility, USDA Forest Service.

Issue of Concern: Pest infestation, wildfire, flooding, and associated sedimentation

Natural Infrastructure Investment: Primarily fuel reduction and reforestation treatments in “zones of concern,” although agreement also enables more conventional sediment-reducing activities related to forest roads and culverts. Goal to restore 38,000 acres of National Forest land over five years.

Built Infrastructure Tradeoff: Lower risk of catastrophic wildfire means lower likelihood of substantial built infrastructure costs (dredging, variable treatment costs) associated with sedimentation.

Funding Scale & Mechanism: Total costs of \$33 million paid for by Forest Service and public utility based on 50-50 cost share. Utility funds come from ratepayers. Rates not explicitly increased for project—instead, rates are tied to costs for capital infrastructure and operating expenses. Large costs due to past fires have factored into current rates. Average residential household will pay a total of \$27 over five year period to cover costs.

Business Case Made: No explicit, detailed cost-benefit analysis conducted; however, the utility incurred \$26 million in costs in the wake of two devastating fires in 1996 and 2002. Fire suppression costs were another \$47 million, the Forest Service has spent another \$37 million on post-fire restoration and stabilization, and private insured property losses were an additional \$38.7 million.

Regulatory Factors: Not primarily driven by regulation.

Suppliers: USDA Forest Service—National Forest lands

Background

Denver Water is Colorado’s oldest and largest water utility, serving 1.3 million people in Denver and many surrounding suburbs—nearly a quarter of all Coloradans. Established in 1918, the utility is a public agency funded by water rates and new tap fees, not taxes. As Denver Water’s collection and delivery infrastructure receives water from snowpack and streams on U.S. Forest Service lands, we directly depend on healthy forests and watersheds.

Almost all of its water comes from mountain snowmelt and Denver is the first major user in line for that water. Denver Water’s collection system covers about 4,000 square miles, or 2.5 million acres, and extends into more than eight counties. Denver Water’s primary water sources are the South Platte River, Blue River, Williams Fork River, and Fraser River watersheds. It also uses water from the South Boulder Creek, Ralston Creek, and Bear Creek watersheds. Colorado’s forests are critical to the water supply for tens of millions of Americans, billions of dollars of agricultural production, and vast economic activity, from California to the Mississippi River.

Risk Drivers

Increasing incidence of insect infestations and wildfires that can cause sedimentation impacts on reservoirs and other water infrastructure has highlighted the need to take aggressive steps to protect forest health. Fire risk in Colorado is exacerbated by insect infestation. The mountain pine beetles have affected 3 million acres of land in Colorado since the first sign of outbreak in 1996. The heart of the epidemic in Colorado and Wyoming contains the headwaters for rivers that supply water to 13 Western states.

The 1996 Buffalo Creek Fire burned 11,900 acres. In 2002, the Hayman Fire—the largest wildfire in Colorado’s history—charred another 138,000 acres of land. The combination of these two fires, followed by significant rainstorms, resulted in more than 1 million cubic yards of sediment accumulating in Strontia Springs Reservoir. Prior to the wildfires, the reservoir had approximately 250,000 cubic yards of sediment, which had been accumulating since 1983 when the dam was completed. Increased sediment creates operational challenges, causes water quality issues, and clogs treatment plants.

Hayman Fire caused \$42 million in suppression costs for state and federal agencies, and another \$37 million for restoration and stabilization efforts by the Forest Service. Denver Water itself spent \$26 million in the aftermath of the fires. The Hayman Fire also led to a loss of 600 structures, including 132 residences. Total insured private property losses were estimated at \$38.7 million. Losses to wildlife habitat, aesthetics, tourism, and recreation were also substantial.

The Buffalo Creek Fire was the first time Denver Water experienced the devastation that can be caused by fire followed closely by flood. The aftermath of this fire prompted a forest treatment and revegetation relationship between Denver Water and the Colorado State Forest Service. Forest treatments, such as thinning, clearing, and creating fuel breaks, influence how quickly and intensely a wildfire can burn. Treatments can slow the spread of a fire, allowing firefighters to stop a fire before it reaches homes, power lines, or valuable watersheds. Smaller, less severe fires also reduce the amount of soil erosion and other impacts to the watershed.

When the Hayman Fire occurred, Denver Water was better prepared. The Hayman Fire is still the largest in Colorado history, but it had less impact to Denver Water than it might have had were it not for the lessons of the Buffalo Creek Fire. The utility's forest treatment efforts after the Buffalo Creek Fire saved its facilities during the Hayman Fire. Denver Water also installed upstream monitoring to allow it to anticipate water treatment issues and take appropriate action as necessary, and built sediment control structures in drainage areas (like straw bale dams and log sediment traps) to slow runoff into Cheesman Reservoir after the Hayman Fire. The utility expects to see sediment as a result of the Hayman Fire for years to come.

Restoration efforts will help the forests become more resilient to future insect and disease epidemics, reduce wildfire risks for communities, and lessen the impact from fire on habitat for fish and wildlife. More resilient forests also will be more adaptive to the impacts of a changing climate.

“There is a direct connection between healthy forests and sustainable supplies of clean water. Denver Water has spent more than \$26 million in the aftermath of the Buffalo Creek and Hayman fires. Through this partnership, we are investing in the future by keeping our watershed healthy rather than paying for impacts from a catastrophic fire in the future.”

-Jim Lochhead,
CEO, Denver Water

BOX 25 | PROGRAM-IN-THE-MAKING: NORTHERN COLORADO FRONT RANGE

| James Mulligan, Green Community Ventures

The upper portion of La Cache Poudre River Watershed, drinking water supply for Fort Collins and Greeley, Colorado, is largely in public ownership as national forest. However, sedimentation risks associated with wildfire present major water quality challenges to the City of Fort Collins. The fires in summer 2012 caused the Poudre to turn black with ash, forcing Fort Collins to shut down its intake for more than 100 days, relying instead on its reservoir, which fills from water largely piped from the western side of the Continental Divide (from the Colorado River Basin). Fort Collins plans to spend up to \$24 million on sedimentation stabilization alone in the aftermath of the High Park fire (Gertig 2013). For Fort Collins and Greeley, a natural infrastructure approach to fire risk management (i.e., fuel reduction) could be a cost-effective risk management strategy. At the same time, the utility also maintains the critical built infrastructure capability to blend water from its reservoir and from the Poudre, and treat accordingly, in the event of major wildfires like those of 2012.

In the wake of the 2012 fires, the water utilities and a consortium of Fort Collins breweries began working with natural infrastructure experts, including the World Resources Institute, and a group of stakeholders facilitated by the Colorado Conservation Exchange. The beginning components of the effort include a preliminary economic analysis to identify the potential economic benefits and financial returns of fuel reduction, as well as a number of other measures on forestland (e.g., road decommissioning), on rangeland, and in ex-urban areas within the watershed.

From Forests to Faucets Partnership

Denver Water and the USDA Forest Service have a shared interest in improving forest and watershed conditions to protect source water, as well as to continue providing other public benefits, such as wildlife habitat and recreation opportunities. The USDA Forest Service administers more than 14.5 million acres of National Forest System lands in Colorado, and nearly 90 percent of these lands are located in watersheds that contribute to public water supplies.

Denver Water and the USDA Forest Service signed a Memorandum of Understanding on August 25, 2010, initiating the work to accelerate mutual efforts to improve forest and watershed conditions. Through this partnership, Denver Water plans to match the Forest Service's \$16.5 million investment, totaling \$33 million, toward forest treatment and watershed protection projects over a five-year period in priority watersheds critical to Denver Water's source water. The focus is on reducing the risk and severity of wildfires, although the agreement also makes possible more conventional sediment-reducing projects related to roads and culverts.

