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The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value

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About NRDC

The Natural Resources Defense Council (NRDC) is an international nonprofit environmental organization with more than 1.4 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Bozeman, MT, and Beijing. Visit us at www.nrdc.org and follow us on Twitter @NRDC.

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EXECUTIVE SUMMARY

Green infrastructure—water quality management techniques like green roofs, tree plantings, rain gardens, and permeable pavement—has been proven to help solve major urban stormwater problems and improve the health and livability of neighborhoods. Cities and others have promoted these practices to commercial property owners as a way to improve stormwater management and, in some communities, to reduce stormwater utility bills. But relatively little information has been publicized about the range of benefits that these practices, when used on private property, can provide to commercial property owners and their tenants—until now.

This issue brief explores how the multitude of green infrastructure practices can help advance the bottom line for the commercial real estate sector. It provides illustrative examples for specific building types, based on published research, as well as a summary of key findings from that research.

Commercial properties with well-designed green infrastructure can reap the rewards of higher rents and property values, increased retail sales, energy savings, local financial incentives (such as tax credits, rebates, and stormwater fee credits), reduced life-cycle and maintenance costs, reduced flood damage, reduced water bills, reduced crime, and improved health and job satisfaction for office employees. In fact, green infrastructure and other green building practices are increasingly becoming a quality benchmark for the private sector, because they illustrate a developer's commitment to healthier, sustainable communities and place-making, while creating measurable value added for property owners and tenants alike.

As illustrated below, the cumulative value of these benefits can total in the millions of dollars over a long-term (40-year) planning horizon—far exceeding the potential stormwater utility fee savings and dramatically accelerating the expected payback of green infrastructure investments on commercial properties.

BUILDING EXAMPLES: OFFICE BUILDING, MULTI-FAMILY RESIDENTIAL, AND RETAIL CENTER

The following examples show the potential value of a set of hypothetical green infrastructure retrofits to owners (and tenants) of medium-sized office buildings, midrise apartment buildings and retail centers. In both the office building and apartment building examples, the total present value of benefits approaches $2 million; for the retail center, benefits exceed $24 million, including nearly $23 million of increased retail sales for tenants. These examples clearly illustrate that considering the full range of green infrastructure benefits is essential for making wise investment decisions.

Benefits of green infrastructure for private, commercial property owners

- Increased rents and property values
- Increased retail sales
- Energy savings
- Stormwater fee credits and other financial incentives
- Reduced infrastructure costs
- Reduced costs associated with flooding
- Reduced water bills
- Increased mental health and worker productivity for office employees
- Reduced crime

A note on methodology: The following examples are based on findings from published research and some basic assumptions. For building and property characteristics, we relied on data from the Department of Energy's commercial building benchmark specifications and other online data sources, or made reasonable assumptions. To estimate the potential benefits of green infrastructure for each building type, we applied findings from the literature and/or relied on existing models.

Where the value of a certain benefit is known to be contingent on factors that vary from one city to another—such as electricity rates or the value of local tax credits—we have used data from Philadelphia for illustrative purposes. However, the analysis is intended to be relatively generic in terms of location, such that the basic lessons to be drawn from these examples are broadly applicable nationwide. Further detail on sources and methods is set forth in our full report.

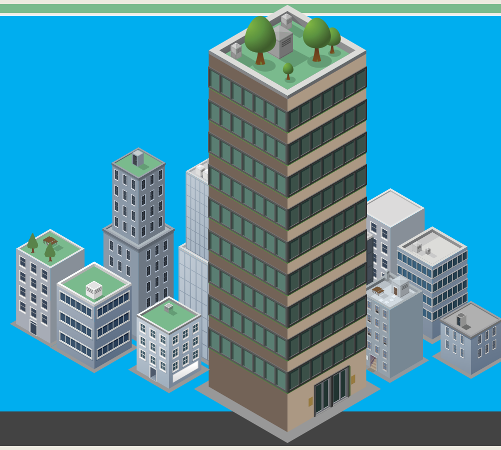
THE BENEFITS OF GREEN STORMWATER INFRASTRUCTURE ON PRIVATE COMMERCIAL PROPERTY

GREEN ROOFTOPS

Apartment buildings with green roofs received a 16% rental premium, according to one study.

Green roofs typically last twice as long as conventional roofs, saving hundreds of thousand of dollars in roof repair/replacement costs.

The green roof on the Target Center Arena in Minneapolis has decreased annual energy costs by $300,000.

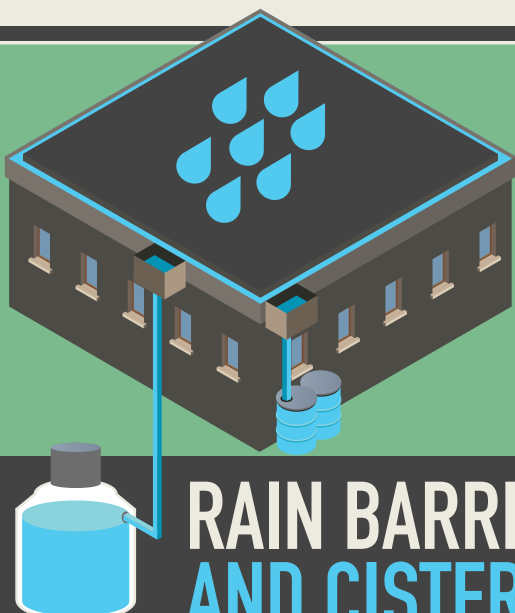


LANDSCAPING
WITH RAIN GARDENS AND BIOSWALES

Well-designed landscaping boosts average rental rates for office buildings by approximately 7 percent

ECO-LABELS

LEED, Sustainable Sites Initiative or other certifications can increase property values, rents, and occupancy rates in commercial office buildings.



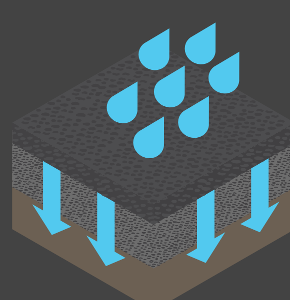
TREE COVER

Trees can reduce building energy demand for heating and cooling by providing shade in summer and blocking wind in winter. Multiple trees on a site can save hundreds of dollars in annual energy costs.

Retail customers are willing to pay 8% to 12% more for products in shopping centers with mature tree canopy.

RAIN BARRELS AND CISTERNS

Capturing rainwater for reuse can help save on water bills for landscape irrigation and other non-potable water uses.



PERMEABLE PAVEMENT

Permeable asphalt, concrete, or paver blocks allow water to seep into gravel and soil below. These systems can have significantly lower maintenance costs than traditional pavement, resulting in lower overall life-cycle costs.

RETAIL CENTER

The figures below present the key assumptions, proposed green infrastructure property improvements, and the resulting benefits for a midsize retail center.

GREEN INFRASTRUCTURE IMPROVEMENTS

40,000-sq.-ft. **green roof**, installed at the end of the life of the existing conventional roof, with green covering 90 percent of surface, or 36,000 sq. ft.

50 strategically planted **medium-size trees**, 25 opposite west-facing walls and 25 opposite south-facing walls

Bioswales and **rain gardens** that manage 1 inch of runoff from 2,000 sq. ft. of adjacent impervious area

72,000-sq.-ft. **permeable-pavement** parking lot

Cisterns to capture runoff from 5,000 sq. ft. of roof area and use for irrigation

BUILDING ASSUMPTIONS
(BEFORE IMPROVEMENTS)

SIZE	40,000 sq. ft.
STORIES	1
ROOF SIZE	40,000 sq. ft.
LOT AREA	128,000 sq. ft.
PERMEABLE AREA (COVERED IN TURF)	4,000 sq. ft.
NUMBER OF STORES	15
ANNUAL RENT	$17 per sq. ft.
ANNUAL RETAIL SALES	$2,182,000 per store

POTENTIAL BENEFITS

Energy savings due to reduced demand for heating and cooling	**$3,560** Annually
Avoided costs for conventional roof replacement	**$607,750** net present value over 40-year analysis period
Tax credit	**$100,000** one-time credit in year of installation
Increased **retail sales**	**$1.2 MILLION** per year
Stormwater **fee reduction**	**$14,020** Annually (projected to increase 6% per year)
Total present value benefits (over 40-year analysis period)	**$24,202,000 +** (including $22,963,800 in increased retail sales, which accrue to the tenants)

NON-QUANTIFIED BENEFITS

Water **conservation**	+
Increased **property value**	++
Reduced infrastructure costs due to use of permeable pavement system	+/U
Reduced crime	+/U
Improved **health and employee satisfaction**	+ (for tenants and employees)
Reduced costs associated with flooding	U

+ would likely increase net benefits;
+ + would increase net benefits significantly;
U direction of net change is uncertain.

Present value benefits over 40-year period were estimated on the basis of a 6 percent discount rate, projected CPI, projected increase in electricity and natural gas prices in relation to CPI (based on historical relationship), and 6 percent annual increase in stormwater fees. Improvements assumed to be implemented in 2015. Avoided conventional roof replacement costs were added to net present value of other benefits.Tax credit and stormwater fee reductions are based on available credits and fee structure in Philadelphia; many other localities have similar incentives.

APARTMENT BUILDING

The figures below present the key multifamily building assumptions, the proposed green infrastructure property improvements, and the resulting benefits.

GREEN INFRASTRUCTURE IMPROVEMENTS

8,435 sq. ft. **green roof,** installed at the end of the life ofthe existing conventional roof, with green covering 90 percent of the surface, about 7,600 sq. ft.

12 strategically planted **large trees**, 6 opposite a west-facing wall and 6 opposite an east-facing wall

Bioswales and **rain gardens** that manage 1 inch of runoff from 2,635 sq. ft. of adjacent impervious area

POTENTIAL BENEFITS

Energy savings due to reduced demand for heating and cooling	$1,780 Annually
Avoided costs for conventional roof replacement	$128,160 present value over 40-year analysis period
Tax credit	$52,720 one-time credit in year of installation
Increased **rental income**	$77,720 Annually (assuming no vacancies)
Increased **property value**	$37,500 one-time benefit to property owner at time of sale
Stormwater **fee reduction**	$1,230 Annually (projected to increase 6% per year)
Total present value benefits (over 40-year analysis period)	**$1,740,000 +**

Present value benefits over 40-year period were estimated on the basis of a 6 percent discount rate, projected CPI, projected increase in electricity and natural gas prices in relation to CPI (based on historical relationship), and 6 percent annual increase in stormwater fees. Improvements assumed to be implemented in 2015. Avoided conventional roof replacement costs were added to net present value of other benefits.Tax credit and stormwater fee reductions are based on available credits and fee structure in Philadelphia; many other localities have similar incentives.

NON-QUANTIFIED BENEFITS

Reduced crime	+/U
Reduced costs associated with flooding	U

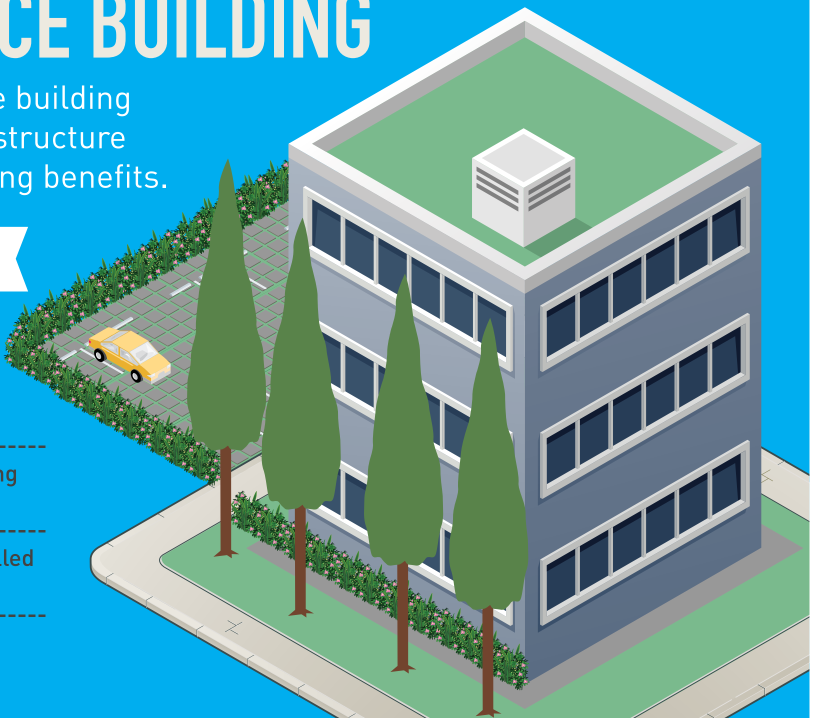
\+ would likely increase net benefits;
U direction of net change is uncertain.

BUILDING ASSUMPTIONS
(BEFORE IMPROVEMENTS)

SIZE	33,740 sq. ft.
STORIES	4
ROOF SIZE	8,435 sq. ft.
LOT AREA	12,435 sq. ft.
PERMEABLE AREA (COVERED IN TURF)	1,000 sq. ft.
NUMBER OF UNITS	32
MONTHLY RENT	$1,265 per unit

MEDIUM-SIZE OFFICE BUILDING

The figures below present the key office building assumptions, the proposed green infrastructure property improvements, and the resulting benefits.



GREEN INFRASTRUCTURE IMPROVEMENTS

17,900-sq.-ft. **green roof**, installed at the end of life of the existing conventional roof, with green covering 80 percent of the surface, or 14,300 sq. ft. (Remainder of roof is impervious area.)

20 strategically **planted trees**,10 opposite a west-facing wall and 10 opposite an east-facing wall

10,000-sq.-ft. **permeable pavement** parking lot, installed at the end of life of the existing parking lot

Bioswales and **rain gardens** that manage 1 inch of runoff from 4,700 sq. ft. of adjacent impervious area

POTENTIAL BENEFITS

Energy savings due to reduced demand for heating and cooling	**$1,630** Annually
Avoided costs for conventional roof replacement	**$271,970** present value over 40-year analysis period
Tax credit	**$67,130** one-time credit in year of installation
Increased **rental income**	**$72,150** annually (assuming no vacancies)
Stormwater **fee reduction**	**$3,490** Annually (projected to increase 6% per year)
Total present value benefits (over 40-year analysis period)	**$1,863,000 +**

Present value benefits over 40-year period were estimated on the basis of a 6 percent discount rate, projected CPI, projected increase in electricity and natural gas prices in relation to CPI (based on historical relationship), and 6 percent annual increase in stormwater fees. Improvements assumed to be implemented in 2015. Avoided conventional roof replacement costs were added to net present value of other benefits.Tax credit and stormwater fee reductions are based on available credits and fee structure in Philadelphia; many other localities have similar incentives.

NON-QUANTIFIED BENEFITS

Increased **property values**	++
Reduced infrastructure costs due to use of permeable pavement system	+
Reduced crime	+/U
Improved **health and employee satisfaction**	+ (for tenants and employees)
Reduced costs associated with flooding	U

\+ would likely increase net benefits;
\+ + would increase net benefits significantly;
U direction of net change is uncertain.

BUILDING ASSUMPTIONS
(BEFORE IMPROVEMENTS)

SIZE	53,600 sq. ft.
STORIES	3
ROOF SIZE	17,900 sq. ft.
LOT AREA	32,000 sq. ft.
PERMEABLE AREA (COVERED IN TURF)	1,000
ANNUAL RENT	$19.23 per sq. ft.

THE MANY BENEFITS OF GREEN INFRASTRUCTURE

The sections below describe the types—and the potential magnitude—of benefits that commercial property owners can reap from green infrastructure. This discussion is drawn from a wide range of published studies, which our full report documents in detail.

HIGHER RENTAL RATES, RETAIL SALES, AND PROPERTY VALUES

The landscaping that is a hallmark of green infrastructure can add tremendous value to a property, all while serving the purpose of keeping rainwater on site. Researchers have found that landscaping adds approximately 7 percent to the average rental rate for office buildings. Considering average rental rates in Philadelphia, a medium-sized office rental property could see an additional $72,150 in rental income each year.

Similarly, research on urban business districts and strip malls has found that consumers are willing to spend more on products, visit more frequently, or travel farther to shop in areas with attractive landscaping, good tree cover, or green streets. In areas with a mature tree canopy, customers indicate that they are willing to pay 8 to 12 percent more. For a mid-size retail center, this could generate over $1 million of increased sales annually. Further, this increased revenue for retail tenants suggests that retail building owners should be able to earn rental premiums for providing green infrastructure amenities. These greening efforts can be especially effective when multiple landowners, as in a Business Improvement District, work together to improve a retail corridor.

