Springfield, Missouri
Integrated Planning Support:

Task 2 Report (Draft)
Literature Review on the Value of Water Resources

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Contents

Introduction

The City of Springfield, Greene County, and City Utilities of Springfield (project partners) are developing a comprehensive Integrated Plan to prioritize future environmental programs and address the region's various Clean Water Act regulatory obligations as well as their obligations regarding Air Quality and Land Resource Quality. With the integrated plan, the project partners seek to prioritize investments in water, land, and air resource improvements that provide the greatest value to the area's citizens. Proposed control actions are being evaluated using a Sustainable Return on Investment (SROI) analysis which measures the return on investment in terms of environmental, social, and economic effects of the proposed projects in the long-term.

To support the SROI analysis as well as the broader decision analysis and public outreach efforts, the project partners wish to illustrate the value of their water resources and demonstrate that the purpose of the integrated plan is to sustain that existing value and achieve additional value through further restoration of water quality. The values sought in this analysis relate to the ecosystem services that the water resources provide to the community.

Ecosystem services are the benefits that ecosystems provide to people. They are often discussed in four categories: provisioning (food, water supply, etc.), regulating (flood mitigation, disease control, etc.), cultural (recreational opportunities, spiritual benefits, etc.) and supporting (soil formation, nutrient cycling, etc.). To illustrate the importance of these services and evaluate their importance relative to economic goods and services, studies have been conducted to estimate the monitary value of these services. A variety of valuation methods have been developed and refined, including methods for estimating the impact on the economy from these ecosystem services (economic impact analysis), the impact on property values (hedonic analysis), surveying the public on their willingness to pay for the services (stated preference), and collecting data on expenditures related to enjoyment of ecosystem services (revealed preference, e.g., travel cost). Valuation studies have also used the cost to replace an ecosystem service or costs avoided due to an ecosystem service (replacement cost and avoided cost approach, respectively). The benefit transfer approach involves using values from other studies and applying these values in a different geographic location that bares a similarity to the study's demographic, morphologic, and geographic characteristics. EPA (2010) provides an explanation of each of these methods in more detail.

When seeking a value estimate for a particular water resource, it is important to consider how the four categories of ecosystem services are related. Supporting services often represent intermediate processes necessary for provisioning, regulating, and cultural services. For instance, nutrient cycling supports the provisioning of safe drinking water. When the value of safe drinking water is estimated, the value of nutrient cycling towards the provisioning of safe drinking water is already reflected in the value of safe drinking water. If both services were valuated separately and then the values were summed, that total value would likely be double counting and overestimating the overall value of both services. In this case, safe drinking water is considered the final ecosystem series, and nutrient cycling is considered an intermediate ecosystem service (Fu et al, 2011).

To avoid double counting, it is important to identify the group of people benefiting from the services and the final ecosystem services that benefit that population. The value of final services may also overlap depending on how they are measured. For example, property value increases attributed to water quality may be related, in part, to recreational opportunities. If a waterbody is both valued for scenic beauty as well as recreation, one final ecosystem service can be selected for valuation to avoid double counting (Fu et al, 2011). Alternatively, a range of values can be reported, or the sum of the values used with sufficient caveats or a demonstration that the double counting is negligible.

To support the integrated planning process while ensuring that information is reported accurately to the public, a community might select its approach depending on the availability of expertise in the valuation of ecosystem services (Table 1). Communities who do not have direct access to a valuation expert (e.g., a professional with an economics degree and direct experience with ecosystem services valuation) would select one final ecosystem service per waterbody and use available literature to support that valuation. If using benefit transfer, it will be important for that community to evaluate how relevant the literature values are to their own geographic, morphologic, and demographic characteristics. If a community does have access to a valuation expert for at least a limited review or consultation, summing multiple ecosystem services values might be possible if the potential for double-counting can be clearly explained, addressed, and verified by valuation experts. Finally, if valuation experts are working directly with the community and developing the valuation, the community would work with these experts to develop the most defensible approach, which may involve summing of ecosystem services values if the potential for double-counting is minimized.

Table 1. Tiered Approach to Valuation Depending on Available Expertise

Available Expertise	Potential for Double Counting	Valuation Approach
Limited	High	Select one final ecosystem service per waterbody, or research a range and use the most valuable ecosystem service to represent the value achieved by all.
Moderate	Medium	Avoid summing values of ecosystem services unless potential for double-counting can be clearly explained, addressed, and verified by valuation experts
Strong	Low	Work with valuation expert(s) to determine most defensible approach. Values may be summed if the potential for double-counting is minimized.

To develop the SROI, the project partners are working directly with a consultant with expertise in valuation, and EPA is providing additional expertise in ecosystem services valuation. Therefore, the SROI will involve the aggregation of ecosystem services values relating to the benefits provided by proposed control actions (strong expertise tier in Table 1). In the context of Springfield-Greene County, the purpose of this report is to illustrate the available literature values that can support the integrated planning process, describe how the limited expertise tier might be approached, and provide a literature review as an input to the Springfield-Greene County SROI and public outreach efforts. Valuation of water resource ecosystem services is addressed in terms of existing values first. Then, methods and available literature values are discussed that can quantify the additional value provided by proposed control actions, with a focus on green infrastructure.

