Estimating the Value of Water Resources: A Literature Review

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1 INTRODUCTION

The city of Springfield, Greene County, and the City Utilities of Springfield (project partners) in Missouri are developing a comprehensive integrated plan to address the region's Clean Water Act regulatory obligations and air quality and land resource quality obligations. With the integrated plan, the project partners seek to prioritize investments in water, land, and air resource improvements that address the most pressing problems first and provide the greatest value to the area's citizens. As part of this effort, the partners evaluated proposed projects using a sustainable return on investment (SROI) analysis method, which measures each project's long-term return on investment relative to environmental, social, and economic impacts. To complete the SROI analysis, the project partners first needed to estimate the value of their water resources. EPA supported this valuation process by conducting a literature review of relevant studies that examined how similar communities estimated their water resource value. The project partners' methodology and the EPA literature review results are described below.

View of Valley Water Mill Lake from pedestrian bridge.
City of Springfield, Department of Environmental Services

2 USING ECOSYSTEM SERVICES TO ESTIMATE THE VALUE OF WATER RESOURCES

The project partners estimated the value of the Springfield–Greene County region's water resources by assessing the level and type of ecosystem services in the community. Ecosystem services are the benefits that ecosystems provide to people, and they are often discussed in four categories: supporting, provisioning, regulating, and cultural. Supporting ecosystem services are necessary to produce all other ecosystem services. Provisioning services describe products obtained from ecosystems. Regulating services include benefits obtained from regulating ecosystem processes. Lastly, cultural services include nonmaterial benefits people obtain from ecosystems (Millennium Ecosystem Assessment 2005). Examples of each service type are shown in Figure 1.

Various studies have been conducted to estimate the monetary value of ecosystem services relative to economic goods and services. These studies have developed and refined several valuation methods, including those summarized in Figure 2 below. EPA's *Guidelines for Preparing Economic Analyses*[1] (U.S. EPA 2010a) explains each of these methods in more detail.

Supporting	Provisioning	Regulating	Cultural
Soil formation	• Food supply	• Flood mitigation	• Recreational opportunities
Nutrient cycling	• Water supply	• Disease control	• Spiritual benefits
Primary Production	• Raw Materials	• Carbon sequestration	• Education

Figure 1. Ecosystem service benefits.

[1] Available online at https://www.epa.gov/environmental-economics/guidelines-preparing-economic-analyses.

Economic Impact Analysis

- Estimating the impact on the economy from ecosystem services

Hedonic Analysis

- Esimating the impact on property values

Stated Preference Method

- Analyzing public survey data on willingness to pay for services

Revealed Preference (Travel Cost) Method

- Analyzing collected data on expenditures related to enjoyment of ecosystem services

Replacement Cost Approach

- Estimating costs to replace an ecosystem service

Avoided Cost Approach

- Estimating costs avoided due to an ecosystem service

Benefit Transfer Approach

- Applying values from other studies to a different geographic location similar to the study's demographic, morphologic, and geographic characteristics

Figure 2. Ecosystem services valuation methods.

When using the value of ecosystem services to estimate the value of a water resource, it is important to consider how the four ecosystem services relate to each other. Supporting services often represent intermediate processes necessary for the other services; they are thus included in valuations of these other services, posing a risk for double counting. For instance, nutrient cycling is a supporting service for the provisioning of safe drinking water. Thus, the value of nutrient cycling (the supporting service) is already reflected in the value of safe drinking water (the provisioning service). If both services were valuated separately and the values were then summed, that total value would likely double count and overestimate the overall value of both services. In this case, safe drinking water is considered the final ecosystem service, and nutrient cycling is considered an intermediate ecosystem service (Fu et al. 2011). This example is illustrated in Figure 3 below.

To avoid double counting, it is important to identify the final ecosystem services that benefit the target population. However, the value of final services may also overlap depending on how they are measured. For example, property value increases attributed to improved water quality may be related, in part, to recreational opportunities. If a waterbody is valued for both scenic beauty and recreation, one final ecosystem service value—or the range of values—can be used to avoid double counting (Fu et al. 2011).

To ensure that information is reported accurately to the public (a vital part of integrated planning), a community's available expertise may dictate its choice of valuation approach (Table 1). For example, communities that do not have direct access to a valuation expert (e.g., a professional with an economics background and direct experience with ecosystem services valuation) may select only one ecosystem service per waterbody and use available literature to support the valuation. If using the benefit transfer approach, a community must evaluate how relevant the literature values are to its own geographic, morphologic, and demographic characteristics. If a community does have access to a valuation expert(s) for at least a limited review or consultation, they could work together to develop the most defensible approach, which might involve summing multiple ecosystem service values if the expert can clearly explain, address, and verify the potential for double counting.

