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Green, Clean, and Dollar Smart

Ecosystem Restoration in Cities and Countryside

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Prepared for Environmental Defense Fund

Environmental Defense Fund

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EXECUTIVE SUMMARY

Green, Clean, and Dollar Smart

As the 21st century opens, cities are restoring nature and its functions to the metropolis. Across the country, urban "greening" is gaining considerable momentum. Moreover, urban greening initiatives are often taking place within broader regional and increasingly ambitious ecosystem restoration efforts, where their success both depends upon and contributes to landscape-scale, non-urban conservation.

Climate change, continuing challenges with air and water quality, high energy costs, loss of open space and wildlife habitat, and other challenges are prompting a rethinking of urban landscapes and their relationship to surrounding areas. Natural landscapes such as wetlands and sea marshes, watersheds of free-flowing rivers and streams, forests, grasslands, even urban parks and greenways purify water; absorb pollutants from the air; protect communities from flooding; and prevent erosion.

Yet the connection between these benefits—called ecosystem services—and the natural world around us is often invisible and sometimes neglected, resulting in underinvestment in environmental protection and increased impacts from land, water, and coastal transformation. Through this neglect, cities have also missed opportunities for infrastructure cost savings and other economic, environmental, and community benefits.

Numerous federal, state, and local policies, many outlined in this paper, at least implicitly recognize the value of intact ecosystems services and the services those ecosystems provide to human communities. Many city greening efforts embody ecosystem services concepts, but much more could be done.

Four Opportunities—Integration, Metrics, Regions, and Policy Tools

Four areas present significant opportunity to enhance urban greening and contiguous regional ecosystem restoration efforts:

- **Integration:** Greening activities often unfold as a set of distinct or separate initiatives rather than as an integrated suite of activities that address climate change, energy, air quality, water supplies and quality, wildlife, and other issues on an urban landscape scale.
- **Multi-benefits measures:** Many urban efforts could benefit from more finely tuned measures, metrics that integrate multiple benefits, and monitoring to estimate and track benefits of greening investments. Such integrated metrics could better support opportunities to "market" the services generated through urban greening and take advantage of some Environmental Protection Agency regulatory innovations.
- **Regional Restoration:** These urban efforts are often not integrated into regional strategies that link urban greening to non-urban, contiguous landscape-scale ecosystem restoration, limiting the potential to optimize ecosystem services benefits in terms of both environmental outcomes and revenue streams to support greening goals.

- **Policy Leveraging:** Many city efforts have not fully utilized various federal policy tools available in Clean Air Act, Clean Water Act, and other laws, regulations, and policy guidance to generate possible ecosystem services revenue sources, use incentives to support investments in ecosystem services, or seek regulatory credits for these efforts. Full leveraging of policy opportunities could also benefit from development of some new federal, state, and local policy tools.

This guidebook offers cities, counties, states, and stakeholders some discussion, examples, and a summary of tools and policy recommendations that may stimulate further interest in expanding, integrating, and refining the greening of urban infrastructure using an ecosystem services framework.

Key goals that shape that framework include:

- facilitating regional, **landscape-scale**, or watershed-level actions;
- enhancing local and state decision-making **coordination** across jurisdictional boundaries;
- strengthening **performance accountability** through a focus on outcomes rather than prescriptions;
- nurturing **private stewardship** and **ecosystem services markets**; and
- sustaining **place-based decision-making** to take advantage of existing institutions and situational knowledge.

Why Urban Greening? Why Now?

Several circumstances augment the relevance and timeliness of urban greening efforts. Aging infrastructure means cities face prospects of expensive replacement. Budget constraints strain the capacity of cities to supply services. Traditional infrastructure has not consistently performed well, as storm surges breach levees, storm water overflows, stream waters exceed EPA temperature standards, and water quality falls short of desired goals. Climate change; challenges

Many cities are intoducing urban greening concepts into their planning efforts as a way to meet their economic, social and environmental goals.

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of managing water supplies, water quality, and water flows in extreme storm events; and escalating energy costs and associated impacts all strain current urban infrastructure and resource management.

Cities are seeking new solutions to meet their economic, social, and environmental goals. Tapping the services of Nature through urban greening offers potentially cost-effective, high-performing options to meet these goals. At the same time, landscape-scale conservation adjacent to cities presents linkage opportunities to improve results in cities and on these larger landscapes.

Going for Green—Policy Context

While the nation's major environmental laws generally do not explicitly reference ecosystem services, several agencies have launched projects that use ecosystem services concepts. Several federal laws may also hold potential to support urban greening, ecosystem services investments, and associated landscape-scale conservation. In addition, new local, state, and federal tools could further strengthen urban greening efforts and their links to landscape-scale conservation and restoration.

Opportunities for Action—Protecting and Enhancing Ecosystem Services

Many federal, state, and local tools are available to cities and regions to: 1) provide a more holistic context for urban greening efforts and measure their benefits, and 2) integrate urban greening with regional and landscape-scale conservation and restoration. These tools offer examples for possible replication or adaptation to local circumstances and provide some potentially useful policy and governance concepts.

These tools include mechanisms to establish structures to coordinate the different components of urban greening initiatives. They also include tools to develop, refine and combine metrics across multiple performance dimensions that include air quality, greenhouse gases, energy conservation, stormwater runoff, water quality and supply. In addition, cities and states should assess the applicability of existing federal, state, and local regulatory and financing tools that facilitate urban greening. Options include:

- **Clean Air Act: Air Quality Credits and Trees.** Evaluate the applicability of Clean Air Act "emerging measures" provisions that allow tree planting to qualify for ozone-reduction credit.
- **Clean Water Act 2003 Phase II Stormwater Regulations.** Consider using the Environmental Protection Agency's model stormwater permit guidance to support tree-planting for purposes of improving runoff control.
- **Clean Water Act pollution trading and permit bundling opportunities.** Develop state and local policies that build upon EPA pollution trading and related tools. In 2003, the EPA issued a Water Quality Trading Policy. In 2004, EPA issued a Water Quality Trading Assessment Handbook to facilitate water trading to improve water quality.
- **Clean Water Act and Safe Drinking Water Act grant provisions.** Use EPA grant and loan programs under the Clean Water Act and the Safe Drinking Water Act that allow infrastructure greening and land acquisition to protect water supplies.
- **Green infrastructure and ecosystem services funds, bonds and surcharges.** Develop funding provisions through utility or other state and local fees that support green infrastructure and land protections.
- **Ecosystem services evaluation laws.** Develop state laws that create a framework to evaluate and protect ecosystem services. One model is SB 513—Oregon's Ecosystem Services Bill. In the first state bill to focus specifically on ecosystem services, SB 513 states that "it is the

policy of this state to support the maintenance, enhancement and restoration of ecosystem services throughout Oregon, focusing on the protection of land, water, air, soil and native flora and fauna." (SB 513, Sec. 2)

- **Watershed-based framework.** Use Clean Water Act watershed permitting guidance to develop a watershed framework for evaluating, planning, and implementing greening strategies that link urban and non-urban actions.
- **Clean Water Act Total Maximum Daily Loads.** Develop state and/or local laws, policies, and regulations regarding nonpoint source pollution, which can provide impetus to water quality credit trading.
- **Offsite Mitigation Banking.** Consider opportunities to implement Clean Water Act Sec. 404 wetlands mitigation requirements through banking to complement on-site requirements and improve ecosystem results. Section 404 (b) (1) Guidelines promulgated in 2005 provide regulatory authority to consider ecosystem services benefits of wetlands, such as water purification.

This paper also recommends further federal actions that could encourage protection of and investment in ecosystem services. These include:

- **EPA development of infrastructure greening guidelines,** including provisions to strengthen use of state revolving fund grants under the Clean Water Act and Safe Drinking Water Act for ecosystem and infrastructure greening.
- **EPA development of Safe Drinking Water Act incentives** or requirements for states to implement the Source Water Assessment Plans that they have already developed.
- **Development of Coastal Zone Management Act incentives** to states to include ecosystem services criteria in their coastal management plans developed under the Coastal Zone Management Act.
- **Creation of Federal ecosystem services guidance and support** for ecosystem services that could include: 1) developing an Overall Performance Guidance on Integrated Ecosystem Services; 2) improving federal budgeting to support ecosystem services and landscape-scale restoration through multi-year and cross-agency integrated budgets; 3) developing guidance on how to incorporate ecosystem services evaluations into National Environmental Policy Act evaluations.
- **Improvements to Federal conservation grants** to: 1) focus on ecosystem priorities and performance effectiveness; and 2) strengthen integration of ecosystem services investments by focusing grant awards on landscape-scale initiatives. A model could be the USDA State Forestry program that uses competitive grants for a portion of its funding, with a focus on awarding grants to landscape-scale initiatives.

Summary of Guidebook Sections

Part I: Greening Journey—Cities Meet Nature briefly summarizes urban greening.

Part II: Strengthening Greening Effectiveness outlines opportunities to strengthen urban greening using ecosystem services concepts and tools through 1) integrating diverse actions and coordinating them to achieve multiple benefits; 2) using clear, transparent metrics and measures to document results; and 3) integrating urban greening into regional endeavors that connect with adjacent non-urban restoration projects.

Part III: Why Urban Greening, Why Now summarizes some key benefits of urban greening and broader landscape protections that include addressing impacts of climate change, reducing greenhouse gas emissions, improving air and water quality, enhancing urban wildlife habitat, and conserving energy.

Part IV: Green, Blue, and Gold—Ecosystem Services Tools for Communities sets forth policy tools that may support ecosystem services investments in cities and their surroundings.

CHAPTER 1

The Greening Journey—Cities Meet Nature

In the 1930s, the City of Los Angeles began extensive paving of the Los Angeles River to facilitate flushing of waters out to sea more rapidly. Now, much of the 52 miles of the river is a concrete corridor. Los Angeles was not alone. In the 20th century, cities across America tamed urban rivers and streams. Water management for most of the 20th century largely meant flood control. The tools of choice called for taking Nature out of cities, directing rivers and streams through tunnels, steering them through engineered channels, and walling them off with levees. Wetlands, too, were filled to give way to urban development. Trees became street ornaments or offered an occasional shaded haven in an occasional city park. Paved surfaces and highly fragmented greenspace characterized the urban landscape.

Nature and cities, in symbols, rhetoric, and often in practice, represented a dividing line between the wild and the civilized. As author John Tallmadge observed, "Nature was 'other.'" Eying one downtown, he described his first impressions: "to my eye the downtown environment actually blurred the line between inside and outside." Both were places of geometry, "planar trajectories of sidewalk and pavement."[1]

Nature never entirely left America's cities. Trees, shrubs, grasses, and flowers squeezed into planter boxes, sidewalk strips, or city plazas. Waterfronts of greenery sometimes offered an aesthetic respite to the concrete geometry of cities. But Nature was not an integral part of the functioning of cities, their infrastructure, and the life-supporting supplies of clean water, clean air, and waste disposal essential to human communities.

This 21st century, cities are changing, restoring nature and its functions to the metropolis. Seventy years after Los Angeles began major paving of the Los Angeles River, the city is now chipping away at that concrete. The river is becoming a river again. Across the nation, urban "greening" has gained momentum. New York, Pittsburgh, Philadelphia, Baltimore, Chicago, Miami, Portland, Los Angeles, and other cities are rethinking cities and Nature.[2] These urban greening initiatives situate within regional watersheds and increasingly ambitious ecosystem restoration efforts. In many locations, the success of urban greening efforts depends upon integrating with landscape-scale, non-urban conservation and vice versa.

Many urban greening initiatives began largely for aesthetic purposes to make cities more "livable." These early efforts have given way to much broader greening policies, plans, and projects in which Nature offers essential infrastructure and services to communities. Urban greening now builds upon a concept sometimes referred to as ecosystem services. Climate change, continuing challenges with air and water quality, high energy costs, flood control, loss of open space and wildlife habitat, and other challenges have provided impetus for rethinking urban landscapes, structures, and infrastructure and their relationship to surrounding areas.

Ecosystems—Serving People, Too

Natural landscapes—wetlands and sea marshes, watersheds of free-flowing rivers and streams, forests, grasslands, even urban parks and greenways—purify water; absorb pollutants from the air; help protect coastal communities from catastrophic storms; and prevent erosion. Yet the connection between these services and the natural world is often invisible and sometimes neglected.[3]

Ecosystem services refer to benefits to human communities that result from the processes, structures, and functions of natural systems (wetlands, watersheds, grasslands, forests, etc.) and their components (for example, trees, other plants, soils, and waterways).

This neglect has resulted in underinvestment in environmental protection and increased impacts from land, water, and coastal transformation. With ecosystem degradation have come corresponding losses of natural system functions and their benefits to human communities. This neglect has also resulted in missed opportunities for infrastructure cost savings and other economic, environmental, and community benefits.

City and county planning, building codes, and infrastructure decisions influence much of this nation's land use. Maryland, Oregon, Florida, and a handful of other states pioneered statewide statutes to govern urban growth, and some cities have established limits on development, with varying results. Some cities, including Los Angeles and New York City, have set tree canopy goals. Bellevue, Washington encourages permeable landscaping to reduce stormwater runoff through applying more favorable stormwater utility fee structures for projects that maintain permeability. Other cities, such as Philadelphia, are transitioning to similar stormwater fee structures based on gross impervious area that incorporates the full cost of the service.[4]

Through greening of their infrastructure, cities are incorporating ecosystem services concepts and practices into urban landscapes. Portland, Oregon and Philadelphia, Pennsylvania, for example, are developing integrated, watershed approaches to managing water quality. Through this integration, these cities coordinate infrastructure planning and management of water supplies, stormwater, wastewater and sewage and situate city water management within a regional context. The Southeastern Wisconsin Watersheds Trust, a

In the 1930s, the City of Los Angeles paved the Los Angeles River into a concrete corridor in order to flush waters out to sea more rapidly. Now, 70 years later, the city is removing the concrete and allowing the River to return to a natural flow.

Lee Pettet/iStockphoto

voluntary partnership among governments, businesses, organizations, and individuals, is linking cities and rural areas to address water quality and related issues throughout the Greater Milwaukee watersheds. With its PlaNYC, New York has developed actions and measures for greener infrastructure, more open space, clean up of land and water, and reduction of air pollution, and other measures using a watershed focus to provide multiple, interconnected benefits.