Valuing the Region's Water Resources

While water resources values can be described in categories, every community has a unique relationship with its water resources, and the perspective and perceptions of that individual community are important considerations when describing the value of their water resources. The City of Springfield and Greene County community are no exception. Several small streams flow into the City of Springfield from rural agricultural areas where cattle and other livestock are produced, among other land uses. As the streams flow through the urban areas, they are used to drain the city of stormwater runoff, and at several points are impounded for municipal water supply and recreational benefits. Several lakes are used for fishing, boating, and swimming. Treated sanitary wastewater effluent enters the stream at certain points. Several industries intake source water for processing food and other products, and a number of industries discharge permitted wastewater to the streams. Access points along the streams allow for paddlers and other boaters to enjoy the water resources within and downstream of the city. Much of the streamflow from the Springfield-Greene County area drains to either Stockton Reservoir or Table Rock Lake.

With the project partners' unique qualities in mind, EPA reviewed the valuation literature and identified studies that report value estimates for provisioning and cultural services of water resources, with a focus on studies in Missouri or nearby states. The final ecosystem services that were considered were recreational opportunities and scenic beauty and how these benefits contribute to a community's overall quality of life.

Recreational Opportunities

The Springfield-Greene County region boasts of numerous water-related recreational opportunities. Within the vicinity of the City of Springfield, several lakes provide boating and fishing opportunities, and state-maintained stream access points allow for boating access to major streams. Many greenways and other trails follow or connect to streams or lakes and provide opportunities for scenic views. Farther downstream of the Springfield-Greene County region, two major reservoirs, Table Rock Lake and Stockton Reservoir, are popular watersport destinations where visitors enjoy boating, fishing, swimming, water skiing, and scuba diving, among other activities. Overall, these water resources contribute to the quality of life for the region's residents as well as tourists and other visitors to the area.

The water resources of the region have not always been as accessible to recreation as they are today. Prior to wastewater treatment plant improvements, waterbodies like Wilson's Creek were too eutrophic for use as paddling streams. Water quality improvements over time have provided more freedom to residents to enjoy the nearby waterbody of their choice with assurance that water quality is being maintained. When a community achieves this level of water quality, the residents likely perceive a substantial value in the peace of mind afforded by consistent water quality in their lakes and streams.

Several techniques have been used to estimate the value of recreational opportunities for a particular waterbody. Two of the most common are stated preference studies and revealed preference studies. Generally considered the most comprehensive, stated preference studies involve surveys to estimate the public's willingness to pay for recreational opportunities, and these studies often measure values based on different lake conditions, including fishable, boatable, or swimmable water quality (EPA 2010, Loomis et al. 2000). Revealed preference studies collect data on spending during recreational trips and derive the economic benefit of recreational opportunities from these data, sometimes referred to as the travel cost method.

While the value of recreational opportunities in Springfield-Greene County has not been estimated directly, studies in other Missouri counties and other states can help inform an estimate of this value. Termed the benefit transfer approach, this valuation approach involves identifying valuating studies that are similar to the resource in question in terms of environmental commodity, baseline and extent of environmental changes, and characteristics of affected populations (EPA, 2010).

For this report, EPA conducted a literature review to identify relevant literature values for recreational benefits of lakes and streams. Many of the identified studies were conducted in distant states or for waterbodies different in size and morphology compared to the Springfield-Greene County lakes and streams. From this broader list, EPA identified several that provided more relevant literature values due to similar demographics, geography, morphology, or other factors.

Cartwright (2006) used a benefit transfer approach to estimate the economic effects of a new reservoir in the Green Hills area of northern Missouri. To estimate the value of recreation for this proposed reservoir, Cartwright (2006) estimated the number of user days provided for each recreation activity, based on an estimate of demand for these activities, then this number was multiplied by values reported in Rosenberger and Loomis (2001), a meta-analysis of 163 recreation valuation studies conducted from 1967 to 1998. A similar approach could be used to value Springfield-Greene County lakes, with the assumption that lake conditions in Springfield-Greene County are similar to lakes studied in Rosenberger and Loomis (2001). When using this approach, the more recent meta-analysis by Rosenberger and Stanley (2007) should also be considered (Table 2).

Table 2. Recreation Activity Access Values in Consumer Surplus Per Person Per Activity Day by US Census Regions (2006 dollars; Rosenberger and Stanley, 2007)

Activity	Northeast	Midwest	South	West	National (in scope)
Boating, Motorized	97.96 (2:6)	10.37 (2:24)	23.56 (4:13)	27.69 (7:19)	28.82 (1:1)
Boating, Non-Motorized	34.17 (2:5)	60.46 (3:12)	119.84 (6:27)	108.89 (15:46)	37.79 (1:3)
Fishing, Freshwater	57.11 (22:125)	34.77 (21:187)	49.40 (24:126)	69.62 (50:279)	61.48 (4:14)
Hunting, Waterfowl	36.30	29.22	56.07	53.46	120.71

Activity	Northeast	Midwest	South	West	National (in scope)
	(5:17)	(3:26)	(4:30)	(8:31)	(2:7)
Sightseeing	---	28.41 (2:2)	56.99 (4:6)	40.74 (4:12)	21.08 (1:2)
Swimming	27.75 (2:2)	18.48 (1:1)	12.65 (2:2)	7.18 (4:8)	26.17 (1:1)
Waterskiing	---	---	18.80 (1:1)	7.18 (1:1)	47.54 (1:1)
Wildlife Viewing	49.79 (9:47)	35.94 (6:50)	50.84 (10:80)	58.87 (16:91)	35.23 (3:14)

[a]In parentheses, #Studies:#Estimates.

