

Prepared in cooperation with the Wharton School at the University of Pennsylvania and the Penn Institute for Urban Research

A symposium organized by the Spatial Integration Laboratory for Urban Systems—A Wharton School/USGS Collaborative, cosponsored by the Penn Institute for Urban Research

Urban Ecosystem Services and Decision Making for a Green Philadelphia



Open-File Series 2014–1155

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By Dianna M. Hogan, Carl D. Shapiro, David N. Karp, and Susan M. Wachter

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Introduction

Traditional approaches to urban development often do not account for, or recognize, the role of ecosystem services and the benefits these services provide to the health and well-being of city residents. Without such accounting, urban ecosystem services are likely to be degraded over time, with negative consequences for the sustainability of cities and the well-being of their residents (Millennium Ecosystem Assessment, 2005; Hirsch, 2008). On May 23, 2013, the Spatial Integration Laboratory for Urban Systems (SILUS), a collaboration between the U.S. Geological Survey (USGS) Science and Decisions Center and the Wharton GIS Lab, convened a one-day symposium—Urban Ecosystem Services and Decision Making: A Green Philadelphia—at the University of Pennsylvania in Philadelphia, Pennsylvania, to examine the role of green infrastructure in the environmental, economic, and social well-being of cities. Cosponsored by the USGS and the Penn Institute for Urban Research (Penn IUR), the symposium brought together policymakers, practitioners, and researchers from a range of disciplines to advance a research agenda on the use of science in public decision making to inform investment in green infrastructure and ecosystem services in urban areas.¹

The city of Philadelphia has recently implemented a program designed to sustain urban ecosystem services and advance the use of green infrastructure. In 2009, the Philadelphia Mayor's Office of Sustainability launched its Greenworks plan,² establishing a citywide sustainability strategy. Major contributions towards its goals are being implemented in coordination with the Philadelphia Water Department (PWD). The Green City, Clean Waters initiative,³ the city's nationally recognized stormwater management plan, was signed into action with the U.S. Environmental Protection Agency (EPA) in April 2012. The plan outlines a 25-year strategy to use green infrastructure to protect and improve the city's watershed. Widespread support for the plan marks a citywide effort to

factor environmental quality concerns into the city's strategic planning, choosing to replace expensive and aging grey⁴ infrastructure, with innovative and resilient green⁵ infrastructure.

The symposium focused on these city of Philadelphia initiatives and also on two new Federal- local partnership programs: America's Great Outdoors,⁶ initiated to promote conservation and recreation, and the Urban Waters Federal Partnership,⁷ a multiagency effort to reconnect urban communities to their waterways.⁸

A second goal of the symposium was to advance a research agenda on urban ecosystem services. While there has been considerable work on ecosystem services, the discussion of the benefits provided by urban ecosystems is not as developed. Benefits range from improved water and air quality to quality of life gains, including aesthetic and recreational considerations.⁹ There is also need for additional focused research toward furthering the understanding of the multiple indirect benefits provided by urban ecosystem services (Bolund and

⁴Grey infrastructure is defined as the infrastructure used to collect, transport, temporarily store, and treat sewage and stormwater, including pipes, treatment plants, and inflatable dams; often called "traditional infrastructure" (PWD, http://www.phillywatersheds.org/what_were_doing/traditional_infrastructure).

⁵Green infrastructure is defined as "a soil- and vegetation-based approach to wet weather management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure management approaches and technologies infiltrate, evapotranspire, capture, and reuse stormwater to maintain or restore natural hydrologies" (U.S. Green Building Council, <http://www.usgbc.org/glossary>).

⁶<http://www.doi.gov/americasgreatoutdoors/index.cfm>.

⁷<http://www.urbanwaters.gov/>.

⁸On May 10, 2013, the USGS recently announced a new partnership in the Delaware River Basin that covers Philadelphia, Pennsylvania (Penn.); Camden, New Jersey; Chester, Penn.; and Wilmington, Delaware; a collaboration of Federal, State, regional, local government, and nongovernment partners focused on the protection and restoration of the Delaware River watershed, through reconnection with economically distressed communities. The initiative aims to promote better utilization of Federal resources to advance sustainable development in communities throughout the watershed. Existing efforts in other watersheds include riverfront master plans, landscape restoration, and building community capacity.

⁹See Center for Neighborhood Technology, 2010; Wise and others, 2010; Wachter and others, 2008; and Wachter and Wong, 2008.

¹Comments made by speakers not affiliated with the USGS do not necessarily reflect the positions of the USGS.

²<http://www.phila.gov/green/greenworks/index.html>.

³http://www.phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan.

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Hunhammar, 1999). Moreover, there is a need for a greater understanding of how best to inform local decision making in this area, as local decision makers in cities across the country are increasingly recognizing the importance of developing sustainability measures for their immediate and long-term planning (United States Conference of Mayors, 2005).

Approaching these local and regional plans from a holistic perspective has become a guiding principle of sustainability¹⁰ and resiliency.^{11, 12} Therefore, there is a need to better understand the gains that have been achieved and to advance a research agenda on ecosystem services going forward. The day's program included presentations on greening initiatives from the Philadelphia's Mayor's Office of Sustainability, as well as discussion about using an urban ecosystem services framework to evaluate these initiatives. Panel sessions included discussion of the Green City, Clean Waters initiative; a dialogue about the management of urban trees and green space; and a conversation addressing the needs for future research. The following provides a summary of the day's events.

¹⁰“Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, which permit fulfilling the social, economic, and other requirements of present and future generations. Sustainability is important to making sure that we have and will continue to have the water, materials, and resources to protect human health and our environment.” (EPA, <http://www.epa.gov/sustainability/basicinfo.htm>.)

¹¹Resiliency refers to the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change. In keeping with this theme, “resilient cities” reduce vulnerability to extreme events and respond creatively to economic, social, and environmental change in order to increase their long-term sustainability. As such, resilient cities define a comprehensive “urban resilience” concept and policy agenda with implications in the fields of urban governance, infrastructure, finance, design, social, and economic development, and environmental/resource management. (Resilient City Series, International Council for Environmental Initiatives (ICLEI), <http://resilient-cities.iclei.org/resilient-cities-hub-site/resilience-resource-point/glossary-of-key-terms/>.)

¹²As of 2012, more than 1,000 U.S. mayors agreed to meet Kyoto Protocol targets for reducing greenhouse gas emissions by signing the Climate Protection Agreement. Focusing on ways to reduce energy consumption, cities have increased investment in public transit, established efficiency standards for lighting, heating, and cooling, and incorporated Lead in Energy and Environmental Design and other standards into their local building codes. Such local efforts to combat global warming extend to goals for reducing sprawl, protecting open space, managing sensitive land use, and restoring natural resources. ICLEI-Local Governments for Sustainability has aided these efforts by helping local governments to develop long-term sustainability plans. ICLEI's STAR Community Index guide describes a commitment to natural resource planning, green infrastructure, and watershed protection. Internationally, the ACES (A Community of Ecosystem Services) conference has been held biannually since 2008 to bring together decision makers and researchers to link science and practice in the area of ecosystem planning and management. The next meeting will be held in 2014.

<http://usmayors.org/climateprotection/agreement.htm>

<http://www.kyotousa.org/>

http://www.iclei.usa.org/library/documents/STAR_Sustainability_Goals.pdf

<http://www.conference.ifas.ufl.edu/aces/index.html>

Introductory Comments

Greenworks: Philadelphia's Sustainability Initiative

Katherine Gajewski, Director of the Philadelphia Mayor's Office of Sustainability, presented a brief overview of Greenworks, the city of Philadelphia's sustainability framework and action plan. Gajewski outlined the structure of Greenworks, which was put into action by Mayor Michael Nutter in 2009, with the establishment of the newly created Mayor's Office of Sustainability. With a 6-year timeline, Greenworks establishes 5 core goals, 15 measurable targets, and 166 individual initiatives to be completed by 2015.

Gajewski presented a basic summary of the city's efforts and progress thus far, expressing the need for the city to continue its current momentum and leadership forward, in building and planning for a more sustainable future. She explained that the next wave of sustainability planning will need to implement a “comprehensive strategy that crosses multiple parts of government in order to achieve impactful outcomes and multiple benefits.” Director Gajewski emphasized the importance of government adaptation and the modification of fixed systems for long-term impact, specifically noting asset management as an area that needs attention. As the Mayor's term in office is coming to a close, Gajewski stressed the need for both governmental and nongovernmental commitment to sustainability goals, highlighting in particular the interagency constituency that made Greenworks possible. The ability to endure and adapt together with these changes will dictate Philadelphia's long-term standing as a leading city in the sustainability movement.

Bringing Science to Provide Ecosystem Service Approaches to Meeting the Challenges of an Urban Center

Carl Shapiro, Director of the USGS Science and Decisions Center, posed the central question for the day's discussion: How can understanding the provisioning and valuing of urban ecosystem services help inform local decisions about prioritizing the preservation and enhancement of ecosystem services in different locations and in different timeframes? Beginning with a definition of what those services produce—“the benefits that humans receive from nature”—Shapiro explained that our collective understanding of these services and our ability to measure their benefits is continuing to develop, while concerns regarding the monetization of nature persist.

As with all public goods, the benefits of urban ecosystem services are not adequately described in markets nor easily estimated. Nonetheless, without an understanding of the function and benefits of these services, the community incurs the risk of underestimating their value and not including that

value in decisions. Thus, an understanding of how to estimate and apply the benefits of ecosystem services is required to inform policy regarding the use and protection of these natural resources.¹³

The mission of the USGS Science and Decisions Center is to advance the use of science in decision making, in part by improving the understanding of ecosystem services and their economic and social values, especially when these benefits are not reflected in markets. The Spatial Information Laboratory for Urban Systems (SILUS), established by the USGS in partnership with the University of Pennsylvania and co-led by Susan Wachter of Wharton and Dianna Hogan of the USGS, is part of this effort.¹⁴

Shapiro ended his comments by highlighting questions for participants to keep in mind for the day's concluding panel on advancing a research agenda: How can science most effectively be incorporated into urban decision making? What are the key scientific opportunities and challenges? And how might we develop partnerships and create incentives for ecosystem services to be more effectively and routinely considered to inform sustainable urban decisions?