These efforts are yielding environmental results. They are also often reducing city costs to provide important infrastructure and benefits. For example:

- The City of New York invested over $1.5 billion to protect and restore the Catskill Mountain watershed, a web of natural systems purifying the city's water supply, rather than spending up to $9 billion on filtration plants.
- Using ecosystem services concepts, Portland, Oregon achieved a 95 percent flow reduction through bioretention, and Seattle reduced the volume of runoff by 98 percent in one neighborhood with extensive use of "green infrastructure" that cost 25 percent less than traditional alternatives.
- Chicago's Green Alleys Program repaved 3,500 acres of impermeable alleys with permeable pavers, using ecosystem services concepts to reduce stormwater.
- Through its Green Highways program, Maryland is reducing surface imperviousness and increasing the environmental functions and values of watersheds to reduce disruptions to ecological processes, protect the hydrology of wetlands and stream channels through restoration of natural drainage paths, and encourage smart growth.

Four Opportunities—Integration, Metrics, Regions, and Policy Tools

Despite these achievements, four areas present opportunities to enhance urban greening and connect these efforts to contiguous regional ecosystem restoration:

- **Integration:** Urban greening activities often unfold as a set of distinct or separate initiatives rather than as an integrated suite of activities to address climate change, energy, air quality, water supplies and quality, wildlife, and other issues on an urban landscape scale.
- **Multi-benefits measures:** Many urban efforts could benefit from more finely tuned measures, metrics that integrate multiple benefits, and monitoring to estimate and track benefits of greening investments. These metrics could support "marketing" of the services generated through urban greening and take advantage of some Environmental Protection Agency regulatory innovations and voluntary programs.
- **Regional Restoration:** These urban efforts are often not integrated into regional strategies that link urban greening to non-urban, contiguous landscape-scale ecosystem restoration, limiting the potential to optimize ecosystem services benefits in terms of both environmental outcomes and revenue streams to support greening goals.
- **Policy Leveraging:** Many city efforts have not fully utilized various federal policy tools available in Clean Air Act, Clean Water Act, and other laws, regulations, and policy guidance to generate possible ecosystem services revenue sources, use incentives to support investments in ecosystem services, or seek regulatory credits for these efforts. Full leveraging of policy opportunities could also benefit from new federal, state, and local policy tools.

City greening efforts are encyclopedic in breadth. Yet many untapped opportunities remain. This guidebook offers cities, counties, states, and stakeholders some discussion, examples, and a summary of tools and policy recommendations that may stimulate further interest in expanding, integrating, and refining the greening of urban infrastructure using an ecosystem services framework. While the guidebook centers on cities, the paper casts a broader lens at cities and their links to larger, landscape-scale conservation. In addition to describing current

policies and practices that support urban greening using an ecosystem services approach, the paper describes opportunities to strengthen federal support of this framework.

Key goals that shape that framework include:

- facilitating regional, **landscape-scale**, or watershed-level actions;
- enhancing local, service district, and state decision-making **coordination** across jurisdictional boundaries;
- strengthening **performance accountability** through a focus on outcomes rather than prescriptions;
- nurturing **private stewardship** and **ecosystem services markets**; and
- sustaining **place-based decision-making** to take advantage of existing institutions and situational knowledge.

CHAPTER 2

Strengthening Greening Effectiveness

In 2004, Canada's Centre for Sustainable Community Development examined efforts of Canadian municipalities to address energy, water, and other local infrastructure and service requirements for cities. As a starting point, the Centre proposed that there are "synergies inherent in comprehensive and integrated solutions."[5] Surveying Canadian municipalities, the Centre concluded:

> *Much has been accomplished in related fields of green buildings, industrial ecology, and ecosystem planning. By reframing problem solving and planning from a more holistic perspective, countless opportunities arise to accomplish more with less capital investment....Typically, the current administrative structure of municipal government and its relationship to the private sector and civil society can pose significant barriers to developing integrated approaches to sustainable infrastructure and community services. Likewise, current governmental fiscal policy and management reinforce this compartmental culture.*[6]

Though the Centre's focus was on Canadian municipalities, its conclusions apply to many U.S. cities and their greening initiatives. These efforts are laudable and extensive. However, untapped opportunities to integrate greening efforts persist and include, for example:

- combining demand-side management of resource use with improvements in efficiency and reductions in environmental impacts of existing buildings, infrastructure, and energy systems;
- integrating various greening infrastructure components; and
- integrating green building initiatives with green infrastructure initiatives that expand tree canopy, create more permeable surfacing, and return urban streams to more natural forms.

The Whole Is Bigger than the Sum of the Parts: Integrating Benefits

Several U.S. cities are pushing the integration envelope, but expanding these efforts may require new governing tools and innovative use of existing tools. Several factors contribute to difficulties in urban integration of greening efforts. These include:

- **Agency "silos"** that inhibit coordination across air, water, wastewater, stormwater, climate, energy, open space, and other infrastructure and services.

  In Albany, New York, for example, the city owns the wastewater plants but does not own the piping leading to the plants. This ownership segregation inhibits opportunities to rethink wastewater infrastructure and use wastewater fee revenue to revise pipe infrastructure. At the state level, similarly fractured responsibilities are common. In the State

of Virginia, for example, the Department of Environmental Quality permits wastewater while the Department of Conservation and Recreation handles stormwater permits.

- **Federal and state permitting structures** that segregate planning and actions into discrete activities and issue areas that make integrated ecosystem planning difficult.

Consider Philadelphia. Requirements for managing combined sewage overflow (CSO) under provisions of the Clean Water Act lie behind efforts to broadly integrate urban greening in the City of Philadelphia. CSO requirements provide the "enforcement teeth" to prompt action. At the same time, the high costs of traditional tools, such as investing in more tunnel capacity to handle flows, have triggered a search for better approaches premised on pollution prevention.[7]

In its long-term plan update for EPA, Philadelphia took a novel urban greening approach to the challenges of CSO management, with benefits intended to meet sewage overflow requirements while also producing cleaner air; cleaner water; and more GHG reductions relative to alternative, traditional investments. The greening plan also provided other environmental, social, and economic benefits. Fundamentally, the plan would re-align the city's infrastructure, moving it from "gray" to "green" infrastructure, with conversion of 34 percent of the city to permeable surfaces as a central foundation of the plan. Using "triple bottom line" calculations that include full life-cycle environmental and other costs, the city concluded that every million dollars spent on "gray" infrastructure such as CSO tunnels generates $1.1 million in environmental and other costs that result from materials usage, land transformation, and other impacts. Tunnel expansion would reduce combined sewage overflow, but total net environmental effects, according to the city, would be negative.[8]

City managers believe a green infrastructure approach would be more cost-effective and yield more benefits while still meeting CSO requirements. A complete tunnel system, with an estimated price tag of $6-$8 billion, would require 80 years to build at $100 million per year, estimated by the city as a realistic spend rate. By contrast, over 20-30 years the city could spend a total of $1 billion and transform the city's landscapes, dramatically enhancing

City managers in Philadelphia have developed a long-term plan that would move the city towards a green infrastucture, but the policy tools are lacking to put this plan into action.

Bonnie Jacobs/Stockphoto

the sustainability profile of Philadelphia and producing multiple environmental, health, social, energy, and economic benefits.

While Philadelphia has a holistic, integrated vision for its greening efforts, the federal policy tools to accomplish this kind of vision are lacking. Several challenges stand out. First, the currently required EPA timeline for building CSO tunnels has negative cost and environmental performance implications. Second, the absence of clear EPA policies regarding green infrastructure limits city opportunities. Third, EPA's uncertainty about how green infrastructure will perform raises concerns about how to define violations of EPA combined sewage overflow standards and enforce those standards.

EPA generally assumes a 20-year timeframe to build CSO tunnels. At least implicitly, the agency also appears to recognize that, even with more tunnel capacity, combined sewage overflows will still occur. Nonetheless, EPA typically will deem a city to be compliant with standards if the commitments are made to build tunnels within a certain timeframe to specified performance parameters.

A "green infrastructure" approach, by contrast, involves an evolution of urban landscapes over time as part of ongoing infrastructure maintenance and renewal processes as streets, energy and electricity infrastructure redevelopment, and new development occur. Through these processes, old "gray" infrastructure is replaced with new "green" infrastructure. Over a 30-year timeframe, replacement and renewal goals are met. Costs are incremental, incurred during natural replacement or new development cycles rather than requiring displacement of existing infrastructure with entirely new investments. The challenge for the city (and for EPA) is that current compliance tools and procedures are not well configured to evaluate and give compliance "credit" for this gradual urban greening, even when incremental pollution reduction begins right away with the first greening investments, while results from new tunnels loom 15 years or more into the future.

- **Jurisdictional structures** that limit budgets and authorities for working across governing boundaries and at scales commensurate with ecosystems and natural landscape dynamics.

  City government budgets and operations are divided among specific services that include stormwater management, wastewater treatment, parks and recreation programs, drinking water, public building management, and so on. In many areas, municipal residents are served primarily by private power companies. The benefits of green infrastructure are, thus, dispersed across these different services, making them difficult to perceive. In addition, the beneficiaries of these ecosystem services have little or no authority, incentives, or responsibility to pay for them. One study of Washington, DC, found that trees provided annual benefits of some $5.55 million per year in reducing energy costs in buildings, removing air pollution, and other ecosystem services.[9] Yet budget structures consider trees largely as a "cost" with no corresponding way to charge for their benefits, such as the avoided energy costs they provide to building managers.

- Governing jurisdictions and **political boundaries** seldom align with watersheds or other ecosystem landscapes.

  As human settlements emerged, largely around hubs of economic activities, city boundaries were established to encompass these hubs. State boundaries resulted from historic circumstances and land ownership patterns largely unrelated to ecosystems, their components, and their functions. As a consequence of these historic political processes, many city boundaries do not fully encompass the watersheds on which they are dependent. A few cities, such as Seattle, acquired lands a century ago that supplied the city's source water, but such acquisitions were infrequent. In some cases, such as the Chesapeake Bay, a single watershed includes a jumble of city and state boundaries. In other cases, such as Milwaukee, the city is situated amid multiple watersheds.

Metrics Mean Better Management and Market Opportunity

Several cities are integrating their urban greening efforts across multiple goals, ecosystem services, and city service delivery functions.[10] Yet these urban greening efforts often lack fully developed metrics and measures to evaluate, track, and validate environmental and other benefits. While these metrics generally identify city goals and track their achievement, they often do not use the sorts of measures and metrics that would be required for greening efforts to take part in ecosystem services market transactions or to achieve regulatory credits.

Ecosystem services concepts have spawned an entire field of ecological economics centered on putting price tags to the many services, by type and location, generated by natural landscapes and their components. Many of these calculations examine non-urban settings including rural lands, watersheds, wetlands, and forests. Some ecosystem services calculations, however, have targeted urban environments. These efforts include, especially, the U.S. Forest Service's urban forests research as well as valuation tools developed by the nonprofit organization American Forests.

The U.S. Forest Service's Northeast Research Station, for example, developed its Urban Forests Effects Model (UFORE), which includes i-Tree, a tool that enables users to calculate ecosystem services such as pollution absorption, carbon sequestration, reductions in stormwater runoff, and temperature regulation of trees and estimate their economic value. [Information about the model is available at http://www.nrs.fs.fed.us/tools/ufore]. The modeling and data tool provides area and linear information (along streets) of vegetation extent and composition in urban areas and links that information to ecosystem services benefits. Using standard calculations for economic benefits of these services, the model can be used to assess dollar values of tree canopy and other vegetation. The model can help identify the best locations for expanded tree canopy to achieve pollution removal, reduce "heat island" effects, and meet other environmental and community sustainability goals.[11]

In 2003, the Trust for Public Land began developing a tool to measure the economic value of park systems. The tool looks at seven values, including property value, tourism, direct use, health, community cohesion, clean water, and clean air. Developed by economists and park experts, the tool was initially used in five test cases in Washington, D.C., San Diego, Boston, Sacramento, and Philadelphia.[12] Its broader applicability to ecosystem services evaluations remains untested.

Greg McPherson of the U.S. Forest Service notes that developing workable metrics that would enable investments in urban forests to qualify for Clean Air Act compliance or other credits remains challenging for several reasons. First, benefits vary by location, age, diversity, and structure of tree stands. The more complex the tree stands, the greater the stability of ecosystem service benefits. Second, benefits depend upon long-term maintenance, not simply initial tree-planting. Third, metrics for "service life," reliability, and long-term performance of benefits are not well-developed.[13]

Though tools to measure benefits and assess the economic values of urban greening initiatives are emerging, anchoring urban greening investments with transparent, verifiable, and creditable measures remains a challenge for many cities and broader ecosystem restoration initiatives. Even more challenging is to develop or access tools that integrate multiple benefits within a single measurement platform, and translate measures into potential "trading values." Since regulatory standards can often drive investments in ecosystem services, development of metrics and evaluation tools that fit into regulatory compliance structures is especially important. Experience from carbon markets suggests that such measures must be transparent and verifiable, at a minimum.

The U.S. Green Building Council, which developed a Leadership in Energy and Environmental Design (LEED) rating and certification system for green buildings (see www.

usgbc.org/LEED/), has a collaborative effort underway to develop ratings for the broader land development context. In 2008, another initiative, the Sustainable Sites Initiative, developed draft Guidelines and Performance Benchmarks for "sustainable land practices that will enable natural and built systems to work together to protect and enhance the ability of landscapes to provide services such as climate regulation, clean air and water, and improved quality of life."[14] This initiative sets forth performance goals, corresponding performance requirements, and associated documentation. The initiative uses an integrated framework that links multiple ecosystem performance goals. The actual rating system will be available in 2011. This tool could help guide greening of built environments, but its purpose is not to provide metrics or measurements of environmental outcomes. For ecosystem services markets, measured outcomes are an essential building block. Development of such measures remains largely a work in progress through i-Tree and other tools.

Connecting with Nature Next Door: Regional Restoration

The landscape-scale nature of environmental challenges underscores that cities and countryside could benefit from ecosystem conservation and restoration efforts that transcend jurisdictional boundaries and link what cities are doing with what the nation and rural communities are doing to restore ecosystems.

Consider one example: the state and federally funded, multi-year, landscape-scale restoration of the Florida Everglades. Parallel to but separate from the Everglades restoration program, Miami/Dade County has developed an aggressive greening master plan for parks and open space. The plan, if fully implemented, would create an interconnected regional system of greenways, waterways, and conservation lands.