In a state preference study on Minnesota and Iowa lakes, Keeler (2015) studied how lake clarity affects the public's willingness to travel for recreational trips and found that improved water clarity is associated with increased numbers of visits to lakes and that lake users were willing to incur greater costs to visit clearer lakes. Lake users were willing to travel 56 minutes farther (equivalent to US$22 in travel costs) for every one-meter increase in water clarity in Minnesota and Iowa lakes, when controlling for other lake attributes. People were also willing to incur greater travel costs to visit larger lakes, lakes in wilderness areas, and lakes with a boat ramp (Keeler et al. 2015). Clarity measurements in Springfield-Greene County lakes could be used to estimate the travel costs that users would be willing to pay to visit the region's lakes. Then, using visitor counts, travel costs per users could be translated into travel spending per year to visit the region's lakes.

Additional data are available from several lake studies in Iowa. The Iowa Lakes Valuation Project involved multi-year surveys of Iowa households and indicated that water quality was the most important factor they consider when choosing a lake for recreation, with proximity of the lake and park facilities also being relatively important (Egan 2004). While this Iowa-based study did not estimate a monetary value for recreation, the survey results provide additional support for assigning value to the water quality of recreational lakes. In another Iowa Lake study, a survey of spending by recreational users generated estimates of daily per party spending for five Iowa lakes (Otto, 2012). Lakes studied included Storm Lake and Rock Creek Lake in 2002, and Clear Lake, Lake Manawa, and Pleasant Creek Lake in 2009. Daily per party spending ranged from $67.95 to $163.37, and the highest spending occurred at the lake with the most amenities. The lakes studies are more similar to Stockton Reservoir and Table Rock Lake in terms of amenities and size. However, the spending measured at Rock Creek Lake may be similar to the scale of spending by boaters along Springfield-Greene County streams. Otto (2012) used a value of $34.75 per-person spending (2009 dollars), based on Rock Creek Lake, to estimate spending by river users in Iowa. While this value reflects the availability of tent camping as an amenity, it could be used as an upper bound for a per-person spending estimate along Springfield-Greene County streams.

Surveys of local recreational users, either directly on their willingness to pay (stated preference) or on their trip spending (revealed preference) offer the most reliable measurement of recreational values of area lakes. In the absence of local research, the studies identified by EPA provide methods and literature values for estimating the perceived value of the region's lakes and streams by recreational users.

Midwest literature values from Rosenberger and Stanley (2007) would offer an approximate estimate of the potential perceived value per activity, and Cartwright (2006) can be cited as an in-state example of this benefit transfer approach. If estimating the marginal value of lake water clarity improvement is of interest, Keeler (2015) can be used to estimate perceived user values based on differing lake clarity measurements, supported by the findings of Egan (2004) that water quality was the most important factor considered by respondents when choosing a lake for recreation. When using any literature values for benefit transfer to another location, it is important to consider sources of bias in the estimates and potential for double counting and to note any related caveats when reporting the value estimates. EPA (2010) provides additional guidance for the benefit transfer process in general, and Rosenberger and Stanley (2007) discuss bias specifically related to recreation value estimates.

Property Values

Property values can be impacted both positively and negatively by a number of ecological and environmental factors related to water resources. Waterfront property is especially impacted by proximity and views, water quality, and recreational value. Water quality and aesthetics can be affected by a number of factors including polluted runoff, sedimentation, and invasive species. Any of these factors can influence actual and perceived measures of water quality. Economists using hedonic property models have established that public water bodies provide external benefits that are reflected in the value of nearby residential real estate. The literature has utilized a number of approaches to quantify these nonmarket services. Several studies have used distance to the water to measure the nonmarket services generated by public water bodies.

The hedonic pricing method is often used to estimate economic values for ecosystem or environmental services that directly affect market prices. It is most commonly applied to variations in housing prices that reflect the value of local environmental attributes. This method involves estimating the statistical relationship of a residential property price with measurable environmental qualities while controlling for other housing, demographic, or land cover characteristics.

Studies have found that waterfront, particularly at lakes, tend to have higher property values compared to similar, non-waterfront properties (Feather et al 1992, Lansford et al 1995). The public's perceptions about water quality and clarity also tend to affect property values, especially for waterfront properties or properties near a waterbody (Feather et al 1992, Boyle et al 1999, d'Arge et al 1989, Kashian et al 2006, Krysel et al 2003, Leggett et al 2000). Related to water quality, the presence and density of invasive species also can negatively affect property values (Horsch and Lewis. 2009, Zhang and Boyle. 2010, Johnson and Meder 2013). These studies support the general conclusion that access to scenic views of water resources as well as water quality and clarity are valuable to residents across many different geographic, morphologic, and demographic characteristics.