Goals for a Green Philadelphia

Michael DiBerardinis, Deputy Mayor for Environmental and Community Resources for the City of Philadelphia and Commissioner of the Department of Parks and Recreation, addressed the necessity for the city to invest in green infrastructure—both to improve the quality of its environment and to remain attractive and competitive with other cities to advance economic development. The overarching goal of the Greenworks plan is to integrate science and decision making with the goal of improving the lives of Philadelphians.

DiBerardinis emphasized the importance of engaging citizens. He described the city's sustainable action strategies that include: a city government energy conservation plan, efforts toward improving city-wide access to green spaces to all citizens, the greening of recreation centers and school yards, and tree-planting goals. To accomplish these, he emphasized the importance of partnerships among public, private, and nonprofit entities. DiBerardinis closed by stating the unique opportunity for municipal governments to lead by example. As owner and manager of public lands, the city can influence and drive a green agenda by setting high standards for urban ecosystem management.

Science and Urban Ecosystem Services—A National Perspective

Bill Werkheiser, Acting Deputy Director of the USGS, offered a Federal perspective on the utility of real-time data and science-based quantitative analysis to monitor and value ecosystem services, explaining that you “cannot manage what you cannot monitor.” He affirmed up front the importance of developing a strong identity for urban ecosystem services, stressing that “connecting people with nature must happen in an urban landscape.” From an historical context, Werkheiser explained how the definition of ecosystem services has developed from meaning the “products of the national domain” to a more modern interpretation as the “benefits people receive from nature.” It is now important to have the science, the incentive frameworks, and the governance to specifically address urban ecosystem services. He emphasized that since the majority of the national and global population now resides in urban areas, we must look to these areas as the primary source of action concerning ecosystem service provision and protection.

Werkheiser pointed to ongoing efforts to monitor the quality of ecosystems for science-based quantitative analysis of benefits and services, including real-time stream monitoring programs, such as WaterSMART,¹⁵ to provide information about water availability and effects of stream restoration efforts. To highlight the role of stakeholders in developing these initiatives, he posed the question, “What information do we need in order to manage water resources effectively?”

Werkheiser discussed the need for future research to develop a better understanding of the value of nature, from mussels in streambeds to riparian tree canopy, to restoring and maintaining the quality of urban streams and fisheries, and a long-term assessment of the impact of stream restoration policies. He emphasized a focus on improving our understanding of the economic impacts of restoration efforts and stressed the importance of ongoing monitoring and assessment to identify unexpected outcomes and adjust strategies to ensure the achievement of intended goals.

Urban Water—Managing Stormwater, Rivers, and Watersheds

Howard Neukrug, Commissioner of PWD, described the city of Philadelphia's “First in the Nation” agreement with the U.S. Environmental Protection Agency (EPA) to substitute green infrastructure for grey infrastructure in managing stormwater.¹⁶ David Hsu, Assistant Professor of City and Regional

¹³See Callicott, J.B. (2001).

¹⁴SILUS and Wharton GIS Lab researchers are currently investigating instruments of stormwater management financing under an EPA STAR grant [EPA-G2012_STAR_G1]. Dr. Susan Wachter is a researcher on the project, along with other leading Penn faculty.

¹⁵<http://water.usgs.gov/watercensus/WaterSMART.html>.

¹⁶In June 2011, the Philadelphia Water Department's (PWD's) Green City, Clean Waters plan was publically endorsed by the Pennsylvania Department of Environmental Protection, signing a consent agreement acknowledging its

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Planning at Penn's School of Design, and Tom Daniels, Professor of City and Regional Planning at Penn's School of Design, followed Neukrug's presentation, giving their review of the issues and innovations in stormwater planning.

Commissioner Neukrug addressed the importance of watershed restoration and protection as a key objective of reconnecting hydrological processes into urban design. He noted that this objective means ensuring access to and conservation of scarce water resources through effective, efficient, and ecologically sound stormwater management. Neukrug spoke of the need for an integrated approach to water management, recognizing the connection between the watersheds, drinking water provision, and stormwater and wastewater treatment (fig. 1). Nonetheless, Philadelphia's "one water, one city" approach raises questions around the scale of governance, the engagement of private actors in infrastructure provision, and the acceptability of spending taxpayers' dollars on preservation.

Within the context of Philadelphia's decision to develop an innovative green infrastructure investment plan in lieu of a more costly¹⁷ "grey infrastructure" solution (involving the construction of new, separate pipes for waste water and stormwater), Neukrug discussed the logistics of managing a billion-dollar "green utility." Key to these logistics is the 25-year green infrastructure strategy—Green City, Clean Waters—which decentralizes the city's stormwater management through citywide greening efforts. Pointing to the key flaw of the city's Combined Sewer Outfall (CSO) system,

\$2-billion, 25-year plan. In April 2012, the EPA also entered into an agreement with PWD to collaborate on the implementation of the plan—through developing demonstration projects, efforts to streamline and integrate the plan on a large scale, and to conduct studies to test and monitor water quality in the Delaware River watershed. In that first year, 184 green stormwater projects were built. Through improvements made to streets, schools, public facilities, parking lots, and other public and private properties, the PWD's plan aims to implement green stormwater infrastructure tools in order to capture runoff close to its point of origination, slowing the rate that it enters the sewer system, and preventing polluted water from entering into the rivers and creeks. In a partnership with the city's Department of Parks and Recreation, the PWD has begun working towards a goal of realizing 500 "greened acres" by 2015, through an effort to locate "at least a patch of parkland within a 10-minute walk of anywhere in the city."

http://phillywatersheds.org/what_were_doing

http://www.phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan

<http://www.phillywatersheds.org/philly-500-city-begins-speeding-toward-500-new-green-acres-2015>

¹⁷The Pennsylvania Water Department (PWD) explored alternatives in the development of the Green City, Clean Waters Program. Options included a comprehensive overhaul of the existing "grey" stormwater management and sanitation systems. This option met the Combined Sewer Outfall policy goals but failed to serve any beneficial environmental purpose. The estimated present worth capital cost for a complete sewer separation would have been \$16 billion as opposed to the estimated \$2.4-billion green structure investment. The selected approach involves a 25-year commitment of \$2.4 billion (\$1.67 billion in Green Stormwater Infrastructure, \$345 million in upgrades to treatment plant capacity, and \$420 million in a category of "flexible spending").

An Integrated Approach to Water



Figure 1. An integrated approach to water. Community is at the center of the PWD's approach to stormwater management. Source: Howard Neukrug, Philadelphia Water Department, panel presentation slide.

Neukrug explained that every time it rains, the city's sewers overflow into the two major rivers. Focusing on innovative designs to "manage water where it falls," Neukrug explained the long-term strategy to avoid having to increase capacity of sewer tunnels and treatment plants. He highlighted site projects such as streetscape improvements; permeable basketball courts; green roofs on new and retrofitted development; and new green spaces, parks, and riparian landscapes. As shown in figure 2, collectively, these improvements would constitute a dynamic and diversified system, which from its integrated approach would depend heavily on regulation, policy, incentives, and education; the benefits also could be far reaching. Neukrug stressed the community component, explaining that green space needs to be "clean, safe, and accessible," to ensure that the community is willing to engage in its maintenance and to improve its value.¹⁸

To facilitate the success of Green City, Clean Waters, the PWD is working with stakeholders, including the EPA, the Pennsylvania Department of Environmental Protection, and local environmental groups. The PWD is expected to invest \$2.2 billion in green and grey infrastructure over the next 25 years, working toward a goal of 10,000 "greened acres"—the Water Department's metric of determining the amount of stormwater managed and diverted from the sewer system (which translates to the removal of 34 percent of the city's existing impervious surface, or 15 square miles).

¹⁸In the end, the improvements are to be financed by the rate-paying public; thus, the importance of both advancing and expanding the benefits that accrue and contribute to the overall revitalization of the city; and therefore a complete understanding of societal costs and benefits is critical in justifying these initiatives to rate payers. The PWD outlines a list of the quantifiable benefits and external costs associated with its long-term strategy: water-quality and ecosystem improvement; recreation benefits; reduction in heat-stress mortality; air-quality improvement from trees; energy savings; and improved property values.

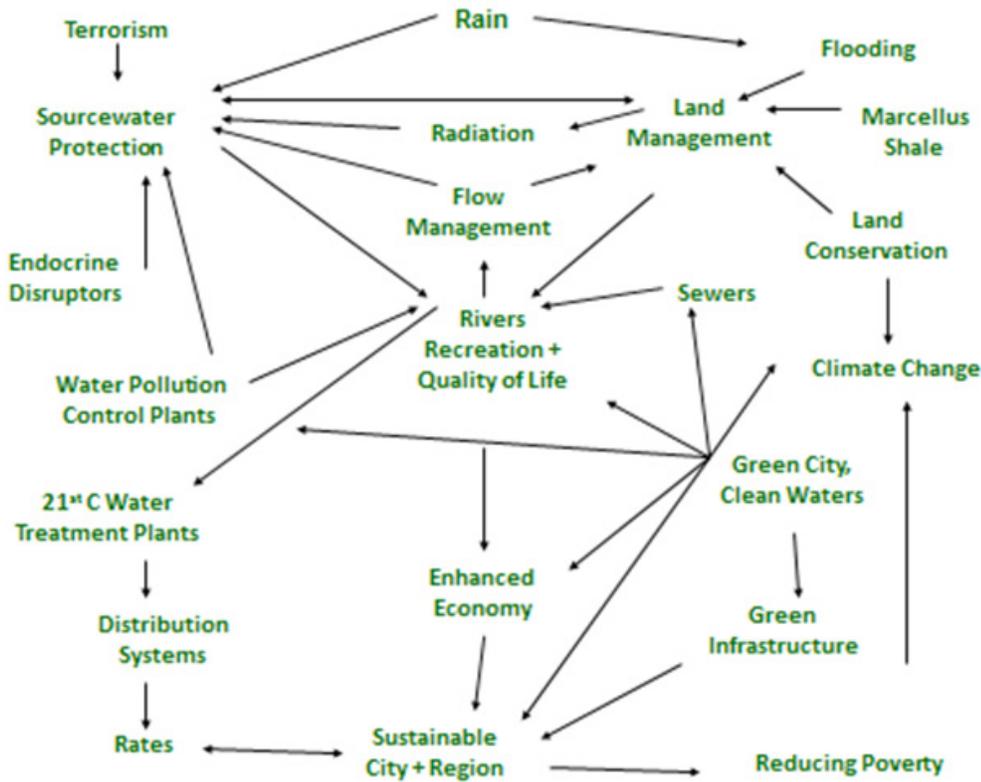


Figure 2. Water management impact web. Factors and linkages involved in Philadelphia’s water management plan. Source: Howard Neukrug, Philadelphia Water Department, panel presentation slide.

