# ASSESSMENT OF DECISION-SUPPORT TOOLS TO COMMUNICATE THE ENVIRONMENTAL, SOCIAL, AND ECONOMIC BENEFITS OF URBAN GREEN SPACES

A Dissertation

by

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# ABSTRACT

The purpose of this research is to provide decision-makers of publicly managed landscapes with a systematized assessment of existing decision-support tools that can estimate environmental, social, and economic impacts. These tools can also be utilized by businesses, governments, and other entities to assess the value provided to their surrounding communities. Neoclassical economics has traditionally diminished the role of ecosystem services as a sub-component in the global economy. The resulting understated value of ecosystem services has led to extensive allocation of natural capital and other resources to satisfy the high consumption needs of anthropogenic activities to the detriment of the environment. The Millennium Ecosystem Assessment completed by the United Nations was a catalyst for the sustainability movement and enabled the recognition of the global economy as a sub-component of the social and environmental configurations. This recent trend toward a more sustainable approach for the allocation of natural resources has led to the development of a diversity of assessment models to quantify ecosystem services and the environmental, social, and economic benefits they deliver to society. A state of the industry of public gardens survey was conducted to ascertain familiarity with decision-support and impact assessment tools and to determine how many have conducted environmental, social, and/or economic impact assessments. As expected, not many public gardens conducted any type of impact assessment, but most public gardens are considering addressing that issue. This research analyzed eighty-two decision-support tools based on a set of eight evaluative criteria and utilized twenty-seven decision-support tools in the case studies of six parks managed by the City of College Station (TX) Department of Parks and Recreation to evaluate the performance of the tools in publicly managed landscapes and determine an economic value of the environmental and socioeconomic benefits of the parks. Finally, recommended uses of the decision-support tools were made and lists of recommended tools for specific assessments and evaluations were generated based upon the analyses, with the i-Tree suite of tools being the overall recommended decision-support tool.

# DEDICATION

To the love of my life, Rebecca, to “Molly Girl” and “Brody Bud” for their constant companionship throughout, and to Milton and Carolyn.

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# CONTRIBUTORS AND FUNDING SOURCES

## Contributors

This work was supervised by a dissertation committee consisting of Professor Charles R. Hall (advisor) and Professor R. Daniel Lineberger of the Department of Horticultural Sciences, Professor Urs P. Kreuter of the Department of Ecosystem Science and Management, Associate Professor Marco A. Palma of the Department of Agricultural Economics, and at-large committee member, Dr. Casey Sclar, Executive Director of the American Public Gardens Association.

Assistance for principle component analysis conducted in Section 2 was provided by Assistant Professor Justin Scheiner of the Department of Horticultural Sciences and Associate Professor Louis Hodges and Professor Gerard T. Kyle of the Department of Recreation, Parks and Tourism Sciences. The case study analyses in Section 4 were conducted with the assistance of the Aggie Research Scholars Program team: Kenneth Adams, Kelcie Brien, Angela Kraus, Sophie Malis, Gabrielle Melchor, Madeleine Shay, Abby Sivinski, and Kathleen Sullivan.

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# INTRODUCTION

Over the past few years, public gardens have become more concerned about their role in urban sustainability. According to Raven (2011), the increased interest in public gardens in the United States has arisen from the promotion by public gardens of sustainable horticulture and the education of the public to become environmental stewards. Public gardens have been motivated to expand their traditional roles of plant collections and botanical records to undertake issues in water conservation, food provision and security, community development, waste reduction, and other related issues (Gough & Accordino, 2013; Lacerte 2011).

According to a report published by the Botanical Gardens Conservation International (BGCI), public gardens are working to broaden their audiences by enhancing their relevance to surrounding communities, by being role models for sustainable behavior, conducting research that has local and global impact, and providing educational programs to provide multi-sensory, high impact learning with plants and landscapes for the public (Dodd & Jones, 2010). The authors of the report proposed that the social roles of public gardens would change more rapidly if there were evidence of public garden impacts on visitors to the gardens, were more community focused, increased staff capacity and skillset, had more funding, and had upper management support.

A more recent report by the BGCI identified the lack of impact (change in behaviors after visiting gardens, visitor satisfaction, etc.) being measured among public gardens, but that they typically were assessing only activities occurring at the gardens (Smith & Harvey-Brown, 2018). Even more revealing was the fact that most gardens were not conducting any impact assessment. Based upon their understanding of environmental issues and their extensive plant collections, public gardens have a great opportunity to provide leadership in climate change research and education and enhance their role in sustainable development and plant conservation (Borsch & Lohne, 2014; Primack & Miller-Rushing, 2009).