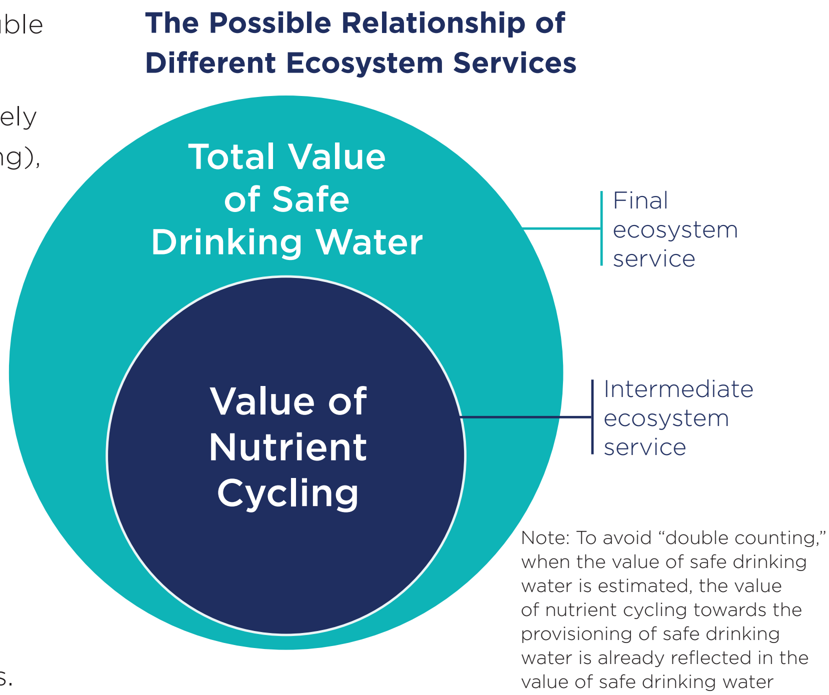


Figure 3. Example of the relationship between intermediate and final ecosystem services.

The project partners' approach for Springfield–Greene County will aggregate the ecosystem service values of proposed project benefits and couple them with strong available expertise.

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 valuation experts can clearly explain, address, and verify the potential for double counting.
Strong	Low	Work with valuation expert(s) to determine most defensible approach. Values may be summed if the potential for double counting is minimized.

2.1 Evaluating Ecosystem Services For Springfield–Greene County's Water Resources

While generalized categories can be used to help estimate the value of a community's water resources, every community has a unique relationship with its resources that can impact the actual value. The city of Springfield and Greene County are no exception. The city is on a plateau and many streams start within its boundaries and flow through the city, providing greenway corridors for recreational trails and wildlife while conveying stormwater from urban development. At several locations inside and outside the city, streams and rivers are impounded for municipal water supply and recreational benefits. Several lakes are used for fishing, boating, and swimming. Treated sanitary wastewater effluent enters receiving streams at certain points. Several industries intake source water for processing food and other products, and many industries discharge wastewater or stormwater to the city's publicly owned treatment works, municipal separate stormwater system, or directly to surface waters.

Access points along local streams allow paddlers and other boaters to enjoy the community's water resources within, upstream, and downstream of the city. Several small streams surrounding Springfield drain into rural agricultural areas that support cattle and other livestock. These small streams also drain into larger streams and rivers upstream and downstream from the city. Much of the streamflow from the Springfield–Greene County area drains into either Stockton Reservoir or Table Rock Lake (Figure 4).

With the project partners' unique qualities in mind, EPA reviewed the valuation literature and identified studies about water resources that report monetary values for provisioning and cultural services, 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. The literature review

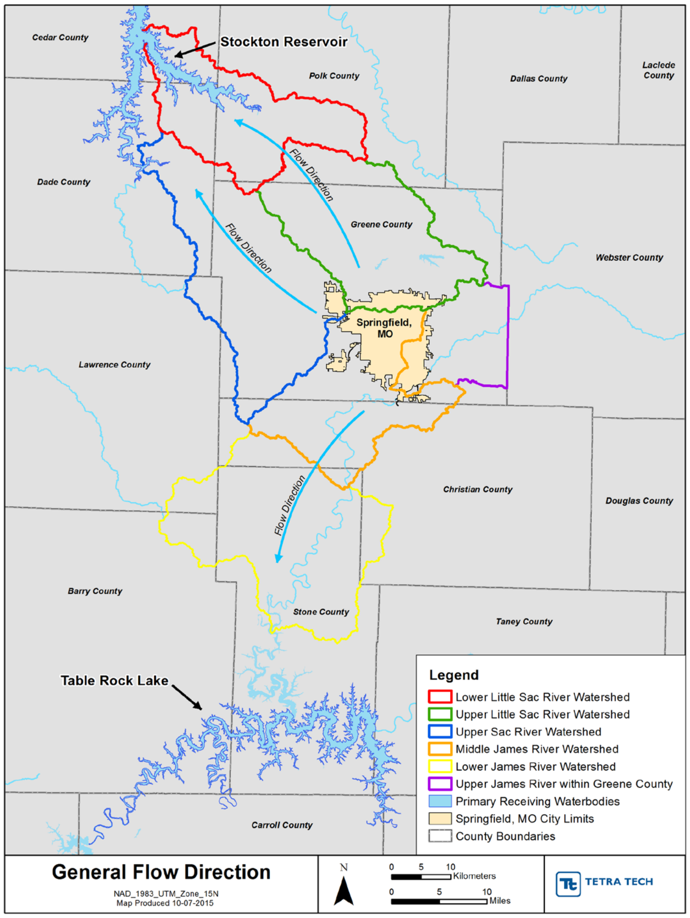


Figure 4. Map of streamflow from Springfield–Greene County to Stockton Reservoir and Table Rock Lake.

revealed several promising studies to help valuate Springfield–Greene County's water resources.