Neukrug noted the importance for the PWD to plan its actions in conjunction with other initiatives around the city, including the Greenworks plan and the Planning Commission’s Philadelphia 2035 long-range plan. Emphasizing a theme of building towards long-run sustainability policy, Neukrug expressed the goal of working toward institutionalizing the incentives, policies, regulations, and fees the PWD is putting in place in order to ensure that funding is available for ongoing investments in the city’s green infrastructures.

David Hsu began his presentation by asking three general questions that he suggested are relevant to all ecosystem initiatives:

1. How can we get people to respond through incentives to environmental concerns?
2. What do we need to know to make urban environmental policy?
3. How do we coordinate to achieve good environmental outcomes?

Hsu pointed to the importance of getting incentives right; short-sightedness and comfort with “business as usual” slow the adoption of new practices and must be overcome with incentives. On environmental policy, Hsu discussed the importance of the scale of the impact and the need for solutions that move from the property level to the street to the neighborhood, city, region, and Nation. Hsu highlighted the importance of place, and the importance of structural design and policy design to be unique to a local and ecological context,

identifying the need to understand how urban and natural landscapes overlap and the need to coordinate on all levels to achieve desired environmental outcomes. Hsu used this broad frame to examine the management of stormwater flow in the city. Thinking about how we can reconfigure street trees and landscape to help “detain, infiltrate, and reuse sheeting water,” Hsu explained that this is an open question for designers, planners, and engineers (fig. 3). The challenge is to figure out how to build systems that work together to maintain multiple functions, given slow incremental change (of ecosystems), existing property rights and laws, and various structures of urban economics and public policy.

Hsu used the illustrations presented in figure 3 to point to the differences between natural and built landscapes, and the design challenges of reconfiguring urban landscapes to incorporate elements of green infrastructure. The first illustration depicts the main fluxes of water in a natural setting, including evaporation, precipitation, and flows across the landscape. Hsu used the other three illustrations to point to questions that arise when we shift to an urban context: How does stormwater flow in the city? Hsu discussed the incremental approach that should be taken to reconfigure an urban landscape to manage stormwater more efficiently. Highlighting the individual components of the illustrations, Hsu asked what challenges arise in efforts to detain, infiltrate, and reuse water in the local landscape, including policy questions that arise with regard to property rights. What rights does a property owner have to below-ground uses, and what rights does a building owner have to the street in front? Property rights, the science of

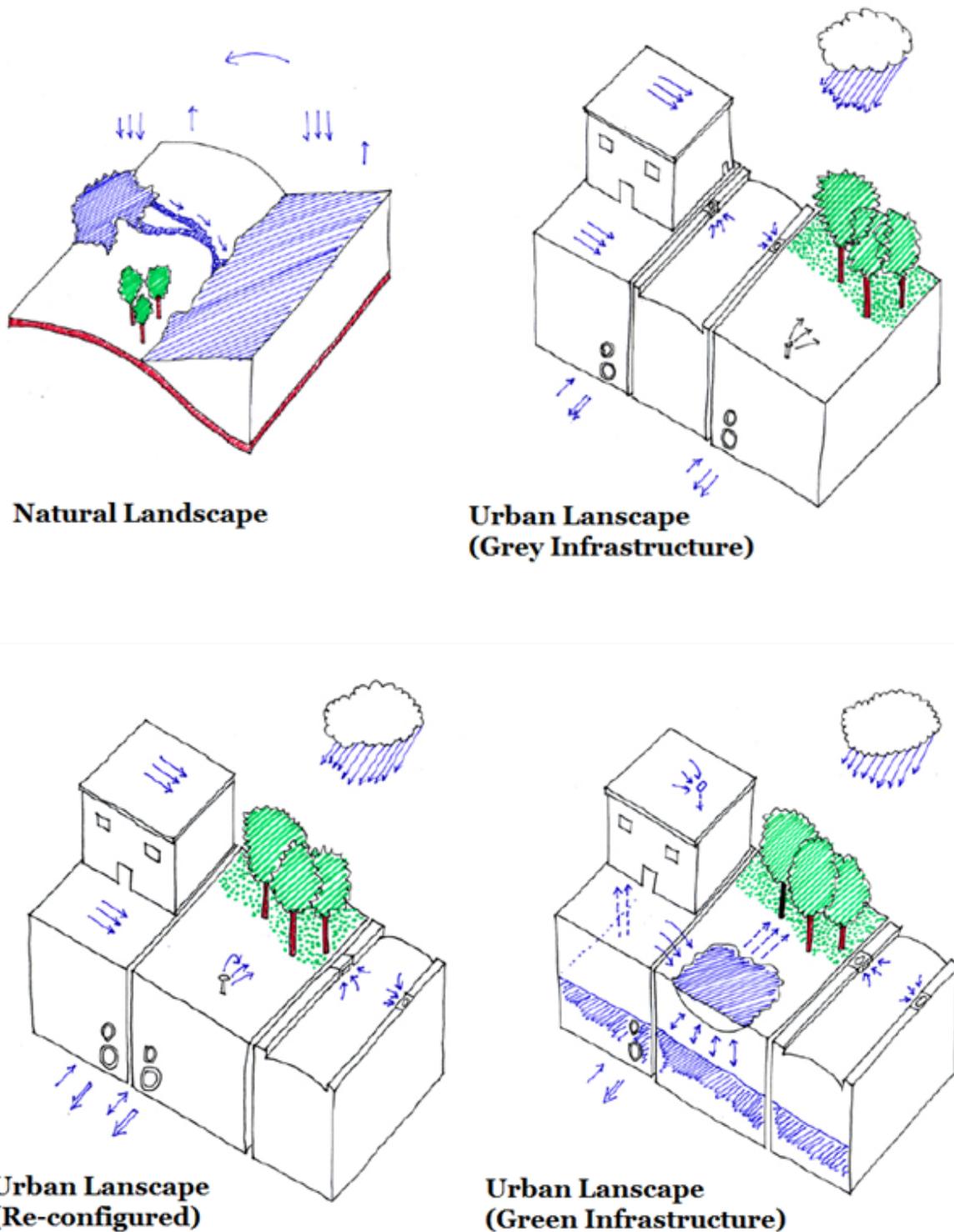


Figure 3. Where do cities and nature overlap (or should they?) Illustrations by David Hsu. The series of illustrations present (from left to right) the shift from natural to built landscape, and the changes of an incrementally reconfigured urban landscape. The first depicts a flow of water in a natural setting; the second shows water sheeting off of impervious surfaces and entering the sewer system; the third envisions a redesigned landscape where runoff can flow through green space before entering the sewer (diverting some water for reuse); and the final demonstrates a scenario with multifunctional green infrastructure (where water is collected on the roof, and retained in a cistern (temporarily) or in a bioswale, which can recharge the groundwater. Source: David Hsu, panel presentation slide.

permeation, and the spatial configuration of the grey infrastructure all must be taken into account in determining how to proceed.

Tom Daniels, Professor of City and Regional Planning at Penn's School of Design, expanded on the importance of establishing a local ecological framework by stressing the need to embrace the entire regional watershed. Professor Daniels' presentation focused on managing Philadelphia's urban watershed, especially in regard to land use and water supply and quality regulations. The Delaware and Schuylkill watershed regions directly impact the quality of Philadelphia's water; thus, comprehensive research, planning, and policy implementation is needed to secure the management and safety of the city's water supply. Daniels specifically noted New York City as a "gold standard" in terms of watershed protection. The program in New York was widely successful due to practices such as land preservation, rehabilitation and replacement of failing septic systems, and the implementation of a "whole farm management plan" that encouraged farmers to adopt better conservation practices. The city also focused on protecting water quality at its original source, looking upstream towards the "headwaters," in particular. While Philadelphia faces different challenges than those of New York City, Daniels points out that practices such as these could dramatically improve the state of Philadelphia's watershed and its drinking water.

America's Great Outdoors and Urban Waters Federal Partnership

David Russ, Regional Director of USGS Northeast Region, presented two recent Federal initiatives: America's Great Outdoors (AGO) and the Urban Waters Federal Partnership (UWFP). Bringing attention to these collaborative efforts between Federal agencies and local governments, Russ suggested that there is growing concern surrounding the importance of natural resource protection and responsible urban and economic development.

The America's Great Outdoors (AGO) initiative is a collective effort to reconnect people to nature. Access and awareness figure prominently in the focus of the program and are intended to enhance parks and green spaces across the country and to promote outdoor recreation and park visitation. Initiative goals include (1) establishing urban parks and community green spaces, (2) conserving and restoring large landscapes and working lands, and (3) enhancing rivers and waterways by improving physical access and restoring riparian areas. Using examples from the Chesapeake Bay and the Everglades, and discussing national support for sustainable farming within major watersheds, Russ highlighted the need to "keep these working landscapes functioning and sustained, while conserving the important aspects of the outdoors and ecosystem

health."¹⁹ He asked, "From a watershed approach, how do we work together at all levels of government, with watershed associations and other groups, to restore ecosystems, restore habitat, and make them healthier as a system?"

The UWFP is a partnership of 11 Federal agencies, led by the EPA, the Department of the Interior (DOI), and the U.S. Department of Agriculture's (USDA) Forest Service, with a goal to "restore and protect urban water quality, and revitalize and reconnect people to the waterfronts in cities." The question of access is at the center of this initiative, pointing out that while many large cities were historically founded on a major body of water, riverfronts today are often blocked off to citizens, making it difficult to provide access, provide recreation, enhance tourism, build economic opportunity, and encourage new business and industry.