To better inform a valuation of Springfield-Greene County water resources, EPA conducted a literature review of property value studies and identified those studies that provided literature values relevant to Springfield-Greene County lakes and streams. In Omaha, Nebraska, Schultz and Schmitz (2008) examined values of lake views of man-made lakes from nearby single-family homes. Hedonic modeling determined that lake views increased home values by between 7.5 and 8.3 percent, which is substantial considering that the lakes were designed primarily for flood control and stormwater management rather than recreational use (Schultz and Schmitz 2008). The lakes ranged from 35 to 255 acres in surface area, similar to local Springfield-Greene County lakes. The results of this study could be used to estimate the benefits, in terms of property value, provided by Springfield-Greene County lakes. A GIS viewshed analysis would be used to identify single-family properties with views of local lakes similar in size to those studied in Schultz and Schmitz (2008). The property value of these homes could be estimated through tax values or a comparative market analysis of recent sales. Then, the range of 7.5 to 8.3 percent could be applied to the estimate property values to estimate the benefit of scenic lake views realized by residents.

Several studies on the effect of water quality on lake property values have been conducted in nearby states, including Iowa and Wisconsin. These studies have focused on lakes with much greater surface areas than local Springfield-Greene County lakes and may be more relevant when estimating property value effects of Stockton Reservoir or Table Rock Lake. However, these studies reinforce that water quality is an important factor in the perceived value of a water resource. D'Arge and Shogren (1989) found that 13 to 23 percent of the residential property value along the Lake Okoboji shoreline is accounted for by water quality increasing from a boating/fishing use to a swimming/drinking use. Kashian et al (2006) and Krysel et al (2003) also found that water quality was an important variable affecting lakeshore property values in Wisconsin and Minnesota, respectively.

Schultz and Schmitz (2008) was the only study in EPA's literature review that presented an opportunity for benefit transfer to local Springfield-Greene County lakes. As noted above, the literature values from this study could be used in conjunction with GIS and real estate market analysis to estimate a value for scenic views. Other literature in nearby states can be used to support the concept that scenic views, water quality, and water clarity are valuable.

Summary

The literature review revealed several promising methods for valuating Springfield-Greene County water resources. From the perspective of the limited expertise tier (Table 1), a conservative approach to valuation would involve selecting one final ecosystem service to assign a value or to investigate the range of values and use the most valuable ecosystem service to represent the value achieved by all. The literature review identified studies relating value to the value of recreational opportunities in general, the value of recreation in terms of differing levels of lake clarity, and the value of scenic views of lakes from single-family homes. Reflected in the identified meta-analysis of Rosenberger and Stanley (2007), a much greater body of research is available to support an estimate of general recreational values. A recommended approach would be to develop an estimate of the general recreation values based on this meta-analysis since the lake clarity and property value estimates are each only supported by one study.

Within the meta-analysis of Rosenberger and Stanley (2007), it is important to note that literature values are reported for individual recreation activities (fishing, boating, swimming, etc.). A valuation using these findings would need to consider potential for double counting when summing values across the different activities. One consideration is whether users who visit Springfield-Greene County lakes participate in more than one activity per visit, which would likely diminish the value placed on a single activity. It is also important to consider the frequency of each activity based on local information on recreational users. Approaches to valuation may include reporting the value for each activity separately, indicating that users may participate in more than one per day. Another approach would be to select the activity that communicates the highest value for each water resource and indicate that this value may be greater if users participate in other activities separately.

Control Action Co-Benefits

Ecosystem services were discussed above in terms of how literature values can be used to communicate the value of the region's water resources, which helps support the integrated planning process. Another way to incorporate ecosystem services values into the integrated planning process is by using these values as a decision-making factor. The Springfield-Greene County project partners have chosen to conduct a Sustainable Return on Investment (SROI) which incorporates ecosystem services values, project costs, and other factors, and calculates the long-term return on investment for each proposed control action.

The SROI is one example of how to incorporate ecosystem services values into decision-making. A number of case studies exist throughout the U.S., and EPA has summarized these recent case studies in EPA (2013). In general, the term co-benefits are used to describe ecosystem services values provided by control actions beyond water quality improvement. While co-benefits can be estimated for any control action, green infrastructure tends to offer the greatest number and value of co-benefits as reported by the recent case studies. For the purposes of providing examples of co-benefit valuation methods, this section focuses on highlighting values and methods applied to green infrastructure.

The City of Springfield and Greene County are familiar with green infrastructure and have been developing a number of control actions that include these techniques. At a broader scale, the State of Missouri has developed the *Missouri Guide to Green Infrastructure*, which describes the overall processes and tools available to Missouri communities for incorporating green infrastructure into site designs and development plans, land use plans, stormwater management programs, land use ordinances and technical design manuals. The Guide also describes the many co-benefits of green infrastructure, which are summarized in Table 3.

Table 3. Green Infrastructure Co-Benefits

Environmental Benefits	
Annual Volume Reductions	Green infrastructure focuses on decreasing the rate and volume of runoff to the collection system which better simulates pre-construction runoff conditions.
Improved Capacity to Piped Collection Systems	Green infrastructure can reduce the rate of runoff to existing collection systems, resulting in increased capacity for downstream inlets. It may also reduce peak rates used in sizing collection systems.