With increasing pressure from urban development, municipalities and other public entities, including public gardens, are faced with the challenge of justifying the allocation of limited budgetary funds to green space development, tree plantings, and natural area management needs (Vandermeulen et al., 2011; Wolf, 2004). One method used to achieve public approval for green space expenditures is increasing public perception of the value of these spaces by applying sustainability assessment or decision-support tools that estimate health benefits, economic and social impacts, community revitalization, and environmental stewardship (Bagstad et al., 2013; Boulanger & Brechet, 2005; Schmolke et al., 2010; Singh et al. 2009, 2012; Wolf, 2004). Public gardens can estimate their environmental, social, and economic impacts to demonstrate their value to surrounding communities and regions by using decision-support tools for development and sustainability policies (Christie et al., 2012). The use of impact studies can play a vital role for managers and directors of public gardens to garner additional funding and support (Smith & Harvey-Brown, 2018). Public gardens can become more appealing, and marketable, by relating to the public how their existence is vital to conservation and sustainability efforts (Smith & Harvey-Brown, 2018).

The objective of this study is to provide a systematized assessment of selected decision-support tools that can estimate environmental, social, and economic values and impacts for public gardens. In this review, decision-support tools are described and evaluated according to potential usefulness for public gardens and other horticulturally-related organizations to assess their environmental, social, and economic impacts on their surrounding communities. This will enable officials of public gardens, municipalities, and other organizations to better comprehend which tools will better suit their needs in assessing ecosystem services and social impact.

# REVIEW OF DECISION-SUPPORT TOOLS TO DETERMINE ENVIRONMENTAL AND SOCIO-ECONOMIC BENEFITS OF URBAN GREEN SPACES

Although valuation tools have been utilized for several decades (Jorgensen & Fath, 2011), the use (and scope) of these tools for valuing services has increased more recently (Bagstad et al., 2013; Jorgensen & Fath, 2011; National Research Council, 2005; Ness et al., 2007; Schmolke et al., 2010). Traditionally, neoclassical economic models have focused on allocating resources based on market forces (Daly & Farley, 2011; Mankiw, 1998). However, a shortcoming of this allocation approach is that the value of ecosystem services and social impact are rarely and adequately quantified because they are characteristically non-market public goods, and, therefore, lie outside of the scope of most economic analyses (Daly & Farley, 2011; National Research Council, 2005).

Since ecosystem services are frequently characterized by undefined access and use rights, they are not marketed in the conventional manner (Walker & Salt, 2006). For example, Sutton and Anderson (2016) estimated that, based on opportunity cost of not developing Central Park in New York City, the public value of ecosystem services provided by the green space was roughly $70 million per hectare per year, totaling about $25 billion per year. If Central Park did not exist, the value of the land would potentially be lower, and the ecosystem services provided would be substantially less. Since Central Park does exist, the public would object to its being sold for development due to the aesthetic, recreational, and social benefits provided by the park.

Typical economic markets have failed to maximize the net benefits of ecosystem services and social impact by neglecting to value them. The result of the undervaluation of these benefits is that resources to preserve or enhance ecosystem services and social causes may be allocated to supposedly higher valued activities, such as urban or municipal development (Ash et al., 2010; Chee, 2004; Costanza et al., 1997; Peacock, 2016; Plieninger et al., 2015; Sagoff, 2008). As a result, natural capital and associated natural resources have been allocated extensively to satisfy the expanding anthropogenic consumptive demands to the detriment of the environment (Gowdy & Carbonell, 1999). For example, local municipalities that fail to realize the ecosystem benefits of a wetland and allow commercial and residential development in wetlands, undermine ecosystem services including biodiversity, wildlife habitats, flood mitigation, and water purification, which potentially leads to increase in flood damages and water contamination and associated declines in human health and well-being.

The valuation process also provides a credible degree of worth and enables the inclusion of ecosystem service benefits in economic value that allows tradeoff evaluations (Scholes et al., 2010). Communicating the importance of benefits is greatly enhanced through valuation tools by providing credibility, relevance, and legitimacy to the results of the assessments (Ash et al., 2010). Additional reasons for valuing benefits include: justification of the allocation of resources (i.e., funds for public spending) to ecological restoration, conservation, preservation, and other environmental concerns; comparison of benefits of programs and projects; prioritization of current and/or future projects for conservation, restoration, preservation, or development; encouragement of public support and participation for environmental initiatives; and maximization of money spent on environmental efforts (King, Mazzotta, & Markowitz, 2000).

Pleininger et al. (2015) further recommended that socio-cultural valuation techniques for cultural ecosystem services should be incorporated into a comprehensive ecosystem services valuation methodology to ascertain areas of conservation without resulting in tradeoffs of other ecosystem benefits. Stated another way, areas in need of conservation may not be socially acceptable or desirable, such as restoration of a wetland area that exists in a highly profitable land development area of a city, and the resulting loss of stormwater management would be a tradeoff of an ecosystem benefit (reduced flooding). Development in such areas often come at the expense of landowners and future generations who are unaware of the elevated flooding risks. The valuation methodology advocated by Pleininger et al. (2015) would enable the public to be more aware of development-related risks; they contended that cultural ecosystem services assessment led to increased community engagement and more comprehensive and integrated planning of the community landscape as a result of intrinsic values revealed through the application of valuation methods. Walker and Salt (2006) describe this as creating social capital.