A wide range of studies have found that landscaping and trees increase residential property values by 2 to 5 percent. In one study, green roofs have been found to add 16 percent to the average rental rate for multifamily units.

Green infrastructure can also help commercial buildings attain certification under LEED and similar eco-labeling programs. LEED certification has been shown to increase occupancy rates in office buildings and rental rates in residential buildings. A new eco-labeling progam focused on green infrastructure, the Sustainable Sites Initiative (SITES), is scheduled to come online in 2014.

LOWER ENERGY COSTS

Both green roofs and tree plantings can generate valuable savings on heating and cooling costs. Green roofs provide better insulation than conventional roofs, reduce the amount of solar radiation reaching the roof surface, reduce roof surface temperatures, and improve the operational efficiency of rooftop air conditioning units. Empirical research demonstrates energy savings across climates. The Chicago City Hall-County Building's 20,300-square-foot green roof yields $3,600 in annual energy savings. The Target Center Arena's green roof in Minneapolis decreased annual energy costs by $300,000. A recent NRDC study showed that during the summer in Southern California, a green roof can reduce daily energy demand for cooling in a one-story building by more than 75 percent. A Green Roof Energy Calculator developed by the Green Building Research Laboratory at Portland State University allows any building owner to estimate potential energy savings.

Extensive research by the U.S. Forest Service demonstrates that something as simple as trees can reduce building energy consumption for cooling in the summer and, depending on factors such as climatic region, size, tree type and the location of the tree, can also reduce heating costs in the winter. For example, based on Forest Service models for the Midwest region, a single large tree can generate nearly $45 in energy savings annually; multiplied by numerous tree plantings on a commercial property, annual savings can easily total hundreds of dollars per year.

CASH BACK: TAX CREDITS, STORMWATER FEE CREDITS, REBATES, AND DEVELOPMENT INCENTIVES

In many cities, a substantial portion green infrastructure costs can be recouped directly through tax credits, stormwater fee credits, rebates, and development incentives. For example, in New York City, recently-passed legislation renews and expands upon a property tax credit for green roofs, allowing property owners to earn a one-year credit up to $200,000 for the inclusion of a green roof on at least 50 percent of a structure. In Philadelphia, businesses are eligible for a credit of 25 percent (at a maximum of $100,000) of green roof installation costs. For example, a midrise apartment building in Philadelphia with an 8,400-square-foot green roof could receive a one-time tax credit of over $50,000. Philadelphia also provides up to an 80 percent reduction in stormwater utility fees for property owners who install green infrastructure. (Many other cities provide similar credits, in varying amounts.) A medium-sized office building in Philadelphia, with retrofits to manage an inch of runoff from the entire property, could save over $100,000 (present value) in stormwater fees over a 40-year timeframe.

Other municipalities offer rebates and cost-sharing programs for green infrastructure development. For example, Milwaukee's Regional Green Roof Initiative provides up to $10 per square-foot for green roof projects. King County, Washington pays builders for 50 percent of the costs of green infrastructure retrofits, up to $20,000. Portland, Oregon has a green roof bonus in its zoning code, which provides an additional three square-feet of floor area for every one square-foot of green roof installed, provided the green roof covers at least 60 percent of the roof area. Austin, Chicago, and Santa Monica provide discounts for builders who employ green infrastructure practices.

Finally, direct funding may be given to property owners and/or community groups to implement a range of green infrastructure programs. New York City's Green Infrastructure Grant Program has committed more than $11 million to 29 green retrofit projects on private property since 2011. Onondaga County, New York provides grants to commercial properties that install green infrastructure retrofits in specific sewer districts and has distributed about $3.8 million. Philadelphia has awarded $7.9 million in competitive grants for green infrastructure retrofits on commercial properties.

REDUCED INFRASTRUCTURE COSTS

Green infrastructure can also reduce life-cycle costs associated with private property improvements. Green roofs do not need to be replaced as frequently as conventional roofs—they are typically considered to have a life expectancy of at least 40 years, as compared to 20 years for a conventional roof. For example, in a midsize retail building (with a 40,000-square-foot roof), a green roof could avoid a net present value of over $600,000 in roof-replacement costs over 40 years; a medium-size office building, with a roof half that size, could save over $270,000. In some instances, green roofs can also reduce air conditioning system capital costs by allowing for use of a smaller HVAC system.

Parking lots constructed with permeable pavement, though they carry higher initial capital costs, can have significantly lower maintenance costs compared with asphalt, resulting in lower overall life-cycle costs. For example, in designing a green street project, West Union, Iowa compared the life cycle costs of using a permeable paver system instead of traditional concrete pavement. Despite higher up-front costs, analysis showed that the city would begin to realize savings by year 15 of the project, with cumulative savings over the 57-year analysis period of close to $2.5 million.

Additionally, for development projects, integrating green infrastructure into the site design can result in net cost savings by decreasing the amount of required below-ground drainage infrastructure and other stormwater management-related facilities.

OTHER HARD-TO-QUANTIFY BENEFITS: REDUCED FLOOD DAMAGE, WATER BILLS, AND CRIME; IMPROVED HEALTH AND JOB SATISFACTION FOR OFFICE EMPLOYEES

Green infrastructure can also provide many other valuable benefits, which are difficult to quantify, in a generalized way, at the scale of individual properties. Nonetheless, these are important benefits for property owners to consider.

Reducing the volume of stormwater runoff can provide a cost-effective way to manage the frequency and severity of localized urban flooding. Large floods with catastrophic damage and costs are relatively infrequent, but small events (which can be mitigated by green infrastructure) are generally more frequent and widespread; though they cause less damage per event, their repetitive nature can create a greater overall economic burden. Mitigating flooding risks reduces these flood damage costs, and can increase property values (by 2 to 8 percent, according to some studies).

Green infrastructure practices that capture rainwater for reuse—like rain barrels and cisterns—can help save on water costs for landscape irrigation and other non-potable water uses. Opportunities to achieve these savings will vary widely depending upon such factors as the non-potable water needs of a given property, local water rates, and the number and intensity of storms throughout the year. For example, the EPA reports that one large building in Seattle and another in New York City use large-capacity cisterns to meet 60 percent and 50 percent of their toilet flushing needs, respectively.

Recent research indicates that green infrastructure even has the potential to reduce crime on private properties, especially in urban areas. Crime reduction is associated with specific types of vegetation, such as open space covered with grass and tall trees. Shrubs and bushes, if situated in places that provide places for criminals to hide, have been found to increase crime; however, they can be designed and arranged to minimize impacts on sight lines, providing pleasant places for people to gather and thus improving safety and security. Overall, numerous studies have found significantly lower rates of property crime, violent crime, graffiti, vandalism, and littering in urban areas with high levels of vegetation, when controlling for other factors. Deterring such crimes can result in significant avoided costs for commercial property owners.

Researchers have also found that office workers have a clear preference for nature near the workplace, leading to improved health and job satisfaction, and reduced levels of stress. Importantly, green space does not need to be extensive or pristine to provide these benefits; trees, landscaping, and other vegetation situated among buildings and parking lots have been found to be effective. These benefits accrue most directly to the companies that rent commercial space and their employees, rather than the property owner, although they may also be reflected in the increased rents tenants are willing to pay for offices and shops that have nice landscaping and shading.

THE GREEN EDGE: HOW COMMERCIAL PROPERTY INVESTMENT IN GREEN INFRASTRUCTURE CREATES VALUE

This report explores the range of economic benefits that accrue to commercial property owners (including owners of multifamily residential buildings) when they install green infrastructure on their property to improve stormwater management. Green infrastructure practices include green roofs, rain gardens, bioswales, trees, parks, roadside plantings, rain barrels, permeable pavement, and other mechanisms that mimic natural hydrologic functions or otherwise capture runoff on-site for productive use.

In many cities, private property owners can receive a stormwater fee credit for installing green infrastructure. However, even in cities with relatively high stormwater fees and available credits, the value of the credit alone often will not provide a sufficient economic incentive to motivate investment in these environmentally beneficial practices. In order to encourage additional implementation of green infrastructure, this report identifies and quantifies (to the extent feasible) the range of additional economic benefits that green infrastructure can bring to commercial property owners. The goal of this paper is to show that, when accounting for these benefits, commercial property owners receive a much greater return on investment—and have a much stronger business case for green infrastructure investments—than when considering stormwater fee savings alone.

Sections 1 through 3 provide a background on green infrastructure in general and the need for private property owners to be involved for effective implementation. Section 4 describes the benefits of green infrastructure for private commercial property owners, based on a review of relevant literature. Finally, Section 5 demonstrates the potential value of these benefits by applying the findings from the literature review to three representative property types.

1. SHIFTING TO A MORE SUSTAINABLE APPROACH TO STORMWATER MANAGEMENT

Traditionally, many cities in the country have managed stormwater runoff through "gray" infrastructure systems, which rely primarily on underground networks of pipes and pumps to carry rainwater away from where it falls and dispose of it as a waste. This traditional approach is costly and frequently directs large amounts of pollution into urban waterways.[1] As population and development increase and new challenges arise—including climate change, increasing energy costs, and aging water infrastructure—issues of water quantity and quality are intensified. Traditional infrastructure has not met the challenge of these changing conditions.

Recognizing the need for a different approach, many cities have begun to incorporate green infrastructure into their existing stormwater management systems. While traditional gray infrastructure solutions rely on physical infrastructure to convey rainwater away from where it falls, green infrastructure relies on more natural approaches to infiltrate, evapotranspire, or capture and reuse rainwater on or near the site where it falls. These practices can also yield many important co-benefits to communities, such as beautifying neighborhoods, cooling and cleansing the air, reducing asthma and heat-related illnesses, lowering heating and cooling energy costs, and creating "green-collar" jobs (Garrison and Hobbs 2011).

Toronto's City Council adopted construction standards in May 2009 that require all new buildings and retrofits with more than 2,000 square meters (approximately 21,528 square feet) of floor area to include a green roof; since the bylaw went into effect, approximately 1 million square feet of additional green roofs have entered the planning phase.

2. WIDESPREAD IMPLEMENTATION WILL REQUIRE PARTICIPATION OF PRIVATE PROPERTY OWNERS

Green infrastructure approaches are increasingly being implemented in dense urban areas to help reduce combined sewer overflows (CSOs) and meet requirements of the Clean Water Act. Philadelphia, for example, plans to invest at least $1.67 billion in green infrastructure over the next 25 years as part of its Green City, Clean Waters Program, which was designed to meet the Clean Water Act's requirements for CSO control. Under Philadelphia's plan, the city will retrofit nearly 10,000 impervious acres of public and private property to manage runoff generated by up to one inch of rainfall. Many other cities, such as New York City, Seattle, Portland (Oregon), and Kansas City, have also adopted ambitious green infrastructure programs to manage stormwater runoff and improve local water quality (Garrison and Hobbs 2011; Chen & Hobbs 2013).

These cities are making major investments in green infrastructure in the public right-of-way (i.e., roadways and sidewalks) and on other public property. However, in order to implement green infrastructure at the scale necessary to fully protect urban waterways, cities like Philadelphia will need private property owners to implement projects on their land as well. Regulatory requirements for new development and redevelopment projects to retain runoff on-site are one critical tool that cities are using to reduce runoff from private property. But cities are also seeking additional means to promote green infrastructure retrofits at *existing* private development. Cities can facilitate private investment in such projects by providing financial incentives and by educating private property owners about the full range of benefits that green infrastructure can provide them.

This cistern at a Whole Foods Market in Raleigh, NC, collects rainwater for interior restroom use.

3. WHAT'S THE INCENTIVE?

Currently, more than 1,400 local jurisdictions have stormwater utilities that charge property owners stormwater fees, which are applied toward the capital and operating expenses associated with publicly owned stormwater infrastructure. A majority of these base the level of the fee, in whole or in part, on the amount of impervious area on a property or some other surrogate for the amount of runoff generated by the property (Western Kentucky University 2013). Many of these stormwater utilities provide property owners the opportunity to obtain a credit or discount on their stormwater fees by installing green stormwater management retrofits, which reduce the volume of runoff. Philadelphia, for example, recently established a parcel-based stormwater billing structure that provides a credit of up to 80 percent for commercial property owners (including owners of multifamily residential buildings) who can demonstrate on-site management of the first inch of rainfall over their entire parcel. As a result, a Philadelphia commercial property owner's investment in green infrastructure retrofits provides ongoing savings in the form of reduced stormwater bills (Valderrama, et al. 2012).

Although Philadelphia's incentive program serves as a key step toward public engagement and the broader implementation of green infrastructure on private land, it does not in itself provide sufficient economic motivation, in the form of an acceptable payback period on green infrastructure investment, for most commercial property owners. For example, using avoided stormwater fees as the sole measure of project payback, a retrofit project on a given parcel in Philadelphia would need to cost less than $36,000 per impervious acre managed ($0.82 per square foot) in order to achieve full payback within 10 years (Valderrama et al. 2012). Based on general cost estimates (scaled to Philadelphia construction costs) for a variety of green infrastructure management practices that can be used at commercial sites, installing low-cost vegetated swales is the only practice that meets this criterion; however, swales are suitable for only a limited percentage of all commercial sites. In the current market environment, management practices that are suitable for a wider range of sites, such as the use of porous pavement, rain gardens, green roofs, and flow-through planters, have higher retrofit costs that would not achieve a 10-year payback based solely on avoided stormwater fees (Valderrama et al. 2012).

Accordingly, the purpose of this report is to demonstrate the additional potential monetary benefits that can accrue directly to commercial property owners who install green stormwater infrastructure. As illustrated in this study, comprehensive project benefit accounting—an approach that factors in the wider range of benefits produced by green infrastructure—can dramatically accelerate the expected payback of such projects.

While this report focuses on benefits for commercial property owners, many of these benefits also apply to residential properties. This is often noted in the discussion of particular studies in Section 4 following.

A green roof on the offices of YouTube in San Bruno, California.

Looking onto the green roof at the YouTube offices in San Bruno, California.

4. POTENTIAL BENEFITS FOR PRIVATE, COMMERCIAL PROPERTY OWNERS

When implemented on a broad scale, green infrastructure can improve community livability, beautify neighborhoods, provide recreational opportunities, cool and cleanse the air (helping to reduce asthma and heat-related illnesses), reduce the need for expensive gray infrastructure solutions, reduce costs associated with flooding, and create green-collar jobs. Several studies have quantified or valued these public benefits at the community level (e.g., Stratus Consulting 2009, American Rivers et al. 2012, Garmestani et al. 2012).

The benefits that accrue to individual property owners as a result of small, distributed green infrastructure projects have not been comprehensively studied. As noted above, the purpose of this report is to identify (and quantify to the extent feasible) these benefits in order to provide commercial property owners with a fuller picture of the economic rewards for implementing green infrastructure on their own land.

Benefits of green infrastructure for private, commercial property owners

- Increased rents and property values
- Increased retail sales
- Energy savings
- Stormwater fee credits and other financial incentives
- Reduced infrastructure costs
- Reduced costs associated with flooding
- Reduced water bills
- Increased mental health and worker productivity for office employees
- Reduced crime

Based on a review of relevant literature, the following sections describe the potential benefits of green infrastructure for private, commercial property owners. An important caveat: This discussion assumes that green infrastructure would be designed and implemented in a way that maximizes, the co-benefits described. For example, studies show that user preferences (as demonstrated through such indicators as increased rents and property values) are positively influenced by both the presence of vegetation and the configuration of natural elements (Kaplan and Kaplan 1989, 1998). Thus, the collaboration of resource planners, private property owners, and designers is necessary to optimize potential benefits (such as higher rents) beyond the stormwater management functions of green infrastructure.

4.1 INCREASED RENTS/PROPERTY VALUES

Trees and plants improve urban aesthetics and community livability. The property value benefits of green infrastructure, such as landscaping, trees, or vegetation additions, for single-family homes is well documented in empirical studies (e.g., Braden and Johnston 2003; Wachter and Wong 2008; Been and Voicu 2007; Ward, MacMullan, and Reich 2008; Stratus Consulting 2009; Donovan and Butry 2010). Depending on the improvement, residential property values have been found to increase by as much as 7 percent (Been and Voicu, 2007). However, most estimates of residential property value increases range from 2 percent to 5 percent.

Less work has been completed to document the property value benefits of green infrastructure to nonresidential property owners. Nevertheless, closely related benefits have been documented for many types of properties, including multifamily buildings (which are often classified as commercial properties), office buildings, retail stores, and some other commercial buildings. These benefits include higher occupancy rates and rents, as discussed following.

Commercial office building at 1050 K Street, Washington, D.C.