Environmental Benefits	
Enhanced Groundwater Recharge	Green infrastructure can help to infiltrate runoff, which can improve groundwater recharge rates. Enhanced groundwater recharge also boosts the supply of drinking water for private and public uses.
Improved Air Quality	Green infrastructure facilitates the incorporation of trees and vegetation in urban landscapes, which can contribute to improved air quality.
Increased Carbon Sequestration	The plants and soils that are part of the green infrastructure approach serve as sources of carbon sequestration.
Additional Wildlife Habitat and Recreational Space	Greenways, parks, urban forests, wetlands and vegetated swales are all forms of green infrastructure that provide increased access to recreational space and wildlife habitat.
Improved Human Health	An increasing number of studies suggest that vegetation and green space can have a positive impact on human health.
Urban Heat Island and Energy Demand Reduction	Green infrastructure provides increased amounts of urban green space and vegetation, helping to mitigate the effects of urban heat islands and reduce air conditioning related energy demands.
Social Benefits	
Aesthetics and Sense of Community	The nature of green infrastructure encourages community outdoor recreation and provides more walkability, "bikability" and functional and aesthetic gardens and landscapes.
Multi-Use Amenities	Communities can benefit from recreational amenities skillfully designed into utility services as multi-purpose capital projects.
A Greater Choice of Lifestyles	Sustainable communities provide a greater choice for buyers who are increasingly aware of development impacts to the environment, to the tax base and to neighborhood amenities.
Flexibility	On-site infrastructure can allow communities more flexibility to effectively use their land base and can thereby minimize the challenges of locating gray infrastructure within right-of-ways and long-term costly maintenance and repair.
Conflict Avoidance and Resolution	Integrating green infrastructure into development recommendations will more likely be amenable to community acceptance of development projects, thereby minimizing delays commonly associated with public protest.
Reduced Flash Flooding	Preventing flash floods will reduce the threat they pose to public safety.
Public Education	Green infrastructure can provide increased public awareness of environmental issues and the community's role in stormwater management
Economic Benefits	
Lower Costs and Delayed Capital Outlays	Depending on the type of development, green infrastructure can result in lower capital cost and lower operation and maintenance costs.

Environmental Benefits	
User-pay	Integration of green infrastructure into the development project, on-site and within buildings, results in lower public expenditure due to demand side management.
Improved Investments by Stakeholders	Monthly management fees can be reduced for homeowners and their associations, as well as commercial and industrial owners. Such reductions increase marketability of development.
Local Green Job Creation and Procurement	Choosing green infrastructure requires green design services that can be procured locally, along with landscaping services and less money is spent on constructing and operating systems in remote locations.
Increased Land Values	A number of case studies suggest green infrastructure can increase surrounding property values.
Utility Savings	Installing rain water harvesting systems such as storage tanks or cisterns for can lower a facility's water costs significantly.

There are a number of additional benefits that can be provided by green infrastructure, however, the list above includes those benefits that have the most potential to directly or indirectly impact economic drivers. For more information on the benefits of green infrastructure in Missouri, the State Department of Natural Resources maintains a website with links to Missouri's Guide to Green Infrastructure and additional resources <http://dnr.mo.gov/env/wpp/stormwater/mo-gi-guide.htm>.

A wealth of information resources exists on the design, implementation, and benefits of green infrastructure. EPA maintains a website with green infrastructure tools and examples from throughout the U.S. (http://water.epa.gov/infrastructure/greeninfrastructure/), and EPA (2013) describes case studies on quantifying green infrastructure co-benefits. Several on-line tools exist that facilitate the calculation of co-benefits, including USDA's i-Tree tools <https://www.itreetools.org> and the Green Values National Stormwater Calculator <http://greenvalues.cnt.org/national/calculator.php>. Since communities can access these resources to explore the breadth of co-benefits information, this report focused on two examples of co-benefits, providing more detailed information on how they are calculated and local factors to consider. The first example involves estimating jobs created for unskilled workers through the maintenance needs of green infrastructure and the associated reduction in social costs resulting from this job creation. The second example reviews literature available for estimating increases in property value due to green infrastructure. Methods for estimating other co-benefits are reviewed briefly in addition to the two more detailed examples.

Green Jobs and Reducing the Social Cost of Poverty

The development of green infrastructure can create jobs for local low-income individuals, which not only can provide direct, indirect, and induced economic benefits but can also reduce the cost of social poverty. While design of green infrastructure requires certain skilled individuals, such as architects, designers and engineers, its implementation yields "green collar" jobs in construction, operation, maintenance, and installation. In the United States, between July 2007 and January 2009, there was a thirty-one percent increase in people being hired specifically for green jobs, and some predictions anticipate 6.9 million green jobs by 2020 (Dunn 2010).

Jobs created through green infrastructure not only stimulate local economies through additional employment but also can reduce government costs. Maintenance of landscaping and other green infrastructure features provides jobs for unskilled laborers who may otherwise be unemployed. Through unskilled job creation, government costs are reduced because employed persons require less government assistance or intervention.