Russ summarized the roles of AGO and UWFP and their abilities to "recognize [the value of] putting communities first, engaging the municipal authorities, the watershed associations, the [nongovernmental organizations] NGOs, and the academic folks, to see what programs are in place, and to see what the Federal authorities can bring to the table to enhance or support [existing] efforts." He asked, "How can we work together collectively to make this a more effective type of program?"

Concluding with an overview of progress to date, Russ described seven pilot programs as part of the UWFP, each of which has one or more Federal cosponsors. He talked about the need for geographic information system (GIS)-based tools to help decision makers compile an inventory of efforts across jurisdictions and to see where there are gaps and where there is a need for added information and collaboration.

Russ noted that on May 10, 2013, 11 new program sites were announced at a launch event in Grand Rapids, Michigan, including the Greater Philadelphia area. Russ credited the leadership of the USDA Forest Service (USFS) in sustaining Philadelphia as a site, with Michael Leff based at the Urban Forest Station as ambassador for the Delaware River Watershed Urban Waters Partnership.

Thinking Holistically and Making Connections

Mark Alan Hughes, School of Design, University of Pennsylvania, discussed his work with the city of Philadelphia developing the Greenworks initiative. He explained Greenworks as a "framework," describing it as "a simplifying tool for decision making in the face of complexity." Expanding on the benefits of the "framework" strategy being more guiding principles than a formalized "plan," he explained how it encourages the alignment of short-term and long-term decisions that are being made simultaneously, among agencies

¹⁹Russ also provided examples of two National Blueways, which are federally designated waterways that USGS sponsors through partnerships of stakeholders focused on river and watershed stewardship.

and partners both inside and outside of city government, while also holding policymakers accountable to target metrics. Reiterating Howard Neukrug, Hughes emphasized that while short-term goals are set for the scope of a two-term mayoral administration, outcomes still need to be understood in context of 25- and 50-year frameworks. He explained that Greenworks had been “designed to align accountability with power,” addressing the importance of having quantifiable benchmarks, objectives, and structures of accountability.

Hughes went on to discuss three main themes: capacity, scale, and jurisdiction. Describing how the ecosystem services conversation relates to broad-scale sustainability, he stressed the importance of understanding that sustainability is “not just about making and balancing resource allocations, but also about fundamental integrity or resilience of the system.” He stressed the need for the institutional capacity to manage complex urban ecosystems. He also noted the importance of “clearly delineating between ecological phenomena (functions), their direct and indirect contributions to human welfare (services), and the welfare gains that they generate (benefits)” (De Groot and others, 2010). The system’s organization, he suggested, has a necessary spatial component. Recognizing the often artificial construction of physical delineation, he acknowledged the pragmatic benefit of drawing boundaries in order to shape and organize the social and political conversation.

Hughes pointed out the key problem of ecosystem service management: being a mixed public²⁰ good, valuation is uncertain and usage difficult to regulate. Nonetheless, the real trouble with effectively managing ecosystem services, he explained, is not the science, nor the design and engineering, but rather the politics. A critical issue is whether the community has the ability and interest in paying for ecosystem investments. The technical conversation, he claimed, is actually a distraction from the more challenging task of facilitating real institutional change. Crediting the PWD with its innovative approach, he explained that much can be done when a city agency is sufficiently equipped with control of public assets and provided with adequate financial resources. The PWD, he explained, has unlocked the buried value in “the city’s legacy assets.” He described how the PWD has taken what could be seen as a burden or a liability and instead “pivoted urban surfaces into a whole new use.” He closed by saying that the relationship between legacy and innovation, with the PWD being an exemplar of such innovation, is critical to enabling cities like Philadelphia to thrive. Arbitrating its legacy assets is a relatively low-cost way to accomplish environmental and economic gains that would otherwise appear impossible.

²⁰Mixed public goods incorporate both elements of public goods (a commodity or service that is provided without profit to all members of a society, either by the government or a private individual or organization) and private goods (“an item that yields positive benefits to people” that is excludable; that is, its owners can exercise private property rights, preventing those who have not paid for it from using the good or consuming its benefits) (EconPort Handbook, 2006).

Urban Green—Managing Forests, Trees, and Greenspace

This panel focused on how public agencies and nonprofit organizations are building capacity for managing and valuing green infrastructure, particularly green places and tree canopy, within an urban context. Focusing on the emerging roles of the USFS and the Pennsylvania Horticultural Society (PHS) in their efforts to grow and manage Philadelphia’s tree canopy, panelists covered topics of tree planting, sustainable harvesting, community capacity building, and data collection and analysis. Additionally, a series of mapping tools being developed by the EPA were presented in the context of providing integrated and innovative tools for decision making, planning, and spatial analysis. Led by moderator Emily Pindilli, USGS Science and Decisions Center, presentations were made by Michael T. Rains, Director, Northern Research Station, USFS; Laura Jackson, Research Biologist, Sustainable and Healthy Communities Research Program, EPA; and Nancy Goldenberg, Senior Vice President for Programs, PHS.

Michael T. Rains accentuated the importance of the urban dimension in the overall concept of ecosystem services: services need to be provided to people where they live. Today, 83 percent of Americans live in urban areas. Rains discussed the evolving role of the USFS and its focus on Urban Natural Resources Stewardship (UNRS), a comprehensive approach to caring for the land and serving people in towns and major metropolitan areas. Rains noted that there are about 851 million acres of forest across our country and that 103 million of these acres are classified as urban forests—almost as much as all the national forests combined. Urban forests are a critical part of America’s landscape and these forests produce a variety of valuable services, including clean air and water, low energy costs, watchable wildlife habitat, stormwater protection, open space, and recreation. Reinforcing the importance of UNRS, Rains talked about the need to address social well-being through urban resource management—identifying the positive links between environmental health and community stability as a result of sound urban natural resource stewardship. Rains spoke about the growing focus and support being directed toward the stewardship of urban areas. He described UNRS as a cohesive, comprehensive approach, focusing not only on the trees, but also on community engagement and economic development. Rains emphasized the importance of the partnerships discussed by David Russ, specifically highlighting the UWFP for its promotion of “banding together, sharing resources, and avoiding duplication” to help improve people’s lives. Rains referred to the UWFP as a “conservation legacy event” and urged us to “think big to act big.”

Laura Jackson (EPA) presented a new Web-based GIS data tool, EnviroAtlas,²¹ which is designed to provide deci-

²¹The community component provides detail for select cities at a local level, summarizing data by block group to show the availability, accessibility, and beneficial qualities of natural amenities in the area. Precompiled analytics are included to provide information about proximity to green space, exposure

sion makers and researchers with a map-based resource for understanding and valuing ecosystem services (released as a beta version in June 2013; fig. 4). Emphasizing the link between ecosystem services and human health and well-being, Jackson pointed out EnviroAtlas's Community component, which presents data at a finer geographic scale, compiled with a variety of metrics for valuing ecosystem benefits.²² She highlighted the value of this component for its relevance to issues of environmental justice, equity, and civic empowerment. Jackson referred to the EnviroAtlas's integration of tools to develop its datasets and analysis—like iTree²³ (which illustrates value derived from the urban tree canopy), BenMap²⁴ (which illustrates the health benefits of air pollution reductions), and the Eco-Health Relationship Browser²⁵ (which illustrates the directional links between human health and ecosystem services)—and indicated the process of sourcing data from local municipalities, institutions, and community groups and organizations. EnviroAtlas is currently in its first stage of development, which is the compilation of data and construction of metrics in an integrated, usable, and accessible format. The second stage will be to learn and improve upon how communities can be empowered by access to such information and how this information can support local and regional decision making and research. Jackson highlighted two core goals of the community component of EnviroAtlas:

to air pollution, capacity of vegetative cover to address water-quality and heat-island effects, and health benefits and avoided costs due to air-quality improvements gained from tree cover. Through the use of aerial imagery and other software tools, the EPA explains that these analyses “illustrate the protective and health promotional benefits of natural resources, and how their loss or degradation may be contributing to cumulative burdens on community health and well-being.” (<http://www.epa.gov/research/priorities/docs/enviroatlas-community-factsheet.pdf>)

²²The community component provides detail for select cities at a local level, summarizing data by block group to show the availability, accessibility, and beneficial qualities of natural amenities in the area. Precompiled analytics are included to provide information about proximity to green space, exposure to air pollution, capacity of vegetative cover to address water-quality and heat-island effects, and health benefits and avoided costs due to air-quality improvements gained from tree cover. Through the use of aerial imagery and other software tools, the EPA explains that these analyses “illustrate the protective and health promotional benefits of natural resources, and how their loss or degradation may be contributing to cumulative burdens on community health and well-being.” (<http://www.epa.gov/research/priorities/docs/enviroatlas-community-factsheet.pdf>)

²³“Through a partnership with the USDA Forest Service, EnviroAtlas leverages i-Tree, an ecosystem services calculation toolkit, to produce some of the community metrics. I-Tree helps identify the extent to which trees and other natural infrastructure meet community needs and where the availability of these assets falls short.”

²⁴BENmap is a map-based software, developed by EPA, designed to model estimated health and economic impacts related to changes in air quality. For more information, visit <http://www.epa.gov/air/benmap>.

²⁵The EnviroAtlas interactive mapping tool adds a visual and spatial component to the existing Eco-Health Relationship Browser (<http://www.epa.gov/research/healthscience/browser/index.html>), which is a catalogue of scientific research, systematically organized to illustrate directional pathways of how natural ecosystems contribute benefits to human health and well-being.

(1) to help communities assess the current and potential role of “green infrastructure” to mitigate hazards and promote health, and (2) to work with cities to produce useful data for on-the-ground analyses. She also pointed out the need to gather feedback from a range of users (of varying skill, knowledge, and discipline). The project is currently being launched in six pilot communities. Fifty cities, including Philadelphia, are slated for inclusion by the end of 2017.