These two ambitious efforts are not integrated. The Everglades Restoration plan, conceived over two decades ago, envisions a virtual wall between urbanized areas and the restored "river of grass." The virtual separation is intended to prevent the Everglades waters from seeping into or flooding urban areas, an important goal for urban communities. Yet the greening of Miami/Dade County may present new opportunities to rethink this original strategy and explore whether new east/west greenways in the city and county might support some freshwater flows. Such interconnections are not simple, and technical issues may limit integration potential.

But a first step is to broaden planning horizons, in Miami and elsewhere, to explore how large non-urban restoration efforts might link to city greening efforts, thereby achieving landscape-scale benefits.

Recognizing that stormwater is a major source of pollution in southwestern Wisconsin, the area's Regional Planning Commission began modeling six watersheds for population growth, development patterns, and other variables as a precursor to exploring how to better integrate municipal and non-urban watershed management. That initial effort resulted in the creation of a voluntary partnership involving the six watersheds and priority-setting of actions associated with two rivers.

The voluntary partnership is striving for a regional approach while, at the same time, developing actions that "drill down" to the neighborhood level.[15] While stormwater management is the province of each municipality or stormwater district, a single flood management authority creates the common "glue" upon which to build integrated action among municipalities. The agency responsible for flood management regulations is using its flood management requirements to coordinate actions among 28 different municipalities. Each municipality, under the flood management regulations, has a specific "load share" for handling floodwaters. Water quality trading may tier off these "load sharing" regulatory provisions.

Yet Wisconsin's laudable effort at regional watershed management in many ways underscores the difficulties associated with such efforts and explains their infrequent

Watershed Permits: An EPA Innovation

Under the Clean Water Act, the EPA oversees a National Pollutant Discharge Elimination System. In traditional permitting, EPA addressed individual pollutant sources on a discharge-by-discharge basis. Each wastewater treatment effluent release site was required to obtain a permit. Watershed permitting, according to EPA, "is a process that emphasizes addressing all stressors within a hydrologically defined drainage basin. Watershed-based permitting can encompass a variety of activities ranging from synchronizing permits within a basin to developing water quality-based effluent limits using a multiple discharger modeling analysis." (See www.epa.gov/npdes/wqbasedpermitting/wspermitting).

emergence. Urban areas still largely lack tools for integrating urban greening with non-urban restoration and management at a watershed scale. For example, EPA is, for the first time, just now selecting pilots for its new watershed-level permits (See Sidebar). And a key player, agriculture, still has not joined the Southeastern Wisconsin Watersheds Trust. Agricultural runoff remains a significant contributor to impaired water quality. Federal Clean Water Act regulations do not currently regulate nonpoint sources of pollution from agricultural runoff. As a result, the agricultural community does not generally have a strong incentive to participate in initiatives to alter agricultural practices to reduce pollution or take part in watershed management greening programs. Through their procedures to develop Total Maximum Daily Load allocations for streams and rivers covered under the Clean Water Act, some states have included mandatory "load" reductions for the agricultural sector, but such requirements are not widespread among the states.

Use of regional councils, or metropolitan area Councils of Governments, is widespread and offers a potential platform for better regional or landscape-scale coordination of greening efforts. However, many regional councils lack cross-jurisdictional planning and budgeting authorities that are necessary to implement ecosystem services investments outside of city boundaries or create multi-jurisdictional ecosystem markets such as the buying and selling of credits under Clean Water Act or Clean Air Act programs.

In addition to public-sector integrating institutions, some nonprofit organizations provide an integrating platform for greening and sustainability initiatives. The Cascade Agenda in the northwest, for example, is striving to bring together urban, suburban, and rural public and private participants to better integrate ecosystem services protection and sustainability initiatives.[16]

CHAPTER 3

Why Urban Greening? Why Now?

Several circumstances highlight the relevance and timeliness of urban greening efforts. First, constrained city budgets and extremely high costs of traditional infrastructure are prompting cities to look for alternative ways to meet environmental performance requirements. Second, cities are facing both persistent and new environmental challenges for which urban greening and investment in restoring and protecting ecosystem services offer potential remedies.

Setting the Stage: Why Cities Are Taking Green Infrastructure Seriously

Aging Infrastructure: Many cities currently rely on aging infrastructure. Sometimes over 100 years old, this infrastructure has high maintenance requirements. Increased populations have placed growing demands on antiquated systems. Replacement and system expansion costs are often exorbitant. Washington, D.C., for example, is building three tunnels to handle sewer overflows at a cost of $2.2 billion. In Philadelphia, revising its system of combined sewage and stormwater pipes into separate systems would entail restructuring over 1,600 miles of pipes. Cities are looking for alternatives to traditional infrastructure that carry a lower price tag while meeting city needs.

Poor Performance: In New Orleans, the failure of its flood control infrastructure in the wake of Hurricane Katrina made world headlines. But the New Orleans tragedy was not an isolated one. Levee failure in California during heavy rainfalls in 2006 triggered emergency state spending to shore up infrastructure. Devastating floods continue to imperil communities. These infrastructure failures are notable as the number of natural disasters rises. Over the past century, "the annual number of natural disasters has increased more than 40-fold: fewer than 10 in the first decades to 400 to 500 in the last decades of the 20th century."[17] These disasters have translated into mounting costs that have climbed from less than $1 billion in 1900 to over $200 billion in 2005.[18] Eying these mounting costs, communities are re-examining natural systems and their potential to meet their economic, environmental, and safety needs.

Persistent Challenges: Climate change; challenges of managing water supplies, water quality, and water flows in extreme storm events; and escalating energy costs and associated impacts all strain current urban infrastructure and resource management. Alongside these challenges, continued urban development and land fragmentation, loss of tree canopy, and paving of landscapes are degrading wildlife habitat. For example, across the nation, polluted stormwater runoff contributes to 70 percent of urban water pollution and is a major cause of degraded aquatic habitat.[19] Sediment entering streams and rivers from construction sites in urban areas can be as much as 20 times higher than sediment loss from agricultural sites.[20]

Budget Constraints: Cities across the nation struggle to generate revenues sufficient to cover their costs. While these struggles are not new, in recent years they are particularly pronounced. In part, those struggles result from the need to address the significant maintenance backlogs of aging infrastructure and the expanding needs of growing populations. Compounding those ongoing challenges are the effects of the financial crisis and recession that began unfolding in 2008. Detroit's budget gap in 2009, as a percentage of its general fund, hit 20 percent. Atlanta, Philadelphia, New York, Chicago, Phoenix, and Los Angeles all had deficits greater than 10 percent of their general funds.[21] (See Figure) To address these budget challenges, cities are cutting services, reducing staffing, raising fees, and introducing new service efficiencies. Within this context, infrastructure greening options that could provide the same or better services at lower costs are receiving increased scrutiny.

Why Greening Can Make a Difference

Climate Change

The world's urban areas generate an estimated 75 percent of all greenhouse gases (GHG) as a consequence of manufacturing, transportation, and the full suite of heating, cooling, lighting and other power uses concentrated in cities.[22] Without vigorous action by cities, in partnership with residents and the private sector, these GHG emissions are projected to steeply increase. Chicago, for example, estimates that GHG emissions in the city rose 25 percent over the past 50 years but could increase an additional 35 percent over the next 50 years if the City, its businesses, and residents continue current practices.[23]

For cities, the warming associated with a changing climate will have significant impacts. Chicago's Climate Change Action Plan, for example, concludes that the city: "could experience extreme heat in summer, many more heavy rainstorms, growing flood risks, stresses on our public health and threats to the city's economy."[24] The report adds details to this overview, estimating that "the number of extremely hot days (over 100° F) in Chicago could increase from the current two days per year to as many as 31 days per year."[25] These increases in extremely hot days could trigger a vicious cycle of increased energy use to cool residences and businesses, increased water consumption to meet the needs of both people and their surroundings, higher health care response costs, and other negative effects.[26]

Acknowledging these prospective challenges, over 780 mayors signed a U.S. Conference of Mayors Climate Protection Agreement, launched in February 2005. The Agreement's three provisions commit signatory communities to strive to meet or beat Kyoto Protocol targets in their communities; urge state and federal legislators to enact policies to meet the suggested greenhouse gas reduction targets for the United States set forth in the Kyoto Protocol (a 7 percent reduction from 1990 levels by 2012); and urge the U.S. Congress to pass greenhouse gas reduction legislation and establish a national trading system.

Greening strategies can contribute to urban climate change strategies. One 2006 study in the southwestern United States calculated that six million trees stored over 300,000 tons of atmospheric carbon.[27] Through its urban research program, the U.S. Forest Service has calculated that a "typical tree can reduce atmospheric carbon dioxide by about 200 pounds annually over a 40-year period."[28] Looking at the Million Tree Program in Los Angeles, the Forest Service's McPherson calculated that it "would reduce atmospheric carbon dioxide by about one million tons over 35 years, equivalent to taking 7,000 cars off the road every year."[29] Another study evaluated urban tree planting in California, concluding that 50 million additional trees in California's cities, in which over 240 million empty tree planting sites exist, "would sequester about 4.5 Mt CO2 (million tons) annually. If they were planted strategically to shade east and west walls of residential buildings, they would reduce air conditioning energy use by 6,408 GWh,

equivalent to an average annual CO2 equivalent emission reduction of 1.8 Mt. The estimated total CO2 reduction of 6.3 Mt annually is 3.6 percent of the 173 Mt statewide goal."[30]

Old Infrastructure, New Needs

Water Supplies, Water Quality, Storms and Water Flows: Cities share with the nation significant challenges in managing water to assure clean, fresh supplies; treat wastewater and stormwater runoff; and avoid flooding and other adverse impacts of extreme storm events. Much urban water infrastructure is antiquated. The EPA reports that there are 240,000 water main breaks per year in the United States, and "the U.S. Geological Survey estimates that water lost from water distribution systems is 1.7 trillion gallons per year at a national cost of $2.6 billion per year."[31] In its 2009 Report Card for America's Infrastructure, the American Society of Civil Engineers grades drinking water and wastewater infrastructure as poor, an assessment reflected in EPA's estimates that the nation requires at least $390 billion over the next two decades to update or replace wastewater systems alone, using current technologies.[32]

Alongside aging infrastructure, demands for water have grown in part due to a 30 percent increase in U.S. population from 1980 to 2005. Population growth has been especially rapid in urban areas of the arid West where growth rates in many states exceeded 50 percent in that time period. Nevada's population grew a staggering 202 percent; Arizona grew by 119 percent.[33]

A recent National Science Foundation report concluded that: "Abundant supplies of clean, fresh water can no longer be taken for granted." Yet urban water use and water management often remain locked within limitations of old infrastructure and urban design that contribute to increased stormwater runoff and urban stream erosion and do not facilitate water conservation.[34]

Water Quality: Water quality requirements for drinking water, treated wastewater, and stormwater have increased over the past two decades, yet cities still struggle to meet these standards. Some 83 percent of urban and suburban streams have contaminant levels above guidelines required to protect aquatic life, and 7 percent exceed levels required to protect human health.[35]

Increasing demand and aging infrastructure are threatening water quality as cities struggle to keep water supplies safe and free from contaminants.

Andi Berger/iStockphoto

Some of these contaminants come from stormwater runoff. Authors of an Environmental Protection Agency-sponsored report on urban wet-weather flow management observe that: "Traditionally, wet-weather collection systems were designed to move stormwater from the urban area as quickly as possible. This design approach often simply transferred the problem from upstream to downstream areas."[36]

Impermeable surfacing, in particular, contributes significantly to stormwater runoff. The 2008 State of the Nation's Ecosystems Report of The Heinz Center reports that "nearly 60% of urban and suburban landscapes in the nation had more than 30% impervious surface cover, a level at which adverse impacts on stream ecosystems have been observed."[37]

With paving of city surfaces has also come a loss of tree cover in urban areas. East of the Mississippi, tree cover has declined 30 percent over the past 20 years, while the urban footprint has increased 20 percent. An estimated 634 million trees are "missing" from urban areas across the United States as a result of urban and suburban development. These losses of trees and associated permeable surface areas have cost cities an estimated $100 billion in increased stormwater management needs. According to American Forests, trees "help manage stormwater by intercepting rainfall and slowing the rate at which it runs over the surface of the land and seeps into the ground. When trees are present, the flow of water is spread over a greater amount of time . . . and the impact of a storm on the facilities built to handle it at any one time is smaller."[38] The USDA Natural Resource Conservation Service has evaluated the effects of stormwater movement associated with different land covers, including areas with trees, documenting the role trees play in intercepting rainwater, diminishing stormwater flows, and facilitating groundwater recharge.

Several studies indicate that in natural watershed systems, about half of precipitation infiltrates into the ground, with just 10 percent flowing across land surfaces as runoff. In highly built areas with impermeable surfaces and little vegetation, about 15 percent infiltrates; some 55 percent becomes runoff.[39] More forest cover in watersheds also reduces water treatment costs. One study of 27 water suppliers concluded that each 10 percent increase in forest cover in a water source area decreased treatment and chemical costs by some 20 percent.[40]

Restoring permeable surfacing and expanding tree canopy in cities can significantly reduce stormwater runoff and associated contaminants from entering urban streams. Using ecosystem services concepts, Portland, Oregon achieved a 95 percent stormwater flow reduction through bioretention, an "upland water quality and water quantity control practice that uses the chemical, biological, and physical properties of plants, microbes and soils for removal of pollutants from stormwater runoff."[41] Seattle reduced the volume of runoff in one neighborhood by 98 percent, at a cost 25 percent lower than with traditional street design, with extensive use of green infrastructure that included decreasing impermeable surfaces by 11 percent and replacing a gravel road shoulder and surface drainage with permeable bioswales.[42]

The Stormwater Center at the University of New Hampshire concluded that ecosystem services achieved through bioretention can reduce key polluting constituents in stormwater runoff by almost 100 percent. Integrating urban greening to re-establish tree cover and permeable surfaces with larger-scale restoration of riparian buffers and natural flood plains in adjacent watersheds can dramatically alter stormwater flows and traditional infrastructure requirements.

In the Tualatin Basin, in Oregon, stormwater and wastewater managers required new permits to meet EPA water temperature standards. Under traditional approaches, they could have met these standards by investing in refrigeration systems for a price tag of $60 million. Instead, using ecosystem services concepts, they combined five permits into a single bundle and, using trading tools available under the Clean Water Act, paid farmers to plant trees along 37 miles of streams to meet required temperature standards. (See Sidebar for a more detailed discussion).