The major employment benefit of green infrastructure is that required maintenance creates a permanent need for unskilled laborers since the majority of work involves landscaping and other activities that require minimal training. Unemployed persons in poverty tend to be unskilled laborers, and the creation of recurring green infrastructure jobs provides a mechanism to bring these persons out of poverty. In turn, less funding is needed to support the unemployed through welfare and other social services. Overall, jobs created through green infrastructure provide an economic value added beyond the jobs themselves.

A number of management efforts throughout the United States are taking advantage of the job creation benefits of green infrastructure (for stormwater management and other co-benefits). These efforts include urban greening initiatives in Philadelphia, Pennsylvania; Lawrence, Massachusetts; and Stamford, Connecticut (USEPA 2009b; Schilling and Logan 2008; Dunn 2010) and funding for green collar jobs in several California cities (Rangwala 2008). The urban greening efforts in Lawrence and Philadelphia have led to the creation of more stable neighborhood environments and established innovative programs that provide jobs, skills training, and local fresh food for residents through the reclamation of vacant properties.

The City of Philadelphia (2009) conducted a detailed estimate of job creation and reduction in social costs as part of their green infrastructure plan to reduce CSOs. They estimated that spending over $100 million dollars over 20 years on operation and maintenance would provide 250 permanent jobs for unskilled workers and save about $2.5 million dollars in social costs annually, or $10,000 per new green infrastructure job created per year. This estimate is based on local and national studies and accounts for the social costs of health services and crime related to persons in poverty. This is a conservative estimate as the literature review by the City of Philadelphia (2009) illustrated a range of estimates for the cost of poverty from $15,000 to $45,000 per person per year.

Some additional examples of job impacts of green infrastructure are listed below (Green For All 2012).

- Philadelphia's $1.6 Billion investment in stormwater infrastructure has the potential to generate 8,600 green collar direct jobs (GSP Consulting and Ecolibrium Group 2010).
- In Northeast Ohio, 31,000 direct jobs could be created between 2012-2016 from a $3 billion investment in stormwater infrastructure (Green For All 2011).
- Montgomery County, Maryland expects to employ 3,300 workers over the next 3 years building its new network of green stormwater controls (Chesapeake Bay Foundation 2011).

- PlaNYC anticipates the creation of 266 total jobs from investing $23 million in green roofs and 1,446 direct jobs from a $346 million investment in watershed protection programs (The Louis Berger Group 2008).
- Installing green roofs on 5% of Chicago's buildings would create 7,934 jobs from an investment of $403 million (American Rivers and Alliance for Water Efficiency 2008).

Job creation benefits can be estimated through modeling, and economic models can be used to estimate job creation from green infrastructure and similar spending. Modeling can be used to determine the number and type of jobs expected from both the construction and maintenance of proposed green infrastructure projects. The economic model IMPLAN (IMpacts for PLANning), can be used to estimate jobs and associated monetary benefits generated for each green infrastructure project. IMPLAN is a software model that uses an input-output dollar flow table. For a specified region, the input-output table accounts for all dollar flows between different sectors of the economy. Using this information, IMPLAN models the way a dollar injected into one sector is spent and re-spent in other sectors of the economy, generating waves of economic activity, or "economic multiplier" effects. The model uses national industry data and county-level economic data to generate a series of multipliers, which in turn estimate the total implications of economic activity (City of Richmond, 2010).

If modeling is not possible, a municipality could estimate jobs created based on how many staff the city/county estimates they would need. Note that this would be a conservative estimate and would not include any indirect or induced economic benefits, including additional jobs created indirectly, that modeling would provide. The reduced social cost of poverty can be estimated by multiplying the total number of jobs created by an assumed per-employee amount of societal costs that will be avoided due to the altered poverty status of the new employee. Reduced social cost can be based on national estimates of the cost of poverty and a city or county's share of low income households. Once an estimate of the city or county's share of social costs is estimated, this can be converted to social costs per unemployed person using U.S. census data.

Property Value Benefits of Green Space

A number of studies have estimated the effect that green infrastructure and similar practices have on surrounding property values. Many aspects of green infrastructure can increase property values, including improved aesthetics, drainage, and recreational opportunities. One of the better documented benefits is the effect that the additional plants and trees associated with green infrastructure have on property value due to their aesthetic nature. Increases in property value not only benefit individual property owners, but also can lead to increased tax revenue and general economic improvement, including increased jobs.

To estimate the impact of open space on nearby property values, simple hedonic regression analyses can be conducted on real estate sales based on data from a city of county property assessor. Assessor's offices often maintain extensive data on all parcels in the area, including land use, buildings on the parcel, taxes, and sales information as well as proximity to amenities such as green infrastructure, parks, and waterbodies. GIS can be used to determine property value increases or decreases based on distance to amenities.

Table 4 summarizes several recent studies that have estimated the effect that green infrastructure or related practices have on property values. The majority of these studies addressed urban areas, although some suburban studies are also included. The studies used statistical methods for estimating property value trends from observed data (hedonic analysis). To estimate the effect of green infrastructure aesthetics on property value, a municipality would select relevant values from Table 4, then take the average percent increase and the average distance from green infrastructure associated with that increase. Then, properties within that average distance would be selected, and the average percent increase applied to their estimated property values. The total property value benefit of green infrastructure can be calculated by summing these individual property value increases.