2.1.1 Recreational Opportunities

The Springfield–Greene County region boasts numerous water-related recreational opportunities. Several lakes near the city of Springfield 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 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.

The region's water resources have not always been as accessible for recreation as they are today. Surface water quality problems in the James River were documented as early as 1965. Historically, the major concern was low dissolved oxygen due to sewage and urban stormwater runoff (Missouri DNR 2004). Before wastewater treatment plant improvements, waterbodies like Wilson's Creek were too eutrophic for paddling. A 1969 study found that fish could not live below Wilson's Creek's wastewater treatment plant because it was severely polluted (Kerr 1969). Later, in 1998 and 1999, two large algal blooms occurred on Table Rock Lake during peak tourist season.

In 1999, Missouri's Clean Water Commission passed a regulation limiting the amount of phosphorus that sewage treatment plants can discharge in the Missouri portion of Table Rock Lake's watershed. Springfield's Southwest Treatment Plant started meeting the required phosphorus reductions in 2001, which eventually led to significant reductions in phosphorus levels throughout the James River Basin (Obrecht et al. 2005). Water quality improvements over time have provided more freedom for residents to enjoy the recreational value of their local waterbodies with assurance that the water quality is being maintained.

Two of the most common techniques for valuating a waterbody's recreational opportunities are stated preference and revealed preference studies. Generally considered the most comprehensive technique, stated preference studies use surveys to estimate the public's willingness to pay for recreational opportunities and often measure values based on different lake conditions, including water quality as it relates to fishing, boating, and swimming (U.S. EPA 2010a, Loomis et al. 2000). Revealed preference studies collect data on consumer 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 for water resources in Springfield–Greene County has not been estimated directly, EPA estimated this value using the benefit transfer approach. The benefit transfer approach identifies valuation 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 (U.S. EPA 2010a). For this report, EPA conducted a literature review of similar studies in other Missouri counties and states to identify relevant literature values for the recreational benefits of lakes and streams. Many of the identified studies were conducted in distant states or for waterbodies different in size and morphology when compared with the Springfield–Greene County lakes and streams. From this broader list of studies, EPA identified several that provided more relevant literature values due to similar demographics, geography, morphology, or other factors (Table 2).

Before the East Locust Creek Watershed community constructed a new reservoir, Cartwright (2006) used a benefit transfer approach to estimate the proposed reservoir's value of recreation. Specifically, Cartwright (2006) estimated the number of user days for each recreational activity, based on an estimate of demand for these activities, and then multiplied this number by the values reported in Rosenberger and Loomis' (2001) 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 3).

Study Reference	Study Title
Cartwright 2006	*Recreation Evaluation of the Multiple Purpose Reservoir for the East Locust Creek Watershed, Missouri*
Rosenberger and Loomis 2001	*Benefit Transfer of Outdoor Recreation Use Values: A Technical Document Supporting the Forest Service Strategic Plan (2000 Revision)*
Rosenberger and Stanley 2007	*Publication Effects in the Recreation Use Value Literature: A Preliminary Investigation*
Keeler et al. 2015	*Recreational Demand for Clean Water: Evidence from Geotagged Photographs by Visitors to Lakes*
Otto et al. 2012	*Economic Value of Outdoor Recreation Activities in Iowa*
Egan et al. 2004	*Valuing Water Quality in Midwestern Lake Ecosystems*

Table 2. Studies identified for estimating the value of recreational opportunities in Springfield–Greene County

Table 3. Recreation activity access values (2006 dollars) in consumer surplus per person per activity day by U.S. Census region (Rosenberger and Stanley 2007)

Activity	Northeast	Midwest	South	West	National
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 (5:17)	29.22 (3:26)	56.07 (4:30)	53.46 (8:31)	120.71 (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)

Note: (# studies: # estimates)

As the Rosenberger and Stanley (2007) meta-analysis shows, a much greater body of research is available to support an estimate of general recreational values. A recommended approach would be to estimate the general recreation values based on this meta-analysis because the lake clarity and property value estimates are each only supported by one study.

Within Rosenberger and Stanley's (2007) meta-analysis, it is important to note that literature values are reported for individual recreational activities (fishing, boating, swimming, etc.). A valuation using these findings would need to consider the 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

In a stated preference study on Minnesota and Iowa lakes, Keeler et al. (2015) examined how lake clarity affects the public's willingness to travel for recreational trips. The study 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. For example, lake users were willing to travel 56 minutes farther (equivalent to $22.00 in travel costs) for every 1-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 multiyear surveys of Iowa households and indicated that water quality was the most important factor they consider when choosing a lake for recreation, with proximity and park facilities also being relatively important (Egan et al. 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 recreational user spending generated estimates of daily per-party spending for five Iowa lakes (Otto et al. 2012): 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 Iowa lake 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 et al. (2012) used a value of $34.75 per-person spending (2009 dollars), based on Rock Creek Lake, to estimate spending by Iowa river users. 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 lake recreational values. 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 et al. (2004) that water quality was the most important factor that respondents considered 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. U.S. EPA (2010a) provides additional guidance for the benefit transfer process in general, and Rosenberger and Stanley (2007) discuss bias specifically related to recreation value estimates.