4.1.1 Benefits from landscaping and tree cover

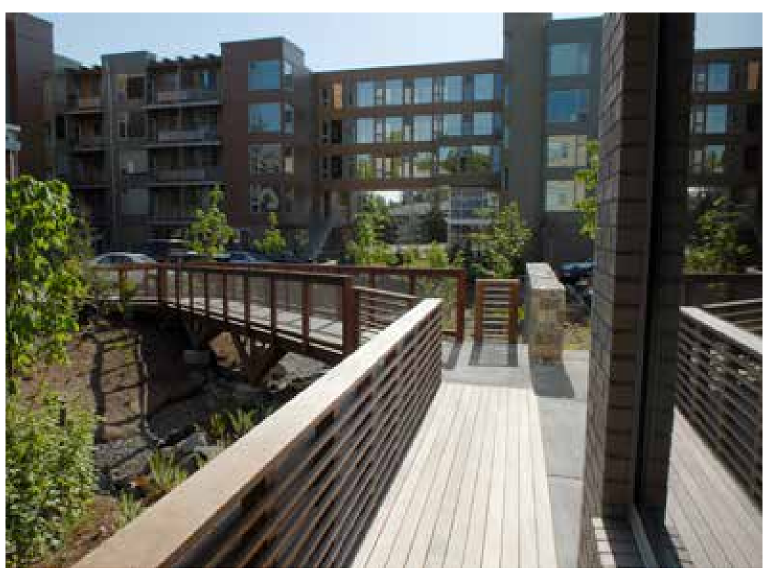
Access to green space and views of nature are considered desirable in both residential and commercial settings. Just as with single-family residences, the value of a commercial property in urban areas is determined by various factors, including characteristics of the land (e.g., lot size) and the structure (e.g., square footage), the closeness to natural amenities (e.g., parks, trails, waterways, open space), and other attributes (e.g., crime rate, population, location relative to business and transportation centers). Making green infrastructure improvements to commercial sites can make them more appealing to potential customers, tenants, or buyers and improve a site's economic vitality (Bisco Werner et al. 2001).

Various studies of the value of natural spaces in urban and suburban environments have found that commercial office space, retail locations, and multifamily housing may fetch higher rents as a result of on-site landscaping decisions. For instance, Laverne and Winson-Geideman (2003) find that well-designed landscaping added approximately 7 percent to the average rental rate for office buildings. Shade also increased rental rates for office buildings by about 7 percent. Conversely, excessive tree cover that created a visual screen decreased rental rates 7.5 percent (Laverne and Winson-Geideman, 2003). Tyrväinen and Miettinen (2000) found that units in multifamily buildings with views of trees or forest cover can increase rents by as much as 4.9 percent (Wolf 2007).[2] Very little quantitative research has been conducted in relation to the impact of vegetation and trees on retail rents. However, there is evidence that retail rents increase with urban quality improvements. For example, Whitehead et al. (2004) report that creating pedestrian-only zones and related improvements in retail areas increase rents by about 22 percent, on average (based on Hass-Klau, 1993; Colliers Erdman Lewis, 1995; Hass-Klau and Crampton, 2002).

The construction of wetlands can benefit commercial office property owners as well. In the Washington, D.C., metropolitan area, several studies identify rent premiums for office spaces with views of constructed wetlands or ponds. Benefits of these desirable views range from a 5.7 percent to 7.5 percent increase in rents (U.S. EPA 1995). Additionally, these properties may be easier to rent, with higher occupancy rates and shorter periods between leases (U.S. EPA 1995). However, construction of retention ponds that lack attractive vegetation or recreation opportunities, for instance, may decrease property values, as is the case in the residential sector (Lee and Li 2009).

4.1.2 Benefits of green roofs

Much like ground-level landscape improvements, the installation of green roofs can provide economic benefits for private property owners. A recent hedonic regression analysis of 44 apartment units assessed the benefits of green roofs to apartment buildings in the Battery Park area of New York City (Ichihara and Cohen 2011). In this study, 27 percent of the apartment units were located in buildings that had green roofs. The authors found rental premium of 16 percent for buildings with green roofs compared with those lacking them, after controlling for other factors such as apartment size (number of bedrooms and bathrooms) and distance to parks and transit. In general this study demonstrates the attractiveness of green infrastructure improvements; however, these results represent just one study. Additional analysis of the economic benefits of green roofs, particularly in other markets, would improve the confidence of these findings.



Apartment complex at Headwaters at Tyron Creek, in Portland, Oregon.

Mixed-use development at Hill Center Green Hills, Nashville, Tennessee.

4.1.3 Benefits of green infrastructure "eco-labels" or certifications

In addition to green infrastructure itself, there may be benefits associated with recognition or eco-labeling, through certification or award programs, for properties that implement green infrastructure practices on their land. The U.S. Environmental Protection Agency (U.S. EPA 2009) acknowledges recognition and labeling programs as effective incentives for implementation. In addition, Fuerst and McAllister (2009) report that "the rapid increase in allocation of corporate resources to environmental, social, and governance issues . . . .has created potential marketing and image benefits for occupying and investing in buildings labeled as environmentally responsible."

Studies of eco-labeling programs, including Leadership in Energy and Environmental Design (LEED) or EnergyStar certifications, have found that they can increase property values, rents, and occupancy rates in commercial office buildings (Fuerst and McAllister 2008, 2009, 2011; Miller, Spivey, and Florance 2008; Eichholtz, Kok, and Quigley 2009, 2011; Wiley, Benefield, and Johnson 2010). For example, controlling for differences in building age, height, class, and quality, Fuerst and McAllister (2009) found office building occupancy rates to be 8 percent higher in LEED-labeled buildings and 3 percent higher in EnergyStar-labeled buildings. Kok, Miller, and Morris (2011) found that occupancy rates in LEED-certified buildings are roughly 2 percent higher than in noncertified buildings and command higher rents. Further, several research surveys have found that tenants are willing to pay higher rents to live in eco-labeled buildings (McGraw Hill Construction 2006, GVA Grimley 2007, and *National Real Estate Investor*, 2007, as cited in Fuerst and McAllister 2009).

An eco-labeling program geared specifically toward green infrastructure, such as the Sustainable Sites Initiative (SITES, which is scheduled to come online in 2014), has the potential to impart similar benefits. Given the limited implementation of such programs, these benefits have not yet been studied or quantified.[3]

4.2 INCREASED RETAIL SALES

Retailers can benefit from green infrastructure improvements, particularly the addition or maintenance of trees and landscaping on their properties. An ongoing body of work focusing on urban business districts and strip malls has found that consumers are willing to spend more (or pay a premium) on products, visit more frequently, or travel farther to shop in areas with attractive landscaping, good tree cover, or green streets (Wolf 2013). These findings are supported by Bisco Werner et al. (2001), who find that consumers are willing to travel farther to shop in greener areas. Newell et al. (2012) also mention green alleys as an option to create green infrastructure and develop "a new walkable, public space that will help attract more visitors." Customers indicated that they are willing to pay 8 percent to 12 percent more in areas with a mature tree canopy (Wolf 2005, 2007, 2009).

It is important to note that these local greening efforts have been found to be most effective when retailers work together, as they would in a formalized business district, to create a larger-scale shopping environment for customers (Wolf 2004). Moreover, design and execution matter. Green infrastructure improvements should not interfere with a customer's ability to see store signage and must be properly maintained in order to produce an appealing environment (Wolf, 2004).

4.3 ENERGY SAVINGS

Trees and green roofs can decrease the amount of energy needed for heating and cooling individual buildings, which leads to direct cost savings for owners. On average, heating accounts for 26.6 percent of total energy use in commercial buildings, and cooling accounts for about 10.1 percent (U.S. Department of Energy 2011).

4.3.1 Tree-related energy savings

Trees can reduce building energy demand for heating and cooling by providing shade and evaporative cooling and blocking winter winds. Extensive research conducted by the U.S. Forest Service demonstrates that trees tend to reduce building energy consumption for cooling in the summer, and can either increase or decrease energy use for heating in the winter, depending on the climatic region, size and type of tree, and location of the tree relative to the building (Nowak et al.2012, McPherson et al. 2006, Center for Neighborhood Technology and American Rivers 2010). For example, studies have found that in colder areas, shading can actually increase energy demand for heating. At the same time trees that serve as wind breaks in warm areas generally do little to reduce building energy demand (Center for Neighborhood Technology and American Rivers 2010). Several studies have estimated the per-unit energy savings imparted by trees for individual buildings, based on these factors.[4] For example, McPherson et al. (2006) estimated that in the Midwest region, annual electricity savings due to reduced demand for cooling range from 54 kWh for a small tree in a residential yard opposite a south-facing wall to 268 kWh for a large tree in a residential yard opposite a west-facing wall. Tables 1 and 2 present the estimated energy savings from the McPherson study for different types of trees, as well as annual dollar savings based on average electricity and natural gas prices for the commercial sector as of March 2013.[5]

The Energy Information Administration (EIA) reports that average annual residential electricity use in the Midwest is about 10,764 kWh. Average annual residential natural gas use in the region amounts to about 93,942 kBtu (EIA 2010).[6] Thus, the findings of McPherson et al. suggest that a large tree planted opposite a west-facing wall in a residential yard would reduce annual electricity and natural gas demand by about 2.5 percent and 3.3 percent, respectively.

Table 1. Annual electricity savings due to trees strategically planted in residential yards, averaged across 40-year life of tree

	Opposite west-facing wall		Opposite south-facing wall		Opposite east-facing wall	
	Energy savings (kWh/yr)	$ savings	Energy savings (KWh/yr)	$ savings	Energy savings (kWh/yr)	$ savings
Small tree: Crab apple (22 ft. tall, 21-ft. spread)	96	$9.59	54	$5.39	68	$6.79
Medium tree: Red oak (40 ft. tall, 27-ft. spread)	191	$19.08	99	$9.89	131	$13.09
Large tree: Hackberry (47 ft. tall, 37-ft. spread)	268	$26.77	189	$18.88	206	$20.58

Sources: McPherson et al. 2006, EIA 2013a, b.

Table 2. Annual natural gas savings due to trees strategically planted in residential yards, averaged across 40-year life of tree

	Opposite west-facing wall		Opposite south-facing wall		Opposite east-facing wall	
	Energy savings (kBtu/yr)	**$ savings**	**Energy savings (kBtu/yr)**	**$ savings**	**Energy savings (kBtu/yr)**	**$ savings**
Small tree: Crab apple (22 ft. tall, 21-ft. spread)	1,334	$10.23	519	$ 3.98	1,243	$9.53
Medium tree: Red oak (40 ft. tall, 27-ft. spread)	1,685	$12.92	–316	$(2.42)	1,587	$12.17
Large tree: Hackberry (47 ft. tall, 37-ft. spread)	3,146	$24.12	2,119	$ 16.25	3,085	$ 23.65

Sources: McPherson et al. 2006, EIA 2013a, b.

In a study of five American cities—Berkeley, California; Fort Collins, Colorado; Bismarck, North Dakota; Cheyenne, Wyoming; and Glendale, Arizona—McPherson et al. (2005) used computer simulations to examine changes in building energy use caused by shade from street trees. For this study, the location and distribution of street trees with respect to buildings was based on a field sample for each city. Results indicated that

> *energy savings were particularly important in Berkeley ($553,061 per year, $15/tree)*[7] *and Cheyenne ($186,967 per year, $11/tree). The close proximity of street trees to buildings in Berkeley resulted in substantial shading benefit during the summer (95 kWh/tree). In Glendale, where summer cooling loads were much greater, trees provided virtually no shade to buildings because of their location along wide boulevards. Their cooling benefit (44 kWh/tree) largely was due to air-temperature reductions associated with evapotranspiration. Winter heating savings were substantial in Cheyenne ($88,276, $5/tree), where low temperatures and strong winds accentuated tree windbreak effects.*

4.3.2 Energy savings from green roofs

Green roofs can also provide energy savings for building owners. Green roofs provide better insulation than conventional roofs, reduce the amount of solar radiation reaching the roof surface, and lower roof surface temperatures through evaporative cooling (Wise et al., 2010). The energy savings provided by green roofs depend on:

- Local climate factors, such as temperature, relative humidity, and wind speed
- Building characteristics, including number of stories and the portion of the building's heating and cooling load that is caused by heat flow through the roof;
- Characteristics of the roof itself, including soil depth, extent of foliage, moisture content of the growing media, and materials used for areas not covered in plantings (Theodosiou 2003, Gaffin et al. 2005, as cited in Wise et al., 2010; Clark, Adriaens, and Talbot 2008, Garrison, Horowitz, and Lunghino 2012).

Empirical research demonstrates the energy saving benefits of green roofs across climate ranges (American Rivers et al. 2012). For example, Chicago's 20,300-square-foot green roof located on half of its City Hall–County Building is estimated to yield $3,600 in annual building-level energy savings (American Rivers et al. 2012). The green roof on the Target Center Arena in Minneapolis, which encompasses 113,000 square feet, has reportedly decreased annual building energy costs by $300,000 (American Rivers et al. 2012). As further evidence of green roof energy savings in cooler climates, a Canadian model of a 32,000-square-foot green roof on a one-story commercial building in Toronto found reductions in total cooling and heating energy demand of 6 and 10 percent , respectively (American Rivers et al. 2012, U.S. EPA 2008). When applied to the warmer climate of Santa Barbara, California, the same model estimated a 10 percent savings in cooling costs (American Rivers et al. 2012, U.S. EPA 2008). The sources consulted for this report do not differentiate between energy savings associated with extensive green roofs (generally defined as having a depth of 3 to 6 inches) versus intensive green roofs (having a depth of more than 6 inches to accommodate larger plants).[8]

In a report prepared for the city of Portland, Oregon, David Evans and Associates (2008) reviewed a number of studies that quantified the energy savings associated with green roofs (e.g., Dawson 2002, Acks 2006). Results of this review suggest that total energy savings from reduced heating and cooling generally range between 5 percent and 15 percent compared with buildings with conventional roofs. Moreover, two Portland-based studies found that extensive roofs were effective in reducing annual cooling and heating by 12 percent for a single-story, 17,500-square-foot building. Savings ranged between 0.17 kWh and 0.63 kWh per square foot due to reduced cooling demand, and 0.02 therm per square foot due to reduced heating demands (David Evans and Associates 2008, Lee et al. 2007).

In a recent NRDC study on the benefits of green roofs in Southern California, Garrison, Horowitz, and Lunghino (2012) report that during the summer, a green roof can reduce the average daily energy demand for cooling in a one-story building by more than 75 percent. However, modeling results have generally indicated overall energy savings of up to 25 percent annually, depending on building and green roof characteristics and the site's climate (Garrison, Horowitz, and Lunghino 2012).

The NRDC study also notes that a green roof's impact on electricity use for cooling "is greatest on the top floor of a building, immediately below the roof surface, and declines with each additional story below the roof" (Garrison, Horowitz, and Lunghino 2012). For example, results from a recent study of green roof energy savings for a two-story office building in Athens, Greece show that from May to September, the green roof reduced energy demand for cooling on the building's top story by 27 percent to 58 percent per month. Energy demand for cooling the entire building was reduced by 15 percent to 39 percent per month (Garrison, Horowitz, and Lunghino 2012).

Another finding of the NRDC report is that green roofs can provide additional energy savings for buildings that have rooftop air-conditioning systems. Air-conditioning systems typically begin to decrease in operational efficiency at about 95°F. Because green roofs reduce the ambient air temperature on-site, they can help to avoid efficiency losses that occur on hot summer days, thereby reducing costs and energy used for cooling (Garrison, Horowitz, and Lunghino 2012).

In sum, although results vary depending on local climate, and building and roof characteristics, studies consistently show that green roofs can provide considerable energy savings. This economic benefit, combined with reduced life cycle costs (discussed below), have helped to make green roofs "an increasingly favorable option for new construction and the retrofit of existing structures" (American Rivers et al. 2012).

4.4 REDUCED COSTS ASSOCIATED WITH FLOOD DAMAGE

By reducing the volume of stormwater runoff, green infrastructure practices provide a cost effective way to manage the frequency and severity of localized urban flooding (i.e., flooding caused by too much rain overwhelming drainage systems and waterways during relatively small rain events (Center for Neighborhood Technology 2013)). When implemented at the watershed scale, green infrastructure can also provide measurable flood control benefits for larger, less frequent events (American Rivers 2012). However,

> *Although large flood events impacting river systems may lead to catastrophic damages and costs, these events occur relatively infrequently. Smaller events are generally more frequent and widespread, so although the damages tend to be smaller in scale, the higher number of events can create a greater overall economic burden on communities (American Rivers et al. 2012).*

For the private property owner, green infrastructure implementation on-site can decrease the costs associated with localized flooding by reducing property damage, lessening stress and illness, and cutting the time lost to the cleanup process. In addition, hedonic studies show that a reduced risk of flooding can result in a 2 percent to 8 percent increase in property values (Center for Neighborhood Technology (CNT) and American Rivers 2010, Stratus Consulting 2009).