Pope, Annandale, & Morrison-Angus (2004) characterize this comprehensive valuation as an integrated assessment which is derived from environmental impact assessment and strategic environmental assessment to incorporate social as well as economic and environmental impacts. The authors and others refer to this as the "triple bottom line" – economic, environmental, and social values – so that decision-makers can make informed decisions to maximize sustainable actions or minimize unsustainable ones to achieve the triple bottom line goals (Pope, Annandale, & Morrison-Angus, 2004).

From a global perspective, a study completed by the United Nations in 2005, the Millennium Ecosystem Assessment, further catalyzed the environmental movement by extending the concept of sustainability to sustainable development in our economic systems (Millennium Ecosystem Assessment, 2005). It recommended that to enhance sustainability, all development should address three key areas: human well-being (social), economic (ecosystem services), and environmental (conservation) (Millennium Ecosystem Assessment, 2005). The report described the important benefits that nature and ecosystems provide human societies, how humans have weakened the natural infrastructure upon which societies depend, and how vigorous ecosystems are vital to the ambitions of humankind (Millennium Ecosystem Assessment, 2005).

In an article reviewing the study by the United Nations, Fred Powledge (2006) wrote that the report makes note of the fact that protecting the world's ecosystems is good business – in other words, it is an economic advantage. However, changes in the way humans behave within their surroundings have a profound effect on changes in the ecosystem. When changes occur to the ecosystem services, then human behaviors may be forced to change (Powledge, 2006). These changes affect the services provided by those ecosystems, some being positive and others negative. For example, misuse of pesticide applications can have a negative effect on ecosystem services forcing a change in human behavior to take more precautions concerning water quality and safety. However, reclaiming a vacant lot for a community garden can have a positive outcome due to increased social interactions, decreased crime rates, and improved health benefits – all culminating in improvements in the ecosystem services being provided resulting in changed human behavior to be more proactive in caring for their surrounding environment.

Public gardens are uniquely able to effect change in public attitudes in urban settings toward environmental stewardship through their education programs (Gough & Accordino, 2013). The use of valuation tools can assist in shifting these cultural attitudes and influencing public value (Wolf, 2004; Yigitcanlar & Dizdaroglu, 2015) by quantifying their organizational impacts economically, environmentally, and socially. These assessments are supportive in increasing the awareness of the benefits of ecosystem services to the public (Chee, 2004; Hauck et al., 2013; Schmidt, Sachse, & Walz, 2016; Wolf, 2004).

An important usage of valuation tools is to provide decision- and policy-makers with quantifiable and reliable information with which to make more informed planning and sustainability decisions (Ash et al., 2010; Barrow, 1997; Ness et al., 2007; Schmidt, Sachse, & Walz, 2016; Singh et al., 2009, 2012; Yigitcanlar & Dizdaroglu, 2015). Stakeholders may include business owners, public garden directors, city planners and other city officials, state and national leaders and officials, and other entities which desire to minimize their impact on the environment and maximize their social impact on communities.

Yigitcanlar and Dizdaroglu (2015) list three main purposes of sustainability assessments: 1) Define targets for sustainable development and monitor the progress in achieving those targets; 2) Revise current policies as necessary to ensure effectiveness of sustainability efforts and to make the necessary adjustments when assessments reveal changes are needed; and 3) conduct performance evaluations over time to compare current progress with previous results in order to plan for future actions. This enables organizations to regularly monitor their past and present activities to connect to future sustainability measures.

## Valuation Methods

A range of methods are used to ascertain ecosystem services valuations. These methods can be classified according to biophysical methods and preference-based methods (Figure 1.1) (Christie et al., 2012; Pascual & Muradian, 2010). Biophysical valuation methods measure cost of production parameters such as labor costs or inputs of energy or materials (Pascual & Muradian, 2010). Preference-based methods, which are more dominant in ecosystem services valuations (Pascual & Muradian, 2010), are further divided into monetary valuation and non-monetary valuation (Figure 1.2) (Christie et al., 2012). Monetary valuation techniques, as the term implies, typically measure those attributes of ecosystem services that can be quantified with a dollar value. Whereas, non-monetary valuation techniques are useful for assessing the socio-cultural aspects of ecosystem services that are generally more difficult to quantify, but can be determined qualitatively (Christie et al., 2012; Daly & Farley, 2011; Kelemen et al., 2016; King, Mazotta, & Markowitz, 2000; Schmidt, Sachse, & Walz, 2016).