Denver Water's and the Forest Service's planning processes and is becoming a model for similar partnerships in Colorado.

The work will take place in the Upper South Platte River, South Platte River Headwaters, St. Vrain River, Colorado River Headwaters, and Blue River watersheds on Forest Service lands. These watersheds are the primary water supply source areas for Denver Water's customers. The collaborative effort addresses "zones of concern," or areas at risk of wildfire hazard, flooding, debris, and soil erosion within large watersheds. The process of identifying zones of concern was developed by Front Range water providers in cooperation with the state and federal agencies through a standardized methodology in 2009 (Front Range Watershed Protection Data Refinement Work Group 2009).

The first contract, Indian Creek Task Order, was awarded in January 2011 for treatment of 677 acres. Work was completed in April 2012. The treatment types for this project included mastication (400 acres) and product removal (277 acres).

A second contract was issued in July 2011 for hand thinning of 866 acres along the South Platte River from Willow Bend downstream to Eagle Rock. The contractors completed the project in October 2011. The treatment type for this project included hand thinning, with lop and scatter slash treatment.

Two recently initiated projects of the Denver Water partnership are underway on the White River National Forest on the Dillon Ranger District near Breckenridge, Colorado. Cary Green, the east zone timber management assistant, noted, "The partner-

ship is hugely beneficial to cost-sharing vegetative treatments in the Blue River Watershed. Together, we are able to improve forest health, forest vegetative diversity, and achieve substantial fuels reduction in and around high priority watersheds.”

Most of the restoration work in areas affected by the mountain pine beetle outbreak will utilize clear-cutting. Clear-cutting lodgepole pine is the best management practice for the vegetative type that most closely mimics its natural regeneration pattern. After the dead and dying trees are removed, slash (limbs, needles and tops of trees) are left on the ground to provide micro-sites for seedlings and the next generation of forest to establish itself. This practice further helps to prevent soil erosion. In recently harvested areas, seedlings have already begun to establish themselves at a rate between 300 and 1,800 seedlings per acre.

To date, more than 2,700 acres have been treated in the Blue River watershed zones of concern in and around the Dillon Reservoir. Another 2,000 acres are partially complete, prepped for contract, or set to be completed in 2013. As the USDA Forest Service looks ahead as an agency, with water health as one of its top priorities, the partnership between Denver Water and the USDA Forest Service in Colorado serves as a prime example of how partnerships for restoration work should be accomplished in the future.

In future years, forest thinning and other wildfire fuels reduction work will take place around, and upstream of, Denver Water’s Strontia Springs, Gross, Antero, Eleven Mile Canyon, and Cheesman reservoirs, and near the town of Winter Park. All of this work will reduce the risk of wildfires upstream of Denver Water’s reservoirs and other water delivery infrastructure.

By investing in wildfire risk management in its watersheds, Denver Water is working strategically to protect its source water and reservoirs from the costly impacts of sedimentation. By partnering with the USDA Forest Service, Denver Water shares the cost of forest treatments and accelerates wildfire fuels reduction work on the ground. The partnership is now serving as a model for other cities in the Intermountain West (see, e.g., Box 25).

Case 2: Upper Neuse River Basin, North Carolina

| Lisa Creasman, Conservation Trust of North Carolina (Current Affiliation: The Nature Conservancy)

CASE AT A GLANCE

Players & Stakeholders: Land trusts, multiple public water utilities and other local government departments, conservation organizations, land-owners, academia, USDA NRCS

Issue of Concern: Declining water quality in local reservoirs due to population growth and development (also periodic drought and flood issues).

Natural Infrastructure Investment: Land acquisition, conservation easements, and forestry best management practices and sustainable management, including buffer and field reforestation, stream crossing stabilization, and removal of exotic species. Focus on riparian buffers, floodplains, and wetlands.

Built Infrastructure Tradeoff: Improved source water quality avoids higher costs of treatment at existing filtration plants; potentially relieves Clean Water Act pressure on sources of water quality degradation like septic tanks and point sources.

Funding Scale & Mechanism: \$7.5 million raised since 2005 by Raleigh through “nutrient impact fees”—one-time fees collected from new hook-ups to the water and sewer system. An additional \$1.8 million per year from a permanent watershed protection fee on the Raleigh public water bill (1 penny per 100 gallons). Additional funds were delivered from increased water rates in nearby Durham, North Carolina.

Business Case Made: No explicit, detailed cost-benefit analysis conducted; however, a revenue “dashboard” used to communicate the substantial fundraising impact of small increases in water rates.

Regulatory Factors: In part motivated by TMDL placed on local reservoir under Clean Water Act.

Suppliers: Upstream private forest landowners.

Status at Publication: Ongoing implementation.

Background

The Upper Neuse Clean Water Initiative (the Initiative) was founded in 2005 to help protect drinking water supplies through strategic upstream land conservation. The geographic focus of the Initiative's efforts, the Upper Neuse River Basin, is located in the north-central region of North Carolina known as the Piedmont. The Basin provides a ripe setting for optimizing the relationship between forests and downstream water quality—over 50 percent of the Basin is forested (56 percent) and nine drinking water supply reservoirs are located within its boundaries. Both water quality and water quantity issues have begun to surface. Falls Lake, the City of Raleigh's drinking water reservoir, was added to the Clean Water Act 303(d) list of impaired waters in 2008. In the same year, the region suffered from a drought resulting in government-imposed water use restrictions and fears of emergency measures. Two years later, the area suffered flooding that closed roads, schools, and forced evacuations in several low-lying areas.

These issues promise to continue without a natural infrastructure response. Overlapping with the "Research Triangle," the Basin is one of the fastest growing regions in the country with a population predicted to increase by 50 percent by 2050. Even with the economic downturn, the region continues to experience development pressure and forests are

vulnerable as landowners consider their options financially. The opportunity exists to target conservation of the most critical forested areas through sustainable forestry management and conservation easements—thereby providing landowners with a source of income while attending to the critical issue of water quality protection.

The Initiative

In response to growing population and declining water quality, the Initiative developed a GIS-based conservation plan to guide the investment of public and private dollars into priority land parcels—primarily focused on riparian buffers, floodplains, and wetlands. The Initiative is led by the Conservation Trust for NC (CTNC) and six additional land conservation groups working in the Basin. Working together, land trusts, landowners, municipalities, and other government agencies have used voluntary measures to protect over 6,000 priority acres along 63 miles of stream in the Basin.

The Initiative has approached funding for natural infrastructure by tying it to the provision of ecosystem services on a case-by-case or opportunity-by-opportunity basis, rather than creating a more complex overall trading program or establishing a watershed-wide "market." Working through champions and other strategic leverage points, the Initiative has worked with the City of Raleigh



to secure allocations of \$7.5M since 2005 to help address the declining water quality in Falls Lake. These funds initially came from the city’s “nutrient impact fees”—one-time fees collected from new hook-ups to the water and sewer system—and are primarily used for land acquisition or conservation easements on priority lands. Then, before leaving office at the end of 2011, Raleigh’s Mayor Meeker established a permanent watershed protection fee on the public water bill (1 penny per 100 gallons) that will provide approximately \$1.8M per year for the Initiative and strategic land conservation.

Also, in nearby Durham, the city voted in 2011 to increase water rates to help fund land protection projects upstream of its two water supply reservoirs. Durham and Raleigh manage their watershed funds differently. While Raleigh supports the Initiative, Durham allocates its funds to an internal department that is acquiring lands around the city’s two water supply reservoirs, with some guidance from the Initiative on priority sites.