In a recent survey of flood damage claims in Cook County, Illinois (which encompasses Chicago), the Center for Neighborhood Technology (CNT) found that urban flooding "is chronic and systemic, resulting in damage that is widespread, repetitive and costly" (CNT, 2013). The CNT identified 176,980 damage claims made by households and businesses in 96 percent of all Cook County zip codes over five years (this is equivalent to one in six properties in the county making a claim). Payouts averaged $3,733 each across all types of claims, with total payouts amounting to $660 million. In an online survey of Cook County property owners that had suffered from flooding within the last five years, seventy percent of respondents estimated that their property had flooded three or more times in the past five years, and 20 percent indicated they had undergone floods 10 or more times. In addition, the survey found no correlation between flood damage payouts and location in floodplains, indicating that the majority of flooding was caused by impervious area cover.

In addition to damages found through claims, CNT's online survey findings indicate that there are widespread social and economic costs that are not covered by claims. Specifically:

- 84 percent of respondents suffered stress;
- 13 percent suffered from ill health;
- 41 percent lost the use of part of their property;
- 63 percent lost valuables; and
- 74 percent lost hours of work due to cleanup.

Although green infrastructure has the potential to reduce on-site flooding, the effectiveness of improvements at the individual property level is not clear (and to our knowledge has not been thoroughly studied). In CNT's analysis, the majority of respondents (76 percent) had invested in measures to prevent future flooding, such as downspout disconnection, rain gardens, structural modifications, and pumps, with downspout disconnection and pumps being the most common investments. Only 6 percent of respondents believed that these investments had solved their flooding problem. Fifty-four percent said it had not solved their problem, and 40 percent indicated that they did not know (CNT, 2013). The flood reduction benefits of green infrastructure may be more applicable at slightly larger scales (e.g., housing developments, business improvement districts).

Source: PWD 2013b.

A 55–gallon household rain barrel in Philadelphia.

4.5 REDUCED WATER BILLS FROM USE OF CISTERNS/RAIN BARRELS

Rain barrels and cisterns can be a relatively low-cost option for reducing stormwater runoff. During storm events, water runs from roofs into downspouts and then into rain barrels and cisterns, captured for later use. This water can be used to water lawns, gardens, or plants; flush toilets; or clean outdoor furniture and equipment (PWD 2008). However, rain barrels and cisterns must be disconnected in wintry or freezing conditions to prevent damage to downspouts and barrels or cisterns. Additionally, certain roofing materials, such as treated wood shingles, among others, have the potential to affect water quality (PWD 2008). The benefit to property owners from stormwater capture is a reduction in metered water use.

The benefits to property owners from rain barrels and cisterns vary, in part due to:

- the number and intensity of storm events throughout the year;
- the number of months the barrels are disconnected (to prevent damage from freezing);
- roof dimensions;
- cistern or barrel capacity;
- current usage of metered water for non-potable applications (or future possible uses of non-potable water); and
- local water rates.

In addition, stormwater management goals and water reuse goals are not always in complete alignment. Stormwater management may require faster dewatering to get ready for the next storm than the pace of water reuse required by the building.

With these considerations in mind, researchers have attempted to measure the effectiveness of rain barrels for homeowners. A study of Cleveland Heights, Ohio, found that 500 square feet of roof can produce up to 6,750 gallons of runoff from mid-April to the beginning of November during an average year (Jennings et al. 2013). However, only the first 0.17 inch of runoff can be managed by a 50-gallon rain barrel, assuming it is empty for each storm event (Jennings et al. 2013). Therefore, the maximum capacity of the rain barrel over the course of an average year is 4,313 gallons. In a Washington, D.C., case study, researchers found that over eight months (January–August), a 900-square-foot roof and 75-gallon rain barrel captured approximately 2,752 gallons of water (Metropolitan Washington Council of Governments 2001). The Philadelphia Water Department

(PWD) estimates that with average local rainfall (from about 64 storms a year), a 54-gallon residential rain barrel captures a total of 3,456 gallons of water annually (PWD 2012). A similar evaluation homes with 1,200-square foot rooftops in Milwaukee found that the use of two 90-gallon rain barrels per home would annually capture more than 6,000 gallons per residence, taking into account seasonal disconnection and overflow during large storm events (Sands and Chapman 2003). These studies demonstrate that the variability of rain-barrel effectiveness depends heavily on roof size and barrel capacity.

Nonresidential properties with large roofs can accommodate large-capacity cisterns. The EPA reports that one large building in Seattle and another in New York City use large-capacity cisterns to meet 60 percent and 50 percent of their toilet flushing needs, respectively (U.S. EPA 2008, as cited in Foster, Lowe, and Winkelman 2011). In rainy Seattle, one commercial office building plans to install a 56,000-gallon cistern to meet the entire building's water needs after filtration and disinfection (Nelson 2013). Projects like this can greatly reduce—or eliminate—a building's metered water expenses. However, they can also have large up-front capital costs and ongoing maintenance requirements.

For further information, the EPA provides guidance and a calculator on how much rain an individual roof will produce (U.S. EPA 2013). Information on historical rainfall is available from the National Weather Service (water.weather.gov/precip/index.php).

4.6 STORMWATER FEE CREDITS AND OTHER FINANCIAL INCENTIVES

Private property owners can benefit from stormwater fee credits (i.e., discounts) and other local incentives associated with green infrastructure implementation, such as grants, tax credits, rebates and cost-share programs, and development incentives. Examples of each of these incentive programs are discussed below.

4.6.1 Stormwater fee credits

Stormwater fee discounts are the most common type of green infrastructure incentive program (WEF 2013). As described above, many municipalities and clean water agencies are adopting fee structures that account for the impact of stormwater from private properties. There are currently more than 1,400 local stormwater utilities across the nation, and the majority bill property owners, in whole or in part, on the basis of the amount of impervious surface on their properties or some other surrogate for the amount of runoff generated by their properties (Western Kentucky University 2013). Many of these localities offer discounts based on a property's installation of green infrastructure or on its ability to meet a specific performance standard, which can lead to significant savings. In Philadelphia, for example, an 80 percent discount on a property's stormwater fee can be achieved if green infrastructure is installed to manage runoff from a 1-inch storm event (PWD 2013c, 2013d).

Primary types of financial incentives for green infrastructure

- **Stormwater fee discounts:** These require a stormwater fee that is based on impervious area. If a property owner lessens his need for service by reducing the impervious area and volume of runoff from the property, the municipality reduces the fee.
- **Grants:** Direct funding may be given to property owners and/or community groups to implement a range of green infrastructure projects.
- **Rebates and installation financing:** Property owners who install approved green infrastructure practices may receive funding, tax credits, or reimbursements. Financing is often tied to practices needed in certain areas or neighborhoods.
- **Development incentives:** These are offered to developers when they apply for development permits. Examples include zoning upgrades, expedited permitting, reduced gray infrastructure stormwater requirements, and increases in floor area ratio.

Source: Adapted from U.S. EPA 2009.

4.6.2 Grants

Grants to private property owners can encourage green infrastructure implementation. The Green Improvement Fund in Onondaga County, New York, provides grant funding to commercial properties that install green infrastructure retrofits in specific sewer districts. Grants are determined by the amount of stormwater captured. As of June 2013, the county has distributed about $3.8 million in these grants. New York City has a Green Infrastructure Grant Program, which has committed more than $11 million to 29 green infrastructure retrofit projects on private property since 2011. Philadelphia, under its Stormwater Management Incentives Program, has awarded $7.9 million in competitive grants for green infrastructure retrofits on commercial properties. (Chen & Hobbs 2013.)

4.6.3 Tax credits

Many municipalities offer tax credits to property owners who install green infrastructure. In New York City, recently-passed legislation renews and expands upon a property tax credit for green roofs, allowing a property owner to earn a one-year credit of up to $200,000 for the inclusion of a green roof on at least 50 percent of a structure (New York State Legislature 2013). Similarly, in Philadelphia, tax credits are granted to businesses that install green roofs on their buildings. The credit can be claimed against an applicant's Business Privilege Tax for the year in which the green roof installation is completed. The credit amounts to 25 percent of the cost of installing the green roof, up to $100,000 (Philadelphia Industrial Development Corporation 2013). Anne Arundel County, Maryland, enacted a credit toward real property taxes for the implementation of green stormwater management techniques. The value of the credit is up to 10 percent of the cost of materials and installation, taken annually for five years. The maximum is $10,000 over the five years (Anne Arundel County 2010).

4.6.4 Rebates and cost-share programs

A number of municipalities around the country offer rebate and cost-share programs for green infrastructure development. These rebate programs help subsidize the up-front cost of green infrastructure project implementation in an effort to encourage greater private-parcel owner investment in such projects. Rebate and cost-share programs typically offer a list of eligible practices, such as installation of cisterns, permeable pavement, or green roofs. For example, Milwaukee's Regional Green Roof Initiative provides up to $10 per square foot of an approved green roof project (Milwaukee Metropolitan Sewerage District 2013). In Maryland, Montgomery County coordinates RainScapes Rewards, providing rebates based on the amount of runoff captured through green infrastructure practices. Residential properties are capped at $2,500, and commercial, industrial, and institutional parcels are capped at $10,000 (Montgomery County Department of Environmental Protection 2013). King County, Washington pays builders for 50 percent of the costs of green infrastructure retrofits, up to $20,000(MacMullan and ECONorthwest 2010, as cited in Roseen et al. 2012). Seattle's Rainwise program offers private property owners a rebate that covers most of the cost of installing cisterns and rain gardens (Seattle Public Utilities 2013).

4.6.5 Development incentives

Many municipalities offer additional incentives for including green infrastructure in new development or redevelopment projects. MacMullan (2010, as cited in Roseen et al. 2012) reports that Portland, Oregon, has a green roof bonus in its zoning code that provides an additional three square feet of floor area for every one square foot of green roof installed, provided the green roof covers at least 60 percent of the roof area. Meanwhile, cities like Austin, Chicago, and Santa Monica provide discounts for builders who employ low-impact development (LID) practices (Roseen et al. 2012).

4.7 REDUCED CRIME

As stated by Wolfe and Mennis (2012), there are two schools of thought regarding the impact of vegetation on crime: "The first is the belief that vegetation facilitates crime because it hides perpetrators and criminal activity from victims and bystanders. The second, and more recent, school of thought claims that the presence of vegetation can actually deter crime." The concept of crime prevention through environmental design (CPTED) recognizes that social monitoring of public spaces—of having "eyes on the street"—and quality landscape can encourage more public use of city spaces.

The impact of vegetation/landscaping on crime

- Among minor crimes, there is less graffiti, vandalism, and littering in outdoor spaces with natural landscapes than in comparable plant-free spaces (Brunson 1999).
- Public-housing residents with nearby trees and natural landscapes reported 25 percent fewer acts of domestic aggression and violence (Kuo and Sullivan 2001).
- Public-housing buildings with high levels of vegetation had 52 percent fewer total crimes, 48 percent fewer property crimes, and 56 percent fewer violent crimes than buildings with little vegetation (Kuo and Sullivan 2001).
- Studies of residential neighborhoods found that property crimes were less frequent when there were trees in the right-of-way and more abundant vegetation around a house (Lorenzo and Wims 2004, Donovan and Prestemon 2012).
- In a study of community policing innovations, there was a 20 percent overall decrease in calls to police from the parts of town that received location-specific treatments. Cleaning up vacant lots was one of the most effective treatment strategies (Braga and Bond 2008).
- Research in the Baltimore region suggests that a 10 percent increase in tree cover would be associated with an 11.8 percent decrease in crime rate, all else being equal (Troy, Grove, and O'Neil-Dunne 2012).

Source: Adapted from University of Washington 2013.

Overall, recent research indicates that green infrastructure has the potential to reduce crime on private property, especially in urban areas. Crime reduction is associated with specific types of vegetation, such as open space covered with grass and tall trees. Conversely, vegetation such as shrubs and bushes that provide places for criminals to hide has been found to increase crime. However, shrubs and bushes can be designed and arranged to minimize their impact on sight lines, providing pleasant places for people to gather and thus improving safety and security.

Despite existing research showing crime-reduction benefits, the extent of the reduction is unknown, and "it is possible that crimes are merely displaced to other areas of the city" (Donovan 2009 as cited in Entrix, Inc. 2010). Based on the literature reviewed below, crime reduction is likely to be achieved by trees, green streets, and landscaping (in a business district), and potentially by green roofs. A study on the costs associated with specific types of crime in the United States (in terms of both government resources and costs to victims) estimates that the average cost of a property crime (i.e., stolen property) amounts to $7,974 (2008 USD) and the average cost of an act of vandalism is $4,860 (2008 USD) (McCollister, French, and Fang 2010).

As cited in Entrix, Inc. (2010), the Landscape and Human Health Laboratory at the University of Illinois at Urbana/Champaign describes several ways in which vegetation lowers crime:

"First, greenery helps people to relax and renew, reducing aggression. Second, green spaces bring people together outdoors, increasing surveillance and discouraging criminals. Relatedly, the green and groomed appearance of an apartment building is a cue to criminals that owners and residents care about a property and watch over it and each other" (University of Illinois).

Kuo and Sullivan (2001) used police crime reports to examine the relationship between vegetation and crime in buildings located within the same housing development in inner-city Chicago. Controlling for building characteristics (i.e., number of apartments per building and building height), the authors found that buildings with high levels of vegetation had 48 percent fewer property crimes and 56 percent fewer violent crimes than buildings with low levels of vegetation. Buildings with medium levels of vegetation were found to have 40 percent fewer property crimes and 44 percent fewer violent crimes. This study specifically looked at grass and widely spaced, high-canopy trees.

Donovan and Prestemon (2012) investigated the relationship between vegetation and crime based on data for 2,800 single-family homes in southeast Portland.

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Buckman Heights Apartments, Portland, OR.

Results of the study found that on private lots, low trees that decreased views from first-floor windows were associated with increased crime occurrence, while taller trees were associated with decreased crime. Street trees were generally associated with decreased crime, especially decreased vandalism. The authors reason that "trees may reduce crime by signaling to potential criminals that a house is better cared for and, therefore, subject to more effective authority than a comparable house with fewer trees." (Donovan and Prestemon 2012)

Troy, Grove, and O'Neil-Dunne (2012) found a strong inverse association between crime rates and tree canopy cover in the Baltimore region, after controlling for many factors. However, the authors report geographic variability in the relationship between crime and trees, and in a few areas a positive relationship was found—that is, areas with high levels of tree canopy cover had increased crime rates. The authors suggest that results in these areas "may relate to the fact that they contain relatively large interface zones between residential and industrial uses, where vegetation tends to be more unmanaged." (Troy et al. 2012) Thus, the trees provide potential concealment for criminals rather than acting as a deterrent.

In a study of trees and crime in Philadelphia, Wolfe and Mennis (2012) found that vegetation abundance is associated with lower crime rates for assault, robbery, and burglary (increased vegetation was not found to significantly impact theft). This study controlled for several socioeconomic indicators of crime, including educational attainment, population density, and poverty rates.

4.8 IMPROVED HEALTH AND JOB SATISFACTION FOR OFFICE EMPLOYEES

Workers have a strong and clear preference for nature near the workplace. Satisfying this preference is not necessarily difficult to achieve. Kaplan (2007) found that office workers have a moderate preference for native plants and rain gardens. However, even more than native plants or rain gardens, workers appreciate access to areas with flowers or color, large trees, and especially nature-lined walking paths (Kaplan 2007, Hands and Brown 2002, Snep 2008).

The benefits of these physical improvements have been explored to some extent. In a study in Denmark, Lottrup (2012) found that physical access to green space improved employee satisfaction and well-being and reduced levels of stress. Views of nature also produced these improvements, but to a lesser extent. Kaplan (1993) made similar findings, demonstrating that nature improves employee satisfaction and that workers with a view of nature reported better health than those without a view. (However, the study stopped short of evaluating whether employees with views of nature reported fewer sick days.) In a study of nurses in a hospital setting, researchers found improvement in alertness (i.e., performance) for nurses who had views of nature (Pati, Harvey, and Batach 2008). Plympton, Conway, and Epstein (2000) and Kellert (2004) describe how greater exposure to nature and natural lighting can result in improved cognitive performance, improved overall health and development, higher test scores, improved attendance, and greater teacher satisfaction in schools.