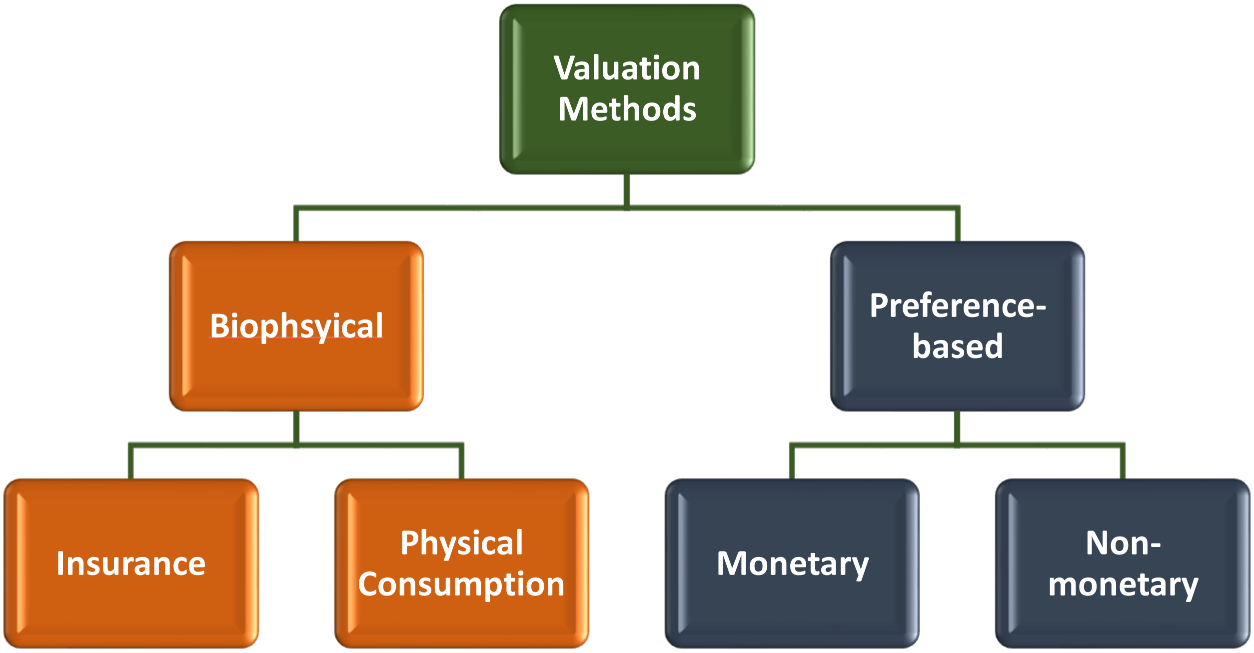

Figure 1.1. Categories of valuation methods used to assess ecosystem services values adapted from Christie et al. (2012) and Pascual & Muradian (2010).

Monetary valuation methods are further divided into six categories: market price; market cost; revealed preference; stated preference; participatory approaches; and value transfer (Christie et al., 2012; Daly & Farley, 2011; King, Mazotta, & Markowitz, 2000) (Figure 1.2).

The market price method, or revealed willingness-to-pay, simply provides an estimated value of goods or services of ecosystems that can be bought and sold in a market. Market cost methods include damage cost avoided, replacement cost, and substitute cost methods, which estimate the values to restore, replace, or substitute ecosystem services that have been lost, and production function methods that provide estimated values for products or services that contribute to the production of marketed goods (Christie et al., 2012; Daly & Farley, 2011; King, Mazotta, & Markowitz, 2000; Schmidt, Sachse, & Walz, 2016).