Water Quantity and Conservation: Existing infrastructure also results in extensive missed opportunities for water conservation, including conservation achieved through green

Tualatin Basin Water Trading: Clean, Green and Dollar Smart

Across the Nation, cities, counties and water districts want clean water; they must treat wastewater to federal standards; they seek to reduce stormwater runoff and associated contaminants. But they face a dilemma. Regulatory mechanisms and permits, usually directed at geographic governing units, don't always align with the watersheds these tools are designed to protect. And these regulatory mechanisms usually come in small packages—one permit at a time for each wastewater system and a whole different set of permits for stormwater management.

Water managers in one community, the Tualatin Basin in Washington County, Oregon, wanted a more holistic approach. Through some big picture thinking, a bit of circumstantial good fortune, and strong partnerships with the Environmental Protection Agency, the state, and farmers, these pioneers may be rewriting the future of watershed management.

The Tualatin Basin, once primarily an agricultural community nestled southwest of Portland, is now home to suburbs that fall within Portland's urban growth boundary. Basin residents have spent over $300 million over the past decade on wastewater treatment facilities. They also created a comprehensive surface water management utility. With these actions, the Tualatin River, according to the local water agency, "is healthier than it's been in generations."

But the local surface water utility, Clean Water Services (CSW), saw complex challenges looming that required looking at the whole watershed, a watershed that includes a number of towns, four wastewater systems, and stormwater runoff from multiple locations. Permits at four wastewater treatment plants expired in 2000. Rather than renew each permit and, separately, seek a required stormwater permit, CSW decided to try a watershed approach. They wanted to bundle into a single permitting action the renewals of all four wastewater treatment permits and the stormwater permit.[43]

They had another innovation in mind, as well. Rather than investing $60 million in expensive refrigeration systems, they wanted to work with the adjacent farming community to plant shade trees along the river to cool water temperatures to required standards for $6 million, a tenth the cost of the mechanical cooling equipment.

Here's where the circumstantial good fortune comes in. Their big-picture idea required coordination among several towns, the County, and farmers. In the Basin, the County Board of Supervisors also acts as the governing board for Clean Water Services, which serves most of the urban portions of the Tualatin Basin. This overlapping of County and water management governance helped pave the way for CSW to spend utility monies "outside" its jurisdiction on farmlands in the County.

Though water managers benefited from this governance good fortune, it was their innovative thinking about permits and their partnerships that led to one of the most-path breaking watershed permits in the Nation. They used provisions championed by Tracy Mehan, Assistant Administrator for Water at the U.S. Environmental Protection Agency during the early planning years for the permit. These provisions allowed for "water quality trading" in which temperature goals for water systems could be met through "credits" from paying farmers to plant trees at particular locations in the watershed.

The permit used trading provisions to pay farmers $6 million to plant 35 miles of shade trees in riparian areas, avoiding the $60 million in costs to construct refrigeration systems at two wastewater treatment plants. For the trade, Clean Water Services

Continued on next page

received in 2004 "the first-ever fully integrated municipal National Pollutant Discharge Elimination System permit." Through this combined permit, CSW has been able to "balance heat released from the treatment facilities with cool water released from Hagg Lake and new shade from planting trees in rural riparian areas," according to analysts at the Institute for Natural Resources at Oregon State University.

To avoid risks that some trees would die off, CSW worked with farmers to plant twice as many trees as was necessary to achieve desired water temperatures. Farmers participate on a voluntary basis. Initially, farmers were wary of participating in a program that might bring increased scrutiny of their actions or interference with their operations. However, after a slow initial start as farmers eyed with caution any involvement in the permit, CSW now has had to turn farmers away, as the tree-planting goal has been met.

Many trees are now several years old and have begun actually shading the water. Ongoing monitoring puts the whole permit to an accountability test. Many environmental organizations, once skeptical, support the trading program. CSW concludes of its pioneering effort that water quality trading allows them "to work with our agricultural partners to improve the health of the river by investing resources where they will provide the biggest bang for the buck by trading the thermal loads from our treatment facilities for streamside shading improvements outside of the Clean Water Services' boundary."

The Tualatin Basin benefits more broadly, as this holistic watershed management approach, with increased tree planting, also benefits wildlife and does not require energy to power refrigeration systems. The bundled permit is, in short, clean, green, and dollar smart.

infrastructure. Most city infrastructure distributes potable drinking water for all urban water needs, from drinking water to toilet flushing to landscape irrigation. Per capita residential water consumption in the United States, estimated at 161 gallons per capita per day in 1996-1998, is at least fourfold higher than in many European nations, with just a fraction of the U.S. public water supply treated to drinking water standards actually being used for drinking. Nearly 60 percent of this water is used outdoors for gardening, swimming pools, and related uses. One-third of indoor water is used by indoor toilets, 20 percent is used for bathing, 27 percent for clothes and dish washing.[44] Very little of this water is reclaimed and reused.

Some of the high U.S. water consumption may be linked to low water rates. These rates often include flat-rate pricing de-linked from actual usage. Water use rates in the United States, for example, are less than half the rates charged in the United Kingdom or France, with per capita consumption of water from public drinking water systems in the United States estimated at more than double the level in those two countries.[45] Rates are also often not linked to costs, with water rate revenues insufficient to cover long-run capital and operating costs.

But reliance on gray infrastructure contributes to water consumption challenges. Urbanization and land transformation result in reduced water infiltration into the soil and increased runoff to surface water.[46] This shift "will result in more rapidly depleting aquifers and more contaminated surface waters."[47] New and continuing demands on water supplies, at a time when climate change may result in less water availability in some locations, put a premium on protecting and conserving water supplies. Greening strategies to protect source water and expand permeable surfaces in urban areas can play a role both in improving water quality and conserving water.[48] The Aspen Institute report of its Dialogue on Sustainable Water

Infrastructure in the United States concludes that sustainable water infrastructure integrates traditional infrastructure "with the protection and restoration of natural systems, conservation and efficiency, reuse and reclamation, and the active incorporation of new decentralized technologies, green infrastructure and low impact development to ensure the reliability and resilience of our water resources."[49]

Addressing these water conservation needs highlights the relevance of integrating urban greening efforts to broader ecosystem protection and restoration efforts. Many urban water supplies derive from non-urban settings; their protection, thus, requires actions that often transcend city boundaries. Moreover, with the majority of overall water consumption in the United States occurring from agricultural production, improved water management in adjacent rural settings can help secure water supplies for both the city and countryside.[50]

Water management challenges in cities link to another significant driver for greening of city buildings, transportation, and infrastructure. That driver is energy, its rising costs, and the greenhouse gasses and other emissions associated with traditional fossil fuels. Drinking water and wastewater systems account for about 4 percent of the U.S. electricity demand and much higher in some locations.[51]

Infrastructure greening can reduce energy use associated with water management, delivery and treatment systems. For example, when the City of New York invested over $1.5 billion to protect and restore the Catskill Mountain watershed to help purify the city's water supply, it avoided spending up to $9 billion on filtration plants. The investment in Nature's Capital saved the city money, provided clean water, and enhanced habitat. But the investment also translated into avoided energy use that mechanical water filtration systems would have required.

Community Safety: Waterways and coastal infrastructure of the past century largely focused on reducing flooding, building buffers against coastal storm surge, and draining lands for agriculture. In cities, this focus resulted in decisions to transform natural streams into deeper, often paved channels to move large amounts of water quickly out to sea.[52]

In some regions, like the Mississippi Delta, infrastructure choices helped reduce some flooding of agricultural and other lands and facilitated shipping along the Mississippi River. But this infrastructure had some significant unintended, though predictable, consequences. Flushing fast-moving water carrying sediments out to sea gradually resulted in massive losses of sea marshes and coastal wetlands. In addition, nutrient loads in these sediments have contributed to the oxygen-deprived "dead zone" in the Gulf of Mexico.

The U.S. Geological Survey reports that Louisiana lost more than 1,900 square miles of coastal lands between 1932 and 2000.[53] Hurricanes Katrina and Rita increased that loss by an additional 217 square miles. Without these natural coastal buffers, storm surge in Cameron, Louisiana was at least 15 feet; flood waters in downtown Lake Charles reached 6 feet or more. During Hurricane Rita in 2005, areas along the Gulf Coast with significant wetlands experienced less storm surge than the areas that absorbed the brunt of Hurricane Katrina and lacked a buffer due to coastal wetland losses.[54]

Elsewhere, Hurricane Wilma devastated the northeastern Yucatan Peninsula and severely damaged areas of southern Florida. This category 5 hurricane, the largest Atlantic tropical cyclone on record, caused the greatest disruption of electrical service ever experienced in Florida and caused over $20.6 billion in insured and uninsured damage.

The ecological and community impacts of coastal land losses are severe. Climate change and associated increases in sea level over the next 50 to 100 years will likely further transform large expanses of marsh to open water.

Restoring natural coastal wetlands and river flows, along with re-establishing some floodplains within watersheds, offer alternative means of enhancing community safety that may, in some cases, be both more effective and less costly than expanding traditional gray infrastructure.[55]

Energy and Air Quality

As hubs of housing, commerce, manufacturing, and transportation, cities contribute an estimated 75 percent of global carbon dioxide. In large part, these emissions reflect the significant energy consumed in cities for transportation, lighting, heating, cooling, and industrial output, though total energy usage and its composition vary significantly by region and by city.

Development density, city transportation systems, building design and operations, and energy types can affect energy use, associated carbon dioxide emissions, and amounts of air pollution. These city structures and dynamics and their relationship to energy consumption are increasingly well understood and the subject of major changes in city planning, building codes, and energy investments.

Less obvious are the effects of the urban natural landscape on energy use, associated air pollution, and greenhouse gas emissions. U.S. Forest Service studies of urban forests show notable linkages between tree canopy and urban temperatures. Forest Service analysis also shows measurable effects of trees, depending on size, type and location, on both heating and cooling requirements in residential and commercial buildings.[56]

For example, in a study of trees in Minneapolis, Forest Service researchers found annual savings of $6.8 million in energy costs resulting from existing tree canopy.[57] U.S. Forest Service analyst Greg McPherson has documented multiple measurable energy conservation benefits from urban tree canopy. He observes that trees can result in:

- **Lower heating costs:** If trees are planted as windbreaks that reduce wind speed and cold air infiltration by as much as 50 percent, they can reduce heat loss for potential avoided heating costs of 10 to 12 percent.
- **Lower cooling costs:** Particularly if trees are strategically located, they shade buildings and lower surrounding temperatures. In Atlanta, for example, appropriately placed shade trees were able to reduce cooling costs by 34 percent. A single tree shading a house, according to another Forest Service study, can save 100 kilowatt hours in annual electricity use.[58]

Other studies reinforce these conclusions. An American Forest Foundation study of Atlanta concluded that tree cover resulted in avoided energy costs of nearly $3 million annually, and a 3 million-acre area around Houston achieved energy savings from the cooling effects of tree cover valued at $26 million per year. (See www.americanforest.org.)

The flip side of this equation is the increased energy costs that result from loss of tree cover. Consider figures for San Antonio. Lost tree canopy in San Antonio over a 15-year period is estimated to equate to a $17.7 million increase in residential summer energy costs per year.[59]

Sometimes the associated benefits of urban greening are subtle. Parked cars emit hydrocarbons that contribute to urban smog formation and comprise as much as 20 percent of hydrocarbon emission inventories. These emissions evaporate from leaky fuel tanks and worn hoses. McPherson points out that tree shading can lower air temperatures one to three degrees Fahrenheit, reduce "gasoline temperatures four to eight degrees, and temperatures inside the car by as much as 40 degrees."[60]

Trees can provide air quality benefits, but assessment of net benefits is complex since trees also emit volatile organic compounds that can contribution to ozone formation. Greg McPherson of the U.S. Forest Service points out that "the wrong trees in the wrong places can have adverse consequences in terms of air quality, water consumption, GHG emissions, costly repair to damaged infrastructure (roots heaving sidewalks), human health and safety, etc."[61] Key to achieving net benefits is the strategic selection of species types and their location within the urban setting.

TABLE 1

Size of one-year budget gaps

The size of current budget deficits in major U.S. cities.

CITY	DEFICITS FOR EACH CITY (IN MILLIONS US$)	GAP AS % OF GENERAL FUND
Detroit	$302	20
Columbus	$114	18
Phoenix	$201	17
Kansas City	$87	15
Chicago	$769	13
Los Angeles	$926.72	12
New York	$6,600	11
Philadelphia	$428	11
Atlanta	$56	10
Boston	$140	6
Baltimore	$65	5
Seattle	$44	5

Source: The Philadelphia Research Initiative, Pew Trusts, 2009.

TABLE 2

U.S. Water Consumption

Average per capita residential water consumption by end use.

END USE	AVERAGE GPD/CAP	INDOOR USE %	TOTAL USE %
Toilet	18.5	30.9	10.8
Clothes Washer	15.0	25.1	8.7
Shower	11.6	19.4	6.8
Faucet	10.9	18.2	6.3
Other Domestic	1.6	2.7	0.9
Bath	1.2	2.0	0.7
Dishwater	1.0	1.7	0.6
Indoor Total	**59.8**	**100.0%**	**34.8%**
Leak	9.5	n/a	5.5
Unknown	1.7	n/a	1.0
Outdoor	100.8	n/a	58.7
TOTAL	**171.8**	**n/a**	**100.0%**

Source: Adapted from *Residential End Uses of Water*, by permission. Copyright © 1999, American Water Works Association and Awwa Research Foundation.

While tree canopy can provide air quality benefits, loss of tree canopy can adversely affect air quality. A study of Houston showed that its loss of 16 percent of its tree canopy over the last three decades translates into a loss of annual air pollution "removal services" pegged at $38 million (and an even greater annual loss of stormwater management services valued at $237 million.) (See www.americanforest.org.)