3 PROPERTY VALUE IMPACTS OF WATER RESOURCES

Property values can be impacted by many ecological and environmental factors related to water resources. Waterfront property is especially impacted by proximity to water and scenic views, as well as water quality and recreational opportunities. Factors such as polluted runoff and discharges, sedimentation, and invasive species can negatively impact water quality and aesthetics.

Economists use hedonic property models (the impact on property values) to show that public waterbodies provide external benefits that are reflected in the value of nearby residential real estate. The literature has used many approaches to quantify these ecosystem services. Several studies have used distance from the water to measure the ecosystem services generated by public waterbodies. 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 are due to the value of local environmental attributes. This method estimates 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 properties, particularly at lakes, tend to have higher property values than 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 and Shogren 1989, Kashian et al. 2006, Krysel et al. 2003, Leggett et al. 2000). Related to water quality, the presence and density of invasive species can also 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 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 that provided literature values relevant to Springfield–Greene County lakes and streams (Table 4).

Table 4. Studies identified for estimating property values in Springfield–Greene County

Study Reference	Study Title
Schultz and Schmitz 2008	*How Water Resources Limit and/or Promote Residential Housing Developments in Douglas County*
d'Arge and Shogren 1989	*Non-Market Asset Prices: A Comparison of Three Valuation Approaches*
Kashian et al. 2006	*Lake Rehabilitation and the Value of Shoreline Real Estate: Evidence from Delavan, Wisconsin*
Krysel et al. 2003	*Lakeshore Property Values and Water Quality: Evidence from Property Sales in the Mississippi Headwaters Region*

In Omaha, Nebraska, Schultz and Schmitz (2008) examined values of man-made lake views 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 in this study ranged from 35 to 255 acres in surface area; the study results could thus be used to estimate the property value benefits provided by Springfield–Greene County lakes, which are of similar size. A geographic information system (GIS) viewshed analysis could 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 property values to estimate the benefit of scenic lake views realized by residents.

Several studies on water quality effects 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 the 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. For example, d'Arge and Shogren (1989) found that 13 to 23 percent of the residential property value along the Lake Okoboji shoreline is due to 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) is the only study in EPA's literature review that can be used 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.

4 ADDED VALUE THROUGH GREEN INFRASTRUCTURE PROJECTS

Projects and programs implemented through the integrated planning process may bring some added benefits to the table. Beyond simply improving water quality, improving the quality of a community's water resources may indirectly lead to improvements in other areas, such as renewing run-down or neglected parts of the community or creating jobs. This makes improving and restoring water resources even more valuable, and should be a key consideration in integrated planning decision-making.

Green infrastructure projects and practices have created added value for many communities by establishing green jobs and increasing property values. As part of this report, EPA reviewed several recent case studies that highlight successes and the potential for added value through green infrastructure.

The city of Springfield and Greene County are familiar with green infrastructure and have been developing several projects that include these practices. At a broader scale, the state of Missouri has developed the *Missouri Guide to Green Infrastructure* (MODNR 2012), 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 benefits of green infrastructure, which are summarized in Table 5.

Table 5. Multiple benefits of green infrastructure (MODNR 2012)

Environmental Benefits	
Annual runoff 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.*
Enhanced groundwater recharge	*Green infrastructure can help 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 can facilitate the use 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 to reduce energy demands from air conditioning.*

Social Benefits	
Aesthetics and sense of community	*Green infrastructure encourages community outdoor recreation, such as walking and biking, and provides functional and aesthetic gardens and landscapes.*
Multi-use amenities	*Communities can benefit from recreational amenities skillfully designed into utility services as multipurpose capital projects.*
Greater choice of lifestyles	*Sustainable communities provide a greater choice for buyers who are increasingly aware of development impacts to the environment, tax base, and neighborhood amenities.*
Flexibility	*Onsite infrastructure can give communities more flexibility to effectively use their land base, thereby minimizing the challenges of locating gray infrastructure within right-of-ways and long-term costly maintenance and repair.*
Conflict avoidance and resolution	*Communities will likely be more receptive to green infrastructure if it is integrated into development project recommendations, thereby minimizing delays commonly associated with public protest.*
Reduced flash flooding	*Green infrastructure helps prevent flash floods, thereby reducing the threat they pose to public safety.*
Public education	*Green infrastructure can increase 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 costs and lower operation and maintenance costs.*
User pay	*Integrating green infrastructure into the development project—on site and within buildings—results in lower public expenditure due to demand-side management.*
Improved stakeholder investments	*Monthly management fees can be reduced for homeowners and their associations, as well as commercial and industrial owners. Such reductions increase the marketability of development.*
Local green job creation and procurement	*Choosing green infrastructure requires green design and landscaping services that can be procured locally so that less money is spent on constructing and operating systems in remote locations.*
Increased land values	*Several case studies suggest green infrastructure can increase surrounding property values.*
Utility savings	*Installing rain water harvesting systems such as storage tanks or cisterns can lower a facility's water costs significantly.*

Green infrastructure can provide many additional benefits; 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 the Missouri Guide to Green Infrastructure and additional resources: **http://dnr.mo.gov/env/wpp/stormwater/mo-gi-guide.htm**.