Nancy Goldenberg introduced the role of the PHS, describing the focus of their programs on “gardening, greening, and learning” with the goal of improving quality of life by “creating a sense of community through horticulture.” The PHS contributes to greening efforts throughout the city through tree plantings and vacant lot maintenance. Greening lots has been determined to impact communities broadly by reducing crime, increasing property value, and improving neighborhood conditions. The PHS Philadelphia LandCare program has performed the greening of 7.8 million square feet of select vacant lots by removing debris, planting grass and trees, building fences, and performing regular maintenance every 2 weeks.²⁶ Goldenberg described the PHS focus on growing the city’s tree canopy through its partnerships with TreeVitalize and TreePhilly to work toward the “Plant One Million” campaign across 13 counties in southeastern Pennsylvania, New Jersey, and Delaware (fig. 5). Goldenberg pointed to the urgency of urban tree canopy loss in recent decades.²⁷ She described the efforts of the TreeTenders program, a volunteer training program that equips residents with the skills, tools, and supplies to plant and maintain trees across the city; the program is credited with planting 15,000 trees and shrubs annually. Involvement by resident tree tenders, she explained, spiked between 2005 and 2012 (corresponding with the Nutter Administration and the development of Greenworks). In addition to growing the tree canopy, the program promotes community belonging by strengthening residents’ sense of ownership and pride in their neighborhoods. The PHS is expanding local incentives and continues to develop partnerships throughout the region, including those with the Urban Field Station of the Forest Service in Philadelphia. This is an important accomplishment for the PHS, given its long-term role as a steward of greening efforts in the region.

²⁶The PHS has also partnered with the Philadelphia Parks & Recreation’s TreePhilly program, the New Jersey Tree Foundation, the Delaware Center for Horticulture, The Phillies, Aramark, and the Department of Conservation and Natural Resources TreeVitalize program to plant trees around the region. Researchers at Penn Medicine conducted a randomized control study to evaluate the impact of the PHS’s greening efforts on neighborhoods’ conditions, finding that the greening of vacant lots was associated with reductions in crime and improvements in perceptions of safety.

<http://phsonline.org/greening/landcare-program>

http://www.uphs.upenn.edu/news/News_Releases/2012/08/vacant/

<http://injuryprevention.bmj.com/content/early/2012/08/06/injuryprev-2012-040439.full>

²⁷Between 1985 and 2000, the region’s tree canopy declined by 1.5%. http://www.systemecology.com/4_Past_Projects/AF_DelawareValley.pdf

10 Urban Ecosystem Services and Decision Making for a Green Philadelphia

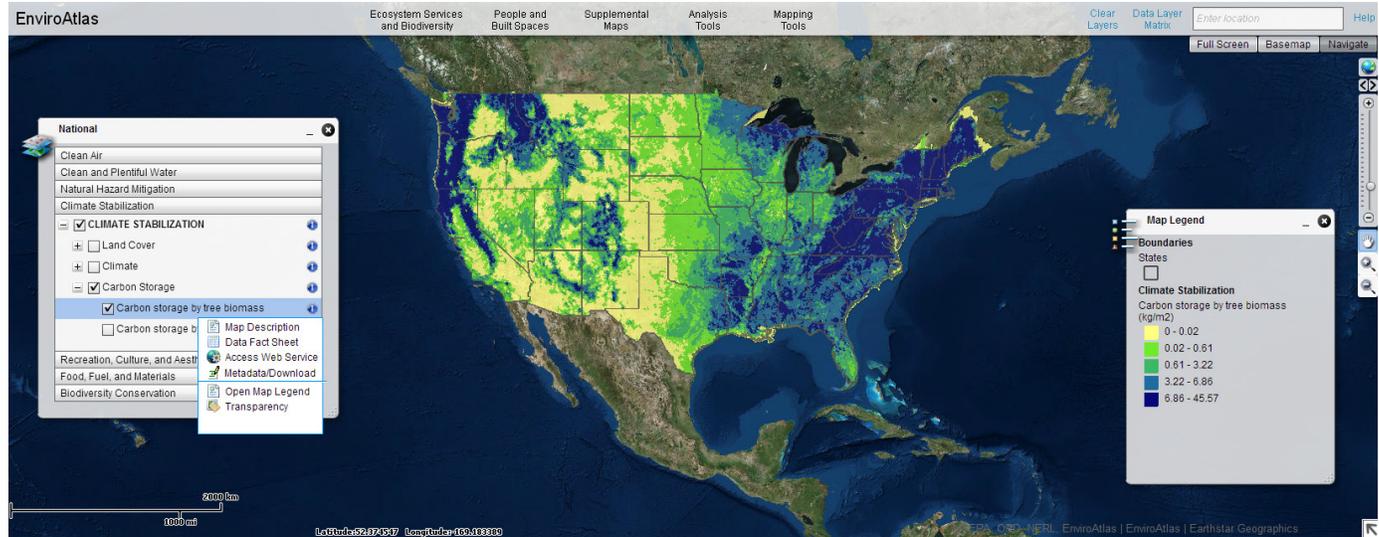


Figure 4. EnviroAtlas, Web-based interactive mapping tool. Source: <http://www.epa.gov>.

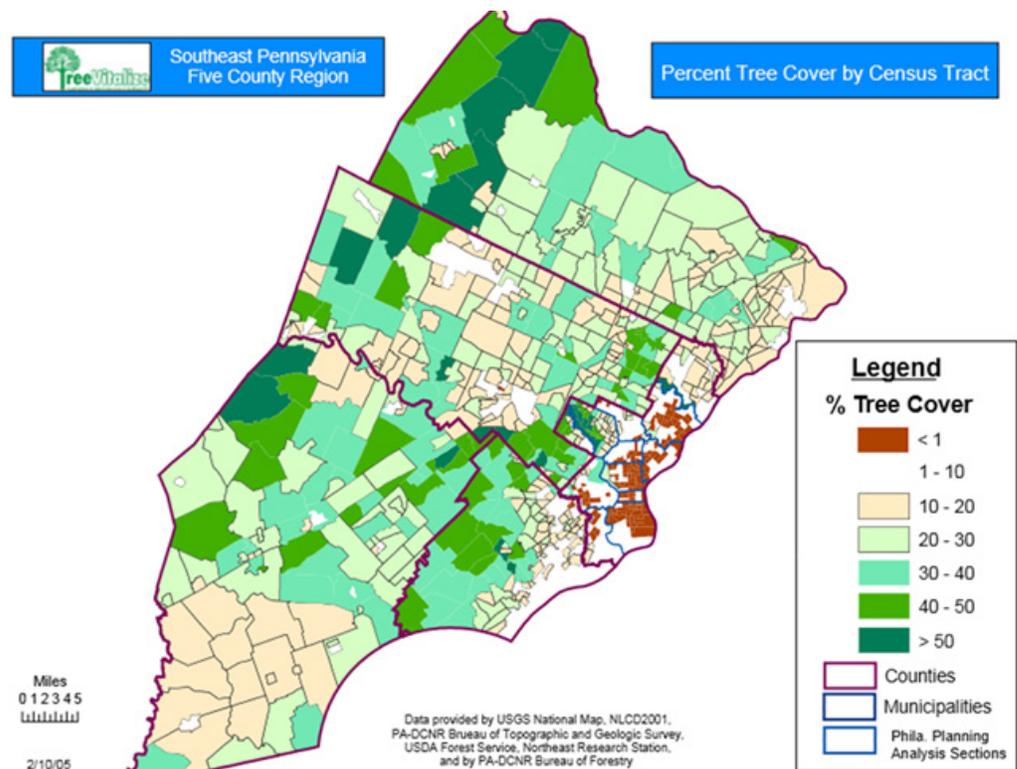


Figure 5. Percent tree cover by census tract, southeastern Pennsylvania, five-county region. Source: PHS, Nancy Goldenberg, panel presentation slide.

Establishing an Urban Research Agenda for Decision-Ready Science—Priorities and Opportunities

This panel, moderated by Dianna Hogan, USGS SILUS Co-Director, focused on existing and emerging research on valuing urban ecosystem services and aimed at initiating a conversation about the gaps, growing needs, and direction of future research. Sarah Low, Coordinator, Philadelphia Field Station, USFS; Kathleen Wolf, Research Social Scientist, University of Washington; and Christopher Crockett, Deputy Water Commissioner, PWD, made presentations.

Sarah Low discussed the need to create a “feedback loop,” where research guides practice, which then informs further research. Recognizing the theme of the day—how science can inform policy—she asked the following questions: Who is making decisions? Who is doing the research? Are they communicating? What spatial scale and level of detail are used? Low focused on the need for data and presented an example of a division between decision makers and researchers that led to inefficiency and resulted in trees dying, due to our lack of knowledge of species and local context. She talked about the iTree tool²⁸ and the importance of developing an inventory and valuation system for ecosystem services and the benefits of trees. She explained that documenting what a forest is worth may help justify efforts to protect that forest.²⁹ She described the process of developing a valuation system by turning a science-based method into a practical tool that can then be applied and implemented by the community. Low discussed other tools used to analyze urban tree cover, in addition to iTree, such as lidar and remote sensing. She closed by asking, “How do we address issues of equity when talking about economic value?” She also pointed to the developing UWFP collaboration, as not only facilitating a conversation but also promoting actions that hopefully will be guided by science.

Kathleen Wolf provided an overview of research on cultural ecosystem services, including amenity and aesthetic benefits, wellness support, and “environmental fitness.” These services are particularly important in urban areas, Wolf noted, as the aesthetic and cultural value of nature have an especially high impact where access to nature is limited. Wolf’s

presentation explored both existing knowledge and research gaps in the field. She reflected on the recent growth in cultural ecosystem services research, noting that over 2,000 articles on the topic have been written across numerous disciplines, ranging from the health benefits of outdoor activities to the healing and therapeutic benefits of exposure to nature.^{30, 31}

Wolf also described “hyperfunctional landscapes” that provide multiple ecosystem services in urban areas, making the point that nature is very good at “multitasking.” These areas may be created to attract people, limit crime, and improve urban safety, while providing stormwater management.

Wolf concluded with a review of future research needs, including: (1) developing a causal understanding about the positive effects of nature on human well-being, rather than the prevailing correlational assessments; (2) improving ecosystem hyperfunction by better integrating the use of green spaces as green infrastructure by design; and (3) providing comprehensive economic assessments of the benefits and costs of human health and well-being impacts.