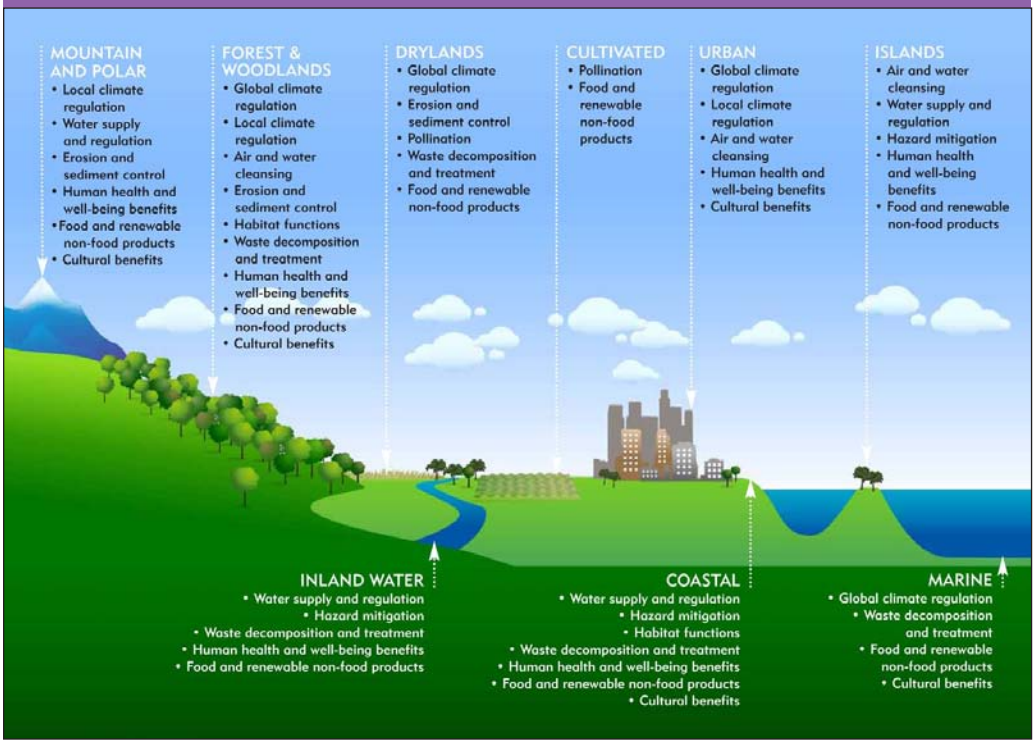
These examples highlight the significant services that natural systems and their components provide to human communities, their health, safety, and prosperity. Failure to recognize these services results in decisions that diminish, degrade, and even destroy natural assets.

Biodiversity—Integrating Cities and the Countryside

Biodiversity and species conservation strategies have traditionally centered on protection and restoration of habitat in rural and natural landscapes. These efforts are critical to species conservation. However, biologists increasingly point to the importance of sustaining habitat in cities and suburbs as part of an overall conservation network. Urban habitat can provide significant links to larger expanses of habitat that support wildlife.

In *The Migration Ecology of Birds*, Ian Newton cites research showing high mortality of birds during migration—for example, as high as 85 percent of total mortality for one species occurred during migration. Research documenting why such high levels of mortality occur is inconclusive or unavailable. However, a number of studies note that food stress during migration, especially in places where habitats "are few and widely scattered," directly affects weight gain, migration speed, and related factors linked to survival, breeding success, and overall population trends.[62] Generally, these places with scattered and scarce habitat occur in cities and urban corridors. In its 2009 State of the Birds report, the U.S. Fish and Wildlife concludes that "creating greenspace

The Bounty of Ecosystems. No one type of ecosystem has a monopoly on the goods and services it can provide, and the services listed here represent only a few of the many services available from each type. With sustainable practices, built landscapes can provide many of these same natural services. Illustration adapted from *The Millenium Ecosystem Assessment* (2005).



for birds in cities can help adaptable urban birds as well as migrants stopping over during their long journeys."[63]

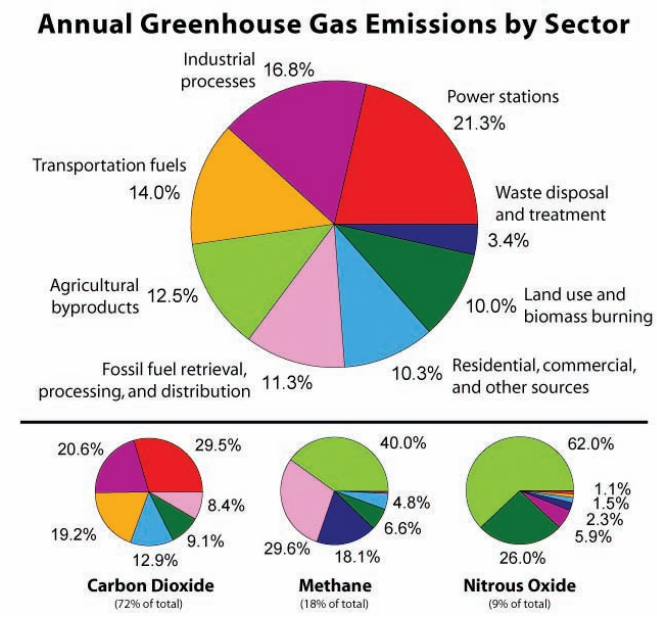
In affecting stream ecosystems, urbanization has also impacted fish species. In a study of urbanization and climate change, authors looking at their separate and combined effects on fish concluded that "urbanization alone stressed 8 of 39 fish species….Six of the ten most common species were predicted to be significantly stressed by one or both stressors."[64]

Current population trends for migratory birds and some fish species underscore the urgency of action to improve their access to suitable habitat, including habitat in urban areas. One study of urbanization in the developed world notes that growth in city extent exceeds population growth, with gradients of development from city centers to suburbs and beyond. This urbanization, report the authors, "had a staggering effect on native flora and fauna. Urbanization is likely to be the single most important driver of extinction during this century."[65] Another study looks at the distribution and causes of species endangerment in the United States. That study finds that urbanization ranks second out of 18 causes of endangerment, trailing only interaction with non-native species as the most frequently cited cause for endangerment.[66]

Urban greening offers a strategy to meet the infrastructure needs of cities while protecting or re-introducing tree canopy, more natural streams and rivers, and open space into the fabric of the built environment. Preliminary data from an Audubon of Florida survey suggest that urban trees and other vegetation, particularly certain species, are food magnets for migratory birds.[67]

Benefits Summary

The result of cumulative ecosystem transformations can be increased environmental harm, higher costs to provide services such as water filtering through mechanical engineering alternatives, and foregone benefits of energy savings and community safety. The 20th century was a time of paving over our cities. The 21st century can be a time of re-creating natural landscapes, natural urban streams, and other permeable landscapes and linking city greening to broader regional ecosystem restoration and conservation.



Source: http://en.wikipedia.org/wiki/File:Greenhouse_Gas_by_Sector.png

CHAPTER 4

Green, Blue and Gold: Ecosystem Services Tools for Communities

Ventures in urban greening are not new. Though these efforts are gaining momentum and growing in extent and complexity, significant opportunities exist to further integrate urban greening initiatives across multiple dimensions to enhance economic, ecosystem services, and broader environmental benefits on both a local and regional scale. These opportunities include some prospects to tap nontraditional funding sources to invest in green infrastructure and to better align private-sector incentives toward supporting green infrastructure, ecosystem services, greener cityscapes, and broader landscape-scale conservation.

Generally, current federal policy is either neutral or sometimes even detrimental to fostering protection of and investment in ecosystem services. For example, neither Council of Environmental Quality regulations nor agency regulations and guidance to implement the National Environmental Policy Act (NEPA) require explicit consideration of ecosystem services in project planning and review, though NEPA requires assessment of all project environmental impacts. The Endangered Species Act does not explicitly provide for consideration of ecosystem services in designating critical habitat for threatened or endangered species. Under the Clean Water Act Sec. 404, wetlands mitigation does not require "parties engaged in the 'trade' of wetland mitigation credits to consider the impact of the transaction on the delivery, location, and possible redistribution of ecosystem service values."[68]

While the major federal environmental laws generally do not explicitly reference ecosystem services, several agencies have launched projects that, in effect, use ecosystem services concepts. Several key federal laws may hold potential to support urban greening and associated landscape-scale conservation. Buoyed by the expanding academic research on ecosystem services, some recent public policy initiatives now acknowledge the economic value of natural systems through the health, safety, and other resource benefits they provide to communities. These initiatives provide a potential focus for broadening application of ecosystem services policies, including their use in urban contexts. With creation within the U.S. Department of Agriculture of an Office of Ecosystem Services, momentum to strengthen the policy foundations to support ecosystem services markets and investments is accelerating.

Situating urban greening efforts within a broader ecosystem services framework and linking those efforts to regional conservation and restoration initiatives can generate environmental, community, and economic benefits. Some existing policy tools can help advance that effort. In addition, new local, state, and federal tools would further strengthen urban greening efforts and their links to landscape-scale conservation and restoration. The following discussion has two sections:

- The first section looks at federal, state and local tools available to cities and regions to: 1) provide a more holistic context for urban greening efforts and measure their benefits; 2) support ecosystem services investments; and 3) integrate urban greening with broader,

Current federal policy is either neutral or sometimes even detrimental to fostering protection of and investment in ecosystem services. For example, the Endangered Species Act does not explicitly provide for consideration of ecosystem services in designating critical habitat for threatened or endangered species.

J&K Hollingsworth/USFWS

regional and landscape-scale conservation and restoration. The options identified are intended to offer examples for possible replication or adaptation to local circumstances. They are neither all-inclusive nor necessarily "ideal" constructs. They do, however, provide some potentially useful policy and governance concepts.

- The second section identifies federal policy tools and possible enhancements of those tools to support ecosystem services investments and urban/regional greening of infrastructure.

TOOLKIT SECTION 1

Sample Policies and Actions

Putting the Urban Greening Pieces Together: Integration and Metrics

Recommendation: Cities should consider establishing governing and implementation mechanisms to coordinate the different components of urban greening initiatives.

Examples include:

- Incorporating greening into city comprehensive plans as an integral part of building and land-use decision making, transportation, housing, water supply and treatment, energy, climate change, and other plan components. Examples include:
  - » **Portland's Comprehensive Planning.** Portland uses its comprehensive plan to incorporate "greening" actions into all aspects of city infrastructure, services, and ordinances that cover buildings, development sites, transportation infrastructure, water and wastewater services, and other elements. To give traction to these greening elements, city managers have strived to quantify benefits. Green infrastructure and ecosystem services investments are not segregated into an environmental agenda. Instead, they are integrated into all city programs.
  - » **Florida Communities Trust Program.** The State of Florida's statewide land acquisition and open space protection program includes grants to its Florida Communities Trust. Grants, which go to cities and other communities, are evaluated, in part, by their linkage to community comprehensive plans as well as for their creation of linked green corridors. These evaluation criteria create incentives for such plans to include some greening components and to link these components to broader ecosystem protection goals.

    A 2008 study of the program between 2001 and 2006 of over 600 applicant communities concluded that funded communities are much more likely to propose trails and greenways projects, suggesting that the program criteria are providing some incentive for cities to invest in urban greening.

- Clustering or grouping permits for wastewater, stormwater, and other related facilities by cities or special districts to integrate greening investments. Examples include:
  - » **Tualatin Basin, Oregon.** The local surface water utility, Clean Water Services (CSW) watershed includes a number of towns, four wastewater systems, and stormwater runoff from multiple locations. Permits at four wastewater treatment plants expired in 2000. Rather than renew each permit and, separately, seek a required stormwater permit, CSW used a clustering approach, bundling into a single permitting action the renewals of all four wastewater treatment permits and the stormwater permit. (See Sidebar for details)

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

- Combining city infrastructure and service districts into regional districts or cooperating partnerships.

  Example: Philadelphia Water Infrastructure. Philadelphia's water infrastructure management includes stormwater, wastewater, and combined sewer overflow management under a single jurisdictional entity to facilitate integrated management that has focused on citywide infrastructure greening. The integration of water management services under a single governing entity has enabled the city to develop a citywide plan to green their infrastructure and develop coordinated service fees and funding sources.

- Creating watershed trusts through state action or collaboration among cities and service districts to coordinate greening activities where a watershed and/or metropolitan area includes many political jurisdictions and management districts.

  Example: Southeastern Wisconsin Watersheds Trust. The Milwaukee Metropolitan Stormwater District (MMSD) has flood management authority across six regional watersheds. However, 28 separate municipalities have stormwater management authority. In 2002, MMSD passed a rule requiring these separate municipalities to adopt flood management measures that include addressing stormwater. This rule helped galvanize the 28 stormwater districts into a partnership resulting in the formation of a nonprofit organization that also includes other stakeholder organizations, universities, and municipalities. The organization will help coordinate and, eventually, provide grants for greening of urban infrastructure in communities that encompass 411 square miles. Because the Trust was recently formed, its performance has not yet been tested or evaluated.

Recommendation: States and cities could develop, refine and combine metrics across multiple performance dimensions that include air quality, greenhouse gases, energy conservation, stormwater runoff, water quality and supply.

Examples include:

- **U.S. Forest Service i-Tree.** The i-Tree software programs and protocols (freely available at www.itreetools.org) use field data to estimate the ecosystem services provided by trees and other vegetation, along with cost-estimates of their value. Data include tree species counts and composition, size, distribution, diversity, and canopy cover, which are used to estimate forest net benefits on energy use, carbon storage, and air pollution. A module now under development also looks at changes in tree and impervious cover within a watershed to evaluate stream flow and water quality effects. The modeling also includes data on pollution dispersion, population centers and future projections, and air temperature. These parameters allow users to evaluate where tree canopy yields the most benefits. A longer term goal is to link i-Tree to EPA tools over time to support regulatory models.[69]

- **Metrics platforms such as TZ1.** TZ1, recently acquired by Market Environmental Registry, provides a multi-credit environmental registry worldwide to facilitate ecosystem market development. TZ1 tracks and manages credits and provides market transparency through an Environmental Registry. Two U.S. conservation and restoration initiatives—the Chesapeake

Bay restoration effort and the Willamette Partnership in Oregon—are using TZ1 as the platform from which to develop multi-credit ecosystem regional programs. The Willamette Partnership, for example, has established a "Counting on the Environment" project to establish a multi-credit marketplace and develop an ecosystem services accounting program. The project will help enable private land managers to generate income through restoration and management of ecological assets. It will focus on water quality credits (temperature), salmonid habitat, prairie habitat, and water quantity. The Bay Bank project in the Chesapeake Bay will focus on carbon sequestration, water quality (nitrogen and phosphorous), habitat conservation, forest conservation, and conservation programs.[70] (See www.thebaybank.org).

Recommendation: Cities should review their budgets and fees to better align incentives for greening investments and as revenue streams for funding investments.