Many information resources discuss the design, implementation, and benefits of green infrastructure. EPA maintains a website with green infrastructure tools and examples from throughout the United States (**http://water.epa.gov/infrastructure/greeninfrastructure/**), and U.S. EPA (2013) describes case studies quantifying green infrastructure benefits. In a 2011 case study, the city of Lancaster, Pennsylvania, prepared a comprehensive green infrastructure plan outlining goals, opportunities, and recommendations for implementing green infrastructure in Lancaster. Through this case study, EPA demonstrated how accounting for the multiple benefits of green infrastructure can provide a more complete assessment of infrastructure and community investments (U.S. EPA 2014).

Many studies reviewed for this report use methods such as the triple bottom line analysis to account for multiple social, environmental, and economic benefits. Several methods, including cost analyses and modeling tools, can be used to estimate the economic value of each of these.

Several online tools facilitate the valuation of various green infrastructure practices, including the U.S. Department of Agriculture's (USDA's) i-Tree tools (**https://www.itreetools.org**) and the Green Values National Stormwater Management Calculator (**http://greenvalues.cnt.org/national/calculator.php**). The following sections highlight information gathered through EPA's literature review, including valuation methods for additional green infrastructure benefits beyond just improving water quality.

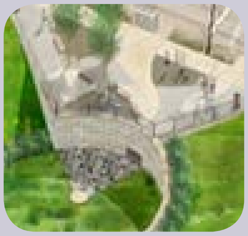
4.1 Green Jobs

Green infrastructure development can stimulate local economies by creating jobs for local residents, which can provide direct, indirect, and induced economic benefits. While the design of green infrastructure requires training in certain professional disciplines, such as landscape architecture, design, and engineering, 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 31 percent increase in people hired specifically for green jobs, and some predictions estimate 6.9 million green jobs in the United States by 2020 (Dunn 2010).

The major employment benefit of green infrastructure is that required maintenance creates a permanent opportunity for local employment and offers low barriers to workforce entry since the majority of work involves landscaping and other activities that require minimal training. Overall, jobs created through green infrastructure give local communities an added economic value beyond the jobs themselves.

Many management efforts throughout the United States are taking advantage of the job creation benefits of green infrastructure. These efforts include urban greening initiatives in Philadelphia, Pennsylvania; Lawrence, Massachusetts; and Stamford, Connecticut (Schilling and Logan 2008, Dunn 2010), as well as 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 resilient neighborhood environments and established innovative programs that provide jobs, skills training, and local fresh food for residents by reclaiming vacant properties and introducing community gardens (Green For All 2011). Some additional examples of green infrastructure's potential job impacts are listed below and in Figure 5.

- 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).
- 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).



In Northeast Ohio, **31,000 direct jobs** could be created betweeen 2012-2016 from a **$3 billion investment in stormwater infrastructure** (Green for All 2011).

Installing green roofs in 5% of Chicago's buildings would create **7,934 jobs from an investment of $403 million** (American Rivers and Alliance for Water Efficiency 2008).

Montgomery County, Maryland expects to employ **3,300 workers** over the next 3 years buildings its new network of green stormwater controls (Chesapeake Bay Foundation 2011).

Investments of **$166 million** in stormwater projects between 2009-2011 in Los Angeles produced an estimated **2,075 total jobs** (Burns and Flaming 2011).

Figure 5. Examples of potential green job creation.

Opportunities for Individuals with Barriers to Employment

Many green jobs are created through green infrastructure work programs for prisoners, parolees, and at-risk youth. These jobs offer training, education, and work experience to these individuals while providing community services through green infrastructure development and neighborhood beautification projects.

Green Streets, part of the New Jersey Tree Foundation, is a program that allows ex-offenders to learn a trade they can use after they leave prison and to raise money for the NJ Tree Foundation's inner-city free tree programs. NJ Tree Foundation staff train Green Streets crew members in tree planting and maintenance, before giving them seasonal jobs to help them transition back into society. Cities and towns can hire Green Streets crew members to plant trees, provide tree maintenance, and perform other green infrastructure work such as creating rain gardens (BKwart 2015).

Greencorps Chicago is the city of Chicago's green industry job training program for individuals with barriers to employment. Greencorps Chicago trainees receive practical experience and professional development in a variety of environmentally related jobs with skills that can be easily transferred to other industries. Participants receive training in horticulture, urban agriculture, tree care, landscaping, carpentry, ecological restoration, integrated pest management, and many other topics (City of Chicago 2015).

North East Trees is a Los Angeles-based program that educates and trains at-risk youth and young adults in environmental disciplines that lead to permanent employment in the green industry. The organization estimates that within the past two decades, it has planted over 50,000 trees and worked with over 1,000 at-risk youth (North East Trees 2009).

PowerCorps PHL, an AmeriCorps program, provides job training opportunities for young adults in Philadelphia. Beginning in 2013, the program enrolled 100 individuals per year, ages 18 to 26. The members work six months full-time with city departments and are then given three months of job placement support. As of 2015, companies in the green services industry were hiring PowerCorps crew members (City of Philadelphia 2015).