Christopher Crockett presented the final part of the panel, expanding on Howard Neukrug’s earlier presentation by providing research questions related to the multidimensional approach taken by Philadelphia in its stormwater management and greening initiatives. He pointed to unknowns in the logistics of designing and constructing the city’s green stormwater infrastructure (designed to achieve the outcomes of the Green City, Clean Rivers program). He spoke about the importance of understanding the response of the private sector and, in particular, of property developers, to regulation and incentives. He explored how to best encourage private builders to adopt various alternative practices. He also expressed the importance of learning from pilot programs to better understand and to advance the outcomes of innovative aspects of engineering urban landscapes, streetscapes, and building designs. He emphasized the need for empirical evidence to back up anecdotal observation. Pointing out the potential indirect benefits from various landscape improvements, he gave an example of a porous pavement basketball court that is dry and usable following a storm; it also is significantly cooler during the heat of the summer. He posed the question, “Could we have sensors to measure that?” He spoke about understanding and needing to assess benefits at various scales, explaining varying points of impact from street corner to street block to a neighborhood of

²⁸i-Tree is a software suite developed by the USFS to support urban forest management. These tools aid communities in gaging and quantifying the benefits of trees in their ecosystems. i-Tree provides baseline data that can be used to model the value of urban tree canopy, through metrics pertaining to forest structure, pollution removed from the air, health and economic improvements, carbon storage, rainwater management, and so forth. i-Tree is peer-reviewed and can be freely downloaded (<http://www.itreetools.org/>).

²⁹The i-Tree tool sets have been used by communities throughout the United States and internationally, to evaluate regional-, neighborhood-, and street-level benefits of urban tree cover. These evaluations have been incorporated into regional plans and resource assessments to analyze the value and effect of urban forests, by identifying trees contributing to improvement, such as air quality, climate regulation, energy efficiency, real estate value, and recreational and aesthetic appeal.

³⁰To provide a history of ecosystem services research, a collaboration between the University of Washington and the USFS has resulted in the development of the *Green Cities, Good Health* Web site (<http://depts.washington.edu/hhwb/>), which provides resource managers, policymakers, and citizens an online repository of information about public health, urban greening, and other cultural ecosystem service benefits.

³¹In particular, Wolf pointed to attention restoration theory (citing the work of Rachel and Stephen Kaplan at the University of Michigan), exploring how people experience nature and how time spent in a natural setting or even with a view of nature from an office can have positive benefits—commonly understood as nonuse value.

blocks, and asked, “What is the critical mass for making real impact in a regional ecosystem?”

He went on to reinforce Neukrug’s point that community, businesses, residents, and other stakeholders are key to creating value and sustaining and maintaining green infrastructure investments for the long run. Putting the question in historical context and emphasizing a long-term vision, he said, “. . . we have [had] a [functioning] pipe in south Philadelphia from 1840. . . Can we plan to have [living] trees [and functioning] pipes and bump outs in 100–200 years?”

Dianna Hogan (USGS) focused on the development of an agenda for future research on valuing urban ecosystem services. Several general themes emerged. Participants expressed the need to develop research projects around incentives to encourage the implementation and financing of green infrastructure, and on engagement with public and private sector leaders and with the general public. Participants highlighted the need to develop additional measurement tools to estimate the value of urban ecosystem services, particularly for public health and community vitality outcomes. They identified the following specific recommendations:

4. Develop methods, tools, and databases to measure ecosystem services provided in urban areas. These measures should leverage the use of existing datasets already gathered by Federal agencies.
5. Create a virtual space for urban ecosystem services practitioners and researchers to share best practices, case studies, and methods to value and advance investments in urban ecosystem services, and to inform decision makers and to engage the public.

Going Forward: Developing a Research Agenda and a Community of Practice

The symposium provided an opportunity to better understand urban ecosystem services and how they can be incorporated into urban decision making and planning. Participants emphasized an integrated approach and community engagement, highlighting interagency and community-based programs currently underway. Bringing together practitioners and researchers, the symposium offered participants an opportunity to envision the holistic role urban ecosystem services can play in creating sustainable and resilient cities. The symposium also offered approaches for applying that vision in practical and pragmatic ways. While long-term planning was recognized as important, learning from ecosystem management experiences and translating new information into adaptive decision making was also highlighted.

Because ecosystems are inherently intertwined, the symposium identified efforts already in place to address water quality and improve urban tree canopies as two components in a broad overarching goal. Green infrastructure can produce

multifunctional landscapes that serve stormwater management goals, while also providing recreational spaces for residents, as well as a host of indirect benefits (including air quality, temperature control, real estate value, and psychological benefits). Multifunctional and interdependent ecosystems make measurements complex; nonetheless, building a scientific foundation to allow cities and regions to account for the magnitude of benefits being produced and their value within and beyond their boundaries is critical for incentivizing and financing the efficient production of urban ecosystem services.

While identifying innovative practices and advances in knowledge currently underway, symposium participants pointed to potential gains to be made by addressing knowledge gaps. Research advances are needed to: (1) better identify and measure values of natural and developed landscapes; (2) better understand the biophysical production of urban ecosystem services; and (3) better account for their role in people’s economic and social well-being in urban areas and beyond. In particular, understanding the interrelationship of urban ecosystem services across spatial scales needs to be improved. Enhancing the knowledge base in these areas is a first step for better informed decision making within and across political jurisdictions.

Considering urban ecosystem services in public and private decision making related to restoring, revitalizing, and protecting natural resources is critical to the ongoing sustainability and well-being of Philadelphia and other cities. The provision of, and benefits from, urban ecosystem services often transcend city boundaries, and it is critical that we advance our understanding of the flow of these services.

Key questions for local, regional, and national decision makers are: (1) how to create more livable places through enhancing urban ecosystem services; (2) how to incentivize and finance the production and use of these services; and (3) how to manage and improve urban ecosystem services that require regional levels of cooperation that cross agencies and levels of government. As the global population becomes increasingly urban, knowledge advances in these areas become even more important.

The discussion and findings of this symposium highlight the need for expanding knowledge in key research areas and point to the importance of developing a national research agenda. The following research topics are critical to these efforts, based on the following findings from the symposium: (1) the impact on nature and society of enhancing urban ecosystem services and replacing grey infrastructure with green infrastructure; (2) consistent methods of identifying, describing, and measuring values from natural and developed landscapes that cut across diverse groups of stakeholders; (3) practices derived from management experiences and that incorporate new information into adaptive decision making; (4) development of incentives to encourage efficient behavior that considers benefits from nature that are not apparent in markets; and (5) methods and measures of urban system resilience and how connections between developed and natural landscapes can enhance ecological and societal resilience.

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Appendix 1: Agenda

Urban Ecosystem Services and Decision Making: A Green Philadelphia

May 23, 2013

8:30 a.m.–4:00 p.m.

8:30–9:00 **Registration**

9:00–9:30 **Session 1: Welcome and Context**

Susan Wachter, The Wharton School, University of Pennsylvania, Spatial Integration Laboratory for Urban Systems (SILUS) Co-Director

Katherine Gajewski, Director of the Philadelphia Office of Sustainability

Carl Shapiro, Director, Science and Decisions Center, U.S. Geological Survey (USGS)

9:30–10:00 **Session 2: Morning Speakers**

Our Goals for a Green Philadelphia: What We Can and Must Achieve, **Michael DiBerardinis**, Deputy Mayor, City of Philadelphia

Science and Urban Ecosystem Services: A National Perspective, **Bill Werkheiser**, Acting Deputy Director, USGS

10:00–10:15 **Break**

10:15–11:45 **Session 3: Urban Water—Managing Stormwater, Rivers, and Watersheds**

Moderator: Susan Wachter, SILUS Co-Director

Howard Neukrug, Water Commissioner, Philadelphia Water Department (PWD)

Tom Daniels, School of Design, University of Pennsylvania

David Hsu, School of Design, University of Pennsylvania

11:45–1:15 **Lunch sponsored by Penn Institute of Urban Research (Penn IUR)**

Session 4: Lunch Speakers

America's Great Outdoors and Urban Waters Initiative, **David Russ**, Regional Director, Northeast, USGS

Thinking Holistically and Making Connections, **Mark Alan Hughes**, School of Design, University of Pennsylvania

1:15–2:15 **Session 5: Urban Green—Managing Forests, Trees, and Greenspace**

Moderator: Emily Pindilli, Science and Decisions Center, USGS

Michael T. Rains, Director, Northern Research Station, U.S. Forest Service (USFS)

Laura Jackson, Research Biologist, Sustainable & Healthy Communities Research Program,
U.S. Environmental Protection Agency

Nancy Goldenberg, Senior Vice President for Programs, Pennsylvania Horticultural Society

2:15–2:30 **Break**

2:30–3:50 **Session 6: Establishing an Urban Research Agenda for Decision Ready Science—Priorities and Opportunities**

Moderator: Dianna Hogan, USGS, SILUS Co-Director

Sarah Low, Coordinator, Philadelphia Field Station, USFS

Christopher Crockett, Deputy Water Commissioner, PWD

Kathleen Wolf, Research Social Scientist, University of Washington

3:50–4:00 **Closing Remarks: Susan Wachter and Dianna Hogan**

Appendix 2: Speaker Biographies

Session 1

Susan Wachter is the Richard B. Worley Professor of Financial Management and Professor of Real Estate and Finance at The Wharton School of the University of Pennsylvania. She is the Co-Director of the Penn Institute for Urban Research, along with Eugénie L. Birch, with whom she edited the volume *Growing Greener Cities* (Penn Press, 2008). At Penn, she is also Founder and Director of the Wharton GIS Lab and the Wharton Geospatial Initiative and Co-Director of the Spatial Integration Laboratory for Urban Systems (SILUS), a collaborative with the U.S. Geological Survey (USGS). As Assistant Secretary for Policy Development and Research at the U.S. Department of Housing and Urban Development (HUD) from 1998 to 2001, she was responsible for national housing and urban policy. During that time, she served as a member of the White House Interagency Taskforce on Livable Cities and directed the Partnership for Advancing Technology in Housing for the development of sustainable design in housing. She is currently an investigator in the Department of Energy (DOE)-funded Energy Efficient Building Hub. The author or editor of over 200 publications, she is a past president of the American Real Estate and Urban Economics Association and past editor of "Real Estate Economics." Among her recent articles is "What is a Tree Worth? Green-City Strategies and Housing Prices."