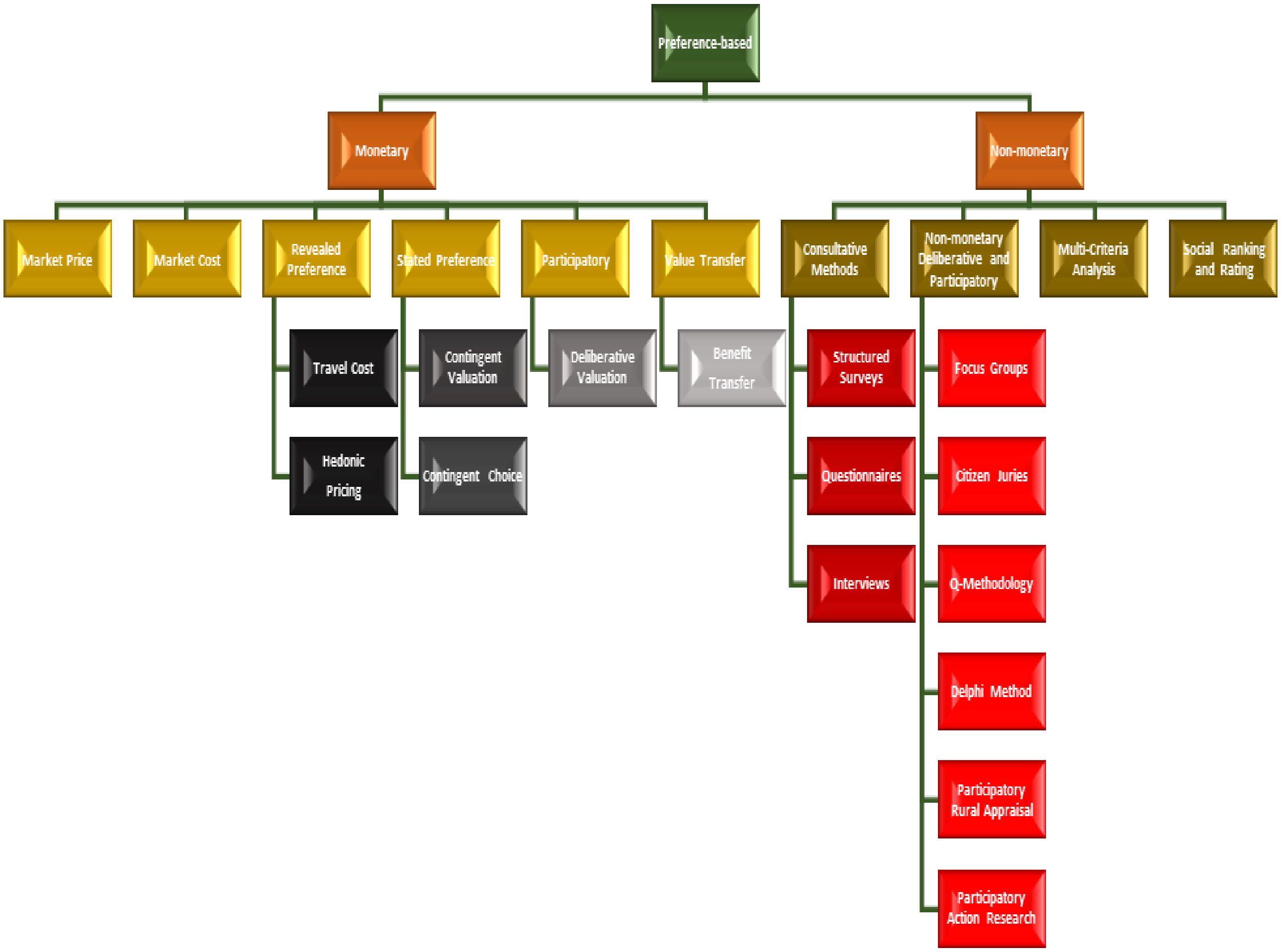

Figure 1.2. Categories of preference-based valuation methods used to assess ecosystem services values adapted from Christie et al. (2012), Daly and Farley (2011), Felipe-Lucia, Comin, and Escalara-Reyes (2015), King, Mazotta, and Markowitz (2000), and Schmidt, Sachse, and Walz (2016).

Revealed preference techniques, also known as circumstantial evidence (King, Mazotta, & Markowitz, 2000), include travel cost and hedonic pricing methods that determine only use values by valuing non-market goods and services based on market or economic transactions (Christie et al., 2012). Stated preference techniques, or expressed willingness-to-pay, include contingent valuation and discrete choice methods (Christie et al., 2012; Daly & Farley, 2011; King, Mazotta, & Markowitz, 2000). These methods usually survey participants by proposing hypothetical scenarios to determine the willingness-to-pay (what would be the maximum an individual would pay to obtain a good or service) and willingness-to-accept (what would be the minimum an individual would relinquish to give up a good or service or for what tradeoff would an individual be amenable for a good or service) certain values for particular ecosystem services (Christie et al., 2012; Daly & Farley, 2011; King, Mazotta, & Markowitz, 2000). All components of total economic value can be assessed by stated preference techniques (Christie et al., 2012).

Participatory approaches to ecosystem valuation involve deliberative valuation which typically allows participants time to reflect, gather information, and deliberate with a group of individuals before arriving at a value for a good or service (Christie et al., 2012). Lastly, value or benefit transfer methods generate economic values from one area or location and use that information to assess the economic value of goods or services at another area or location (Christie et al., 2012; Daly & Farley, 2011; King, Mazotta, & Markowitz, 2000).

As previously stated, non-monetary valuation techniques are useful for assessing the socio-cultural aspects of ecosystem services (Kelemen et al., 2016; Schmidt, Sachse, & Walz, 2016). These techniques can be integrated with monetary valuation techniques to gain a deeper understanding of the human-nature relationship (Kelemen et al., 2016; Schmidt, Sachse, & Walz, 2016). Valuing cultural ecosystem services is an important tool for entities, such as public gardens and public parks, to demonstrate their positive impact on issues such as cultural heritage, conservation, and ecotourism (Kelemen et al., 2016).