Table 4. Studies Estimating Percent Increase in Property Value from Tree Planting, Low Impact Design with Vegetation, or Community Gardens.

Source	Percent increase in Property Value	Notes
Ward et al. (2008)	3.5 to 5%	Estimated effect of LID on adjacent properties relative to those farther away in King County (Seattle), WA.
Shultz and Schmitz (2008)	0.7 to 2.7%	Referred to effect of clustered open spaces, greenways and similar practices in Omaha, NE.
Wachter and Bucchianeri (2008)	7 to 11%	Estimated the effect of tree plantings on property values for select neighborhoods in Philadelphia. The percent price differential is identified within 4000 feet of tree plantings.
Anderson and Cordell (1988)	3.5 to 4.5%	Estimated value of trees on residential property (differences between houses with five or more front yard trees and those that have fewer), Athens-Clarke County (GA).
Voicu and Been (2008)	9.4%	Refers to property within 1,000 feet of a park or garden and within 5 years of park opening; effect increases over time, New York City (NY).
Espey and Owasu-Edusei (2001)	11%	Refers to small, attractive parks with playgrounds within 600 feet of houses, Greenville (SC).
Pincetl et al. (2003)	1.5%	Refers to the effect of an 11% increase in the amount of greenery (equivalent to a one-third acre garden or park) within a radius of 200 to 500 feet from the house, Los Angeles (CA).
Hobden, Laughton and Morgan (2004)	6.9%	Refers to greenway adjacent to property, Surrey (British Columbia).
New Yorkers for Parks and Ernst & Young (2003)	8 to 30%	Refers to homes within a general proximity to parks, New York City (NY).
Sander et al. (2010)	0.29% to 0.48%	A 10% increase in tree cover within 100 m increases average home sale price by $1371 (0.48%) and within 250 m increases sale price by $836 (0.29%). In a model including both linear and squared tree cover terms, tree cover within 100 and 250 m increases sale price to 40–60% tree cover, Ramsey and Dakota Counties (MN).

When estimating the effects green infrastructure on property values, it is important to attribute property value increases to those green infrastructure projects that provide trees and other aesthetic amenities. Property value decreases have been associated with some stormwater management facilities, where only structure or function are emphasized. Aesthetics are often very important in the design of green infrastructure. In Texas, Lee and Li (2009) found that dry basins can have negative impacts on property values, and some wet basins can have a positive effect. This suggests that aesthetics may play a role in the effect of detention facilities on property value.

Recent study findings support estimates for increased property values due to green infrastructure. Madison and Kovari (2013) examined the general impacts that green infrastructure can have on property values for industrial, commercial and residential properties in Wisconsin. The study found that incorporating green infrastructure as part of a tax increment financed development ensured timely payoff for the overall investment. In one location, the study found that green infrastructure improvements had a strong positive impact on the surrounding properties values.

Other Co-Benefits

There are many co-benefits that are achieved through green infrastructure in addition to creating green jobs, reducing the social cost of poverty, and increasing property values. Many studies use methods such as the triple bottom line analysis to account for multiple benefits including social, environmental, and economic. Socioeconomic benefits, including creation of jobs for unskilled workers, increases in property values, and reduction in heat island effects that lead to both energy savings and reduced health risk are among the most impactful benefits. There are a number of methods including cost analyses and modeling tools that can be used to estimate the economic value each of these.

Another study describes the structure, function, and value of street and park tree populations in Fort Collins, Colorado; Cheyenne, Wyoming; Bismarck, North Dakota; Berkeley, California; and Glendale, Arizona. Although these cities spent $13–65 annually per tree, benefits ranged from $31 to $89 per tree. For every dollar invested in management, benefits returned annually ranged from $1.37 to $3.09. Benefits included air quality improvements, energy savings, atmospheric carbon dioxide reductions and others. The authors used the numerical modeling program STRATUM (Street Tree Resource Analysis Tool for Urban Forest Managers) to estimate annual municipal forest benefits and costs (McPherson 2005).

Reduced Infrastructure Costs

Green infrastructure provides an opportunity to reduce the costs of grey infrastructure. As green infrastructure provides infiltration, evapotranspiration, and storage, it reduces the need to control stormwater runoff, which then reduces the need to maintain existing or to build new grey infrastructure. Several cities have implemented green infrastructure on a large scale and have seen significant cost savings. Green infrastructure within the City of Philadelphia has reduced CSO inputs by a quarter billion gallons and has saved the city an estimated $170 million (USEPA, 2010b). In addition to these cost savings, additional savings could be expected from reduced upkeep and maintenance costs for pipe networks and treatment plants. Another cost-benefit analysis by the City of Seattle estimated that natural drainage designs can reduce street drainage costs by about 24 to 45 percent compared to traditional designs (Seattle Public Utilities 2008).

Reduced Energy Use

Green space helps lower ambient temperatures and, when incorporated on and around buildings, helps shade and insulate buildings from wide temperature swings, decreasing the energy needed for heating and cooling. In addition, diverting stormwater from wastewater collection, conveyance, and treatment systems reduces the amount of energy needed to pump and treat the water. Reduced energy demands in buildings, and increased carbon sequestration by added vegetation also result in reduced carbon dioxide emissions.