Katherine Gajewski is the Director of Sustainability for the City of Philadelphia. She leads the Mayor's Office of Sustainability and is responsible for coordinating the implementation of Greenworks Philadelphia. In this role, she works with city government partners and external stakeholders to advance progress across 15 targeted goals. Since Mayor Nutter launched the plan in 2009, Greenworks has received broad support within Philadelphia, has garnered national and international attention, and has positioned Philadelphia as a leader in urban sustainability. Gajewski is also the Director of Energy-Works, a comprehensive energy solutions program for home and commercial building owners in the Philadelphia region. She is active nationally as Co-Chair of the Urban Sustainability Directors Network, a professional network of municipal government sustainability professionals.

Carl Shapiro is the Director of the Science and Decisions Center (SDC) at the USGS. The SDC advances the use of science in public policy decisions and focuses on research and applications in decision science, ecosystem services, and sustainability and resilience. Between 1987 and 2005, Shapiro was the Principal Economist in the Office of the Director at the USGS. There he led numerous studies and initiatives on science and policy, natural resource management, and natural hazards. Shapiro also is Adjunct Associate Professor of Economics in the School of Public Affairs at American University in Washington, D.C.

Session 2

Michael DiBerardinis is Deputy Mayor for Environmental and Community Resources in Philadelphia. DiBerardinis is also Commissioner of the Parks and Recreation Department, as well as Special Advisor to the Mayor on the Free Libraries. DiBerardinis has overseen the merger of the Fairmount Park Commission and the Department of Recreation, which became effective July 1, 2010. He is a graduate of Saint Joseph's University with a bachelor of arts in political science.

Bill Werkheiser is the Acting Deputy Director, USGS, and has served in a number of USGS management positions, including USGS Regional Director for the Eastern Region. He also led the Natural Hazards Initiative Team and the Long-term Hurricane Katrina Response and Recovery Team for the USGS. He has over 25 years of experience with the USGS and other agencies working on a variety of environmental and scientific issues.

Session 3

Howard Neukrug is Chief Executive of Philadelphia's Water Utility and is responsible for providing safe and affordable drinking water and integrated wastewater and stormwater services to over 2.3 million people. Neukrug is a national leader for urban sustainability and the creator of Philadelphia's Green City, Clean Waters program. He is a Professional Engineer, Board Certified Environmental Engineer, and a graduate in civil and urban engineering from the University of Pennsylvania, where he currently teaches a course on Water, Science, and Politics.

Tom Daniels is a Professor in the Department of City and Regional Planning at the University of Pennsylvania, where he teaches Environmental Planning, Land Use Planning, Growth Management, and Land Preservation. Daniels holds a B.A. in economics from Harvard, an M.S. in agricultural economics from the University of Newcastle (UK), and a Ph.D. in agricultural economics from Oregon State University. He has taught in planning departments at Iowa State University, Kansas State University, and the State University of New York at Albany. For 9 years, he was Director of the Agricultural Preserve Board of Lancaster County, Pennsylvania, where he managed the county's nationally recognized purchase of development rights program. Daniels is the author of "When City and Country Collide: Managing Growth in the Metropolitan Fringe" and coauthor of "Holding Our Ground: Protecting America's Farms and Farmland," "The Small Town Planning Handbook," "The Environmental Planning Handbook for Sustainable Communities and Regions," and "The Planners Guide to CommunityViz." Daniels often serves as a consultant to State and local governments and land trusts. Recently,

he was a copresenter at a planner training session on green infrastructure for the American Planning Association. He also has recently consulted for the Delaware Riverkeeper on land use and water-quality issues relating to Marcellus Shale development. He is currently working on the second edition of “The Environmental Planning Handbook” for the American Planning Association.

David Hsu is an Assistant Professor in the Department of City and Regional Planning at the University of Pennsylvania. He studies how environmental policy is implemented in cities. Topics of particular interest include energy and water networks, policies to encourage green buildings, and how implementation of these policies is affected by improving data and analysis tools. He is currently working on a paper, based on data from the U.S. Environmental Protection Agency (EPA), which summarizes the state of green infrastructure efforts in the United States. He is also working on a number of papers with the DOE’s Efficient Buildings Hub on how information tools can inform regulations and overcome barriers to energy efficiency in the real estate market.

Session 4

David Russ is the Regional Director for the Northeast in the USGS. He is located at the USGS National Center headquarters in Reston, Virginia. A geologist by training, he leads 11 USGS science centers in the Mid-Atlantic and New England regions. These centers conduct a broad range of geologic, biologic, and hydrologic investigations and studies. In his current position as Regional Director for the Northeast, Russ serves as the executive leader of the USGS Chesapeake Bay program and he leads USGS participation on the Northeast Regional Ocean Council and the Mid-Atlantic Region Council for the Ocean. He has served as the Department of the Interior representative to the steering committee to develop a Federal multiagency research plan for unconventional oil and gas resources related to hydraulic fracturing, and he is overseeing the development of an interagency plan to study the potential effects of Appalachian shale gas production on the environment. He is a member of the Appalachian Landscape Conservation Cooperative steering committee, chairs the Stakeholder Advisory Committee of the Northeast Climate Science Center, and coordinates USGS participation in the UWFP. Russ received his B.S. (1967) and Ph.D. (1975) degrees from Penn State and an M.S. degree (1969) from West Virginia University, with specialties in geomorphology and structural geology.

Mark Alan Hughes is a Professor of Practice at the University of Pennsylvania’s School of Design and Director of Sustainability Innovation and Policy in the Office of the Vice Provost for Research. He is a Faculty Fellow of the Penn Institute for Urban Research, a Senior Fellow of The Wharton School’s Initiative for Global Environmental Leadership, and a Distinguished Scholar in Residence at Penn’s Fox Leadership

Program. He was Chief Policy Adviser to Mayor Michael A. Nutter and the founding Director of Sustainability for the City of Philadelphia, where he led the creation of the Greenworks Plan. Hughes holds a B.A. from Swarthmore and a Ph.D. from the University of Pennsylvania in regional science. He has published in leading journals in the fields of economic geography, urban economics, political science, policy analysis, and has won the National Planning Award for his research in city and regional planning. He has designed and fielded national policy efforts in a variety of areas, including the Bridges to Work program in transportation, the Transitional Work Corporation in job training and placement, and the Energy Efficient Buildings Hub in regional economic development. This work has been funded by HUD, the U.S. Department of Health and Human Services, DOE, the Ford Foundation, The Rockefeller Foundation, Pew Charitable Trusts, William Penn Foundation, and others.

Session 5

Emily Pindilli is an economist in the USGS Science and Decisions Center, where she specializes in the value of information, integrated environmental and economic analyses, and providing tools for science-based decision making. Pindilli joined the Survey in 2012 having previously worked in Federal government consulting, providing decision analytics in the areas of energy, transportation, and the environment. She has an extensive background in conventional, unconventional, and alternative fuels; in environmental science and management; and in benefit-cost and regulatory impact analysis. Notably, Pindilli has led analyses evaluating the vulnerability of the Nation to crude oil import disruptions; the value provided by Landsat geospatial data; the sustainability of biofuels investments; and the monetized mobility, safety, and environmental benefits of connected vehicles. She is particularly interested in nontraditional, nonmarket benefits assessment. Pindilli received her bachelor’s degree in economics and political science from James Madison University, a master’s degree in environmental science and policy from George Mason University, and is pursuing a Ph.D. from George Mason University in environmental policy, focusing on environmental economics.

Michael T. Rains has had an accomplished 45-year career with the U.S. Forest Service (USFS), focusing on land stewardship. Rains has developed and implemented successful programs across a wide range of landscapes and of large, complex organizations. He currently directs the world’s largest research organization—the Northern Research Station and the Forest Products Laboratory—helping forest landowners manage, protect, and use their rural and urban forests through leading-edge scientific discovery and technology development. Rains leads 140 scientists and 23 experimental forests throughout a 24-State region. He holds a master’s degree in secondary education and teaching certifications in Pennsylvania in Science and Math, a master’s degree in science in

watershed management from Humboldt State University, and a bachelor of science degree in forest management from Humboldt State University. He is a respected national leader in linking environmental health with community stability with significant experience in congressional affairs, strategic planning, partnership development, and communications. Rains has been a member of the Senior Executive Service since 1986. He proudly started his career as a wildland firefighter for California in the mid-1960s. Rains received the Presidential Rank Award in 2011.

Laura Jackson is a landscape ecologist with the EPA's Office of Research and Development in Research Triangle Park, North Carolina. She is a principal investigator in the Sustainable and Healthy Communities Research Program, leading the high-resolution component of the EnviroAtlas online national mapping tool. Her research has explored the links between ecosystem services and human well-being, the landscape ecology of urbanizing areas, and the effects of the built environment on ecological and public health. Current research includes exploring the effects of near-road and neighborhood tree cover on birth weight, associating Lyme disease with forest fragmentation metrics, and characterizing sprawl for EnviroAtlas. Previous research has addressed ecological indicator development, environmental monitoring and assessment, and landscape change analysis. Her record demonstrates a facility for cross-disciplinary synthesis; her recent publications have appeared in ecology, epidemiology, and urban planning journals, and medical and remote-sensing textbooks. Jackson has developed and led research and performed research management and strategic planning for the EPA since 1990. She received her undergraduate degree from Bryn Mawr College, a master's degree in environmental management from Duke University's School of Forestry and Environmental Studies, and a Ph.D. in ecology from the University of North Carolina-Chapel Hill.