Non-monetary valuation techniques can be divided into four categories: consultative methods; non-monetary deliberative and participatory approaches; multi-criteria analysis; and social ranking and social rating (Christie et al., 2012; Schmidt, Sachse, & Walz, 2016) (Figure 1.2). Consultative methods usually involve individuals participating in structured surveys, questionnaires, or interviews. Non-monetary deliberative and participatory approaches employ group activities such as focus groups to attain more detailed information about the human-nature relationship. Other examples of these group activities include Q-methodology, the Delphi method, and citizen juries, all of which are used to ascertain the viewpoints of people toward the natural environment.

Two other examples of non-monetary deliberative and participatory approaches are participatory rural appraisal and participatory action research, both of which are used in developing countries to allow the local people to develop their own assessments and plan accordingly. A third type of non-monetary valuation technique is multi-criteria analysis. Multi-criteria analysis compares monetary and non-monetary results and is useful to circumvent shortcomings of divergence and discordance among the different tools (Christie et al., 2012; Schmidt, Sachse, & Walz, 2016).

When referring to total economic value, multi-criteria analysis improves the credibility and validity of the results from the valuation tools by incorporating facets of economic, environmental, and social aspects of ecosystem goods and services (Schmidt, Sachse, & Walz, 2016). Lastly, social ranking and social rating are methods used to identify the value of certain ecosystem services to individuals by allowing them to rank the importance of these services (Felipe-Lucia, Comin, & Escalara-Reyes, 2015; Schmidt, Sachse, & Walz, 2016). The participants can be grouped to achieve a better representation of actual values according to their use of ecosystem services (Felipe-Lucia, Comin, & Escalara-Reyes, 2015).

## Materials and Methods

Eighty-two valuation tools that assess environmental, social, and/or economic impacts were identified as being appropriate for public gardens and green spaces. An initial screening of tools was made using the United States Environmental Protection Agency (EPA) search tool GIWiz (United States Environmental Protection Agency, 2016), the Sustainability Toolkit of the American Society of Landscape Architects (American Society of Landscape Architects, 2016), and the Landscape Performance Series Benefits Toolkit (Landscape Architecture Foundation, 2016). The tools (Appendix A) were chosen according to their potential relevance for public gardens, but they are also relevant to municipalities, small businesses, nonprofit organizations, and other entities that may have limited resources for conducting such valuations more thoroughly.

Each of the selected tools was evaluated according to type of assessment and accessibility (Table B-1). The categories for the type of assessment were environmental, social, and economic. Each valuation tool was studied to determine which of the three aspects were being measured. Accessibility of the valuation tool was determined by free open source or purchase requirement.

Finally, the valuation tools were evaluated based on the proportion of the thirty-three variables they measured. The thirty-three variables were defined based on all variables that each tool measured and combining similar variables (e.g., walkability was included under the pedestrian friendliness variable and habitat assessment was included under the biodiversity variable). The thirty-three variables were then grouped into environmental, social, and economic variables based upon criteria established by the European Commission (2009) and the

Organisation for Economic Co-operation and Development (2010). Variables that had any effect on renewable and non-renewable resources, climate, quality of air, water, and soil, treatment of waste, and animals were classified as environmental variables. Social variables were determined by impact upon education, health and well-being, and other activities that affected cultural aspects of society. Variables that demonstrated an impact on sectors of the economy, effect on property rights, or influence on pricing and consumer behavior were considered in the economic category (European Commission, 2009; Organisation for Economic Co-operation and Development, 2010).

Twenty variables describe environmental characteristics (Table B-2). Tools that measured air cleanliness and air pollution, including pollutant removal through elements such as the quantity of trees and shrubs or the use of energy efficient appliances and equipment, were considered in the air quality category. Those that measured noise levels from traffic, industry, and other entities were included in noise assessment. Carbon, including carbon sequestration, measured net carbon discharge or capture by a homeowner or business and/or the net carbon sequestered and stored by the environment. Greenhouse gas emissions included the contributions of entities to emissions of carbon dioxide, nitrous oxide, and methane.

Biodiversity, ecosystem impact, pollination, and tree benefits were four more categories included in environmental variables. The biodiversity category, including habitat risk assessment, evaluated the species richness of different plants, wildlife, and other organisms, and it determined the level of habitat endangerment due to anthropogenic activities. Choice of paper usage, cleaning solutions, and other lifestyle and business choices were classified under ecosystem impact. Pollination was measured by potential abundance of pollinators and floral resources that enhance crop yields. Tree benefits were based upon the size and quantity of trees.

Land management and future development impacts projects were considered under the land use assessment. Different scenarios could be simulated to determine the level of impact and tradeoffs that would result from specific land use decisions. Risk and forecasting were variables that determined the effect of certain actions on the environment as well as enabled users to plan strategically for future actions and their impact on the economy and environment if those actions were taken. Coastal assessment evaluated vulnerability to erosion and flooding, carbon sequestration and storage, and coastal habitat diversity. Estimated value and weights of fish in fisheries and other aquaculture industries as well as anthropogenic impacts upon marine life could be evaluated by marine and aquatic assessment tools.