Concurrent with the evolution of new means of financing for land conservation, the land trust’s methods for conserving the land and its ecosystem services has been expanding beyond the traditional as well. While the majority of the projects that have been completed have involved conservation easements or fee acquisitions, the land trusts used a grant from the U.S. Endowment for Forestry & Communities and USDA NRCS to develop a working forest landowner program that involves different outreach methods and landowner strategies. In addition to funding the development of tools, the grant is paying for the development of forest stewardship plans and the implementation of sustainable forest practices on privately owned timberlands, in addition to working forest easements.

Working with landowners to promote active forest management is a relatively new arena for the local land trusts. Finding landowners who are interested and poised to take advantage of the grant’s funding has required building much stronger partnerships with the state’s forest service agency and NRCS. The program is emphasizing forestry best management practices and sustainable management, including buffer and field reforestation, stream crossing stabilization and removal of exotics. The project has required land trusts to operate out of their comfort

Finding landowners that are interested and poised to take advantage of the grant’s funding has required building much stronger partnerships with the state’s forest service agency and the NRCS.

zone, beyond “permanent” projects, to projects that invest in ecosystem service values by basically making payments to landowners to develop and implement sustainable timber practices with limited requirements of the landowner.

Factors of Success

Three key factors have contributed to the Initiative’s success thus far:

1. Access to a champion in a position of influence. The leadership provided by Charles Meeker, the City of Raleigh’s mayor at the time of the program’s inception, was instrumental to the Initiative’s successful establishment. In Mayor Meeker, the Initiative had a champion in a position of influence who appreciated the relationship between land conservation and water resource protection without drilling down into too much minutiae. The mayor and city council allocated substantial funds to watershed protection, and the mayor’s legacy—the \$1.8M per year watershed protection fee—will ensure financial viability into the future.
2. A tool to communicate the affordability of natural infrastructure to municipalities. The Initiative worked with the University of North

Carolina’s Environmental Finance Center to develop a set of tools that could be used by municipalities and others to develop scenarios for generating revenue for watershed protection efforts. The primary interactive tool, termed a “dashboard,” is profiled earlier in the finance chapter. The information this tool generated helped to make the case for the Raleigh and Durham rate increases, demonstrating that a small increase to the water bill could generate meaningful revenues for watershed protection without burdening ratepayers.

3. A science-based conservation plan and parcel prioritization. Using best-available scientific data and methodologies is critical to making a credible case to funders and partners. The Initiative endeavored to ensure the credibility of its analysis every step of the way. While the local municipalities have supported funding for land conservation in the absence of specific measurable costs and benefits, there have been inquiries by public utilities staff (where the fee is administered) about developing some measures of success beyond the general science recognizing the relationship of riparian buffers and water quality. In response, CTNC is creating a science-based and user-friendly tool that will calculate quantitative estimates of the nutrient loading and sedimentation avoided by not developing a site according to a typical build-out scenario for the parcel.

The Initiative has accomplished a great deal of land conservation, and has worked with new partners to develop non-traditional funding sources. Since the project’s inception in December 2005, the land trusts have closed 63 projects protecting 6,170 acres and almost 63 miles of stream buffers. The land value conserved totals over \$60M, and of that, landowners have donated 38 percent. Still, the partners recognize the need to continue to grow the relationship between ecosystem service beneficiaries and producers—looking not only at the potential to expand the program to include additional beneficiaries of the land conservation work, particularly businesses dependent on clean water, but also the marketing of additional ecosystem services beyond water quality.

Case 3: Sebago Lake, Portland Water District (Maine)

| Paul Hunt, Environmental Manager, Portland Water District

CASE AT A GLANCE

Players & Stakeholders: Public utility, USDA NRCS, state drinking water agency, conservation organizations, landowners.

Issue of Concern: Projected land use change due to population growth and development, and associated risks of declining water quality in a generally healthy watershed.

Natural Infrastructure Investment: Land acquisition, conservation easements.

Built Infrastructure Tradeoff: Maintained source water quality avoids loss of filtration avoidance waiver and associated costs of a new filtration plant.

Funding Scale & Mechanism: About \$175,000 annually in public utility funds. Additional funds spent on efforts like development inspections and septic tank permitting. Utility uses some funds as seed or gap funding to leverage larger conservation deals involving local land trusts.

Business Case Made: Explicit cost-benefit analysis conducted, comparing costs of robust watershed protection program with costs incurred if utility loses its filtration avoidance waiver; however, particularly given regulatory uncertainty related to the waiver, PWD and partners are preparing to explore the business case related to variable treatment costs.

Regulatory Factors: Need to maintain filtration avoidance waiver and prevent capital, operations, and maintenance costs of a filtration facility, as well as variable costs of treatment.

Suppliers: Private landowners—primarily in the lower watershed near water intakes, but also in upper watershed (about 1 to 2 percent of utility’s annual expenditures).

Status at Publication: Ongoing implementation, escalated in 2013.

Background

The Portland Water District utilizes Sebago Lake, Maine's deepest and second largest lake, to provide drinking water to 200,000 Maine residents. Sebago Lake is an ideal water supply—deep, cold, low in nutrients and surrounded by mostly forested land—with one major exception: The watershed is almost entirely privately owned and is thus susceptible to future development. Moreover, the lake is one of Maine's most popular recreation resources and is just a 30 minute drive from Portland, the center of the state's population.

The District currently holds a filtration avoidance waiver issued by EPA under the Safe Drinking Water Act (SDWA). While the District was engaged in source water protection decades before the SDWA was written, everything the District does is inextricably linked to the waiver both because the request for the waiver included a series of commitments to watershed protection, and because the District's annual budget for its watershed control program is justified in part by the need to maintain the waiver. Initial scoping analysis suggests that installation of membrane filtration would cost the District between \$50 million and \$75 million, plus an additional \$2.5–\$3.5 million in operations and maintenance costs. Still, even without the waiver, PWD's guiding principle is to enjoy similar water quality decades from now. Accordingly, the utility is dedicated to protecting the watershed and follow a “no regrets” approach—investing in the watershed because it is good for water quality, regardless of whether the utility ultimately needs to filter the water. Maintaining a healthy watershed can also reduce variable treatment costs for the utility.

The Initiative

Because the watershed is owned by many and the lake is a focus of human development and recreation activity, the District's watershed control program is multi-faceted, including: education and outreach, land and water security, watershed and lake water quality monitoring, and land use management. The total annual cost of this program exceeds \$1 million per year, about 5 percent of the total water receipts.

The last of these program elements—land use management—represents the District's annual

investment in natural infrastructure. These are the programs and actions undertaken to avoid or minimize the impact of watershed land use on water quality. In addition to key components like development inspections and septic system permitting, the program focuses on land acquisition surrounding the lake and conservation easements in the upper parts of the watershed.

Historically, PWD overwhelmingly focused its financial resources on acquisition, while funds for conservation in the upper reaches of the watershed have comprised just a sliver of source water protection expenditures. PWD typically engages in conservation easement deals that have been arranged by a local land trust and that need a small infusion of additional funds to go through. While 1,500 acres have been conserved in the upper watershed in this manner, PWD has contributed less than 1 percent of the funds.