Options include:

- **"Green" Service Utility Fees.** Fees that create and reinforce incentives to establish, protect, or enhance natural ecosystems and green infrastructure can motivate "green" investments, strengthen ecosystem services markets, and enhance ecosystem restoration.
  - » **Stormwater fees tied to impermeable surfaces.** A 2007 stormwater utility survey conducted by Black & Veatch showed 9 percent of respondents using a combination of impervious and gross area to set stormwater fees. This fee structure meets the required test that city service fees must be linked to service costs. At the same time, this fee structure creates incentives for developers and landowners to reduce use of runoff-creating impervious surfaces. Some also create incentives to reduce water pollution. A third of cities surveyed indicated that they offer user-fee credits or other incentives to encourage customers to control or reduce stormwater pollution.[71]
  - » **City or electric utility "treebate" programs in which residents receive compensation for tree planting.** The city of Portland had been spending $20,000 to $40,000 per year during the past two decades on tree planting. Through a $1 million program over two years, the city has partnered with Friends of Trees to pay property owners to plant trees. Through the rebates, the program will cover half of tree-planting expenses up to $50, depending on the tree species. Tucson Electric Power also sponsors a "trees for shading" program that includes strict planting location requirements to achieve shading benefits intended to reduce energy use.

Using Policy Tools that Support Ecosystem Services Investments

Recommendation: States and cities should assess the applicability of existing federal regulatory tools that facilitate urban greening.

Options include:

- **Clean Air Act: Air Quality Credits and Trees.** Cities should evaluate the applicability of Clean Air Act "emerging measures" provisions that allow tree planting to qualify for ozone-reduction credit. Most cities have not taken advantage of such provisions to support expanding tree canopy. Through the use of such provisions, regulated entities could include some tree planting among their ozone reduction measures and pay cities (or other entities) to plant and maintain trees provided that these efforts conform to EPA standards and requirements.

Bellevue, WA: Three decades ago, the City of Bellevue, Washington, established a stormwater utility and inaugurated the first-ever stormwater utility fee, in which the utility charged property owners for the costs to build and operate stormwater management systems based on some calculation of their usage of the system. By 1980, over 20 cities and counties had formed stormwater utilities. Today, stormwater utilities and accompanying fees are commonplace. But Bellevue, Washington continues as a pioneer in stormwater management.

The city's stormwater fees, pegged to amount of impervious surface and total surface area, also include credits for stormwater management measures and wetlands. Like all stormwater fees, these fees help Bellevue pay for stormwater infrastructure and operating costs. But so, too, are they a catalyst for conservation—conservation that reduces the quantity of stormwater runoff and brings water quality benefits. Since permeable surfaces absorb rainwater, fees that encourage permeable rather than impervious surfaces in urban landscapes can significantly reduce runoff, help maintain water quality, and lower long-term costs of managing stormwater.

Nationwide, urban development with impervious surfaces has increased 20 percent over the past two decades. Resulting increases in stormwater runoff are costing cities an estimated $100 billion annually to manage and contain this additional runoff.

Three decades ago, most stormwater utilities focused on a single goal—managing stormwater to prevent flooding and associated erosion. The Bellevue, Washington fee structure reflects a broader evolution of stormwater utilities toward integrating water quality, water quantity, flood protection, habitat preservation, and even recreation goals into how stormwater is managed. The result is good for the environment and can help growing cities avoid investment in costly additional stormwater management infrastructure.

Consider what happens as pavement of roads and riverfronts, parking lots and patios, courtyards and commercial centers dominates urban landscapes. Tom Cathcart of Mississippi State University points out that a one-inch storm on a one-acre undeveloped site will experience runoff of 10 percent or less, at most generating some 2,700 gallons of runoff. In the same storm, a newly paved one-acre site, Cathcart explains, will experience runoff of 90 percent or more—some 27,000 gallons of water. "Surprise!" says Cathcart. "Conduits capable of handling 2,700 gallons per acre have trouble with 25,000 gallons per acre."

For cities, observes Cathcart, that trouble translates into more trouble—road flooding, building and property flooding, clogged drainage systems, and utility disruptions. Cathcart's figures may even understate how well permeable surfaces absorb rainwater. When one Seattle neighborhood introduced green infrastructure that included permeable rather than paved surfaces, runoff fell by 98 percent. Similar measures in Portland reduced runoff by 95 percent.

Water quality improves, too. The University of New Hampshire Stormwater Center has found that green infrastructure can reduce key pollutants in runoff by almost 100 percent. In essence, permeable surfaces filter, assimilate, entrap, and degrade pollutants. Two University of Washington researchers, Benjamin Brattebo and Derek Booth, affirmed the effectiveness of permeable pavements in reducing runoff and lowering pollution from motor oil and some heavy metals.

Under Clean Water Act regulations, cities must meet water pollution reduction goals for stormwater. Landscaping and green infrastructure that prevent pollution from entering waterways are, thus, increasingly important. In the Black & Veatch 2007 survey of stormwater utility managers, 35 percent ranked pollution monitoring as the most important measure of stormwater management success. Only flood control, cited by 42 percent of managers, was rated by more managers as the most important measure of success.

Bellevue's fee structure for stormwater management generates the revenues that enable the city to build and maintain necessary infrastructure. But, in the long term, the fee structure, by encouraging landowners to "green" their city by using more permeable surfacing, will reduce the need for expensive additional stormwater management facilities. With this basic economic benefit to cities come environmental benefits of reduced pollution and more wildlife habitat.

What is good for cities is also good for the Nation. More than 25 percent of U.S. lakes have low oxygen levels as a result of pollution from chemicals and other substances. Low oxygen levels make these waters inhospitable for plant and animal life. Reducing stormwater runoff in cities can help restore health to America's streams, lakes, and rivers.

Bellevue pioneered the use of "green" stormwater fees. Today, similar fee structures in place in Seattle, Portland, Milwaukee, and several Florida cities are paving the way for less pavement in our Nation's cities—and that trend will benefit cities, citizens, and ecosystems.

In September 2004, the U.S. Environmental Protection Agency (EPA) issued a new guidance, "Incorporating Emerging and Voluntary Measures in a State Implementation Plan," that sets forth how emerging and voluntary measures may be incorporated into state air quality plans. Two circumstances reinforced the significance and timeliness of the guidance: 1) under new ozone standards, many additional urban areas became non-attainment areas and must meet the new standards, generally by 2010 (though Los Angeles has until 2021 to meet the standard); and 2) existing strategies to achieve ozone standards may be insufficient, in some locations, to assure compliance with the standard.

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

The emerging (untested) measures may account for not more than 6 percent of total incremental additional emission reductions necessary for attainment of air quality standards. According to the US Forest Service, EPA "may approve measures into a SIP in excess of 6 percent where a clear and convincing justification is made by the State as to why a higher limit should apply."[72]

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

Use of the tool is not simple, as calculating benefits and meeting regulatory requirements require much more than simply establishing tree canopy goals. Inclusion of tree planting and maintenance in an air quality strategy requires clear metrics, transparency, demonstration of permanence, and other program characteristics. An example includes:

- **The Sacramento Metropolitan Air Quality Management District.** The District has teamed with the Center for Urban Forest Research and the Sacramento Tree Foundation to examine the feasibility of using trees to clean the air. Preliminary estimates for Sacramento, which is among the ten areas in the nation with the highest ozone pollution, show potential for urban forest strategies to "help meet air quality goals, achieving as much as 8% of the required reductions in VOCs [volatile organic compounds] and 1.1% of the required reductions in NOx, [nitrogen oxides] depending on the scenario."[73]
- **Washington, D.C. and Baltimore.** The air quality management districts of both of these metropolitan areas are also considering trees in their ozone reduction planning, using the EPA emerging measures guidance. These provisions are part of a suite of voluntary measures, with the initial focus on validating "proof of concept," rather than actually counting any emission reductions from these efforts. Little if any reduction credit in State Implementation Plans is expected until quantification and modeling are more refined, yielding greater certainty of results.[74]

- **Clean Water Act 2003 Phase II Stormwater Regulations.** Cities, public utilities, and special service districts should consider using Clean Water Act provisions on stormwater that support green infrastructure options to meet requirements.

The Environmental Protection Agency's model stormwater permit guidance recognizes trees and tree-planting for purposes of improving runoff control, especially in post-construction contexts. The guidance is not a regulatory requirement but states that "by preserving natural drainage patterns, trees, native vegetation, riparian buffers, and wetlands, you might need to construct fewer or smaller structural stormwater controls…."

On trees, specifically, the document states that "large trees and other native vegetation can represent significant value in the long term…. Many studies document that the presence of trees on residential and commercial sites provide many benefits including improved aesthetics, habitat for birds and other wildlife, and energy savings (shade) that ultimately enhance the economic value of the site." The guidance suggests that "techniques, such as *Low Impact Development*, Better Site Design, or *Conservation Development*, which emphasize addressing stormwater where it falls, infiltrating it, preserving natural drainage patterns, and preserving natural vegetation offer the best opportunity to protect nearby rivers, lakes, wetlands, and coastal waters."

These regulations and permit guidance support urban greening and ecosystem services conservation. As with the air quality guidance on emerging measures, using these tools requires good metrics to demonstrate performance. "Uncertainty about…performance is a major stumbling block with point-nonpoint trading."[75] For water quality, establishing credits for "greening" practices involves location-specific calculations and the "discharge point of purchase and sale must be environmentally equivalent to ensure that expected water quality gains are achieved."[76] Aligning timeframes also presents some logistical hurdles. Specifically, transitioning to green infrastructure may take several decades while EPA enforcement of standards often assumes completion of traditional gray infrastructure to meet those standards within 20 years.

For greening and broader ecosystem services investments, several other challenges need to be addressed. On the one hand, if proposed "greening," including tree planting, protection or enhancement of riparian buffers, and so on, requires actions outside a stormwater district, cross-jurisdictional coordination presents challenges. Some cities or service districts, for example, are reluctant or have no authority to expend any funds outside of their

Urban tree planting has the potential to reduce ozone levels and stormwater runoff, as well as provide habitat for wildlife and lower energy costs.

Courtesy Indiana University

governance jurisdictions. Landowner participation can also present challenges, especially for agricultural lands where no "driver" motivates participation by farmers to engage in best management practices to reduce runoff. On the other hand, if the greening measures occur solely within stormwater district boundaries, challenges of assembling sufficiently large amounts of permeable surfaces, expanded tree canopy, and so on, can be difficult.

There are means of addressing these challenges. A 2008 USDA report points to: 1) use of pilots and simulation models to address performance questions; 2) use of reserve pools of credits to use if a "green trade" fails to produce expected results;[77] and 3) use of trading ratios that require more than one unit of nonpoint-source benefits to offset a unit of point-source discharge.[78] The utility of these tools depends on the particular program type and circumstance within a community. In the Tualatin Basin, the water services district used a ratio approach to address uncertainty, paying farmers to plant twice as many trees as were needed to achieve their temperature reduction goals in a bundling of four wastewater treatment and one stormwater permit.

- **Clean Water Act pollution trading opportunities.** States should consider establishing water trading programs as allowed under EPA's administration of the Clean Water Act. While the Clean Water Act directly regulates only point sources of pollution, requirements for states to establish Total Maximum Daily Loads introduce some foundation from which trading among point and non-point sources of pollution can occur. In 2003, the EPA issued a Water Quality Trading Policy and, in 2004, issued a Water Quality Trading Assessment Handbook to facilitate water trading to improve water quality.[79] Through the end of 2006, EPA had sponsored eleven pilot projects to assess trading opportunities and issues in various regions.[80]

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

  Several states, through legislation or other practices, have active trading programs or have initiated state laws to encourage such trading.[81] These programs create some opportunity for urban water managers to pursue greening efforts, especially efforts that link to the broader non-urban watershed and ecosystem restoration and conservation initiatives. Several examples include:

  - **Long Island Sound, Connecticut and New York:** Focused on improving water quality in Long Island Sound, the governors of Connecticut and New York, with the U.S. EPA, adopted a basin-wide plan (the Long Island Sound Comprehensive Conservation and Management Plan) to reduce nitrogen loads in the sound by 58.5 percent over 15 years. The plan set interim targets for years five and ten. In Connecticut, the plan calls for reduction in the pollution loads in effluent at 84 municipal wastewater treatment discharge sites along with a small (10 percent) reduction from nonpoint sources. Using the Total Maximum Daily Load (TMDL) framework, the state adopted waste load

allocations for each point source and a total load allocation for the nonpoint sources. The plan allows for nitrogen credit trading among municipal wastewater point sources, with savings from trades estimated to reach over $200 million. Program management costs are covered through a special fund and fees for service.[82]

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

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

- **Clean Water Act and Safe Drinking Water Act grant provisions.** EPA manages grant and loan programs under the Clean Water Act and the Safe Drinking Water Act that can support infrastructure greening and land acquisition to protect water supplies, though they have only infrequently been used for these purposes.[83] These include the Clean Water State Revolving Fund (SRF, Sec. 212), which offers loans for water quality improvements that have generally funded wastewater treatment infrastructure. However, these funds (over $1 billion, combined with another $4.7 billion in state monies) can be used to implement nonpoint source management plans and develop and implement estuary plans. Just 5 percent of projects target nonpoint source pollution mitigation. Under the Safe Drinking Water Act, State Revolving Fund loans (pegged in 2003 at $787 million in grants and $1.3 billion in loans) help fund public water system infrastructure. A third of these monies can be used for investment in water source protection that includes land acquisition. Of this amount, 15 percent can support voluntary and incentive-based measures. A review of these grants and loans concludes that "since the act's inception, only $2.7 million in assistance has been used by systems to protect less than 2,000 acres of land under the set asides."[84]

  Though these revolving fund loans could be used for greening and land acquisition, their infrequent use for these purposes is, in part, attributable to the enormous backlog of infrastructure needs such that cities tend to steer money toward repairs and replacement of critical infrastructure. One remedy to this problem would be to increase the overall amounts of loan funding available. Another remedy would be to provide incentives to use a portion of these funds for greening and source water protection, particularly where such investments can demonstrate significant cost-effectiveness in achieving water supply, water quality, and water management goals.