It is important to note that green space does not need to be extensive or pristine to provide a benefit. Kaplan (1993) used a series of surveys and found that benefits may come from as little as "a few trees, some landscaping, or some signs of vegetation. In fact, the presence of other buildings or parking lots does not seem to be a problem, as long as the natural world is there too."

4.9 REDUCED INFRASTRUCTURE AND LIFE CYCLE COSTS

Several studies and real-world applications have found that green infrastructure can reduce gray infrastructure and life cycle costs associated with private property improvements. For example, green roofs do not need to be replaced as often as conventional roofs and can reduce heating, ventilating, and air conditioning (HVAC) needs on-site (David Evans and Associates 2008). A parking lot constructed with permeable pavement (such as interlocking concrete pavement blocks) can have significantly lower maintenance costs compared with asphalt. Although these types of benefit are maximized in the context of development and redevelopment projects, they can also be realized by property owners retrofitting existing developed spaces. (Note, however, that the category of benefits described in Section 4.9.3 is specific to development projects and would not apply to retrofits of existing development.)

4.9.1 Green roof benefits

In a study of the benefits of extensive green roofs in Portland, the Evans group reported that a typical conventional roof has a life expectancy of 20 years, while an ecoroof has a life expectancy of at least 40 years. The authors attribute the longer life expectancy of green roofs to growth medium and plantings that help to "protect the roof's waterproof membrane from ultraviolet radiation, extreme temperature fluctuations, and damage from use or maintenance"(David Evans and Associates 2008).[9]

Based on this assumption, a conventional roof would need to be replaced or significantly repaired once over the period of a green roof's expected life. The authors estimated that for a 40,000-square-foot roof, the avoided present-value cost of not having to replace a conventional roof after 20 years would amount to about $561,700 (2008 USD). In addition, depending on the size of the building relative to the square footage of the green roof (the fewer floors, the more pronounced the impact), the building may be able to operate with a smaller HVAC system, thus saving the building owner money. For example, a California study found that green roofs can save about $0.10 per square foot in air conditioning system capital costs (David Evans and Associates 2008). Applying this study to a five-story building with 40,000 square feet per floor, Evans estimated that the use of an ecoroof in Portland would reduce cooling equipment size per floor, resulting in a capital (one-time) cost savings of $21,000.

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Installation of porous pavers at the Energy Exchange in Milwaukee, WI (November 2009).

4.9.2 Permeable pavement benefits

The capital costs of permeable pavement systems range from about $2 to $6.50 per square foot for porous concrete, $5 to $10 for interlocking pavers, and $1.50 to $5.75 for grass/gravel pavers. By contrast, the cost of traditional asphalt is about $0.50 to $1.00 per square foot (U.S. EPA and LID Center, 2007). As exemplified below, despite the higher capital costs, permeable pavement systems can have lower annual maintenance costs, resulting in lower overall life cycle costs compared with conventional pavement. The cost-effectiveness of different types of permeable paver systems depends on site-specific conditions.

Further, the Low Impact Development (LID) Urban Design Tool website (a joint effort of the EPA and the LID Center) notes that an accurate price comparison between permeable pavement and traditional asphalt systems must include the full installation costs of each system (U.S. EPA and LID Center, 2007). For example, an impervious paving system includes drains, reinforced-concrete pipes, catch basins, outfalls, and stormwater connects. When these are taken into account, an asphalt or conventional concrete stormwater management paving system could cost between $9.50 and $11.50 per square foot, whereas the a full permeable pavement system (which can include some of the same components) can reduce costs by 50 percent or more.

In a study of capital and maintenance costs for alternative stormwater management practices in the northeastern United States, Houle et al. (2013) found that of all the practices evaluated (including both conventional and green infrastructure), porous asphalt had the lowest maintenance burden overall in terms of personnel hours, and the second-lowest annual maintenance costs. Annual operations and maintenance (O&M) costs amounted to $0.06 per square foot, which represented 4 percent of the project's total capital costs. The authors noted that pavement vacuuming accounts for the majority of costs associated with asphalt maintenance, but that this service is becoming increasingly available in the private sector. This will serve to further reduce overall maintenance costs. The authors did not compare the costs of porous pavement systems with the costs of traditional asphalt.

In a preliminary analysis of the life cycle costs associated with porous pavement, the Lake County (Illinois) Forest Preserves found that for a 40,000-square-foot parking lot, the cost for installation, biannual vacuum sweeping, and other maintenance associated with a permeable paver system would amount to about $240,365 over 25 years.[10] For an asphalt parking lot of the same size, the cost was estimated to be about $348,637 over 25 years, including installation, crack sealing, seal coat application, striping, patching, and surface replacement (Lake County Forest Preserves 2003). Although this shows significant savings, the expected life spans of the porous pavement and traditional pavement systems were not reported by the authors.

In a study of the benefits of green infrastructure for private property owners, undergraduate students of Columbia University's Workshop in Sustainable Development found significant cost savings associated with the use of interlocking concrete pavement blocks (ICPB) for parking lots compared with asphalt and with other types of permeable pavement systems such as porous concrete or grass/gravel pavers (Columbia University 2011). Relying on data from the Charles River Watershed Association (CRWA), the Interlocking Concrete Pavement Institute, and a permeable pavement vendor (McCormack and Son), the study found that despite the higher capital costs, ICPB is the cheapest and most cost-effective method due to its lower maintenance requirements. For example, porous concrete requires "periodic jetting or brushing to unclog blocked pores and to maintain system performance" (McCormack and Son 2013), and maintenance costs for vacuum sweeping a half-acre parking lot made of porous concrete amount to approximately $400–$500 per year (CRWA 2008). ICPB also requires sweeping (at least once a year) but may have lower maintenance costs overall. For highly clogged pavement openings, the stones can be removed with vacuuming and replaced with clean material. This is a distinct maintenance advantage over pervious concrete and porous asphalt pavements (ICPI 2013).

Savings associated with permeable pavement were also demonstrated in West Union, Iowa. (U.S. EPA, 2013a). When designing a green street project, the city compared the life cycle costs (including capital and O&M costs) associated with the use of a permeable paver system in the downtown area versus using traditional bituminous or Portland cement concrete pavement. Cumulative costs were analyzed over a 57year project period. Results of the life cycle analysis showed that although the use of porous pavement would initially be more expensive, in the long run the lower maintenance and repair costs would result in cost savings. The city estimates that it will begin to realize these savings by year 15 of the project. Estimated cumulative savings over the 57year analysis period amount to close to $2.5 million.

4.9.3 Reduced infrastructure costs and increased sales for development projects

Beyond the specific context of stormwater retrofits, the EPA finds that, in general, implementing well-chosen green infrastructure and/or low impact development (LID) practices in development projects reduces total project costs. "Specifically, utilizing LID can result in net project cost savings by decreasing the amount of required, and expensive, belowground drainage infrastructure and reducing or eliminating the need for other stormwater management–related facilities" (Roseen et al. 2012).

Additional benefits associated with LID for new development projects include reduced site preparation costs and an increase in the number of allowable buildable lots, Clar (2003) demonstrates a number of cost-saving benefits associated with redesigning a conventional subdivision in Maryland with LID designs, including 1) the elimination of two stormwater ponds that would have cost about $200,000), 2) an increase in the number of buildable lots, which added approximately $90,000 in value to the project, and 3) reduced land clearing requirements, which resulted in cost savings of close to $160,000 (Clar 2003 as cited in Roseen et al. 2012).

The city of Lenexa, Kansas, analyzed the potential impacts of green infrastructure–oriented development standards within the city. Using existing site plans for single-family residential, multifamily residential, commercial/retail, and warehouse/office developments, the city selected green infrastructure best management practices (BMPs) that would meet specified water-quality goals for each development. Next, the capital costs associated with BMP construction were estimated. As part of this process, construction items that were originally considered part of the development that could be replaced or eliminated with BMP construction were identified and a cost savings assigned to them (e.g., savings due to reduced earthwork and/or pavement needed). The benefits associated with the availability of additional developable land (due to the reduced need for large stormwater detention facilities) were also included in the calculations.

The study found significant cost savings with the application of BMPs for all four development types, ranging from $89,043 in savings for the multifamily development to $168,898 in savings for the commercial/retail development (U.S. EPA 2013a).

4.10 SUMMARY OF POTENTIAL BENEFITS

As demonstrated throughout the preceding discussion, the implementation of green infrastructure can result in substantial benefits for commercial property owners. These potential benefits include increased rents and property values, increased retail sales, energy savings, reduced flood damage, increased worker productivity, reduced water bills, reduced crime, and lower infrastructure costs. Private property owners can also benefit from stormwater fee credits and other financial incentives, such as grant programs or tax credits, in cities where such programs are available.

The magnitude of benefits realized by individual property owners depends on a number of factors. Most important, green infrastructure must be designed, implemented, and maintained in a way that takes advantage of the benefits it can provide. For example, good design is an important component in realizing the benefits of increased rents, occupancy rates, property values, and retail sales. In addition, energy savings will depend on the location and types of plantings, and avoided flood damage is dependent on proper maintenance of the green infrastructure assets.

Community- and site-specific characteristics will also influence the benefits realized. Factors including climate, existing green space, remaining life of current gray infrastructure assets (such as conventional roofs), and the availability of financial incentives will affect the magnitude of the benefits for any given property owner.

5. EXAMPLES OF BENEFITS TO PRIVATE PROPERTY OWNERS

The following sections provide examples of potential green infrastructure benefits for three representative building types: a medium-size office building, a multifamily residential building, and a set of retail stores. Assumptions and inputs are highlighted for each analysis, and methods are briefly discussed.

5.1 GENERAL METHODS

The examples presented here are based on findings from the literature discussed above and some very basic assumptions. For building specifications, we relied on data from the Department of Energy's (DOE) commercial building benchmark specifications (i.e., size of building and number of stories) for a medium-size office building, a midrise apartment, and a strip mall.[11] For other parameters (e.g., lot size, permeable area, property values, rental rates), we used online data sources or made reasonable assumptions.

To estimate the potential benefits of green infrastructure for each building type, we applied findings from the literature described above and/or relied on existing models. For example, to estimate energy savings associated with a green roof, we input building and green roof assumptions into the Green Roof Energy Calculator developed by the Green Building Research Laboratory at Portland State University (Green Building Research Laboratory, undated).

For each example, we conducted a net present value analysis of benefits over a 40-year period. This analysis includes a discount rate of 6 percent and assumes an annual rate of inflation based on Congressional Budget Office (CBO) projections for the Consumer Price Index (CPI). To project electricity and natural gas prices into the future, we analyzed the historic relationship between the change in price for these commodities and the change in CPI (from 1990 through 2010). We assume these general relationships will hold in the future.

It is important to note that the purpose of this effort is to present the *potential magnitude* of benefits, as this research is limited in scope. The actual application and associated value of green infrastructure depends on site-specific conditions. Further, although the costs (including both capital and O&M costs) associated with green infrastructure improvements are generally not included in this analysis, the benefits calculated here are intended to demonstrate that the payback period associated with green infrastructure is shorter than would be anticipated if only a reduction in stormwater fees were taken into account.[12]

In addition, where the value of a certain benefit is known to be contingent on factors that vary from one city to another—such as local electricity rates used to determine the value of energy savings, or the value of local rebates or other financial incentives—we have used data from Philadelphia for illustrative purposes. However, the analysis is intended to be relatively generic in terms of location, such that the basic lessons to be drawn from these examples are broadly applicable nationwide. A more in-depth research effort would better quantify these values for specific regions and building types.

5.2 MEDIUM-SIZE OFFICE BUILDING

The figures below present the key office building assumptions, the proposed green infrastructure property improvements, and the resulting benefits. Subsequent text describes the methods used for this analysis.

Building Assumptions	
Size	53,600 sq. ft.
Stories	3
Roof size	17,900 sq. ft.
Lot area	32,000 sq. ft.
Permeable area (covered in turf)	1,000
Rent	$19.23 per sq. ft.

Green infrastructure improvements

- 17,900-sq.-ft. green roof, installed at the end of life of the existing conventional roof, with green covering 80 percent of the surface, or 14,300 sq. ft. (Remainder of roof is impervious area.)
- 20 strategically planted trees,10 opposite a west-facing wall and 10 opposite an east-facing wall
- 10,000-sq.-ft. permeable pavement parking lot, installed at the end of life of the existing parking lot
- Bioswales and rain gardens that manage 1 inch of runoff from 4,700 sq. ft. of adjacent impervious area

Potential Benefits	
Quantified benefits[a]	
Energy savings due to reduced demand for heating and cooling	$1,630 annually
Avoided conventional roof replacement costs	$271,970 present value over 40-year analysis period
Tax credit	$67,130 one-time credit in year of installation
Increased rental income	$72,150 annually (assuming no vacancies)
Stormwater fee reduction	$3,490 annually (projected to increase 6% per year)
Non-quantified benefits[b]	
Increased property values	++
Reduced infrastructure costs due to use of permeable pavement system	+
Reduced crime	+/U
Improved health and employee satisfaction	+ (for tenants and employees)
Reduced costs associated with flooding	U
Total present value benefits (over 40-year analysis period)[c]	**$1,863,000 +**

a. All annual values are presented in 2013 USD, with the exception of the stormwater fee reductions which are presented in 2015 USD in accordance with the rates and credits available in the first year of the project.
b. Key: + would likely increase net benefits; + + would increase net benefits significantly; U direction of net change is uncertain.
c. Present value benefits over 40-year period were estimated on the basis of a 6 percent discount rate, projected CPI, projected increase in electricity and natural gas prices in relation to CPI (based on historical relationship), and 6 percent annual increase in stormwater fees. Improvements assumed to be implemented in 2015. Avoided conventional roof replacement costs were added to net present value of other benefits.

5.2.1 Quantified benefits

Energy savings due to reduced demand for heating and cooling. Specific assumptions input into the Green Roof Energy Calculator include the use of an "old" office building located in Philadelphia with a total roof area of 17,900 square feet.[13] The green roof is assumed to cover 80 percent of the roof, to have a soil depth of 6 inches and a leaf area index of 2.5 (based on a scale of 0.5 to 5.0), and to not require irrigation. Pennsylvania average commercial energy prices for July 2013 were also entered into the model.[14]

To estimate the energy savings from 20 strategically planted trees (10 trees opposite a west-facing wall and 10 trees opposite an east-facing wall), we assumed that medium-size trees would be planted. We then applied the energy savings associated with these trees based on McPherson et al. (2006) and determined the value of the energy savings based on current energy rates for Pennsylvania.[15]

Results of these analyses indicate that the green roof would reduce building energy costs by $920 annually, compared with a conventional (dark albedo) roof. Energy savings from the trees amount to $710 ($298 in electricity savings and $412 in natural gas savings), on average, over the assumed 40-year life of the trees.[16] McPherson's model takes into account the time it takes trees to reach full maturity (and therefore to provide the full energy savings benefit) and assumes a 60 percent survival rate over the 40-year period.

Avoided conventional roof replacement costs. To estimate the avoided roof replacement costs due to the longer life span of green roofs, we took the net present value avoided costs calculated by David Evans and Associates (see Section 4.9.1) for a 40,000-square-foot roof, and scaled it to the roof size of our hypothetical building (about 18,000 square feet). On the basis of this simple application, we estimate that the green roof in this example would avoid a net present value of $271,966 in roof-replacement costs over the 40-year analysis period.[17] It is likely that there are economies of scale associated with larger roof replacements (e.g., the 40,000-square-foot roof may cost less on a square-foot basis than a much smaller roof), so this example may underestimate total benefits

Tax credit. As described above, in many cities tax credits are granted to businesses that install green roofs on their buildings. In Philadelphia the credit amounts to 25 percent of the cost of installation, up to $100,000 (City of Philadelphia Business Services, 2013). According to the Philadelphia Water Department (PWD 2013a), green roofs range in cost from $10 to $25 per square foot, depending on the type of roof. The roof in this example contains 6 inches of soil and is therefore considered an intensive green roof. We therefore use $15 per square foot as a conservative estimate for the cost of the green roof (and therefore the tax credit). On the basis of these assumptions, we estimate that the owners of the office building would receive a one-time tax credit of $67,125 (25 percent of the estimated green roof capital cost of $268,500).