Economic modeling can be used to estimate the number and type of jobs as well as the associated economic benefits expected from future green infrastructure expenditures. IMPLAN (IMpacts for PLANning) is one commonly used economic model. For a specified region, IMPLAN's input-output table accounts for all dollar flows between different economic sectors. Using this information, IMPLAN models the way a dollar injected into one sector is spent and re-spent in other sectors, generating waves of economic activity, or "economic multiplier" effects. IMPLAN uses national industry data and county-level economic data to estimate economic impacts (City of Richmond 2010).

If modeling is not possible, a municipality could estimate jobs created based on estimates of staffing or contracting needs. Note that this would be a conservative estimate and would not include any indirect or induced economic benefits—such as additional jobs created—that modeling would provide.

Philadelphia Water Commissioner Howard Neukrug and Philadelphia Water Environmental Scientist Alex Warwood with PowerCorps PHL workers. *PowerCorpsPHL*

4.2 Property Value Benefits of Green Space

Many studies have estimated the effect that green infrastructure and similar practices have on surrounding property values. Many aspects of green infrastructure—including improved aesthetics, drainage, and recreational opportunities—can increase property values. One of the better-documented benefits is how additional plants and trees increase property value by improving aesthetics. Increases in property value benefit individual property owners and can also lead to increased tax revenue and general economic improvement.

To estimate the impact of open space on nearby property values, real estate sales can be analyzed with data from a city or 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. A GIS can be used to estimate distances between real estate and nearby amenities. Using the available GIS data, a hedonic analysis (a statistical method) can then estimate property value trends. Figure 6 provides an example of how to estimate green infrastructure impacts on property values.

Table 6 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. To use literature values to estimate the effect of green infrastructure aesthetics on property value, a municipality would select relevant values from Table 6, then take the average percent increase and the average distance from green infrastructure associated with that increase. The municipality would then select properties within that average distance and apply the average percent increase to their estimated property values. The total property value benefit of green infrastructure can be calculated by summing these individual property value increases.

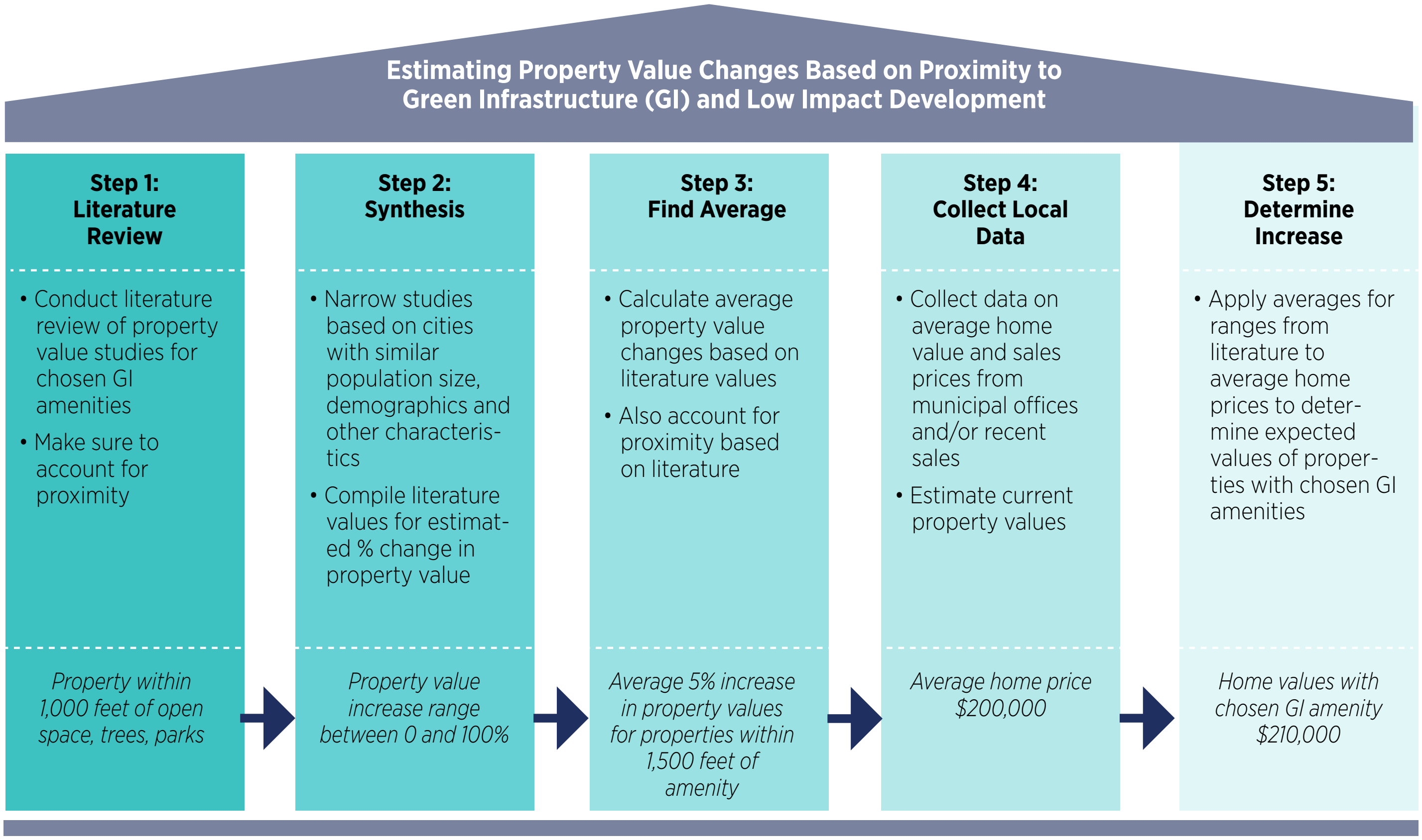


Figure 6. Example of how to estimate property value changes based on proximity to green infrastructure.