  Examples in which states have used the land protection provisions of these loans and grants include:

  » **Ohio Water Restoration Sponsorship Program.** Ohio's program provides significant loan rate reductions for wastewater treatment projects if the recipient uses a portion of the savings to invest in watershed protection and restoration directly or contributes to a land trust, park district or other watershed protection effort.[85]

» **New Jersey Green Acres Program.** The state adjusted its criteria to allocate funds under the Clean Water State Revolving Fund to give three times the weight to projects with a water supply protection benefit through land protections.

- **Green infrastructure and ecosystem services funds, bonds and surcharges.** States and cities should consider developing funding provisions through utility or other state and local fees that support green infrastructure and land protections. Among the earliest cities to recognize ecosystem services (though the term was not used at the time), was Seattle. After a devastating 1889 fire, the city passed a bond to acquire and protect 100,000 acres (almost all) of the Cedar River Watershed that was the source of the city's water. Some recent examples include, but are not limited to:[86]

  » **North Carolina Clean Water Management Trust Fund.** The fund is the first in the nation to provide funds for activities that protect and enhance the state's waterways and water quality. At Mountain Island Lake, using these funds, local bonds, and municipal funds conserved lands with the highest clean water benefits for the region, ultimately protecting 74 percent of the lakeshore and 20 percent of surrounding tributaries.

  » **Arizona Water Protection Fund.** Created by the Arizona legislature in 1994, this fund supports projects that will "maintain, enhance, and restore rivers, streams and associated riparian resources through a yearly competitive public grant process."[87] Since its inception, the fund has spent $41 million to fund 199 projects to improve "water quality, in-stream flows and water supplies, biodiversity, fish and wildlife habitat, recreation, flood control and overall watershed health."[88]

  » **West Groton (Massachusetts) Water Supply District.** The District purchased a commercial property associated with a key contaminant in the district's source water; retained, cleaned, and now manages the site of the contamination; and subdivided and resold the remaining property so the City could recoup most of its investment while, at the same time, protecting water quality through the land acquisition.

  » **San Antonio Water System, Texas.** In 2000, the city passed a bond measure that raised $65 million over four years for land acquisition specifically "to protect the Edwards Aquifer and to create greenways along sensitive creeks within the city."[89] Some funding for its Land Acquisition Program is supported through a portion of its water supply fee.

  » **Milwaukee Metropolitan Sewerage District Greenseams Program.** In a joint initiative with The Conservation Fund, the district used land acquisition and easements to protect an initial 925 acres (now over 1,800 acres) in Milwaukee metropolitan area's growth corridors to help combat flooding and safeguard water quality while simultaneously preserving open space. Funding came from the district, the Wisconsin DNR, the U.S. Fish and Wildlife Service, the Wisconsin Coastal Management Program, and others. The investment helps reduce longer-term needs for other traditional water management infrastructure.

Acting Regionally: Linking Cities to Countryside

Recommendation: Cities should consider adopting a watershed-based or ecosystem framework for evaluating, planning, and implementing greening strategies that link urban and non-urban actions.

Sample options include:

- **Clean Water Act Watershed-based Permitting.** The Clean Water Act watershed permitting guidance outlines a watershed permitting framework. EPA has allowed watershed permits

through which wastewater treatment plants may enter into trading arrangements with farmers to achieve permit requirements for temperature rather than installing high-cost refrigeration systems. The Tualatin River Basin trade described earlier resulted in payments to farmers of $6 million to plant shade trees in riparian areas, avoiding $60 million in costs to construct refrigeration systems at two wastewater treatment plants. For the trade, the Washington County, Oregon water resources management agency (Clean Water Services) received in 2004 "the first-ever fully integrated municipal National Pollutant Discharge Elimination System permit."

Strictly speaking, the Tualatin Basin project was not undertaken using a watershed-based permit. The permit actually blended together five permits—four wastewater treatment facilities permits and one urban stormwater management permit to achieve overall water quality standards. The combined permit allows trading of water quality credits so that the permit holder, for example, has been able to "balance heat released from the treatment facilities with cool water released from Hagg Lake and new shade from planting trees in rural riparian areas."[90] With its recent guidance on watershed permitting, EPA is poised to select one or more location to pilot test watershed permitting.

Recommendation: States and cities should consider developing laws, policies, and regulations regarding nonpoint source pollution in the context of Clean Water Act Total Maximum Daily Load requirements.

An example includes:

- **North Carolina Cluster of Nonpoint Water Pollution Rules and Programs**
  - » **Neuse River Basin Nutrient Sensitive Waters Management Strategy and Agricultural Rule.** The strategy put in place for the first time in the state's history mandatory controls on nonpoint source pollution. About 70 percent of the Neuse River basin has forested riparian areas. The state estimates that if half of these riparian areas were lost, the amount of nitrogen reaching the Neuse River would increase by 1.5 million pounds, or 17 percent. The strategy includes eight rules that affect urban and non-urban areas designed to protect these riparian areas and the ecosystem services they provide as well as to reduce nitrogen loadings. Collectively, the rules targeted achieving by 2003 a 30 percent reduction of point and non-point source pollution in the average annual load of nitrogen delivered to the Neuse River Estuary from the average load from 1991 through 1995. The overall 30 percent reduction goal had not yet been reached by the original 2003 deadline. The Agricultural Rule provides options for individual farmers to implement best-management practices specified in the rule, or to take part in a collective local strategy. Whether North Carolina's nonpoint pollution rules will achieve the intended goals remains an unfinished story. However, the state's rule provides, at a minimum, an example of mandatory rules applied to nonpoint source pollution. Properly designed and enforced, such rules could be a springboard for ecosystem services payments to those implementing best management practices or specific performance goals.

Recommendation: States should consider developing ecosystem services payments programs to support state and regional environmental performance and enhancement of ecosystem services.

A sample model includes:

- **Florida Ranchlands Environmental Services Project**
  Florida initiated in 2005 its Florida Ranchlands Environmental Services Project (FRESP) to field-test payment for environmental services in the northern Everglades ecosystem in a

The Florida Ranchlands Environmental Services Project allows ranchers to sell environmental services to state agencies and other buyers. Such services reduce phosphorous loads, improve water management and restore wetlands at a lower cost than by investing in new public works projects.

Hope Milam/iStockphoto

partnership that included Florida's Department of Agriculture and Department of Environmental Protection, the South Florida Water Management District, the USDA Natural Resources Conservation Service, scientists at the University of Florida, the World Wildlife Fund, and eight participating ranchers. The project was initiated after a World Wildlife Fund study concluded that Florida could "buy" services from ranchers that would reduce phosphorous loads, improve water management and restore wetlands at a lower cost than by investing in new public works projects.

The partnership received $4 million from the NRCS, Florida's agriculture department, the World Wildlife Fund, and other state appropriations for a five-year pilot project in which the ranchers sell environmental services to state agencies and other buyers. Funding supported concept design and testing of water management alternatives on private ranches; development of measures to assess water storage, phosphorous retention, and habitat creation benefits; and operating rules and tools for an environmental pay-for-performance program. These tools included development of model contracts, eligibility provisions, resolution of safe harbor and wetland jurisdictional issues; long-term financing, and methods to target expenditures to maximize results.

In Phase I, from 2006 to 2009, water management alternatives were implemented on eight ranches, accompanied by field testing a Multi-Service Environmental Documentation Approach that includes measures and practices to certify on-ranch provision of water and phosphorous retention and wetland enhancement. In Phase II, beginning in 2010, payments for performance on the volunteer ranches will commence, with a goal of transitioning to a statewide program after 2011.

Program managers outline several key design and implementation issues critical to success of the pay-for-services pilot project in Florida. Design issues include addressing: "how to establish a dedicated, multiyear funding source to pay for services; how to establish what prices will be paid for services; and how to integrate a new pay-for-services program with other state and federal programs."[91] Other implementation issues include evaluating different methods for measuring environmental services and assessing "the trade-off

between the cost of documentation and the accuracy of measurements that is acceptable to buyers and sellers."[92]

Recommendation: States should consider developing offsite mitigation banking opportunities to implement Clean Water Act Sec. 404 wetlands mitigation requirements to complement on-site requirements and improve ecosystem health.

Sample options include:

- **Clean Water Act Section 404 Wetland Mitigation Guidance.**
  Section 404 (b) (1) Guidelines promulgated in 2005 provide regulatory authority to consider ecosystem services benefits of wetlands, such as water purification. Over the past decade, around 30-50 mitigation banks have been approved annually, with the total now over 600. Thirty-four states have at least one mitigation bank, but most are located in 10 states that include California, Colorado, Texas, North Carolina, several Great Lakes states, and northeastern states.[93]

  Based on USDA analysis, there is likely some significant untapped potential for agricultural lands to supply wetlands mitigation banks. Some 60 percent of mitigation counties "have agricultural lands that were once wetlands."[94] USDA analysis shows costs of wetlands on agricultural lands to be significantly lower than costs of creating wetlands mitigation banks outside the farmland context. For example, Wetland Reserve Program wetland restoration costs average $73 to $525 per acre, with a high of $2,500 per acre. According to the USDA, restoration costs of wetlands mitigation banks generally exceed $5,000 per acre, with costs reaching as high as $125,000 per acre. Some of this difference may result from regulatory requirements associated with mitigation banks and not required in Wetland Reserve Program restoration. Although the USDA did not analyze the reasons for the cost differential, the large difference suggests some prospect for cost-effective use of farmlands as wetland mitigation banks.

  Offsite mitigation of wetlands presents a variety of performance issues such as whether ecosystem services losses in one location can be compensated for by gains in ecosystem benefits elsewhere. Nonetheless, states like Maryland are pursuing mitigation banking based on the view that some highly developed areas, such as ports, when required to mitigate losses of some wetlands due to port expansion (for example), simply have no on-site locations that offer intact ecosystem benefits. Clustering wetland protection in high-priority mitigation banks, the state believes, will generate significant net benefits.

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

  For urban areas, wetlands mitigation programs may present some opportunities to work more regionally to achieve broader ecosystem services protections. An example includes:

  » **Maryland Offsite Mitigation Banks.** The State of Maryland is exploring how to leverage mitigation requirements associated with port authority and transportation projects, for example, into investments that enhance and protect high priority ecosystems managed by the Department of Natural Resources as mitigation banks.[95]

  One challenge with mitigation banks is their prospect to redistribute ecosystem services from one location to another. For example, in Florida, wetlands mitigation banking may have stripped wetlands from coastal, densely populated areas and relocated them to rural inland areas. Such distributional effects, thus, need careful consideration in designing mitigation banks.[96]

Recommendation: States and cities should considering developing laws that support ecosystem services evaluation and investments.

Sample models include:

- **SB 513—Oregon's Ecosystem Services Bill**
  In what is the first state bill to focus specifically on ecosystem services, SB 513 in Oregon states that "it is the policy of this state to support the maintenance, enhancement and restoration of ecosystem services throughout Oregon, focusing on the protection of land, water, air, soil and native flora and fauna." (SB 513, Sec. 2) The bill encourages "state agencies to use ecosystem services markets as a means to meet mitigation needs, after carefully avoiding the most sensitive resources and minimizing adverse impacts where development occurs." (Sec. 4) related to ecosystem services and ecosystem services markets" (bill summary), and states that "it is necessary to assist landowners in gaining access to additional sources of revenue such as emerging ecosystem services markets and to help landowners diversify their incomes, improve the ecological functions of their lands and pass along their lands and the lands' associated benefits to future generations." (Sec. 3) The law lays the foundation to incorporate ecosystem services into land and resource agency planning and create the precursors for future offsets against actions that result in losses of ecosystem services. Since the law was enacted in mid-2009, its actual performance has yet to be tested.

- **Forest Resource Trust Act:**
  In 2007, Oregon's legislature included specific references to ecosystem services and defined the term. The Forest Resource Trust Act (HB 2293) provides incentives for landowners to establish and maintain "healthy stands of trees in an environmentally responsible manner on unstocked and underproducing nonindustrial private forestlands," with an overall goal of reforesting 250,000 acres of land by 2010.

  While the Act is not directed at urban forests and urban greening, it includes provisions on ecosystem services that could be adapted to urban and nonurban settings. Specifically, the Act encourages the Board of Forestry to "assist landowners in securing payments for ecosystem services." The Act defines ecosystem services as "environmental benefits arising from the conservation and management of forestland, including, but not limited to, fish and wildlife habitat, clean water and air, pollination, mitigation of environmental hazards, control of pests and diseases, carbon sequestration, avoidance of carbon dioxide emissions and maintenance of soil productivity." In the context of ecosystem services, the Act highlights forestry carbon offsets, authorizing the State Forester, on behalf of the Forest Resource Trust, to "market, register, transfer or sell forestry carbon offsets attributable to the lands enrolled in the stand establishment program…"

TOOLKIT SECTION 2

Federal Leadership—Greening Futures: What's Next?

Over the past two decades, the ecosystem services of natural systems, their components, and their functions have slowly become a focus of environmental science and policy discourse. Environmental economists have a burgeoning repertoire of analysis striving to put a price tag on "ecosystem services" across the globe, in the United States, and within states, regions, and individual communities. Scientists, too, have embraced the study of ecosystems, their functions, and the services these functions provide that are relevant to sustaining human communities. Various estimation models to calculate performance outcomes of practices that protect or enhance ecosystem services have been developed and used by federal, state, and local agencies.

After three decades of academic inquiry, some policies now reflect more explicitly the language and intent of ecosystem services. Many of these emergent ecosystem services policies largely focus on single issues rather than offering an integrated, multi-benefits focus on priority landscapes. Can this change?

The nation's major environmental laws generally do not explicitly reference ecosystem services. However, several agencies have launched projects that now use ecosystem services concepts, and momentum for their use has strengthened, especially since inclusion of ecosystem services language in the Food, Conservation and Energy Act of 2008 (Farm Bill). That legislation (Title II—Conservation) requires that the Department of Agriculture develop a framework for measuring the environmental service benefits from conservation and land management, anticipating possible participation by farmers, ranchers and forest landowners in ecosystem service markets. In 2008, the USDA established a new Office of Ecosystem Services to "develop technical guidelines that outline science-based methods to measure the environmental services benefits from conservation and land management activities in order to facilitate the participation of farmers, ranchers, and forest landowners in emerging environmental services markets." The increasing focus of federal, state, and local governments on climate change, its effects on lands, water, wildlife and human communities, and strategies for addressing these challenges may present a good opportunity to introduce ecosystem services concepts into laws, regulations, and policy guidance.