However, in early 2013, the board voted unanimously to scale up conservation easements component of PWD's efforts. The new policy permits PWD to fund up to 25 percent of the conservation value of easement transactions in the watershed. In general, the closer the parcel is to water and the greater the importance of the hydrologic features that will be conserved, the higher percentage PWD will fund. Two weeks after the policy change, the board was presented with a \$50,000 easement proposal (as much as PWD had spent on easements over the previous five years). The Board passed the proposal unanimously, hoping the deal would trigger additional landowners to come forward. According to one local land trust staffer, “this changes our world in a huge way as you might imagine—providing the potential for profound and lasting impact thanks to the determination of PWD staff and the combined work of so many partners.”

Challenges

In some cases, doing watershed protection work involves taking the opportunity to do things that you know are good things—such as revegetating an eroding embankment—without an easily referenced metric for how many such erosion issues exist overall, how big a priority is a particular issue relative to others, what percent of nutrient input to the lake the project would reduce, and ultimately whether spending money on this natural infra-

BOX 26 | NORTHERN FORESTS CONSERVATION INNOVATION GRANT

In 2009, six project partners including the American Forest Foundation, the World Resources Institute, and the Manomet Center for Conservation Sciences were awarded a Conservation Innovation Grant from USDA NRCS. The project partners set out to create a pathway for the Portland Water District to leverage its early efforts into a larger scale, full-fledged watershed investment program by putting together all of the critical pieces discussed in this guide. The project began by identifying the “hotspot” characteristics of the Sebago Lake watershed, and proceeded to prioritize landowners and parcels for investment, assess the business case using a preliminary green-gray analysis, engage with key stakeholders like landowners and land trusts, and put together innovative finance mechanisms like the Clear Water Carbon Fund.

After three years and a long list of lessons learned, obstacles still remain. However, due to the efforts of CIG partners, the Portland Water District has a sense of the potential cost-effectiveness of various natural infrastructure options and a spatially explicit roadmap for investment to protect source water quality. CIG partners look forward to continuing their work with the Portland Water District toward scaled implementation.

structure project might save at least as much in built infrastructure expenditures. PWD’s watershed protection work proceeds in a more opportunistic manner: We have this money, we have a willing landowner, we know that if we correct this it will mitigate a problem and maybe draw some attention that will attract another potential landowner—so let’s do it. PWD has confidently forged its new easement policy based on a qualitative understanding of the benefits of natural infrastructure in the Sebago Lake watershed. Meanwhile, the World Resources Institute produced a preliminary analysis (Section 1.2; Box 26) focused on the costs associated with securing confidence in PWD’s ability to maintain its filtration waiver. Work is ongoing with partners to flesh out specific quantitative returns—including those associated with variable treatment costs—which would enable the District to operate more strategically in its watershed protection work.

Case 4: Eugene Water & Electric Board (EWEB)

| Drew Bennett, Oregon State University Department of Geography
| Sally Duncan, OSU Policy Analysis Lab (OPAL), School of Public Policy, Oregon State University
| Sue Lurie, Institute for Natural Resources, Oregon State University
| Karl Morgenstern and Nancy Toth, Eugene Water & Electric Board
| Hillary Fishler, Oregon State University Department of Public Policy

CASE AT A GLANCE

Players & Stakeholders: Public utility, conservation organizations, academia, local soil and water conservation district.

Issue of Concern: Declining water quality in generally healthy watershed, due in part to residential development in riparian areas.

Natural infrastructure investment: Payment to landowners for maintenance of riparian buffers within an identified stewardship boundary.

Built Infrastructure Tradeoff: Maintaining source water quality avoids higher treatment costs at the utility’s existing filtration plant.

Funding Scale & Mechanism: Initial funding of \$200,000–\$250,000 annually expected to come from existing public utility funds already earmarked for source water protection; possibility of increase in funds over time and implementation of a watershed protection fee to cover costs.

Business Case Made: Ecosystem service valuation study by Earth Economics, demonstrating value of riparian buffers (including public benefits) of \$1,031 to \$6,713 per acre per year. Additionally, utility has general understanding of relationships between source water quality and treatment costs; however, a full cost-benefit study on treatment costs was not conducted.

Regulatory Factors: Not driven by regulation.

Suppliers: Riparian landowners—primarily residential, small woodlot owners, and small agriculture.

Status at Publication: Under development—program not yet active.

Background

The Eugene Water & Electric Board (EWEB) is the largest customer-owned utility in Oregon. EWEB currently provides drinking water to over 50,000 customers, and electricity to nearly 87,000 consumers in Eugene and nearby areas (EWEB 2013). EWEB's service area is approximately 235.6 square miles. In 1927, it shifted from the Willamette to the McKenzie River as its drinking water source. The McKenzie River, Eugene's sole water source, has long been known for its excellent water quality. EWEB continues to expand its already broad set of source protection programs—from a demonstration farm and forest to acquisitions and easements—to ensure the river's ongoing high quality.

A recent land-use and development trends analysis by the Community Planning Workshop at the University of Oregon identified a continuing trend of residential development along the McKenzie River. Such development has potential negative impacts on water quality due to increased areas of impervious surface, the removal of riparian vegetation, increased yard chemical inputs, and the flooding or leaking of septic systems, among other concerns. Although Lane County implemented a 50-foot riparian setback requirement in 1992, the Community Planning Workshop report documented multiple examples of the issuance of conditional use permits to allow development within 50 feet of the river (CPW 2009). Additionally, development

along the river is typically not contained to just structures, but also includes clearing of native vegetation to enhance river views and establish lawns that reach to the river's edge. Although individual actions often do not have serious impacts to the watershed, the collective actions of hundreds of landowners can have detrimental consequences to downstream water quality.

In response, county officials attempted to implement a new riparian setback ordinance of 200 feet. When the county dropped the effort in the face of resistance from local residents (Cooper 2010), the EWEB source water program decided to pursue a different option—a voluntary, incentive-based approach. Such an approach would reward landowners for good stewardship of their land and for the adoption of management practices that benefit water quality, flood protection, and fish and wildlife habitat. In the current political and economic climate, an incentive-based approach appeared to be more feasible and socially acceptable.

How It Works

EWEB envisions the development of an investment mechanism, called the "Voluntary Incentives Program (VIP)," that would make annual dividend payments to landowners who maintain riparian buffers within an identified stewardship boundary encompassing riparian forests and floodplains. Initially, the fund is expected to be roughly

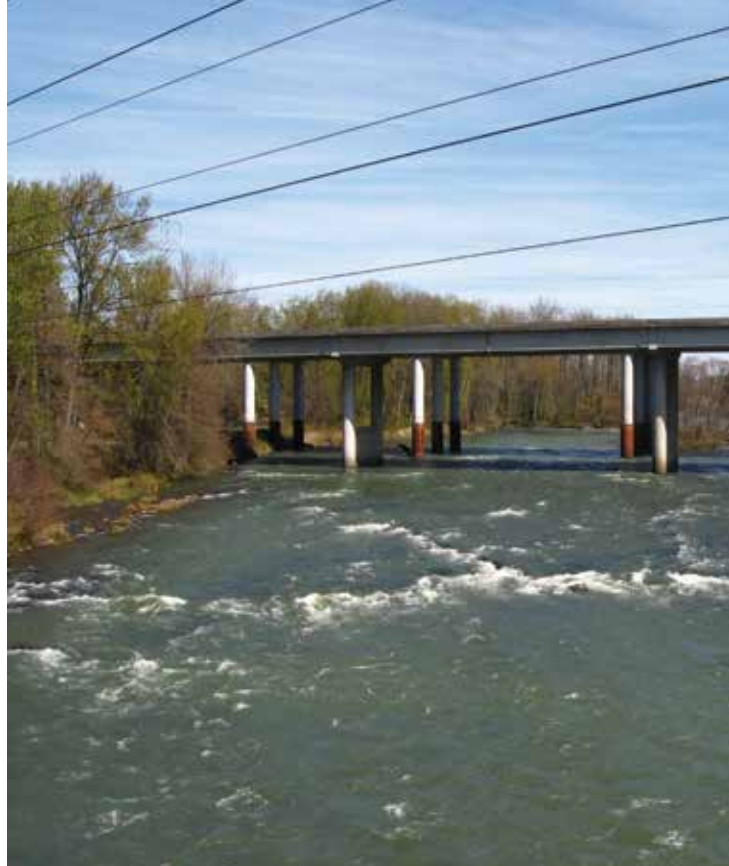


\$200,000–\$250,000 annually. Dividend payments and technical assistance to landowners would be a direct function of available funding, number of acres located within the VIP boundary, and number of acres enrolled in the program. Financing will come from a variety of sources but may be initially endowed through existing source water funds (under existing rate structure) or another utility funding mechanism. Additional possible financing sources other than EWEB include corporate sponsorship, a voter-approved bond measure, state lottery funds, development impact fees, and state and federal mitigation programs.