Table 6. 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%	Estimates the effect of low impact development on adjacent properties relative to those farther away in King County (Seattle), Washington.
Shultz and Schmitz 2008	0.7 to 2.7%	Refers to the effect of clustered open spaces, greenways, and similar practices in Omaha, Nebraska.
Wachter and Bucchianeri 2008	7 to 11%	Estimates the effect of tree plantings on property values for select neighborhoods in Philadelphia. The percent price differential is identified within 4,000 feet of tree plantings.
Anderson and Cordell 1988	3.5 to 4.5%	Estimates the value of trees on residential property (differences between houses with five or more front yard trees and those that have fewer) in Athens–Clarke County, Georgia.

Table 6. 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**
Voicu and Been 2008	9.4%	Refers to property within 1,000 feet of a park or garden and within five years of park opening; effect increases over time in New York City, New York.
Espey and Owasu-Edusei 2001	11%	Refers to small, attractive parks with playgrounds within 600 feet of houses in Greenville, South Carolina.
Pincetl et al. 2003	1.5%	Refers to the effect of an 11 percent 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 in Los Angeles, California.
Hobden et al. 2004	6.9%	Refers to greenway adjacent to property in Surrey, British Columbia.
New Yorkers for Parks and Ernst & Young 2003	8 to 30%	Refers to homes within a general proximity to parks in New York City, New York.
Sander et al. 2010	0.29 to 0.48%	Refers to a 10% increase in tree cover within 100 m of homes, which increases average home sale price by $1,371 (0.48%); within 250 m, tree cover increases sale price by $836 (0.29%). In a model including both linear and squared tree cover terms, tree cover of 40–60% within 100 and 250 m was found to increase sale prices in Ramsey and Dakota Counties, Minnesota.

As discussed above, property value increases can often be attributed to those green infrastructure projects that provide trees and other aesthetic amenities. Where stormwater management facilities are visible to residents or the general public, property value decreases have been associated with those facilities that only emphasize structure or function. In Texas, Lee and Li (2009) found that dry basins can negatively impact property values, whereas some wet basins can have a positive effect. This suggests that aesthetics may play a role in how detention facilities affect property value. However, in places where vegetated green infrastructure cannot be implemented, gray infrastructure or non-vegetated green infrastructure would still provide valuable benefits. While permeable pavement, rain barrels, and other green infrastructure may also affect property values, the literature review did not identify research on these effects.

Madison and Kovari (2013) examined the general impacts that green infrastructure can have on property values for industrial, commercial, and residential properties in Wisconsin. In one residential location along Lincoln Creek, the study found that green infrastructure improvements had a strong positive impact on the surrounding property values. The Lincoln Creek project had multiple components, including channel and habitat restoration, naturalization, concrete removal, addition of adjacent stormwater detention basins, and bridge replacement. The combination of detention basins and green infrastructure provides several ecosystem services and results in a net increase in property values of about 20 percent. However, any significant infrastructure improvement project would likely result in property value increases.

Green infrastructure, such as vegetated swales (top and bottom left), can reduce costs associated with traditional gray infrastructure, such as a curb and gutter (right)

Bioswale: By Brett VA [CC BY 2.0 (http://creativecommons.org/licenses/by/2.0)], via Wikimedia Commons; Grass Swale: By Natural Resources Conservation Service (NRCS) [Public domain or Public domain], via Wikimedia Commons; Curb and gutter: By Robert Lawton (Own work) [CC BY-SA 2.5 (http://creativecommons.org/licenses/by-sa/2.5)], via Wikimedia Commons

4.3 Reduced Infrastructure Costs

Green infrastructure provides an opportunity to reduce the costs of gray 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 build new gray 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 combined sewer overflow (CSO) inputs by a quarter-billion gallons and has saved the city an estimated $170 million (U.S. EPA 2010b). In addition to these cost savings, additional savings could be expected from reduced upkeep and maintenance costs for pipe networks and treatment plants.

Some types of green infrastructure can also be used instead of gray stormwater conveyance, including vegetated swales. CWP (1998) estimated that traditional structural conveyance systems cost two to three times more than grass swales. For the EPA North Carolina campus in Research Triangle Park, several green infrastructure techniques (grassy swales, water quality ponds, and bioretention) were used instead of curb and gutter and oil-grit separators, saving an estimated $500,000 in construction costs (U.S. EPA 2001). Using an enhanced swale design, Seters et al. (2013) demonstrated that a curb and gutter were not necessary, resulting in an estimated savings of $5,500 to treat a 2,000 m2 section of pavement.

The difference between the life cycle cost of vegetated swales and curb and gutter can be estimated locally by assuming a generic road cross-section design and estimating the costs of each conveyance type per linear foot of road. The life cycle cost estimates should include construction, design, engineering, and maintenance costs.