Ecosystem Services—Setting Federal Foundations

To advance ecosystem services, urban greening, and their integration with broader, landscape-scale ecosystem restoration and conservation efforts, federal leadership presents several opportunities shaped with an overall framework. Key goals that shape that framework include:

- facilitating regional, **landscape-scale**, or watershed-level actions;
- enhancing local, service district, and state decision making **coordination** across jurisdictional boundaries;

- strengthening **performance accountability** through a focus on outcomes rather than prescriptions;
- nurturing **private stewardship** and **ecosystem services markets**; and
- sustaining **place-based decision-making** to take advantage of existing institutions and situational knowledge.

There is a tension, though not an irreconcilable one, among these goals. Integrating decisions to encompass a watershed or other defined ecosystem, on the one hand, requires coordination and an overlaying of goals across multiple jurisdictions and agencies. On the other hand, much relevant knowledge of circumstance, community, and place as well as implementation capacity resides in local, decentralized, often unconnected organizations, agencies, and governments. In addition, while strengthening private stewardship is essential for protecting and restoring ecosystem services, performance accountability often involves establishing and maintaining required publicly established goals and standards.

The framework outlined here is one that builds upon local institutions, multiple agencies, diverse communities and their capacities, while strengthening mechanisms to facilitate planning and coordination among them to achieve shared goals. It also includes incentive and market opportunities, with those opportunities often nested within a larger regulatory context.

Federal policy initiatives that could strengthen ecosystem services investments, markets, and protections include executive guidance, regulatory innovations, capacity-building through metrics development and pilot projects, and spending provisions through grants, associated priority setting, and program performance requirements.

Some examples include:

- **Overall Performance Guidance on Integrated Ecosystem Services:** Administration (Executive Order) or legislative guidance could accomplish several minimum goals: 1) focus existing (and any new) grant and ecosystem market services payments on highest-priority areas and outcomes rather than formula grants or first-come, first-served allocations; 2) facilitate development of protocols for ecosystem services metrics, reporting, and monitoring, including protocols for "stacking" or combining of multiple benefits; 3) develop agency guidance on incorporation of ecosystem services into existing regulations and policies.
- **Federal Budgeting:** Administration and congressional opportunities to improve federal budgeting to support ecosystem services and landscape-scale restoration could: 1) explore options for cross-cut federal budgeting for landscape-scale ecosystem restoration projects that involve multiple federal agencies; 2) develop options for multi-year funding of integrated, landscape-scale ecosystem services and restoration initiatives with federal, state, local, and community components.
- **Council of Environmental Quality:** Development of guidance on how to incorporate ecosystem services evaluations into National Environmental Policy Act evaluations.
- **Environmental Protection Agency:**
  - » **Development of Infrastructure Greening Guidelines**, especially with respect to permitting requirements under the Clean Water Act pertaining to stormwater, wastewater, and combined sewage overflow management.
  - » Under the **Safe Drinking Water Act**, consider incentives or requirements for states to implement the Source Water Assessment Plans that they have already developed. The 1996 amendments to the Safe Drinking Water Act required that states assess their source waters and identify threats to water supplies. These plans lay the ground for broadening water management to a watershed level and for exploring ways to protect source water in and beyond cities boundaries through land acquisition or conservation easements

funded through water service fees, existing water infrastructure grant programs, and other public and private funding sources.

» Under the **Clean Water Act** and **Safe Drinking Water Act**, strengthen provisions that allow state revolving fund grants under both programs to invest in ecosystem and infrastructure greening.

- **U.S. Department of the Interior**
  - » **Conservation grants.** As manager of one in every five acres of the United States, Interior's mission unfolds in proximity to many of the nation's communities. It is a key participant in major ecosystem restoration projects. The Department could evaluate its suite of grant programs and administer them in ways that provide incentives for landscape-scale conservation and link urban greening with adjacent non-urban conservation and restoration. Full (and permanent) funding of the Land and Water Conservation Fund could also provide a significant source of funding to increase investment in ecosystem services and green infrastructure, though the purposes of the stateside LWCF grants may need to be broadened beyond their current outdoor recreation focus to make greening projects eligible.
- **U.S. Department of Agriculture**
  - » **Farm Bill, Forest Service, and Other Grant Programs:** As the Florida Rangelands Ecosystem Services pilot project indicates, there is a potential nexus between agriculturally based ecosystem services programs and urban greening efforts. Opportunities to protect source water, create riparian buffer areas to reduce water temperatures, reduce nutrient loadings in waterways, and so on, can 1) broaden urban options for providing basic services beyond traditional "gray" infrastructure; and 2) expand tools for reducing air and water pollution. USDA implemented a reverse
    - –**Performance Focus:** A Conservation Effect Assessment Project, initiated in 2003, was intended to develop recommendations for better aligning Farm Bill spending with high-priority ecosystem services and conservation outcomes. Whether through that process or by tailoring individual grant programs, current federal conservation and other grants need to focus on performance effectiveness. The U.S. Department of Agriculture has experimented with methods to enhance effectiveness. One experiment included use of a reverse auction to allocate funds for the Wetlands Reserve Program. In July 2006, using a reverse auction for its easement acquisitions, USDA prioritized funding to focus on projects using an environmental indicators index.
    - –**Landscape-scale, Integrated Focus:** State Forestry grants, like many other USDA programs, have traditionally been allocated by formula or on a first-come, first-served basis. Recipients of state forestry grants have been individual landowners. Several years ago, the State Forestry program began piloting use of competitive grants for a portion of its funding, with a focus on awarding grants to landscape-scale initiatives.[97]
- **Coastal Zone Management Act:** The Act requires that state plans give "adequate consideration of the national interest involved in planning for, and managing the coastal zone, including the siting of facilities . . . which are of greater than local significance," and plans must include "procedures whereby specific areas may be designated for the purpose of preserving or restoring them for their conservation, recreational, ecological, historical, or esthetic values." (16 U.S.C. Sec. 1455 (d) (8) and (9)) This language could accommodate consideration of ecosystem services, but few states have developed criteria to consider the services provided by natural ecological systems, functions, and components. Options to incentive incorporation of ecosystem services priorities in state plans could be developed.
- **Stafford Act.** In the aftermath of disasters, the Federal Emergency Management Agency (FEMA) provides hazard mitigation funding through provisions outlined in Sections 404 and

406 of the Stafford Act (42 U.S.C. 5121-5206). These sections focus on repair of facilities damaged by a disaster and protection of undamaged parts of facilities. With its emphasis of grant provisions on repair and protection of existing facilities, the Act is not designed to encourage entirely new approaches to hazards protection that might involve ecosystem restoration, urban greening, and green infrastructure. Instead, the emphasis on repair and protection of existing facilities tends to encourage an infrastructure status quo. Review and revision of the Stafford Act and its implementing regulations to amend this bias toward status quo infrastructure may be warranted, especially as recent failures of some traditional infrastructure indicate that new approaches may be more cost-effective. Such a review should give specific consideration of green infrastructure and ecosystem services protection.

Conclusion

Baseball philosopher Yogi Berra once quipped that "the future ain't what it used to be." This nation, its cities, and its countryside are at a turning point. The environmental dynamics of climate change, the increasingly landscape dimensions of resource management challenges, and persistent ecosystem degradation require new mental maps for managing cities and their surrounding environments.

The 20th century was a time of immense and rapid urbanization during which vast networks of infrastructure were built to provide communities with water, wastewater, waste management, and transportation systems, flood protection, and other services. Accompanying these services, agencies—federal, state, and local—proliferated, fulfilling specialized and compartmentalized purposes. Through this infrastructure and these agencies, many benefits were brought to communities. But changing circumstances are outstripping the capacities of both infrastructure and governing structures. Moreover, the cumulative negative impacts of this infrastructure and its transformation of ecosystems point to the need to rethink the nexus of city and countryside; people and places; ecosystems and economies.

Two features loom large for our mental maps of the future. First is the importance of protecting and restoring ecosystems. Their restoration brings benefits both to wildlife and human communities. Urban greening and investment in non-structural, green infrastructure are part of that restoration effort. Second is the importance of finding governing tools and decision settings that facilitate landscape-scale, or watershed-based, actions. Many current challenges in water management, flood control, safety for coastal communities, air quality, biodiversity, and climate change transcend the boundaries of individual cities and the authorities of individual agencies. Addressing these challenges requires, therefore, big picture thought and action.

Policies and management tools that support investment in ecosystem services and facilitate coordination among agencies and across boundaries lie at the crux of a new future. Already, with their urban greening efforts, cities are setting the foundations for this new future. The tools described and proposed in this paper can assist those efforts, while providing mechanisms to integrate urban greening with broader landscape-scale conservation and restoration.

Notes

[1] John Tallmadge, *The Cincinnati Arch: Learning from Nature in the City*, University of Georgia Press, 2004, pp. 6, 14

[2] For details of many urban greening initiatives, see www.greeninfrastructurewicki.com

[3] Gretchen Daily, et al.; see also Millennium Report

[4] Permeable surfaces absorb rainwater. Fees that encourage permeable rather than impervious surfaces in urban landscapes can significantly reduce runoff, help maintain water quality, and lower long-term costs of managing stormwater.

[5] FCM, p. 1

[6] Ibid.

[7] Conversation with Howard Neukreug, Director, Office of Watersheds, City of Philadelphia, June 22, 2009 and Tracy Mehan, The Cadmus Group, June 2009, and Ben Grumbles, AZ Department of Natural Resources, August 2009.

[8] Conversation with Howard Neukreug, City of Philadelphia, June 22, 2009.

[9] Conservation with Amanda Cundiff, U.S. Forest Service, June 2009.

[10] Some leaders in these greening efforts include Chicago, Baltimore, Portland, Seattle, Minneapolis, Philadelphia, and New York.

[11] Conversation with Mark Sendzik, U.S. EPA and David Nowak, U.S. Forest Service, August 20, 2009.

[12] Trust for Public Land, "Measuring the Economic Value of a City Park System," 2009.

[13] Conversation with Greg McPherson, U.S. Forest Service, June 23, 2009.

[14] American Society of Landscape Architects, et al., "Guidelines and Performance Benchmarks," Draft 2008, p. 3. See also Steve Windhager, Frederick Steiner, Mark T. Simmons, and David Heymann, "Performance Based Site Design: Incorporating Ecosystem Services as Explicit Design Goals."

[15] Conversation with Kevin Shafer, Executive Director, Milwaukee Metropolitan Sewage District, June 23, 2009.

[16] See www.cascadeagenda.com.

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[22] "Cities and Climate Change Initiative," UN Habitat for a Better Urban Future, Conference Report, Oslo, March 17, 2009. Numerous reports cite the 75% figure. However, David Satterthwaite estimates that cities worldwide account for 30 to 40 percent of total emissions. (Environment and Urbanization 20, October 2008. The discrepancy in estimates appears to depend on definitions and geography. Cities in developing nations lack both industry and automobiles in some cases, resulting in emissions 100-1,000 times less than in New York or London, according to Satterthwaite. In developed nations, many heavy industries and power facilities are no longer located in cities. Satterthwaite argues that it is more useful to allocate greenhouse gases by consumption rather than production. In developed nations, such an allocation would result in high emission profiles for cities but much lower profiles for cities in poor nations.

[23] Chicago Climate Change Action Plan, Introduction.

[24] Ibid.

[25] Ibid.

[26] Ibid.

[27] Greg McPherson, U.S. Forest Service, Center for Urban Forest Research

[28] *Landscape Architecture*, February 2008 (referencing Greg McPherson, Center for Urban Forest Research).

[29] Ibid.

[30] Greg McPherson, "Capturing carbon in your community," *Winter Arborist*, Winter 2008.

[31] U.S. EPA, Aging Water Infrastructure Research Program.

[32] 2009 Report Card for America's Infrastructure, American Society of Civil Engineers. Report available at www.asce.org/reportcard/2009/grades.cfm See also, "Drinking Water Challenges in the Twenty-First Century," Ronnie B. Levin, et al., Environmental Health Perspectives 110, February 2002.

[33] U.S. Census Bureau.

[34] See "Sustainable Water Systems: Step One—Redefining the Nation's Infrastructure Challenge," Aspen Institute, 2009. See also, Valerie I. Nelson, "Sustainable Water Infrastructure," Coalition for Alternative Wastewater Treatment, report available at www.sustainablewaterforum.org.

[35] State of the Nation's Ecosystems (Heinz Report), p. 226.

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[37] State of the Nation's Ecosystems, p. 226.

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[38] "Trees Tackle Clean Water Regs," American Forests, see www.americanforest.org and the American Forests CITYgreen computer software tool that calculates benefits of urban tree canopy. See also, ICMA, "Trees: The Green Infrastructure," 2002.

[39] Trust for Public Land and American Water Works Association, "Protecting the Source," 2004.

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[43] Conversation with Dean Marriott, Director, Portland Bureau of Environmental Services, Oregon, June 2009.

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[47] Ibid., p. 48.

[48] See Valerie I. Nelson, "Sustainable Water Infrastructure," Coalition for Alternative Wastewater Treatment, p. 4.

[49] Sustainable Water Systems: Step One—Redefining the Nation's Infrastructure Challenge, Report of the Aspen Institute's Dialogue on Sustainable Water Infrastructure in the U.S., 2009, p. 6.

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[53] U.S. Department of the Interior, "Rebuilding Wisely for a Disaster-resilient Gulf Coast: Conceptual Framework and Steps to Address Gulf Area Reconstruction and Reduce Future Risks," Nov. 21, 2005, p. 1)

[54] Conversation with Sarah Mack, Tierra Associates, September 2009.

[55] Ibid. See also, U.S. Fish and Wildlife Service, "Reservoir Fisheries Habitat Partnership: Conserving Healthy Reservoir Systems: A Framework for Strategic Conservation of Fish Habitat in the Reservoir Systems of the United States," prepared by the Partners of the Reservoir Fisheries Habitat Partnership, et al., August 2009.

[56] E. Gregory McPherson, "Evaluating the Cost Effectiveness of Shade Trees for Demand-Side Management," *The Electricity Journal* 6, November 1993.

[57] Landscape Architecture, Feb. 2008, referencing U.S. Forest Service Center for Urban Forest Research.

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[70] Conversations with Sarah Vickerman, Defenders of Wildlife, June 2009, and Eileen McClellan, Environmental Defense Fund, June 29, 2009. Also see www.tz1market.com (last accessed August 20, 2009).

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[72] USDA, U.S. Forest Service, Strategic Tree Planting, p. 4.

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