Tools that assessed energy usage, wave energy, or wind energy were included in the energy use category. Benefits from recycling material generated from construction sites and landscape maintenance projects were measured by tools included in the recycling and waste reduction category. This category also included solid waste assessments. Green infrastructure included the use of vegetative swales, green roofs, and rain gardens to improve the environment by mitigating stormwater runoff, improving health conditions, reducing urban heat islands, and improving air quality. Sediment retention capabilities were determined by vegetative coverage, management practices, and climate information. Some tools assessed stormwater management capacity by determining the contribution of a building or site to runoff. Similarly, water assessment evaluated how buildings, other structures, and site conditions affected the quality of water and the hydrologic cycle. The last environmental category, water harvesting, is the amount of water that could potentially be harvested from a building structure based upon the catchment system was included in the twentieth environmental category, water harvesting.

Ten variables describe social characteristics (Table B-2). Tools included in the activity level category considered the availability of parks, community green spaces, and other recreational amenities that enable physical activity by the residents. The cultural and social activities and impacts category examined volunteerism, community impact from social activities, cultural heritage, cultural events, and other activities that benefit the population. The health benefits category incorporated health and well-being benefits derived from existing or planned green spaces. For food production and security, some tools measured the ability of individuals to access food and how much food could be produced based upon agricultural practices. Other tools assessed availability of recreational opportunities, scenic quality in neighborhoods and communities, and availability of public transportation in urban areas. Litter assessment was determined by the amount of refuse on streets and in neighborhoods. Bicycle friendliness assessed infrastructure for safe use of non-motorized bicycles throughout communities and cities. Similarly, pedestrian friendliness was based upon infrastructure such as walking trails, sidewalks, parks, and other pedestrian-friendly amenities.

Economic characteristics were described using three variables (Table B-2). The economic activity variable was determined by business retention, workforce readiness, job availability, employment mix, cost of living information (e.g., housing and transportation costs), annual income, and strength of the local economy. Maintenance measured life cycle analyses for buildings and other structures and use of materials for economic and environmental sustainability. Property value measured the impact of plants and certain amenities on the monetary value of real estate.

## Statistical Analysis

Principal component analysis (PCA) was performed utilizing STATA statistical software on the thirty-three environmental, social, and economic variables using principal component extraction and exploratory factor analysis (EFA) with orthogonal varimax and oblique promax rotation (statistical results can be found in Appendix C). The extraction method was utilized for exploring factors to reduce the number of variables by grouping those with similar characteristics and potentially explaining the observed variance of the larger dataset. The extraction method can potentially involve several iterations to arrive at adequate and appropriate samples for factor analysis, especially if the correlation matrix is singular (meaning there are linear relationships between columns and rows of the matrix resulting in a determinant of zero). To resolve singular matrices, additional iterations are conducted by removing certain variables with high percentages of unexplained variances until an acceptable level of adequacy is achieved.

According to Osborne and Costello (2004), criteria to determine appropriate sample size when using PCA varies depending upon the research being conducted. No single subject-to-variable ratio will work in all cases. Osborne and Costello (2004), however, concluded that a larger sample size will always provide better results when conducting PCA. The ratio range for this study was 2.5:1-82:1 (most tools measured only one variable, whereas, others measured up to eighteen variables). Components were retained if the unrotated iteration exceeded an eigenvalue of 1.0 and met Horn’s parallel analysis and scree requirement. The Kaiser-Meyer-Olkin Measure (KMO) was used to indicate the adequacy of the valuation tool sample size for PCA and EFA, and Bartlett’s Test of Sphericity was calculated to indicate if the variables were appropriate for factor analysis. Finally, the reliability of the factor groupings was determined by Cronbach's alpha.

The first iteration (Iteration A) of PCA resulted in weak correlations (Table C-1) among the assessed variables (Figure C-1, Figure C-2, Table C-2, Table C-3), and the KMO measure of adequacy indicated the correlation matrix was singular. The variable, "maintenance," with the highest percentage of unexplained variability (89.55%) in the unrotated eigenvector loadings was removed for the next iteration (Iteration B) which also yielded a singular correlation matrix. Other variables were removed in various combinations based upon the loadings of the eigenvectors (if loadings were <0.3) and percentage of unexplained variability in several other iterations, but the correlation matrices continued to be singular. Eventually, after removing the variables "maintenance" and "pollination" (Iteration C), the KMO measure of adequacy returned 0.449. Other iterations with various combinations of variables removed yielded KMO values of 0.440 and 0.441, so Iteration C was chosen for EFA since it had the highest KMO of the three iterations that returned a value. Kaiser (1974) suggested that KMO adequacy values less than 0.5 are generally unacceptable and not useful for EFA, but this chiefly depends upon the objectives of the research and dataset. Bartlett's Test of Sphericity for Iteration C ($\chi^2$ = 1345.525, df = 465) was significant at 5% (p-value = 0.000) indicating that EFA was appropriate and that patterned relationships between the items existed.