The City of Philadelphia Water Department (PWD) considered a wide array of options for controlling Combined Sewer Overflow (CSO) events in its four relevant watershed areas. A key component of PWD's triple bottom line analysis calculates the amount of energy consumption added (or reduced) by the various CSO control options, and calculates the value of the added energy costs (or the energy cost savings), at current energy prices. The energy use levels include, for example, the home energy cost savings provided by the shading offered by trees added under low impact development (LID) options. Also included is the increased consumption of motor fuel associated with construction-related vehicles. For the 50% LID option, the analysis indicates a net energy savings over the 40-year planning period of nearly 370 million kilowatt hours (kWh) of electricity and nearly 600 million British thermal units (Btus) of natural gas. The monetized present value of these changes from the 50% LID option amount to nearly $34 million for energy savings (City of Philadelphia Water Department, 2009).

Carbon Sequestration

Green infrastructure vegetation helps reduce the amount of atmospheric carbon dioxide through direct carbon sequestration and by reducing energy use in buildings, consequently reducing carbon dioxide emissions from fossil-fuel based power plants.

USDA's i-Tree Eco tool (http://www.itreetools.org/eco/overview.php) can be used to calculate the carbon sequestration benefits of green infrastructure. This science-based, peer-reviewed tool is an adaptation of the Urban Forest Effects (UFORE) model, developed by USDA (2008a,b).

While the term "carbon sequestration" is used as a general term, trees remove more greenhouse gases (GHGs) than carbon species alone. Therefore, the carbon dioxide equivalent (CO2e) is the recommended unit of measure (the i-Tree tools provide output on a variety of GHGs). To convert to a monetary value, the reduced CO2e estimates are multiplied by the most recent estimate of social cost of carbon published by the U.S. government's Interagency Working Group on Social Cost of Carbon (USEPA, 2015). Double counting of values may occur from reporting the social cost of carbon, which includes some consideration of energy use, along with a direct estimation of energy use differences.

Improved Air Quality

Poor air quality can affect human health (e.g., cause or worsen respiratory diseases) and damage other environmental resources such as water, aquatic life, and trees. Urban trees can help improve air quality by reducing air temperature, removing pollutants from the air, and reducing energy consumption (USDA 2008b). The Milwaukee urban forest study estimated that trees and shrubs in the City remove 496 tons of air pollution annually, based on field data as well as recent pollution and weather data (USDA 2008b).

This is equivalent to 74 pounds of pollution removed each year per acre of the City's tree canopy. These air quality improvements can reduce the incidence and severity of respiratory illness.

USDA's i-Tree Eco tool provides a readily available method for estimating the air quality benefits of green infrastructure related to vegetation. i-Tree is a software suite from the USDA Forest Service that provides urban forestry analysis and benefits assessment tools. It can be used to estimate the removal of pollutants for green infrastructure projects. Economic analyses can convert this pollutant reduction to a monetary value.

Reduced Heat Island Effect

In the U.S., the increase in air temperature due to heat island effect is responsible for 5-10% of urban peak electric demand for air conditioning use, and as much as 20% of population-weighted smog concentrations in urban areas (Akbari 2001). Trees and other vegetation planted near buildings can affect energy consumption by shading, providing evaporative cooling, and blocking winter winds. Trees generally reduce building energy consumption in the summer months. Green roofs, and bio-retention areas also reduce the amount of heat absorbing materials and emit water vapor, all of which cool hot air and reduce the urban heat island effect.

The study of urban forest in Milwaukee indicates that the location of trees provide a significant energy savings in summer cooling (11,896 Megawatt-hours), but an actual increase in energy needed for heating in the winter (an additional 17,080 Million British Thermal Units) (USDA 2008b). Regardless of the increase in heating costs, trees in Milwaukee were estimated to reduce overall energy related costs from residential buildings by $864,000 annually (USDA 2008b).

Based on a study in Chicago, green roofs can lower heating and cooling demands up to 30 percent (Gilligan 2005). These reduced energy demands in buildings result in energy savings for households and businesses and a decrease in the region's carbon footprint. Further energy savings can be generated by mature tree canopy in the region. Such tree canopy can reduce air temperature by about 5 to 10 degrees F, therefore helping mitigate the heat island effect and lower the temperature in nearby buildings.

There are several tools available that estimate the effects across a larger area. One examples is the Mitigation Impact Screening Tool (MIST), which is a software tool that estimates the impacts of urban heat island mitigation strategies on urban air temperatures, ozone, and energy consumption.

Summary

The co-benefits of green infrastructure provides an example of how ecosystem services values can be considered within the integrated planning process. Extensive information resources are available, and a number of case studies exist throughout the country on how co-benefits can be estimated and reported. As with any ecosystem services valuation, it is important to consider local factors and project-specific assumptions when calculating co-benefits. The above references provide an example of how co-benefits values would be researched and calculated for the Springfield-Greene County integrated plan. Co-benefits values may be reported individually for each service, or summed as an input to a larger cost-benefit analysis, like the SROI. When summing the values, it is important to consult with experts on ecosystem services valuation and control for potential double counting or other sources of bias. Figure 1 provides an example of how co-benefits information can be displayed for the purposes of public outreach.

Figure 1. Example graphic communicating green infrastructure co-benefits.

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