Increased rental income. The average rental rate for office buildings in Philadelphia is $19.23 per square foot per year (Loopnet.com, 2013). Applying this to the total floor space of our hypothetical building (53,600 sq. ft.) amounts to a total rental income of $1,030,728 per year for the property. As discussed in Section 4.1.1, landscaping has been found to add approximately 7 percent to the average rental rate for office buildings. Applying this estimate to green infrastructure improvements implemented at the office building could potentially result in $72,150 of additional rental income each year. In addition, the green infrastructure would likely reduce vacancy rates within the building, helping to maximize rental income. This analysis assumes that very little landscaping design or green area existed at the site previously, the only permeable area being 1,000 square feet of turf.

Stormwater fee reduction. All property owners in Philadelphia pay a municipal stormwater fee to support the capital and operational expenses of the city's stormwater infrastructure. The city's stormwater fee consists of a fixed monthly charge per parcel plus additional charges based on the size of the property and the quantity of impervious area.

The city offers stormwater fee reductions (credits) to property owners who install green infrastructure on their property to reduce impervious area and/or capture runoff on-site. For our analysis, fee reductions were calculated using the city's credit calculation methodology (PWD 2013c, 2013d).

For this hypothetical building, the green roof, permeable pavement, tree plantings, bioswales, and rain gardens installed on the property would produce a stormwater fee reduction of $3,490 in 2015.

Stormwater fees are currently on an upward trajectory; for purposes of this analysis, it was assumed that stormwater fees and the corresponding credits would grow by an average of 6 percent annually for the foreseeable future. Over the 40-year analysis time frame, this building's green infrastructure facilities would produce a present value of $117,140 in stormwater fee reductions.

5.2.2 Non-quantified benefits

Increased property value. Although green infrastructure would be likely to increase the property value at this building, very little literature exists on this topic for commercial properties. Thus, we did not attempt to quantify this benefit.

Reduced infrastructure costs due to use of permeable pavement system. Permeable pavement can have lower life cycle costs than traditional asphalt. However, some uncertainty surrounds the extent of these benefits. For this reason, we did not attempt to quantify the reduced life cycle costs.

Reduced crime. The green infrastructure improvements at this site have the potential to reduce crime at the office building. The average cost associated with property crimes in the United States (in terms of both government resources and costs to victims) is $7,974, and the average cost associated with an act of vandalism amounts to $4,860 (2008 USD, McCollister et. al. 2008). Thus, deterrence of even just one instance of a property crime or act of vandalism would result in notable savings. (In this example, savings would accrue to the companies that rent the office space, and not necessarily to the property owner.) Due to the uncertainty associated with the type of crime avoided and the number of events that would be avoided (if any), we did not attempt to quantify this benefit.

Improved health and employee satisfaction. Studies have found physical access and views of green space can improve employee satisfaction, well-being, alertness, and cognition and reduce levels of stress. In this example, green infrastructure would benefit the companies and employees that rent the office space, and not necessarily to the property owner. This benefit is partly reflected in the increased rents companies are willing to pay for offices that have nice landscaping or shading.

Reduced costs associated with flooding. The green infrastructure improvements at this location may also help to reduce costs associated with flooding (if located in an area prone to flooding). However, benefits at the individual property level are difficult to quantify. Reduced risk of flood can also further increase property values.

5.3 MULTIFAMILY BUILDING

The figures below present the key multifamily building assumptions, the proposed green infrastructure property improvements, and the resulting benefits. Subsequent text describes the methods used for this analysis.

Building Assumptions	
Size	33,740 sq. ft.
Stories	4
Roof size	8,435 sq. ft.
Lot area	12,435 sq. ft.
Existing permeable area (covered in turf)	1,000 sq. ft.
Number of units	32
Rent	$1,265 per unit

Green infrastructure improvements

- 8,435 sq. ft. green roof, installed at the end of the life of the existing conventional roof, with green covering 90 percent of the surface, about 7,600 sq. ft.
- 12 strategically planted large trees, 6 opposite a west-facing wall and 6 opposite an east-facing wall
- Bioswales and rain gardens that manage 1 inch of runoff from 2,635 sq. ft. of adjacent impervious area

Potential Benefits	
Quantified benefits[a]	
Energy savings due to reduced demand for heating and cooling	$1,780 annually
Avoided conventional roof replacement costs	$128,160 net present value over 40-year analysis period
Tax credit	$52,720 one-time credit in year of installation
Increased rental income	$77,720 annually (assuming no vacancies)
Increased property value	$37,500 one-time benefit to property owner at time of sale
Stormwater fee reductions	$1,230 annually(projected to increase 6% per year)
Non-quantified benefits[b]	
Reduced crime	+/U
Reduced costs associated with flooding	U
Total present value benefits (over 40-year analysis period)[c]	**1,740,000 +**

a. All annual values are presented in 2013 USD, with the exception of the stormwater fee reductions which are presented in 2015 USD in accordance with the rates and credits available in the first year of the project.
b. Key: + would likely increase net benefits, + + would increase net benefits significantly, U direction of net change is uncertain.
c. Present value benefits over 40-year period were estimated on the basis of projected CPI, projected increase in electricity and natural gas prices in relation to CPI (based on historical relationship), and 6 percent annual increase in stormwater fees. Improvements assumed to be implemented in 2015. Avoided conventional roof replacement costs were added to net present value of other benefits. (Increased property value is not included in total present value of benefits because it is contingent on whether [and when] the property is sold.)

5.3.1 Quantified Benefits

Energy savings due to reduced demand for heating and cooling. Specific assumptions input into the Green Roof Energy Savings Calculator include the use of an “old” residential building in Philadelphia with a total roof area of 8,435 square feet. The green roof is assumed to cover 90 percent of the roof, to have a soil depth of 8 inches (making it an intensive green roof) and a leaf area index of 3.0, and to not require irrigation. Results of the calculator indicate that the green roof would reduce building energy costs by $873 per year, based on July 2013 residential energy costs for Philadelphia.[18]

To estimate the energy savings from the strategically planted trees (6 trees opposite a west-facing wall and 6 trees opposite an east-facing wall), we assumed that large trees would be planted. We then applied findings from McPherson et al. (2006) to determine total energy savings. On the basis of these assumptions, the trees in this example would reduce energy costs by $908 per year ($456 in natural gas savings and $452 in electricity savings), on average.[19] McPherson’s model takes into account the time it takes trees to reach full maturity (and therefore to provide the full energy savings benefit) and assumes a 60 percent survival rate over the 40-year period.

Avoided conventional roof replacement costs. To estimate the avoided roof replacement costs due to the longer life span of green roofs, we took the net present value avoided costs calculated by David Evans and Associates for a 40,000-square-foot roof, and scaled it to the roof size of our hypothetical building (about 8,435 square feet). On the basis of this simple application, we estimate that the green roof in this example would avoid a net present value of $128,158 in roof replacement costs over the 40-year analysis period. It is likely that there are economies of scale associated with larger roof replacements (e.g., the 40,000-square-foot roof may cost less on a square-foot basis than a much smaller roof), so this example may underestimate total benefits.

Tax credit. Philadelphia’s green roof tax credit amounts to 25 percent of the cost of installing a green roof, up to $100,000 (City of Philadelphia Business Services 2013). For this example, we use the high end of PWD’s cost range as our cost estimate for the green roof ($25/square foot) because it is an intensive green roof (having a soil depth of more than 6 inches, to accommodate larger plants). On the basis of these assumptions, we estimate that the owners of the multi-family building would receive a one-time tax credit of $52,718 (25 percent of the estimated green roof cost of $210,875).

Increased rental income. The average rental rate for apartments in Philadelphia is $1,265 per month (RentJungle.com 2013). With 32 apartments in our hypothetical building, total rental income amounts to $485,760 per year (assuming no vacancies) for this property. As discussed in Section 4.1.2, green roofs have been found to add approximately 16 percent to the average rental rate for multifamily units. Thus, a green roof implemented at the multifamily building would result in a maximum of $77,720 in additional rental income each year. Although other improvements, such as the addition of trees and other landscaping, could also add to the rental rate, it is difficult to separate this effect from the effect of a green roof in this simple analysis. Thus, we use 16 percent as an estimate of potential rental premiums.

Increased property value. As documented in Philadelphia's Triple-Bottom-Line Analysis of Alternative CSO Control Policies (Stratus Consulting 2009), green infrastructure improvements have been found to increase residential property values by 2.5 percent.[20] Based on a review of multifamily buildings for sale in Philadelphia, $1.5 million seems to be a reasonable assumption for the value of this property. Thus, when selling the property, the owner could expect to receive $37,500 more than he or she would have without the green infrastructure improvements. Based on Philadelphia's tax rate of 1.34 percent of assessed value, property taxes may increase by about $500 per year if the assessed value also increased by this amount. The net benefit (increased property value minus cost) is not factored into the net present value analysis because the value of the benefit depends on when (and if) the property is sold and how the assessed value compares with the selling price (the assessed value is often lower than the sale price, and therefore the tax increase would likely be less than $500).

Stormwater fee reduction. All property owners in Philadelphia pay a municipal stormwater fee to support the capital and operational expenses of the city's stormwater infrastructure. The city's stormwater fee consists of a fixed monthly charge per parcel plus additional charges based on the size of the property and the quantity of impervious area.

The city offers stormwater fee reductions (credits) to property owners who install green infrastructure to reduce impervious area and/or capture runoff on-site. Fee reductions were calculated using the city's credit calculation methodology (PWD 2013c, 2013d). For this hypothetical building, the green roof, tree plantings, bioswales, and rain gardens installed on the property would produce a stormwater fee reduction of $1,230 in 2015.

Stormwater fees are currently on an upward trajectory; for the purposes of this analysis, it was assumed that stormwater fees, and the corresponding credits, would grow by an average of 6 percent annually for the foreseeable future. Over the 40-year analysis time frame, this building's green infrastructure facilities would produce a present value of $41,380 in stormwater fee reductions.

5.3.2 Non-quantified benefits

Reduced crime. The green infrastructure improvements at this site have the potential to reduce crime at the multifamily building. The average cost associated with property crimes in the United States (in terms of both government resources and costs to victims) is $7,974, and the average cost associated with an act of vandalism amount to $4,860 (2008 USD, McCollister et. al. 2008). Thus, deterrence of even just one instance of a property crime or act of vandalism would result in significant savings. Due to the uncertainty associated with the type of crime avoided and the number of events that would be avoided (if any), we did not attempt to quantify this benefit.

Reduced flood-related costs. The green infrastructure improvements at this location may also help to reduce costs associated with flooding (if located in an area prone to flooding). However, benefits at the individual property level are difficult to quantify. Reduced risk of flood can also further increase property values.

5.4 RETAIL CENTER

The figures below present the key assumptions, proposed green infrastructure property improvements, and the resulting benefits for a midsize retail center. Subsequent text describes the methods used for this analysis.

Building Assumptions	
Size	40,000 sq. ft.
Stories	1
Roof size	40,000 sq. ft.
Lot area	128,000 sq. ft.
Existing permeable area (covered in turf)	4,000 sq. ft.
Number of retail units	15
Rent	$17 per sq. ft.
Annual retail revenue	$2,182,000 per store

Green infrastructure improvements

- 40,000-sq.-ft. green roof, installed at the end of the life of the existing conventional roof, with green covering 90 percent of surface, or 36,000 sq. ft.
- 50 strategically planted medium-size trees, 25 opposite west-facing walls and 25 opposite south-facing walls
- Bioswales and rain gardens that manage 1 inch of runoff from 2,000 sq. ft. of adjacent impervious area
- 72,000-sq.-ft. permeable-pavement parking lot
- Cisterns to capture runoff from 5,000 sq. ft. of roof area and use for irrigation

Potential Benefits	
Quantified benefits[a]	
Energy savings due to reduced demand for heating and cooling	$3,560 annually
Avoided conventional roof replacement costs	$607,750 net present value over 40-year analysis period
Tax credit	$100,000 one-time credit in year of installation
Increased rental income	~$27,000 or more per year (assuming no vacancies)
Increased retail sales	$1.2 million per year
Stormwater fee reductions	$14,020 annually (projected to increase 6% per year)
Non-quantified benefits[b]	
Water conservation	+
Increased property value	++
Reduced infrastructure costs due to use of permeable pavement system	+/U
Reduced crime	+/U
Improved health and employee satisfaction	+ (for tenants and their employees)
Reduced costs associated with flooding	U
Total present value benefits (over 40-year analysis period)[c]	**$24,202,000+ (including $22,963,800 in increased retail sales, which accrue to the tenants)**

a. All annual values are presented in 2013 USD, with the exception of the stormwater fee reductions which are presented in 2015 USD in accordance with the rates and credits available in the first year of the project.
b. Key: + would likely increase net benefits, + + would increase net benefits significantly, U direction of net change is uncertain.
c. Present value benefits over 40-year period were estimated on the basis of projected CPI, projected increase in electricity and natural gas prices in relation to CPI (based on historical relationship), and 6 percent annual increase in stormwater fees. Improvements are assumed to be implemented in 2015. Avoided conventional roof replacement costs were added to net present value of other benefits. (Increased rental income is not included in total present value of benefits because there are no estimates in the literature of rental increases for retail buildings, specifically; and in order to avoid double counting of increased retail sales, some of which would be passed on to the owners of buildings to cover the higher rents.)

5.4.1 Quantified benefits

Energy savings due to reduced demand for heating and cooling. Specific assumptions input into the Green Roof Energy Calculator include the use of an "old" office building in Philadelphia (retail stores are not an option in the model). The green roof is assumed to span 90 percent of the 40,000-square-foot roof area, have a soil depth of 4 inches and a leaf cover index of 2.5, and to not require irrigation. Average Pennsylvania commercial energy prices for July 2013 were also entered into the model. Results indicate that the green roof would reduce building energy costs by $2,460 per year, on average.

To estimate the energy savings from the strategically planted trees (25 trees opposite west-facing walls and 25 trees opposite south-facing walls), we assumed that medium-size trees would be planted. We then applied the energy savings associated with these trees based on McPherson et al. (2006) to determine the value of the energy savings. Based on these assumptions, the energy savings associated with the trees amounts to about $1,103 per year ($671 in electricity savings and $431 in natural gas savings).[21,22]

Avoided conventional roof replacement costs. To estimate the avoided roof replacement costs due to the longer life span of green roofs, we applied the net present value avoided costs calculated by David Evans and Associates for a 40,000-square-foot roof to our hypothetical building. Based on this simple application, we estimate that the green roof in this example would avoid a net present value of $607,745 in roof replacement costs over the 40-year analysis period.

Tax credit. Philadelphia's green roof tax credit amounts to 25 percent of the cost of installation, up to $100,000 (City of Philadelphia Business Services 2013). For this example, we use the low end of PWD's cost range as our cost estimate for the green roof ($10/square foot) because the roof is an extensive green roof, with a soil depth of less than 6 inches. On the basis of this assumption, we estimate that the owners of the retail center would receive a one-time tax credit of $100,000 (25 percent of the estimated green roof cost of $400,000, and the maximum credit provided).

Increased retail sales. As noted in Section 4.2, an ongoing body of work has found that consumers are willing to spend more (or pay a premium) on products, visit more frequently, or travel farther to shop in areas with attractive landscaping, good tree cover, or green streets (Wolf 2013). Specifically, in areas with quality landscaping, customers indicate that they are willing to pay 8 percent to 12 percent more (Wolf 2005, 2007, 2009).

On the basis of Economic Census data for 2007 from the U.S. Census Bureau, we assume that strip mall retail stores average about $1 million in sales per year.[23] With 15 midsize retail stores in our hypothetical strip mall, this amounts to $15 million in total sales. For analysis purposes, we assume there are no existing trees on this retail site, and only minimal landscaping (i.e., turf), prior to the retrofit.

If consumers were to pay 8 percent more (by buying additional items or paying higher prices) after the addition of vegetation, this would result in increased sales of $1.2 million per year (or $80,000 per store). In addition, this does not include additional profits associated with shoppers visiting more frequently, or coming further away to visit the retail center. Increased sales would not directly benefit the building owner but would benefit the tenants at the strip mall.

Increased rental income. As discussed in Section 4.1.1, major urban quality improvements have been found to add 22 percent (on average) to rental rates for retail buildings. Similarly, the presence of quality vegetation and landscaping, specifically, has been found to add about 7 percent to average rental rates for office buildings. Although we were unable to find specific estimates for the impact of vegetation and landscaping on retail rental rates, findings from this related literature suggest that the benefits of green infrastructure (e.g., increased retail sales) would allow owners of retail buildings to command higher rents. This additional rent would offset a portion of the increased sales realized by the retail tenants.