The numerous benefits provided by riparian buffers for water quality, treatment costs, and wildlife make these investments a logical initial focus for the VIP and will allow partners to address multiple objectives at the same time. A valuation study by Earth Economics, contracted by EWEB, determined that riparian buffers represent a value range of \$1,031 to \$6,713 per acre per year (Schmidt & Batker 2012).

While a cost-benefit analysis focused on treatment costs has not yet been conducted, the utility understands the general value of riparian buffers for water quality and its ratepayers support investments for water quality protection. Consequently, a cost-benefit analysis has not been cited as a prerequisite to moving forward. In a survey of 399 EWEB customers, 71 percent of respondents were definitely or probably willing to pay at least \$0.50 per month to protect water quality in the McKenzie Watershed, while only 17 percent were definitely or probably unwilling to pay the same amount.

Participation in the VIP is open to private landowners, local governments, and non-profit organizations that own land within the designated boundary. Based on EWEB's preliminary analysis, an estimated 6,500 acres of riparian and floodplain areas along the McKenzie and major tributaries are eligible to enroll—about 44 percent of which currently meet the forested threshold required in order to receive payments. EWEB's approach is to reward good land stewards who maintain high quality riparian forest buffers to ensure that these landowners continue these practices. This differs from other programs, such as USDA NRCS's Environmental Quality Incentives Program (EQIP), which offer incentives to landowners with degraded



land to restore their properties to an improved condition. Instead, EWEB has chosen to reward landowners already implementing outstanding management practices, and to provide a high standard for other landowners to strive for. Landowners who do not currently qualify can use existing restoration programs, such as EQIP, to improve their properties to the point where they can participate in EWEB's VIP.

At the time of publication, EWEB is working with an advisory committee made up of landowners to solicit landowner feedback on the proposed program. This effort will help to inform more targeted outreach efforts to engage and enroll eligible landowners. EWEB plans to pilot the program with 8–10 willing landowner properties to inform final program design and implementation in 2014.

Partnerships

EWEB has been effective in building support and expanding its capacity for the initiative by involving in the planning several partner organizations with their own constituencies, connections, expertise,

and capacities—for example, local watershed councils and land trusts, the soil and water conservation district, resource conservation and development councils, the University of Oregon, Oregon State University, and others. The VIP will also rely upon a coalition of partners to provide critical infrastructure, without which successful implementation of the VIP is highly unlikely. Critical tasks include managing the fund, making payments to VIP participants, assessing the quality of enrolled land, negotiating agreements, monitoring properties and verifying compliance, and educating and communicating with the community.

Justification

EWEB's source water program has run into some internal challenges in developing the VIP program, in particular a struggle for limited dollars in the face of other priorities such as aging infrastructure and engineered solutions. Many feel that investment in watershed protection can be small until the utility sees a problem, at which point it can ramp up funding. But because the utility's planning horizon is 30–40 years, the utility identifies trends in urban growth and development pressures in floodplain and riparian areas that cause concern in the face of climate change impacts. Knowing that any sustainable solution cannot be built overnight, the utility feels the need to make sustained investments today as a way to manage future risks and avoid future treatment and other costs that would result from continued degradation of these natural systems that benefit us.

Externally, EWEB has surveyed its customers and landowners to better understand their perspectives and to assist with framing EWEB's message so that it better resonates with both sets of stakeholders. EWEB has worked hard to maintain consistent messaging around the value of protecting the natural capital the community relies on. This messaging and the relationships EWEB has developed with a diverse set of stakeholders have helped EWEB to justify its source water protection efforts.

Lessons Learned

Two core lessons have emerged from EWEB's experience thus far. First, it's all about relationships. This includes taking time and being patient to allow relationships to develop with farmers, landowners,

EWEB has been effective in building support and expanding its capacity for the initiative by involving in the planning several partner organizations with their own constituencies, connections, expertise, and capacities.

partners, and others. The collaborative process for establishing the VIP has been about building trust and regular dialogue that allows partners to work together and coordinate all the various pieces in motion by multiple organizations.

Second, there is an important balance between leadership to move things forward while incorporating input and lessons learned over time, and also empowering others to take ownership or an active role in certain parts of the program. EWEB could not undertake such a project on its own. Thus, the VIP development process must be such that partners see alignment with their own missions. Engaging academia, including students, can also provide substantial value in developing the program concept and understanding the implications of implementation. Finally, partnerships can also create funding opportunities. Most of the source water grant applications written by EWEB include funding for project partners, playing on their strengths and expertise and ultimately strengthening the applications.

Case 5: Staten Island Bluebelt— Natural Infrastructure for Stormwater Management

| Albert F. Appleton, Former Commissioner of the New York City
Department of Environmental Protection and Director of the
New York City Water and Sewer System

CASE AT A GLANCE

Players & Stakeholders: City environmental agency, urban residents, developers.

Issue of Concern: Disruption of historic stream flow paths and associated reoccurring pattern of floods and compromised septic systems, due to development.

Natural Infrastructure Investment: Natural stream corridors in urban setting—400 acres of freshwater wetland and riparian stream habitat and almost 11 miles of stream corridor.

Built Infrastructure Tradeoff: Bluebelt avoided need for a traditional storm sewer system.

Funding Scale & Mechanism: Development restrictions—costs in the form of lost development and associated economic activity and tax revenue.

Business Case Made: Explicit cost-benefit analysis conducted, suggesting \$30 million in net cost savings.

Regulatory Factors: None.

Suppliers: City, in the form of development restrictions.

Status at Publication: Implemented.

While this guide has focused on natural infrastructure in forested landscapes, largely for drinking water, other types of natural infrastructure can be used for other purposes. For example, the concept can be applied in urban settings, farms, and ranches for a range of watershed services, including not just water quality but also quantity, flow regulation, and temperature. An increasingly active area of investment is natural infrastructure for urban stormwater management—the topic of this case.

Background

New York's borough of Staten Island is a social and development outlier from the rest of the city and from the general image of New York as a high density collection of high rises. Prior to the completion of the Verrazano Bridge, between the Island and Brooklyn in 1964, finally creating a car link between Staten Island and the rest of the city, Staten Island had a population of only 150,000 and large tracts of undeveloped land. But the completion of the Verrazano touched off a development boom that continues today, and which has added an average of 8,000 people a year to the island's population, bringing its population close to 500,000.