In addition to the specific comparison of curb/gutter to swales, individual development designs may realize cost savings from green infrastructure through the reduced size of culverts, pipes, and other components of the stormwater conveyance system. These cost savings are often site-specific, but can be estimated at the planning level when both a conventional and green infrastructure site design have been developed.

4.4 Reduced Energy Use and Heat Island Effects

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.

In the United States, the increase in air temperature due to heat island effect is responsible for 5 to 10 percent of urban peak electric demand for air conditioning use, and as much as 20 percent of population-weighted smog concentrations in urban areas (Akbari 2001). Trees and other vegetation planted near buildings and pavement can affect energy consumption by shading, providing evaporative cooling, and blocking winter winds. Green roofs and bioretention 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. In addition to energy savings, reducing the heat island effect can reduce the number of extreme heat days and help prevent illness and mortality due to extreme heat events.

The Philadelphia Water Department (PWD) conducted a triple bottom line analysis to consider a wide array of options for controlling CSO events in its four relevant watershed areas. A key component of PWD's 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 the home energy cost savings provided by shading from trees added under green infrastructure options. Also included is the increased consumption of motor fuel associated with construction-related vehicles. For the 50 percent green infrastructure option, the analysis indicates a net energy savings over the 40-year planning period of nearly 370 million kilowatt-hours of electricity and nearly 600 million British

Green roof on Chicago City Hall.
Conservation Design Forum [CC BY-SA 4.0 (http://creativecommons.org/licenses/by-sa/4.0)] via Wikimedia Commons.

thermal units of natural gas. The monetized present value of these changes from the 50 percent green infrastructure option amount to nearly $34 million in energy savings (PWD 2009).

A study in Milwaukee demonstrated that the location of urban trees can provide significant energy savings in summer cooling and can also increase energy demand for heating in the winter (USDA 2008b). Accounting for the increased heating costs, trees in Milwaukee reduce overall energy-related costs from residential buildings by approximately $864,000 annually (USDA 2008b).

Buildings with green roofs have insulating effects that can reduce the penetration of summer heat and the escape of interior heat in winter (Banting et al. 2005). They can also provide important evaporative cooling effects that decrease the energy needed for heating and cooling. Energy modeling conducted on the green roof installed on City Hall in Chicago showed potential annual heating and cooling savings of $4,000 (NREL 2004). Using the same model, it was estimated that as much as $100 million could be saved citywide if all the buildings in Chicago were covered with green roofs.

USDA's i-Tree tools suite (http://www.itreetools.org/eco/overview.php) can be used to calculate the energy saving benefits of trees used in green infrastructure. The science-based, peer-reviewed tools are adaptations of the USDA's Urban Forest Effects (UFORE) model (2008a, 2008b).

4.5 Carbon Sequestration

Green infrastructure vegetation helps reduce the amount of atmospheric carbon dioxide through direct carbon sequestration and reduced energy use in buildings, consequently reducing carbon dioxide emissions from fossil-fuel-based power plants. USDA's i-Tree tools suite[2] can be used to calculate the carbon sequestration benefits of green infrastructure. While the term "carbon sequestration" is used generally, trees remove more greenhouse gases (GHGs) than carbon species alone. Therefore, the carbon dioxide equivalent (CO_2e) is the recommended unit of measure (the i-Tree tools provide output on a variety of GHGs). To convert carbon sequestration to a monetary value, multiply the reduced CO_2e estimates by the most recent estimate of carbon's social cost published by the U.S. government's Interagency Working Group on Social Cost of Carbon (U.S. EPA 2015). Double counting of values may occur from reporting the social cost of carbon, which includes some consideration of energy use and a direct estimate of energy use differences.

4.6 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 air pollutants, 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 tools suite provides a readily available method for estimating the air quality benefits of green infrastructure vegetation. The tools require data on existing or planned trees and then simulate tree growth and air pollutant reduction. The output includes the monetary value of reduced air pollution based on avoided costs from reduced public health impacts and other externalities.

[2] Available online at http://www.itreetools.org/eco/overview.php.

5 SUMMARY

EPA's literature review revealed several promising methods and studies available to inform the value estimation of Springfield–Greene County's water resources. By focusing on their community's most prominent water resource ecosystem services (i.e., recreational opportunities), the impact of improved water quality on property values, and the added benefits and value gained from projects and programs that restore and enhance water resources, community leaders and stakeholders should begin to see the value of preserving their water resources.

The information obtained through EPA's literature review show existing data and similar cases that can be used as benchmarks and points of reference for assessing the value of Springfield–Greene County's water resources. Community leaders and stakeholders can use the literature review results to help estimate the economic impacts of water resource improvement, a key consideration in integrated planning decision-making. EPA's review revealed that the value in restoring water resources is experienced both directly through water quality improvement—as may be seen with increased water-based recreation—and indirectly through increased property values and integrated planning projects (e.g., green infrastructure) that benefit the community beyond water quality. Stakeholders need to keep this holistic view in mind when planning projects and making decisions that will have long-term impacts on the community.

Boardwalk at Springfield Conservation Nature Center.
City of Springfield, Department of Environmental Services

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