In the third quarter of 2009, the national average asking price for retail rental space was about $17 per square foot per year (Retail Tenant Source 2009).[24] With 40,000 square feet of rental space in our hypothetical strip mall, total rental income amounts to $680,000 per year (assuming no vacancies) for the property. As a conservative estimate, we assume that rental rates would increase by at least half of the amount that we would expect retail sales to increase (*i.e.*, by 4 percent). With this assumption, the green infrastructure at the retail center would result in an additional $27,200 in rental income each year. Applying the same rate as found for office buildings (7 percent), would result in an increase in annual rents of $47,600. Given the lack of specific estimates in the literature, and to avoid double counting of increased retail sales (some of which would be passed on to the owners of buildings to cover the higher rents), this benefit is not included in the NPV calculation.

Stormwater fee reduction. All property owners in Philadelphia pay a municipal stormwater fee to support the capital and operational expenses of the city's stormwater infrastructure. The city's stormwater fee consists of a fixed monthly charge per parcel plus additional charges based on the size of the property and the quantity of impervious area.

The city offers stormwater fee reductions (credits) to property owners who install green infrastructure to reduce impervious area and/or capture runoff on-site. Fee reductions were calculated using the city's credit calculation methodology (PWD 2013c, 2013d). For this hypothetical building, the green roof, permeable pavement, tree plantings, bioswales, rain gardens, and cistern installed on the property would produce a stormwater fee reduction of $14,024 in 2015.

Stormwater fees are currently on an upward trajectory; for purposes of this analysis, it was assumed that stormwater fees, and the corresponding credits, would grow by an average of 6 percent annually for the foreseeable future. Over the 40-year analysis time frame, this building's green infrastructure facilities would produce a present value of $470,990 in stormwater fee reductions.

5.4.2 Non-quantified benefits

Water conservation. The retail center will use water collected in the cistern to irrigate the property's green areas. This will result in reduced water costs for the owner, as well as an improved public image, such as described in Section 4.1.3 in connection with eco-labels. Relative to the benefits described above, the reduction in water costs is not significant.

Increased property value. Although green infrastructure would also likely increase property values at a retail center, very little literature exists on this topic for commercial properties. Thus, we did not attempt to quantify this benefit.

Reduced infrastructure costs due to use of permeable pavement system. Permeable pavement can have lower life cycle costs than traditional asphalt. However, there is still some uncertainty surrounding the extent of these benefits. For this reason, we did not attempt to quantify the reduced life cycle costs.

Reduced crime. The green infrastructure improvements at this site have the potential to reduce crime at the office building. The average cost associated with property crimes in the United States (in terms of both government resources and costs to victims) is $7,974, while the average cost associated with an act of vandalism amount to $4,860 (2008 USD, McCollister et. al. 2008). Thus, deterrence of even just one instance of a property crime or act of vandalism would result in significant savings. Due to the uncertainty associated with the type of crime avoided and the number of events that would be avoided (if any), we did not attempt to quantify this benefit.

Improved health and employee satisfaction. Studies have found physical access and views of green space can improve employee satisfaction, well-being, alertness, cognition, and levels of stress. In this example, green infrastructure would benefit the companies that rent the retail space and their employees, and not necessarily the property owner. This benefit is partly reflected in the increased rents that tenants are willing to pay for stores that have nice landscaping or shading.

Reduced flood-related costs. The green infrastructure improvements at this location may also help to reduce costs associated with flooding (if located in an area prone to flooding). However, benefits at the individual property level are difficult to quantify. Reduced risk of flood can also further increase property values.

References

Acks, K. 2006. "A Framework for Cost-Benefit Analysis of Green Roofs: Initial Estimates." In *Green Roofs in the Metropolitan Region: Research Report,* edited by C. Rosenzweig, S. Gaffin, and L. Parshall.

American Rivers, American Society of Landscape Architects, Eco Northwest, and Water Environment Federation. 2012. *Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide*. Available at www.asla.org/uploadedFiles/CMS/Government_Affairs/Federal_Government_Affairs/Banking%20on%20Green%20HighRes.pdf. Accessed 6/21/2013.

Anne Arundel County. 2010. *Stormwater Management Tax Credit*. Available at www.aacounty.org/DPW/WPRP.Stormwater%20Management%20Tax%20Credit%20HandOut.pdf. Accessed 6/21/2013.

Been, V., and I. Voicu. 2007. "The Effect of Community Gardens on Neighboring Property." *Real Estate Economics* 36 (2): 241–283.

Bisco Werner, J.E., J. Raser, T.J. Chandler, and M. O'Gorman. 2001. *Trees Mean Business: A Study of the Economic Impacts of Trees and Forests in the Commercial Districts of New York City and New Jersey*. National Urban & Community Forestry Advisory Council.

Braden, J.B., and D.M. Johnston. 2003. "The Downstream Economic Benefits of Storm Water Retention." *Journal of Water Resources Planning and Management* 130 (6): 498–505.

Braga, A.A., and B.J. Bond. 2008. "Policing Crime and Disorder Hot Spots: A Randomized Controlled Trial." *Criminology* 46 (3): 577–607.

Brunson, L. 1999. *Resident Appropriation of Defensible Space in Public Housing: Implications for Safety and Community*. Unpublished doctoral dissertation, University of Illinois, Champaign-Urbana, IL.

Center for Neighborhood Technology (CNT) and American Rivers. 2010. *The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental, and Social Benefits*. Available at www.cnt.org/repository/gi-values-guide.pdf. Accessed 6/24/2013.

Center for Neighborhood Technology (CNT). 2013. *The Prevalence and Cost of Urban Flooding: A Case Study of Cook County, Illinois*. Available at http://www.cnt.org/media/CNT_PrevalenceAndCostOfUrbanFlooding.pdf. Accessed 6/24/2013.

Chen, J., and K. Hobbs. 2013. *Rooftops to Rivers II: Green Strategies for Controlling Stormwater and Combined Sewer Overflows – UPDATE October 2013*. NRDC Report. Available at www.nrdc.org/water/pollution/rooftopsII/default.asp. Accessed 10/31/2013.

City of Philadelphia Business Services. 2013. Credits, Grants, and Other Incentives. Available at https://business.phila.gov/pages/taxcreditsotherincentives.aspx. Accessed 11/2/2013.

Clar, M. 2003. *Case Study: Pembrook Woods LID Development Residential Subdivision*. Ecosite, Inc.

Clark, C., P. Adriaens, and F.B. Talbot. 2008. "Green Roof Valuation: A Probabilistic Economic Analysis of Environmental Benefits." *Environmental Science and Technology* 42 (6): 2155–2161. Available at www.mi-wea.org/docs/Green%20Roof%20Economic%20Analysis.pdf. Accessed 6/24/2013.

Columbia University. 2011. *It Is Easy Being Green: A Green Infrastructure Cost-Benefit Analysis for Private Property in NYC*. Workshop in Sustainable Development. December 7, 2011.

CRWA (Charles River Watershed Association). *2008 Low Impact Best Management Practices Information Sheet: Permeable Pavement*. Available at http://www.crwa.org/projects/bmpfactsheets/crwa_permeable_pavement.pdf. Accessed 6/24/2013.

David Evans and Associates. 2008. *Cost Benefit Evaluation of Ecoroofs*. Prepared for City of Portland Bureau of Environmental Services. Available at www.portlandoregon.gov/bes/article/261053. Accessed 6/24/2013.

Dawson, D. 2002. "Plant-Covered Roofs Ease Urban Heat." *National Geographic News*. Available at

news.nationalgeographic.com/news/2002/11/1115_021115_GreenRoofs.html. Accessed 6/24/2013.

Donovan, G.H. 2009. *The Economic Benefit of Urban Trees*. Friends of Trees. March 30, 2009.

Donovan, G.H., and D.T. Butry. 2010. "Trees in the City: Valuing Street Trees in Portland, Oregon." *Landscape and Urban Planning* 94: 77–83.

Donovan, G. H., and J. P. Prestemon. 2012. "The Effect of Trees on Crime in Portland, OR." *Environment and Behavior* 44(1): 3–30.

EIA. 2010. *Trends in U.S. Residential Natural Gas Consumption*. Available at http://www.eia.gov/pub/oil_gas/natural_gas/feature_articles/2010/ngtrendsresidcon/ngtrendsresidcon.pdf. Accessed Nov. 1, 2013

EIA. 2013a. *U.S. Natural Gas Prices*. Available at www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm. Accessed 6/24/2013.

EIA. 2013b. *Electric Power Monthly*, data for April 2013. Available at www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a. Accessed 6/24/2013.

Eichholtz, P., N. Kok, and J. Quigley. 2009. *Doing Well by Doing Good? Green Office Buildings*. University of California Fisher Center for Real Estate and Urban Economics Working Paper W008-001.

Eichholtz, P., N. Kok, and J. Quigley. 2011. *The Economics of Green Building*. University of California Center for Energy and Environmental Economics Working Paper WP 002.

Entrix, Inc. 2010. *Portland's Green Infrastructure: Quantifying the Health, Energy, and Community Livability Benefits*. Prepared for the City of Portland Bureau of Environmental Services. Available at www.portlandoregon.gov/bes/article/298042. Accessed 6/24/2013.

Foster, J., A. Lowe, and S. Winkelman. 2011. *The Value of Green Infrastructure for Urban Climate Adaptation*. Center for Clean Air Policy. February 2011.

Fuerst, F., and P. McAllister. 2008. *Green Noise or Green Value? Measuring the Price Effects of Environmental Certification in Commercial Buildings*. MPRA Paper No. 11446. University Library of Munich, Germany.

Fuerst, F., and P. McAllister. 2009. "An Investigation of the Effect of Eco-Labeling on Office Occupancy Rates." *Journal of Sustainable Real Estate* 1(1): 49–64.

Fuerst, F., and P. McAllister. 2011. "Green Noise or Green Value? Measuring the Effects of Environmental Certification on Office Values." *Real Estate Economics* 39(1): 45–69.

Gaffin, S., C. Rosenzweig, L. Parshall, D. Beattie, R. Berghage, G. O'Keeffe, and D. Braman. 2005. "Energy Balance Modeling Applied to a Comparison of White and Green Roof Cooling Efficiency." *Proceedings of the 3rd Annual Greening Rooftops for Sustainable Cities Conference*, May 4–6, 2005, Washington, D.C.

Garmestani, Ahjond S., J. Clements, J. Pratt, and L. Hair. 2012. "The Economics of Green Infrastructure and Low-Impact Development Practices." In *Economic Incentives for Stormwater Control*, edited by Hale W. Thurston, 101–26. Boca Raton: CRC Taylor and Francis Group.

Garrison, N., and K. Hobbs. 2011. *Rooftops to Rivers II: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. NRDC Report. Available at www.nrdc.org/water/pollution/rooftopsII/default.asp. Accessed 9/17/2013.

Garrison, N., C. Horowitz, and C.A. Lunghino. 2012. *Looking Up: How Green Roofs and Cool Roofs Can Reduce Energy Use, Address Climate Change, and Protect Water Resources in Southern California*. NRDC Report R:12-06-B. June 2012. Available at www.nrdc.org/water/pollution/files/GreenRoofsReport.pdf. Accessed 6/24/2013.

Green Building Research Laboratory. Undated. "Green Roof Energy Calculator (v.2.0)," http://greenbuilding.pdx.edu/GR_CALC_v2/grcalc_v2.php#retain. Accessed 11/25/13.

Hands, D.E., and R.D. Brown. 2002. "Enhancing Visual Preference of Ecological Rehabilitation Sites." *Landscape and Urban Planning* 58 (1): 57–70.

Houle, J., R. Roseen, T. Ballestero, T. Puls, and J. Sherrard. 2013. "A Comparison of Maintenance Cost, Labor Demands, and System Performance for LID and Conventional Stormwater Management." *Journal of Environmental Engineering* 139:932-938. Available at http://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/Houle_JEE_July-2013.pdf.

Ichihara, K., and J.P. Cohen. 2011. "New York City Property Values: What Is the Impact of Green Roofs on Rental Pricing?" *Letters in Spatial and Resource Sciences* 4 (1): 21–30.

ICPI (Interlocking Concrete Pavement Institute). 2013. *Frequently Asked Questions: Permeable Pavement*. Available at www.icpi.org/faq/48. Accessed 6/24/2013.

Jennings, A., A. Adeel, A. Hopkins, A. Litofsky, and S. Wellstead. 2013. "Rain Barrel—Urban Garden Stormwater Management Performance." *Journal of Environmental Engineering* 139 (5): 757-765.

Kaplan, R. 1993. "The Role of Nature in the Context of the Workplace." *Landscape and Urban Planning* 26 (1–4): 193–201.

Kaplan, R. 2007. "Employees' Reactions to Nearby Nature at Their Workplace: The Wild and the Tame." *Landscape and Urban Planning* 82 (1–2):17–24.

Kaplan, R., and S. Kaplan. 1989. *The Experience of Nature: A Psychological Perspective.* Cambridge University Press, New York.

Kaplan, R., S. Kaplan, and R.L. Ryan. 1998. *With People in Mind: Design and Management of Everyday Nature.* Island Press, Washington D.C., 225 pp.

Kellert, S.R. 2004. *Beyond LEED: From Low Environmental Impact to Restorative Environmental Design.* Keynote address, Greening Rooftops for Sustainable Communities Conference, Portland Oregon, June 4, 2004.

Kok, N., N.G. Miller, and P. Morris. 2011. "The Economics of Green Retrofits." *Journal of Sustainable Real Estate* 4(1): 4-22.

Kuo, F., and W. Sullivan. 2001. "Environment and Crime in the Inner City: Does Vegetation Reduce Crime?" *Environment and Behavior* 33(3): 343–367. May. Available at www.outdoorfoundation.org/pdf/EnvironmentAndCrime.pdf. Accessed 6/24/2013.

Lake County Forest Preserves. 2003. *Permeable Paver Research Summary*. Planning, Conservation and Development Department.

Laverne, R.J., and K. Winson-Geideman. 2003. "Influence of Trees and Landscaping on Rental Rates at Office Buildings. *Journal of Arboriculture* 29(5): 281–289.

Lee, J.S., and M.-H. Li. 2009. "The Impact of Detention Basin Design on Residential Property Value: Case Studies Using GIS in the Hedonic Price Modeling." *Landscape and Urban Planning* 89(1–2): 7–16.

Lee, A., D. Sailor, T. Larson, and R. Ogle. 2007. *Developing a Web-Based Tool for Assessing Green*

Roofs. Greening Rooftops for Sustainable Communities Conference Proceedings, Minneapolis, April 29–May 1. Green Roofs for Healthy Cities.

Lorenzo, A.B., and D. Wims. 2004. "Do Designed Landscapes Deter Crime?" *Proceedings of the Florida State Horticultural Society* 117: 297–300.

Loopnet. 2013. "Philadelphia, PA Market Trends." Available at http://www.loopnet.com/Philadelphia_Pennsylvania_Market-Trends. Accessed June 2013.

Lottrup, L. 2012. "Workplace Greenery: Use, Preferences, and Health Benefits of Green Outdoor Environments at Workplaces." *Forest & Landscape Research* No. 50-2012. Forest & Landscape Denmark, Frederiksberg.

MacMullan, E., and S. Reich. 2007. *The Economics of Low-impact Development: A Literature Review*. ECONorthwest. November 2007.

Macmullan, E., and ECONorthwest. 2010. *Using Incentives to Promote Green Stormwater Practices*. Oregon Association of Clean Water Agencies Stormwater Summit.

McCollister, K.E., M. T. French, and H. Fang. 2010. "The Cost of Crime to Society: New Crime-Specific Estimates for Policy and Program Evaluation." *Drug and Alcohol Dependence* 108(1-2): 98-109. Available at www.ncbi.nlm.nih.gov/pmc/articles/PMC2835847/. Accessed 7/18/2013.

McCormack and Son. 2013. *Permeable Paving*. Available at www.pavingexpert.com/permabl1.html. Accessed 6/24/2013.

McPherson, E.G., J.R. Simpson, P.J. Peper, S.E. Maco, and Q. Xiao. 2005. "Municipal Forest Benefits and Costs in Five U.S. Cities." *Journal of Forestry*, December 2005. Available at www.fs.fed.us/ccrc/topics/urbanforests/docs/jof_Dec_2005.pdf. Accessed 6/23/2013.

McPherson, E.G., J.R. Simpson, P.J. Peper, S.L. Gardner, K.E. Vargas, S.E. Maco, and Q. Xiao. 2006. *Midwest Community Tree Guide: Benefits, Costs and Strategic Planting*. General Technical Report PSW-GTR-199. Pacific Southwest Research Station, U.S. Department of Agriculture Forest Service. Albany, CA. Available at www.fs.fed.us/psw/publications/documents/psw_gtr199/psw_gtr199.pdf. Accessed 6/24/2013.