The Staten Island outwash plain was aggressively targeted by home developers in the 1970s and 1980s. Lacking sanitary sewers, they used residential septic systems to provide sanitary services, despite the unsuitability for septic of a large area whose ground water levels were close to the surface. To obtain the necessary regulatory approvals, percolation tests were generally conducted in October, the month of the year when developers had found they obtained the most favorable results. The area also lacked proper storm sewers, a problem developers simply ignored.

Unlike the rest of the city, the drainage plan for Staten Island called for separate storm sewers to avoid the problems of combined sewer overflows (CSOs) that plagued the rest of the City. But the pace of development in the land boom of the '70s and '80s outran the city's financial and logistical ability to build both sanitary and storm water facilities. The result, as development disrupted the historic flow paths of the natural creek system of the area, was a reoccurring pattern of winter and spring floods washing through new developments sited in the path of traditional drainage patterns. The impact of these floods was compounded by the fact that the wet weather compromised poorly designed septic systems. The smell of sewage became a familiar feature of Staten Island's freshwater wetlands. A growing public outcry against these conditions was directed at the city and its water and sewer agency, the New York City Department of Environmental Protection (DEP).

Developing Natural Infrastructure

By 1990, the situation had reached a crisis point. Staten Island was in an uproar over residential flooding in newly developed neighborhoods. But the cost and time required to provide all of those neighborhoods with traditional storm sewers would have been prohibitive.²⁷

Natural stream corridors have evolved their own flood attenuation features that tend to be far more sophisticated than human-designed floodwater infrastructure. Given the natural infrastructure values provided by natural stream corridors, preservation and integration with development might not only be a solution to the floodwater problem, it would also have the added advantage of preserving some of the island's threatened natural stream habitats. In a deliberate echo of Staten Island's publicly popular Greenbelt, the project was named the Staten Island Bluebelt.

Cost-Benefit Analysis

After reviewing several possible stream corridors for an initial project, one was picked for an explicit cost benefit analysis. Projected costs included acquisition of privately owned land in the corridor and lost city revenues from land sales. Projected benefits were avoided infrastructure costs. Though these were originally envisioned as just avoiding the construction of traditional storm sewers, it soon became clear that a Bluebelt would also significantly reduce road and street construction within the corridor. The cost-benefit analysis was highly favorable, suggesting a net cost savings in the neighborhood of \$30 million. There would also be the savings of avoided sewer maintenance costs, but it was assumed that these would be offset by maintenance costs of the natural habitat in the corridor.

The other project benefit that emerged in the analysis was habitat preservation. In designing the corridor, it was assumed that corridor dimensions would be optimized to incorporate all possible natural flood attenuation features and to avoid development densities that would exacerbate the flood runoff. Doing so also maximized the integrity of the stream habitat. As a criterion for analysis, the streams were to be kept as a fully functioning wetland and riparian feature, not reduced to the status of an open drainage swale. These streams, a

Natural stream corridors
have evolved their
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flood infrastructure.

significant element of the historic natural habitat of Staten Island, would come to be preserved.

This proved to create another major project benefit. While opponents of the Bluebelt predicted widespread public opposition to development restrictions, the public in general realized the amenity of having a fully functioning native stream corridor brought to their neighborhoods and the positive impact it would have on their property values. Though the resulting boost in property tax revenues was not factored into the cost benefit analysis, the enthusiastic response the Bluebelt concept generated with the home owning public was clear, not only for its flood protection value, but also for its contribution to local quality of life.

Politics of Adoption

With the results of this analysis in hand, DEP took the Bluebelt proposal to the Budget Bureau, City Hall, and the City Planning Commission for their blessing as the policy would cut across the concerns of all of these and other agencies such as the Department of Transportation. A number of objections were raised during the resulting review. Water infrastructure traditionalists protested it was unproven. What, they worried, if it failed. The DEP answer: nature has been managing floodwater suc-

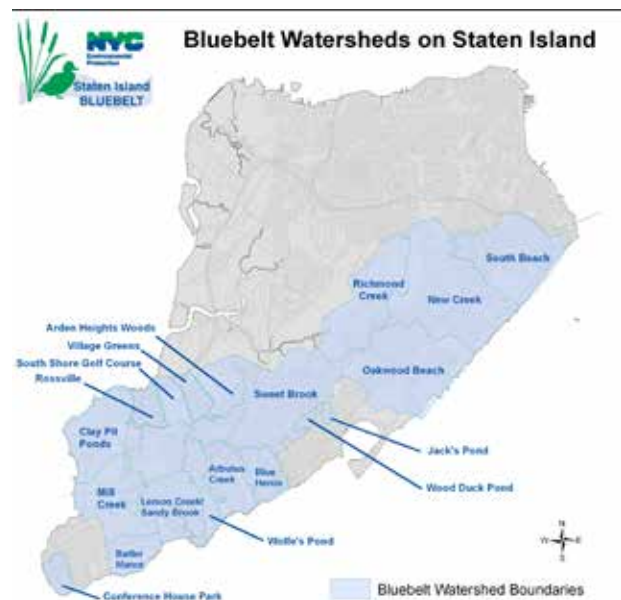
cessfully for a long time. City Planning and development interests argued that the city could not afford to forego valuable development. The DEP answer: Development that cost more than it would return to the city was not valuable and, if the city failed to handle development responsibly and solve the stormwater problem, it would discredit all development. As debate proceeded, it became clear that the Bluebelt approach was the only viable solution to Staten Island's chronic flooding problems, giving the idea powerful momentum. In a last effort to derail the project, opponents tried to raise fear of lawsuits and political controversy, by raising the possibility of neighborhood children drowning in Bluebelt streams. To address this concern, DEP agreed to design additional criteria for addressing when a Bluebelt might be too dangerously attractive. Under these criteria, a small stretch of the trial corridor was agreed to be buried in a traditional stormwater sewer. After several months of this debate, the necessary signoffs were obtained and the first Bluebelt was formally created in the fall of 1990 to widespread public, political, and editorial approval.

Results

Over the next three years, nine other stream corridors were identified and designed as Bluebelts. Though the Bluebelt took its fundamental shape by the end of 1993, since then nine more Staten Island stream corridors have been added for a total of 19 Bluebelt components draining about a third of Staten Island's land area. The map at right sets out the location of all the Bluebelt corridors. The Bluebelt now includes about 400 acres of freshwater wetland and riparian stream habitat and almost 11 miles of stream corridor. It has successfully removed the scourge of regular flooding from southeastern Staten Island, while producing millions of dollars in net savings for the city largely by avoiding the costs of constructing storm water sewers. Successive mayoral administrations have left the Bluebelt system and the Bluebelt effort intact and those concepts of stream management have also been applied to wetland streams in northern Queens and the Bronx. The ultimate testimony to the success of the Bluebelt concept is that the Staten Island Bluebelt has now been incorporated as a part of the official drainage plan for Staten Island and the City of New York.

Bluebelt was an integrated solution with multiple benefits. It not only met an infrastructure need in the most cost-effective manner, it also preserved natural habitat, provided a neighborhood amenity, and encouraged better land use planning. These multiple benefits explain why the Staten Island public so enthusiastically embraced the Bluebelt and why, in the greater scheme of things, the Staten Island Bluebelt has joined with the Staten Island Greenbelt in being a fundamental feature of life on Staten Island.

The author would like to acknowledge the assistance of Dana Gumb, Director of Bluebelt Programs for the New York City Department of Environmental Protection in the preparation of this article.