Nancy Goldenberg is Senior Vice President of Programs and Planning at the Pennsylvania Horticultural Society (PHS), where she manages and develops programs for the Nation's largest horticultural society, including initiatives related to urban gardening and building sustainable communities through innovative greening activities and civic engagement. At the PHS, she also manages the planning and development of design and enhancements to significant landscapes and streetscapes and oversees the tracking of policies and legislation that impact greening, gardening, and educational initiatives related to the work of the PHS. Prior to arriving at the PHS in October 2012, Goldenberg served as Vice President of Strategic Planning for the Center City District for 12 years, where she was responsible for the planning, fundraising, and renovation of several downtown public spaces, including Three Parkway Plaza, Sister Cities Park, Collins Park, and Dilworth Plaza. For 4 years, she also served as Director of Public Information for the Center City District. Between 1997 and 2000, Goldenberg worked for the Fairmount Park Commission

as Program Administrator for a \$26.6 million, nationally recognized initiative to restore the natural areas of Philadelphia's municipal park system and establish a comprehensive system of volunteer stewardship. Today, she serves as Chair of the Philadelphia Commission on Parks and Recreation. Goldenberg is a graduate of the University of Pennsylvania's School of Design, where she earned her master's degree in city planning. She did her undergraduate work at George Washington University. Goldenberg currently serves on the board of PennPraxis, the Fairmount Park Conservancy, the Neighborhood Gardens Trust, and the City Parks Alliance. She is the founder of Outward Bound Philadelphia and has completed eight Outward Bound courses throughout the world.

Session 6

Dianna Hogan is a Research Physical Scientist with the USGS Eastern Geographic Science Center in Reston, Virginia. Her research focuses on ecosystem services and the environmental effects of urban land use on natural systems. She is Co-Director of SILUS, a collaboration between the USGS Science and Decisions Center and the Wharton GIS Lab at the University of Pennsylvania. Her current research includes an assessment of the ability of urban stormwater Best Management Practices (BMPs) in the Chesapeake Bay Watershed to mitigate water quality, quantity, and flow; investigating how environmental data and a consideration of ecosystem services is used in ongoing land use decision making in an urbanizing area; and the exploration of the development of ecosystem service production functions in urban watersheds. Recent projects include the development of an ecological value model to support land use decision making in south Florida and serving on the organizing committee for A Community on Ecosystem Services (ACES 2008), as well on the planning committee as a program manager for ACES 2010 and ACES 2012. She received a B.S. in biochemistry, an M.S. in biology, and a Ph.D. in environmental science and public policy.

Sarah Low works for the USFS as Coordinator of the Philadelphia Field Station. She focuses on bridging the gaps between policy, planning, and science, specifically as it relates to the interaction of people and nature. In her role at the Philadelphia Field Station, Low leads a group of researchers and practitioners who focus on the role trees, forests, and natural resources play in making cities more livable. The group specifically focuses on the ecosystem value of trees and forests, factors that influence tree mortality, socioecological impacts of green infrastructure, and stewardship. The Field Station aims to develop and deliver science that helps decision making on the local and regional levels. Low's passion for the natural world drives her interest in environmental conservation and community engagement. She holds a bachelor of science degree in fish and wildlife conservation and a master of science degree in watershed science and management from the University of Massachusetts Amherst. She has worked

in ecological restoration, community forestry, trail design, stewardship, and park management for over 10 years, and has worked for consulting companies, nonprofit organizations, and government agencies.

Christopher Crockett is the Deputy Commissioner of the Planning and Environmental Services Division at the Philadelphia Water Department (PWD), which is responsible for Green Cities/Clean Waters, capital planning, energy, wet weather, research and development, and laboratory programs at the PWD. Crockett has 20 years of experience in the water, stormwater, and wastewater industry, participating and leading innovative projects to improve customer service, performance, revenue, environmental management, and regulatory compliance. His accomplishments are many and include leading the award-winning source water protection programs, and development and implementation of new stormwater management requirements for development of impervious cover-based stormwater billing for nonresidential customers. He is also a tireless champion for stream restoration and green street efforts. Under Crockett's leadership, his teams continue to help move Philadelphia towards being the greenest city in the country. These efforts include changing the concept of wastewater treatment to include energy and resource recovery initiatives that have created the first full-scale sewer geothermal system in the United States, installed over 1,000 solar panels, recycled over 9 million gallons of aircraft deicing fluid for biogas generation, and resulted in the construction of the 5.6 MW (megawatt) Northeast biogas cogeneration facility that will provide 85 percent of the Northeast wastewater plant's energy needs by harnessing its own biogas. His latest ecosystem research includes understanding the ecosystem services of urban green for not only stormwater, but also climate change resilience and stream and riparian restoration to understand how far urban areas can bring a stream back to "natural" conditions. Crockett received his bachelor's, master's, and doctorate degrees in civil/environmental engineering from Drexel University, where he is also an adjunct professor teaching courses in fluid mechanics, hydraulics, urban hydrology, water quality, and facility design. He is a licensed professional engineer in Pennsylvania.

Kathleen Wolf is a Research Social Scientist with the College of the Environment, University of Washington. She has been a key collaborator with the USFS Pacific Northwest Research Station in the development of a program on urban natural resources stewardship. Since receiving her Ph.D. from the University of Michigan, Wolf has done research to better understand the human dimensions of urban forestry and urban ecosystems. Her studies are based on the principles of environmental psychology; her professional mission is to discover, understand, and communicate human behavior and benefits, as people experience nature in cities and towns. Recent research on connections between urban natural resources and human health and well-being is an effort to expand how we think about cultural ecosystem services in cities. Moreover, she is

interested in how scientific information can be integrated into local government policy and planning. Wolf is a member of the Environmental Design Research Association, the International Society of Arboriculture, the Society of American Foresters, and the Washington State Community Forestry Council, as well as a technical contributor on human well-being to the Sustainable Sites Initiative, and Research Advisor to the TKF Foundation (<http://naturesacred.org/evidence-of-nature-benefits-for-mental-wellness-3/>). She has presented her research throughout the United States, in Canada, Europe, Australia, and Japan. An overview of Wolf's research programs can be found at www.naturewithin.info; additional research findings on Green Cities: Good Health can be found at www.greenhealth.washington.edu.

Appendix 3: List of Participants

Arthur Acoca-Pidole, Spatial Integration Laboratory for Urban Systems (SILUS), The Wharton School, University of Pennsylvania

Alon Abramson, Project Manager of Energy Initiatives, Penn Institute for Urban Research (Penn IUR), University of Pennsylvania

Jennifer Adkins, Executive Director, Partnership for the Delaware Estuary

Paul Amos, SILUS, The Wharton School, University of Pennsylvania

Stuart Andreason, Penn IUR, University of Pennsylvania

Greg Arthaud, National Leader for Ecosystem Services Research, U.S. Forest Service (USFS)

Debbie Beer, Eastwick Friends Neighbors Coalition

Mariana Bergerson, Deputy Refuge Manager, John Heinz National Wildlife Refuge, U.S. Fish and Wildlife Service

Frank Casey, Ecosystem Services Theme Lead, Science and Decisions Center, U.S. Geological Survey (USGS)

Christopher Crockett, Philadelphia Water Department, City of Philadelphia

Tom Daniels, School of Design, University of Pennsylvania

Michael DiBerardinis, Department of Parks and Recreation, City of Philadelphia

Anneclaire De Roos, Associate Professor, Drexel University

Theodore Eisenman, School of Design, University of Pennsylvania

Olivia Barton Ferriter, Deputy Director, Office of Policy Analysis, U.S. Department of the Interior

Katherine Gajewski, Mayor's Office of Sustainability, City of Philadelphia

Sarah Gerould, Staff Scientist, USGS

Pierre Glynn, Chief, Eastern Branch of the National Research Program, USGS

Nancy Goldenberg, Pennsylvania Horticultural Society

Simeon Hahn, Environmental Scientist, National Oceanic and Atmospheric Administration

Dianna Hogan, SILUS, USGS

Amie Howell, Program Coordinator, Delaware National Estuary Program

David Hsu, School of Design, University of Pennsylvania

Laura Jackson, U.S. Environmental Protection Agency (EPA)

Jacqueline Jenkins, Wharton Small Business Development Center, University of Pennsylvania

David Karp, SILUS, The Wharton School, University of Pennsylvania

Michelle Kondo, Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania; Philadelphia Field Station, USFS

Danielle Kreeger, Science Director, Partnership for the Delaware Estuary

David Lange, Chief, Northeast Region Conservation and Recreation Assistance Division, National Park Service

Beth Larry, National Program Lead For Urban Research, USFS

Michael Leff, Urban Research Forester, Ecosystem Services team within the Davey Institute at the USFS Philadelphia Field Station

Sarah Low, Philadelphia Field Station, USFS

Amy Lynch, School of Design, University of Pennsylvania

Maura McCarthy, Friends of the Wissahickon

Erik Meyers, Vice President, The Conservation Fund and Chair, Natural Capital Investment Fund

Amy Miller, Environmental Planner, Delaware Valley Regional Planning Commission

Rachel Muir, Science Advisor, Northeast Region, USGS

Howard Neukrug, Philadelphia Water Department, City of Philadelphia

Matt Nicholson, Landscape Ecologist, EPA, Mid-Atlantic Region

Emily Pindilli, Economist, Science and Decisions Center, USGS

Michael T. Rains, Director, Northern Research Station, USFS

Ramona Rousseau-Reid, Richman, Berenbaum and Associates, PC

David Russ, Regional Director, Northeast Region, USGS

Carl Shapiro, Director, Science and Decisions Center, USGS

Silvia Schmid, Wharton Initiative for Global Environmental Leadership, University of Pennsylvania

Curtis Schreffler, Associate Director for Research and Scientific Investigations, Pennsylvania Water Science Center, USGS

Iliana Sepulveda, wH2O Journal, University of Pennsylvania
Guy Sheets, AMO Environmental Decisions Inc.

Noel Soto, Resource Conservationist, U.S. Department of Agriculture Natural Resources Conservation Service

Susan Wachter, SILUS, The Wharton School, University of Pennsylvania

Richard Weller, Martin and Margy Meyerson Chair of Urbanism and Professor and Chair of Landscape Architecture, School of Design, University of Pennsylvania

Bill Werkheiser, Acting Deputy Director, USGS

Annie Winter, Penn IUR, University of Pennsylvania

Kathleen Wolf, University of Washington

Urban Ecosystem Services and Decision Making: A Green Philadelphia

May 23, 2013

How do we advance the use of science in public decision making and investment in green infrastructure and ecosystem services in urban areas?
 How do we account for nature's role in people's economic and social well-being in urban areas?