David J. Nowak, R. E. Hoehn III, A. R. Bodine, D. E. Crane, J. F. Dwyer, V. Bonnewell, and G. Watson. Urban Trees and Forests of the Chicago Region. United States Department of Agriculture Forest Service Northern Research Station Resource Bulletin NRS-84. Available at http://www.fs.fed.us/nrs/pubs/rb/rb_nrs84.pdf. Accessed 11/2/2013.

Metropolitan Washington Council of Governments. 2001. *Combined Sewer Overflow Rooftop Type Analysis and Rain Barrel Demonstration Project*. Department of Environmental Programs. December 2001.

Miller, N., J. Spivey, and A. Florance. 2008. "Does Green Pay Off?" *Journal of Real Estate Portfolio Management* 14(4): 52–84.

Milwaukee Metropolitan Sewerage District. 2013. *Regional Green Roof Initiative*. Available at www.h2ocapture.com/H2OCapture/Learn/Funding%20Programs/Green%20Roof%20Project. Accessed 6/18/2013.

Montgomery County, Maryland, Department of Environmental Protection. 2013. *RainScapes Rewards Rebates Program*. Available at www6.montgomerycountymd.gov/dectmpl.asp?url=/Content/dep/water/rainrebate.asp. Accessed 6/23/2013.

Nelson, B. 2013. "Going Beyond Green." *New York Times*, April 3, 2013.

Newell, J.P., M. Seymour, T. Yee, J. Renteria, T. Longcore, J.R. Wolch, and A. Shishkovsky. 2012. "Green Alley Programs: Planning for a Sustainable Urban Infrastructure?" *Cities* 31:144–155.

New York State Legislature 2013. Assembly Bill No. A7058 (passed June 2013; awaiting signature by the governor as of Oct. 2013). Available at open.nysenate.gov/legislation/bill/A7058-201.

Pati, D., T.E. Harvey Jr., and F. Batach. 2008. "Relationships Between Exterior Views and Nurse Stress: An Exploratory Examination." *Health Environments Research and Design* 1(2): 27–38.

Philadelphia Industrial Development Corporation. 2013. *Green Roof Tax Credit*. Available at philadelphiaretail.com/pdf/GreenRoofTaxCredit.pdf. Accessed 6/24/2013.

Plympton, P., S. Conway, and K. Epstein. 2000. *Daylighting in Schools: Improving Student Performance and Health at a Price Schools Can Afford*. National Renewable Energy Laboratory. NREL/CP-550-28049. Available at www.nrel.gov/docs/fy00osti/28049.pdf. Accessed 10/14/2013.

PWD. 2008. *Rain Barrel Installation Instructions*. Philadelphia Water Department. Available at www.phillywatersheds.org/sites/default/files/RB_Installation.pdf. Accessed 5/17/2013.

PWD. 2012. *Rain Barrel Map*. Philadelphia Water Department Available at www.phillywatersheds.org/whats_in_it_for_you/residents/rainbarrel/map2. Accessed 5/17/2013.

PWD. 2013a. *Green Roofs*. Philadelphia Water Department. Available at www.phillywatersheds.org/whats_in_it_for_you/residents/green-roofs. Accessed 7/19/13.

PWD. 2013b. *FAQ*. Philadelphia Water Department. Available at www.phillywatersheds.org/whats_in_it_for_you/residents/rainbarrel/faq. Accessed 5/17/2013.

PWD. 2103c. *Storm Water Management Service Charge Credits and Adjustment Appeals Manual*, 2013, Available at www.phila.gov/water/Stormwater/pdfs/scaa_manual.pdf. Accessed 11/1/2013.

PWD. 2013d. *Frequently Asked Questions: Stormwater Management Service (SWMS) Charge, Non-Residential*, 2013. Available at: www.phila.gov/water/Stormwater/pdfs/Non-Res_FAQ.pdf. Accessed 11/1/2013.

Rentjungle.com. Rent trend data in Philadelphia, Pennsylvania. Available: http://www.rentjungle.com/average-rent-in-philadelphia-rent-trends/. Accessed 11/2/2013.

Retail Tenant Source. 2009. Are Retail Lease Rates Finally Coming Down? Available: http://retailtenantsource.blogspot.com/2009/11/are-retail-lease-rates-finally-coming.html. Accessed 11/2/2013.

Roseen, R., T. Janeski, M. Simpson, J. Houle, J. Gunderson, and T. Ballestero. 2012. "Economic and Adaptation Benefits of Low Impact Development." *Conference Proceedings*, 2011 Low Impact Development Symposium. Available at www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/JEE%20FTL%203-30-12.b.pdf. Accessed 6/24/2013.

Sands, K., and T. Chapman. 2003. *Rain Barrels—Truth or Consequences*. Milwaukee Metropolitan Sewerage District.

Seattle Public Utilities. 2013. *RainWise Rebates for Cisterns and Rain Gardens*. Available at www.seattle.gov/util/environmentconservation/projects/drainagesystem/greenstormwaterinfrastructure/rainwise/rebates/. Accessed 9/17/2013.

Snep, R. 2008. "Biodiversity Conservation at Business Sites: Options and Opportunities." *Alterra Scientific Contributions* 28. Wageningen University Research Centre, Netherlands.

Snep, R.P.H., E.C. van Ierland, and P. Opdam. 2008. Enhancing biodiversity at business sites: What are the options, and which of these do stakeholders prefer? *Landscape and Urban Planning* 91(1): 26–35.

Stratus Consulting. 2009. *Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds*. Prepared for

City of Philadelphia Water Department under contract to Camp Dresser and McKee.

Theodosiou T. 2003. "Summer Period Analysis of the Performance of a Planted Roof as a Passive Cooling Technique." *Energy and Buildings* 35(9): 909-917.

Troy, A., J.M. Grove, and J.O'Neil-Dunne. 2012. "The Relationship Between Tree Canopy and Crime Rates Across an Urban-Rural Gradient in the Greater Baltimore Region." *Landscape and Urban Planning* 106: 262-270. Available at www.nrs.fs.fed.us/pubs/jrnl/2012/nrs_2012_troy_001.pdf. Accessed 6/24/2013.

University of Illinois at Urbana-Champaign, Landscape and Human Health Laboratory. *Vegetation May Cut Crime in the Inner City*. Available at lhhl.illinois.edu/crime.htm. Accessed 6/24/2013.

University of Washington. 2013. "Crime & Public Safety." *Green Cities: Good Health*, last modified 5/27/2013. Available at depts.washington.edu/hhwb/Thm_Crime.html. Accessed: June 24, 2013.

U.S. Department of Energy. 2011. *Buildings Energy Data Book*. Table 3.1: Commercial Sector Energy Consumption. Available at buildingsdatabook.eren.doe.gov/TableView.aspx?table=3.1.4.

U.S. EPA. 1995. *Economic Benefits of Runoff Controls*. Office of Wetlands, Oceans and Watersheds. Available at http://water.epa.gov/polwaste/nps/econ_ben_runoff_control.cfm. Accessed Nov. 1, 2013.

U.S. EPA. 2007. *Reducing Stormwater Costs through Low Impact Development (LID)*

Strategies and Practices. EPA 841-F-07-006, United States Environmental Protection

Agency Nonpoint Source Control Branch (4503T), Washington, D.C. Available at water.epa.gov/polwaste/green/upload/2008_01_02_NPS_lid_costs07uments_reducingstormwatercosts-2.pdf.

U.S. EPA. 2008. "Green Roofs." In *Reducing Urban Heat Islands: Compendium of Strategies*. Available at www.epa.gov/heatisland/resources/compendium.htm. Accessed: 6/20/2013.

U.S. EPA. 2009. *Managing Wet Weather With Green Infrastructure – Municipal Handbook – Incentive Mechanisms*. Available at http://water.epa.gov/infrastructure/greeninfrastructure/upload/gi_munichandbook_incentives.pdf. Accessed Nov. 4, 2013.

U.S. EPA. 2013a. Case Studies Analyzing the Economic Benefits of Low Impact Development and Green Infrastructure Programs. Office of Wetlands, Oceans and Watersheds Nonpoint Source Control Branch. EPA 841-R-13-004. Availabe:// http://water.epa.gov/polwaste/green/upload/lid-gi-programs_report_8-6-13_combined.pdf. Accessed November 2, 2013.

U.S. EPA. 2013b. "Rain Barrels." In *Mid-Atlantic Region Green Landscaping*. Available at www.epa.gov/reg3esd1/garden/rainbarrel.html. Accessed May 17, 2013.

U.S. EPA and LID Center. 2007. *Low Impact Development Urban Design Tools Website. Permeable Paver Costs*. Available at www.lid-stormwater.net/permpaver_costs.htm. Accessed 6/24/2013.

Valderrama, A., L. Levine, S. Yeh, and E. Bloomgarden. 2012. *Financing Stormwater Retrofits in Philadelphia and Beyond*. Natural Resources Defense Council. Available at www.nrdc.org/water/files/StormwaterFinancing-report.pdf. Accessed 6/23/2013.

Wachter, S.M., and G. Wong. 2008. "What Is a Tree Worth? Green-City Strategies and Housing Prices. *Real Estate Economics* 36(2): 2008.

Ward, B., E. MacMullan, and S. Reich. 2008. "The Effect of Low-impact Development on Property Values." *Sustainability* 6: 318–323.

Water Environment Federation (WEF). 2013. *Five Types of Green Infrastructure Incentive Programs*. Stormwater Report, January 2013. Available at http://stormwater.wef.org/2013/01/five-types-of-green-infrastructure-incentive-programs/. Accessed Nov. 1, 2013

Western Kentucky University. 2013. *Stormwater Utility Survey 2013*. Available at www.wku.edu/engineering/civil/fpm/swusurvey/western_kentucky_university_swu_survey_2013.pdf.. Accessed 9/12/2013.

Whitehead, T., D. Simmonds, and J. Preston. 2006. The Effect of Urban Quality Improvements on Economic Activity. *Journal of Environmental Management* 80, 1:1-12.

Wiley, J., J. Benefield, and K. Johnson. 2010. "Green Design and the Market for Commercial Office Space." *Journal of Real Estate Finance and Economics* 41(2): 228–243.

Wise, S., J. Braden, D. Ghalayini, J. Grant, C. Kloss, E. MacMullan, S. Morse, F. Montalto, D. Nees, D. Nowak, S. Peck, S. Shikh, and C. Yu. 2010. *Integrating Valuation Methods to Recognize Green Infrastructure's Multiple Benefits*. Center for Neighborhood Technology Publication. Available at www.cnt.org/repository/CNT-LID-paper.pdf. Accessed 6/24/2013.

Wolf, K.L. 2004. "Nature in the Retail Environment: Comparing Consumer and Business Response to Urban Forest Conditions." *Landscape Journal* 23(1): 40–51.

Wolf, K.L. 2005. "Business District Streetscapes, Trees, and Consumer Response." *Journal of Forestry* 103(8): 396-400.

Wolf, K.L. 2007. "City Trees and Property Values." *Arborist News* 16(4): 34–36.

Wolf, K.L. 2009. "More in Store: Research on City Trees and Retail." *Arborist News* 18(2): 22–26.

Wolf, K.L. 2013. *The Urban Forest. Communities & Banking* 24 (2): 25–27.

Wolfe, M.K., and J. Mennis. 2012. "Does Vegetation Encourage or Suppress Urban Crime? Evidence from Philadelphia, PA." *Landscape and Urban Planning* 108 (2–4): 112–122.

Endnotes

1 Storm sewers typically provide no treatment before polluted runoff is discharged to surface waters. In communities with combined sewers that handle both sanitary sewage and storm runoff in the same sewer system, treatment capacity is often inadequate to treat all of the flow during wet weather, resulting in overflows of raw human sewage mixed with polluted runoff. These are known as "combined sewer overflows."

2 This empirical study is based on data from the sales of terraced houses in the district of Salo in Finland.

3 SITES is an interdisciplinary effort by the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at the University of Texas at Austin, and the United States Botanic Garden to create voluntary national guidelines and performance benchmarks for sustainable land design, construction, and maintenance practices.

4 Many of these studies have utilized the Urban Forest Effects (UFORE) computer model (also known as iTree Eco), which was developed by the U.S. Department of Agriculture (USDA) Forest Service to help managers and researchers quantify urban forest structure and its functions. The model calculates various forest functions and values related to tree effects on air pollution, greenhouse gases and global warming, and building energy use.

5 The Energy Information Association (EIA) reports that the average cost of energy for the commercial sector in the United States is currently $0.0999/kWh for electricity and $7.82/thousand cubic feet ($0.0077/kBtu) for natural gas.

6 Represents annual weather-adjusted average for the Midwest region from 2007 to 2009.

7 Dollar values are assumed to be reported in 2005 USD, the year of publication. This was not specifically stated by the authors.

8 Extensive green roofs represent lower-maintenance green roofs that are often installed on residential and commercial buildings. They are typically lightweight (15–150 lbs./sq ft.) and have a soil depth of 3 to 6 inches. Extensive green roofs are limited to drought-resistant vegetation. Intensive green roofs, by contrast, have many more plant options, including trees and shrubs, and require fertilization, irrigation, and maintenance.

9 In addition, the authors reported that "40 years is consistent with international findings, where researchers expect that ecoroofs will last 50 years or more. For example, old ecoroofs in Berlin demonstrate a life span of more than 90 years before important repairs or replacement may be required."

10 Costs updated from 2003 to 2013 USD using the Consumer Price Index (CPI).

11 The commercial building benchmarks were developed for professionals to use when analyzing whole-building energy performance across the commercial building stock. The commercial benchmarks are available for DOE's EnergyPlus simulation software. The models provide a consistent baseline of comparison and improve the value of computer-generated energy simulations. For the retail center example below (section 5.4), we doubled the size of the DOE's representative strip mall building in order to be more representative of an area such as a small business district.

12 For some benefits, capital and O&M costs are taken into account through the comparison of costs associated with green versus gray infrastructure. For example, the analysis of green roof life cycle costs demonstrates capital and O&M cost savings associated with green roofs. A similar analysis is applied to permeable pavement.

13 New buildings are defined in the model as those built according to the ASHRAE 90.1-2004 standard, while old buildings predate this standard.

14 According to the Energy Information Administration (EIA), in July 2013 average commercial energy rates in Pennsylvania amounted to $ 0.093/kWh for electricity (www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a) and $1.26/therm for natural gas (www.eia.gov/dnav/ng/ng_pri_sum_dcu_SPA_m.htm).

15 Although McPherson's estimate is for residential properties, medium-size trees will reach about 40 feet high, thereby providing shade over the entire height of the three-story building. This analysis assumes that the mix of natural gas and electricity use in this office building is relatively close to that of a residential building.

16 Average annual energy cost savings created by the strategically planted trees were derived by multiplying the average energy savings generated by the trees over the 40 year analysis period by 2013 energy prices. The heating and cooling services provided by trees increases as the tree grows, and thus will be lower in the years immediately following planting.

17 In 2013 USD, David Evans and Associates estimates the avoided replacement costs of a 40,000-square-foot green roof to be $607,745 (updated from 2008 USD cost of $561,718 using CPI).

18 According to the Bureau of Labor Statistics, in July 2013 Philadelphia energy rates were $0.159/kWh for electricity and $1.22/therm for natural gas. U.S. Bureau of Labor Statistics, www.bls.gov/ro3/apphl.htm.

19 Average annual energy cost savings created by the strategically planted trees were derived by multiplying the average energy savings generated by the trees over the 40 year analysis period by 2013 energy prices. The heating and cooling services provided by trees increases as the tree grows, and thus will be lower in the years immediately following planting.

20 This represents the midpoint of most estimates from the literature.

21 This analysis assumes that the mix of natural gas and electricity use in this retail building is relatively close to that of a residential building.

22 Average annual energy cost savings created by the strategically planted trees were derived by multiplying the average energy savings generated by the trees over the 40 year analysis period by 2013 energy prices. The heating and cooling services provided by trees increases as the tree grows, and thus will be lower in the years immediately following planting.

23 Based on 2007 Economic Census data on total sales and establishments for retail sales. According to the 2007 data, 45 percent of all retail stores do less than $1 million in sales annually. An additional 20 percent earn between $1.0 million and $2.5 million, averaging about $1.5 million in annual sales. Thus, as a conservative estimate we use $1 million as the average annual retail sales figure for this analysis.

24 2009 is the most recent year for which data were available. We did not update the 2009 number to 2013 USD because changes in retail rental rates do not necessarily correlate to changes in the CPI. For example, in the third quarter of 2008, retail rental rates were 4 percent higher than in same quarter of 2009 (Retail Tenant Source 2009).

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