CONCLUDING REMARKS

● **MAKING THE CASE**

- The Business Case
- The Scientific Underpinnings
- Identifying Opportunity

▼ **DESIGN AND IMPLEMENTATION**

- Players at the Table
- Natural Infrastructure Finance

▼ **CASE STUDIES**

- Cases
- Concluding Remarks

This guide provides the resources needed to foster meaningful dialogue with watershed decision makers and stakeholders around natural infrastructure options, to secure the participation of relevant stakeholders and adoption, and to begin early design and implementation steps on solid footing. While we hope the guide presents a persuasive case for considering natural infrastructure options, ultimately the effective messengers to decision makers and stakeholders are the staff within institutions like water utilities, municipalities, and private businesses. Consistently, behind successful natural infrastructure programs are the often-unsung source water coordinators, conservation staff, and sustainability officers creating real change in these institutions. This guide can be a resource for these champions as they work to gain traction for natural infrastructure in their watersheds.

The overarching message can be delineated in the eleven key take-aways below. This is the increasingly clear “story” of the integrated natural and built infrastructure approaches to securing clean and abundant water.

Making the Case: Business Case, Underlying Science, and Opportunities

- 1. The scientific foundation is imperfect, but robust.** The water-related functions of healthy forested landscapes are well established—maintaining healthy, forested landscapes and implementing best practices in forestry management are effective strategies for promoting source water quality and regulating flow.
- 2. Inherent variability poses challenges for quantification.** While the science is robust, there is inherent variability across and within watersheds in the magnitude of water resources impact of a given land cover change or management practice.
- 3. Risks and uncertainty can be managed.** Despite residual scientific uncertainty, natural infrastructure options are actionable. Utilities and others should prioritize investments, monitor, and manage adaptively.
- 4. The economic benefits can be substantial.** High source water quality and well-regulated flow can reduce the capital and variable costs of providing clean and abundant water.
- 5. The financial case can be made.** The case for natural infrastructure investment has been made in several watersheds nationwide.
- 6. Natural infrastructure investments are actionable despite uncertainty.** While the strength of natural infrastructure economic analyses depends on the quality of the underlying science, conservative assumptions and careful sensitivity analyses can produce actionable results—albeit while tending to underestimate of the returns of natural infrastructure.
- 7. The opportunity is widespread.** Watersheds across the country have opportunities to integrate natural infrastructure alongside critical built infrastructure. High source water quality can reduce capital and variable treatment costs, as well as dredging and other maintenance costs at reservoirs and intakes.

- 8. Local decision maker participation is critical for success.** The success of the approach depends on the ability of natural infrastructure champions to make the case to key local decision makers and stakeholders and to articulate a vision of success.

Design & Implementation

- 9. Cultivating partnerships is a key first step toward success.** In each of the successful attempts to build robust programs for investment in natural infrastructure, an essential component has been collaboration among a variety of stakeholders and experts and the emergence of champions within stakeholder groups to push the program forward.
- 10. Landowner participation is essential in privately owned watersheds.** Landowners are highly independent, value their autonomy, and generally engage in agriculture or forestry because it is a way of life as well as an economic enterprise. In addition to the financial inducement being offered, landowners consider how the program is designed and administered as part of their participation decision.
- 11. Investment must be large scale and sustained.** A long list of public, private, and hybrid public/private finance mechanisms is available to get dollars on the ground to restore, enhance, protect, and manage natural infrastructure for water resources. The primary challenge is to select a finance mechanism (or combination of mechanisms) that is capable of gaining the necessary political support for adoption, while also generating sufficient funds for meaningful and sustained investment in natural infrastructure.

From experience to date with natural infrastructure, a suite of “action items” are evident for both watershed stakeholders and the broader community of practitioners working to scale up the approach nationwide.

Action items for water managers, conservationists, and other stakeholders at the local watershed level:

1. Assess the watershed for ecological condition and trends causing water-related issues tied to substantial current or projected costs;
 2. Engage with key stakeholders and decision makers early and often to articulate a vision of success, expand capacity for program development and implementation through strategic partnerships and consultation with experts, and build on the lessons of past successes and failures;
 3. Conduct necessary economic analyses to determine if natural infrastructure is the best approach and to make the case for financial investment;
 4. Assess a broad array of finance mechanisms with an eye toward securing large-scale “anchor funding” as well as a broader “funder quilt” to ensure meaningful and sustained investment over the long term;
 5. Prioritize investments across parcels and interventions (i.e., reforestation or forest best management practices), monitor outcomes, and adapt investments accordingly.
4. Broaden accounting standards to enable operations and maintenance spending on natural infrastructure by public entities as part of normal business practices;
 5. Build awareness among the water resource management industry, the urban planning field, ratepayers, and taxpayers of the importance of natural infrastructure as a cost-effective and beneficial element of an integrated solution to emerging water issues.

Perhaps the two most important lessons from experience to date are the power of individuals and the importance of partnerships. Ultimately, the most effective messengers to decision makers and stakeholders affecting natural infrastructure decisions at the local level are influential individuals within their own institutions. Behind successful natural infrastructure programs are consistently the often-unsung source water coordinators, conservation staff, and sustainability officers creating real change.

These champions can be those in positions of power, but they need not be. A source water coordinator or manager in a public utility, a risk manager in a private business, or a water program manager in a state environmental agency can have immense impact within their respective institutions—many have been creating that impact for decades. These champions lead and inspire by offering fresh ideas and creativity where precedent might otherwise win the day—and by coming to the table with the evidence base to support those ideas. They identify likely challenges within their institutions and seek external support where appropriate to overcome those challenges.

In the source water context, these champions may need to help decision makers step outside the bounds of their primary roles and grow their competencies through institutional learning processes. Water utilities and municipalities that have been able to innovate in the face of the internal and external challenges they face recognize that bringing the natural infrastructure approach to scale will require institutional change in combination with a concerted effort to provide external cover by raising public awareness.

Action items for the broader community of practitioners:

1. Actively participate in the community of experts, facilitators, consultants, and “mobilizers” seeking to scale up integration of natural infrastructure into water management strategies, in order to leverage others’ efforts.
2. Assist in securing large-scale natural infrastructure funds such as bonds by ballot measure and natural infrastructure “set-asides” like the 20 percent green infrastructure requirement in the state revolving funds;
3. Expand research to quantify forest-to-water connections and improve the reliability and accessibility of watershed models;

At the same time, successful cases have illustrated the importance of leveraging the resources, capacity, and political capital of a wide set of partners—including those who have not traditionally partnered with water utilities. The wide range of benefits offered by natural infrastructure—not just for water but also wildlife, recreation, climate, and rural economic development—offers a salient opportunity to build new coalitions across utilities, rural landowners, conservation groups, and private businesses.

But the task is not easy. As one utility staffer put it, if this were so, we'd have been doing it at scale a long time ago. This guide can be a resource for these individual champions and their partners as they work to gain traction for investment in natural infrastructure in their watersheds.



TABLE OF ACRONYMS

APEX	Agricultural Policy/Environmental eXtender	NWI	National Wetland Inventory
AWWA	American Water Works Association	NLCD	National Land Cover Database
BEF	Bonneville Environmental Foundation	NOAA	National Oceanic & Atmospheric Administration
BMP	Best Management Practice	NRCS	Natural Resources Conservation Service
BOD	Biochemical Oxygen Demand	NTU	Nephelometric Turbidity Unit
CBA	Cost-Benefit Analysis	PWD	Portland Water District
CCPI	Cooperative Conservation Partnership Initiative	PWS	Payment for Watershed Services
CEA	Cost-Effectiveness Analysis	REMM	Riparian Ecosystem Management Model
CPI	Conservation Priority Index	RIOS	Resource Investment Optimization System
CSO	Combined Sewer Overflow	SDWA	Safe Drinking Water Act
CTNC	Conservation Trust for North Carolina	SFI	Sustainable Forestry Initiative
CWA	Clean Water Act	SFWMD	South Florida Water Management District
CWCF	Clear Water Carbon Fund	SPU	Seattle Public Utilities
EPA	United States Environmental Protection Agency	SRF	State Revolving Fund
EWEB	Eugene Water & Electric Board	SWAT	Soil & Water Assessment Tool
FEMA	Federal Emergency Management Agency	SWC	Source Water Collaborative
GASB	Government Accounting Standards Board	TDR	Tradable (or Transferable) Development Right
GGA	Green-Gray Analysis	TMDL	Total Maximum Daily Load
GHG	Greenhouse Gas	TOC	Total Organic Carbon
GIS	Geographic Information System	USDA	United States Department of Agriculture
GWLF	Generalized Watershed Loading Function	VIP	Voluntary Incentives Program
HCP	Habitat Conservation Plan	WBD	Watershed Boundary Dataset
HSPF	Hydrological Simulation Program—FORTRAN	WEPP	Water Erosion Prediction Project
ICLUS	Integrated Climate and Land Use Scenarios	WFMIS	Watershed Forest Management Information System
InVEST	Integrated Valuation of Environmental Services and Tradeoffs	WIFIA	Water Infrastructure Finance & Investment Authority
MCL	Maximum Contaminant Level	WQS	Water Quality Standards
MDIFW	Maine Department of Inland Fisheries & Wildlife	WRI	World Resources Institute
NEWMAN	New England Watershed Managers	WRP	White River Partnership
NHD	National Hydrography Dataset		

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ENDNOTES

1. Non-market carbon-related benefits were calculated based on social cost estimates in Tol (2007). While they are treated as non-market benefits in the analysis, carbon benefits could be sold as credits with programs such as the Clear Water Carbon Fund (Finance Case 5 in Section 5.1), which would have the effect of offsetting natural infrastructure costs. However, some amount of transaction costs would be incurred to do so.
2. With respect to stormwater, see, e.g., American Society of Landscape Architects. Stormwater Case Studies. Available at: <http://www.asla.org/stormwatercasestudies.aspx>.
3. DEFINITION: Skid trails are paths left by heavy vehicles used in logging operations to pull cut trees from the cutting side to a landing (a process called “skidding”), where they are then loaded onto trucks.
4. Rough estimate gleaned from various sources on model performance, including model-specific reviews (e.g., Gassman et al. 2007) and individual studies (such as Lee et al. 2000, Georgas et al. 2009, Singh et al. 2005). In practice, performance depends on a variety of factors and will vary substantially (e.g., see Van Liew et al. 2007). See Moriasi et al. (2007) or Donigan and Imhoff (2009) for an overview of approaches to watershed model performance evaluation.
5. Well-developed “support” can include updated user manuals, theoretical documentation, and online video tutorials; guides to modeling various landscape features; free regional- to global-scale input databases; accessory software for collating and formatting inputs, calibrating the model, visualizing outputs, and running post-processing analyses; and a model development team available to provide implementation support—among other forms of support (see swat.tamu.edu as an illustration).
6. DEFINITION: Hybrid modeling systems integrate highly specialized models for specific purposes with earlier, more comprehensive models that have broader capabilities (see, e.g., Saleh and Gallego 2007, Imhoff et al. 2010, Liu et al. 2007).
7. Note: listed characteristics ascribed to the three models include attributes of the original models themselves as well as updated and expanded model versions and the more comprehensive modeling systems and interfaces that have been built around them.
8. See, for example, for GWLF: Haith and Shoemaker 1987, Haith et al. 1992, Lee et al. 2000, Georgas et al. 2009, Xuyong et al. 2010; SWAT: Gassman et al. 2007; HSPF: e.g., Singh et al. 2005, Saleh and Du 2004 (monthly), Weston Solutions 2006 (monthly), but see Im et al. 2003 (monthly).
9. See, e.g., Arnold et al. (2012)
10. See, for example, AQUA TERRA Consultants 2011.
11. See, for example, Gassman et al. 2007.
12. See, for example, Evans et al. 2008, Penn State 2012, and, e.g., Georgas et al. 2009.
13. Note: InVEST (not profiled for this chapter because it has undergone little formal validation in the literature) is specifically designed to compare alternative land cover scenarios and some management practices, and has the capacity to produce (limited) estimates of economic value of watershed services alongside biophysical outputs (Tallis et al. 2011). InVEST is hydrologically quite simple compared to SWAT or HSPF (far fewer features and processes represented), but it is highly spatially explicit (i.e., performs overland routing; Tallis et al. 2011).
14. Synthesized and reproduced with permission of the U.S. Endowment for Forestry & Communities
15. Accounting and bond disclosure standards play an important role in determining (and typically limiting) the kinds of natural infrastructure in which utilities may invest. Section 2 expands further on this topic.
16. For information on rate setting, see for example AWWA 2012. For a national overview of water rates, see AWWA 2010.
17. Available at <http://www.usendowment.org/watersheddatabase.html>
18. For more information about how the municipal bond market works, visit the Municipal Securities Rulemaking Board website: <http://www.msrb.org/Municipal-Bond-Market.aspx>.
19. More information from the EPA about the Clean Water State Revolving Fund and Safe Drinking Water State Revolving Fund is available at: http://water.epa.gov/grants_funding/cwsrf/cwsrf_index.cfm and http://water.epa.gov/grants_funding/dwsrf/index.cfm, respectively.
20. More information about current Farm Bill conservation programs is available at: <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/farmbill/>
21. More information about the WIFIA concept and legislation is available at: <http://www.awwa.org/legislation-regulation/issues/infrastructure-financing.aspx>
22. More detail on this process is available on The Freshwater Trust’s website: <http://www.wri.org/publication/paying-for-environmental-performance-reverse-auctions>
23. An informative overview of state and local tax incentives, including a report with guidance on creating incentives for conservation, is available on the Land Trust Alliance website: <http://www.landtrustalliance.org/policy/tax-matters/campaigns/state-tax-incentives>
24. For a good definition of nutrient trading, see Commonwealth of Pennsylvania, Nutrient Trading, available at http://www.dep.state.pa.us/river/Nutrient%20Trading_files/Trading%20Fact%20Sheet-%203900-FS-DEP4073.pdf.
25. <http://insights.wri.org/news/2011/07/new-fact-sheet-helps-chesapeake-bay-states-design-nutrient-trading-programs>
26. An informative overview of TDR programs is available at <http://government.cce.cornell.edu/doc/html/Transfer%20of%20Development%20Rights%20Programs.htm>
27. Due to its single family home development pattern, Staten Island produced a very low level of water and sewer tariff revenue, far below what would have been needed for a full program of storm sewer construction. Even existing programs of infrastructure and water management, including provision of some sanitary sewers, were costing DEP in 1990, far more than the \$40 million in revenue Staten Island produced. Moreover, during the early 1990s, the water and sewer system faced a citywide political revolt against water and sewer rates that had grown in the 1980s at an average rate of 14 percent per year, due to poorly planned capital management programs and a series of new, construction-heavy environmental mandates.
28. The technical inquiry is available for download on Earth Economics’ website: <http://www.earthconomics.org/> and here, <http://www.earthconomics.org/FileLibrary/file/21st%20Century%20Utility/Request%20to%20GASB%20for%20Natural%20Resources%20Reporting%202013%20-%20FINAL.pdf>.
29. Water Environment Research Foundation’s website (WERF): www.werf.org.

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