For Iteration C, nine components were retained where eigenvalues exceeded 1.0 in the initial PCA and confirmed by the scree plot (Figure C-3), explaining a cumulative variance of 70.59% (Table C-4). The data were then subjected to Horn's parallel analysis (PA) (Figure C-4), and seven components with eigenvalues that exceeded PA (Table C-5) were retained (Dinno, 2009; Horn, 1965) explaining a cumulative variance of 63.54% (Table C-4). Orthogonal varimax and oblique promax rotations were conducted using a significant component loading of 0.3 (Table C-6, Table C-7). Variables “greenhouse gas emissions” and “recycling/waste reduction” have a negative influence on Component 1; whereas, variables “biodiversity,” “scenic quality,” and “green infrastructure” positively influence Component 1. Variables “active living,” “bicycle friendliness,” “pedestrian friendliness,” and “recreation” have a negative influence on Component 2, whereas, variables “carbon,” “risk,” “stormwater management,” “tree benefits,” and “property value” have a positive influence on Component 2 (Figure C-5). The score plot demonstrated three clusters that have correlated variables (Figure C-6). After confirming KMO adequacy value and Bartlett’s Test of Sphericity, the data were subjected to EFA resulting in seven factors with an eigenvalue exceeding 1.0 (Figure C-7) being retained that explained a cumulative variance of 82.97% (Table C-8). After conducting PA (Figure C-8), eight factors with eigenvalues that exceeded PA were retained (Table C-9) which explained a cumulative variance of 98.88%.

Orthogonal varimax and oblique promax rotations were conducted using a significant factor loading of 0.3 (Table C-10, Table C-11). Similar to the PCA component loadings, the factor loadings graph validates that variables “greenhouse gas emissions” and “recycling/waste reduction” have a negative influence on Component 1; whereas, variables “biodiversity,” “scenic quality,” and “green infrastructure” positively influence Component 1. Variables “active living,” “bicycle friendliness,” “pedestrian friendliness,” and “recreation” have a negative influence on Component 2, whereas, variables “carbon,” “risk,” “stormwater management,” “tree benefits,” and “property value” have a positive influence on Component 2 (Figure C-9). The score plot demonstrated three clusters that have correlated variables (Figure C-10).

Both rotation methods yielded similar factor loadings and scale reliability coefficients (Cronbach's alpha). Oblique promax rotation was chosen for interpretation since this method resulted in three factors with significant coefficients and three factors with marginally significant coefficients (Table C-12) compared to two and three, respectively, for the orthogonal varimax rotation. Using the oblique promax rotation factor loadings, the factors may be interpreted as follows:

- Activity level (0.5675), bicycle friendliness (0.3177), health benefits (0.6083), litter (0.5699), pedestrian friendliness (0.3667), recreation (0.8822), and scenic quality (0.8116) have strong positive loadings on factor 1, so this factor describes active lifestyle and aesthetics of communities.
- Forecasting (0.4065), green infrastructure (0.7971), stormwater management (0.7722), tree benefits (0.3273), water (0.4044), and economic activity (0.3523) have strong positive loadings on factor 2, so this factor describes economic impact of green infrastructure on ecosystem services.
- Risk (0.9331), tree benefits (0.6437), and property value (0.7980) have strong positive loadings on factor 3, so this factor describes impact trees and potential pest risks have on property value.
- Biodiversity (0.3978), coastal aspects (0.7795), marine/aquatic (0.7474), and sediment retention (0.9122) have strong positive loadings on factor 4, so this factor describes habitat and erosion issues for aquatic areas.
- Biodiversity (0.6426), ecosystem impact (0.5770), water (0.3273), active living (0.6393), cultural/social activities/impact (0.5138), health benefits (0.4460), and economic activity

(0.3527) have strong positive loadings on factor 5, so this factor describes economic impact of cultural activities on the ecosystem, habitat, and health-related aspects.

- Air quality (0.5485), carbon (0.5618), energy use (0.7222), greenhouse gas emissions (0.7337), and recycling/waste reduction (0.4963) have strong positive loadings on factor 6, so this factor describes energy and recycling impacts on the environment.

Together, these six factors explain 78.73% of the variation in the data.

**Results**

An overview of the eighty-two valuation tools chosen is included in Appendix A. Sixty-seven valuation tools (81.7%) (Figure 1.3) assessed one or more environmental variables (Figure 1.4). Of those sixty-seven tools, thirty-three (49.3%) had some form of energy assessment, twenty-six (38.8%) contained a water assessment, twenty-one (31.3%) contained a forecasting component, twenty (29.9%) measured greenhouse gas emissions, and eighteen (26.9%) included some form of carbon or carbon sequestration assessment. (Figure 1.4, Table B-3).

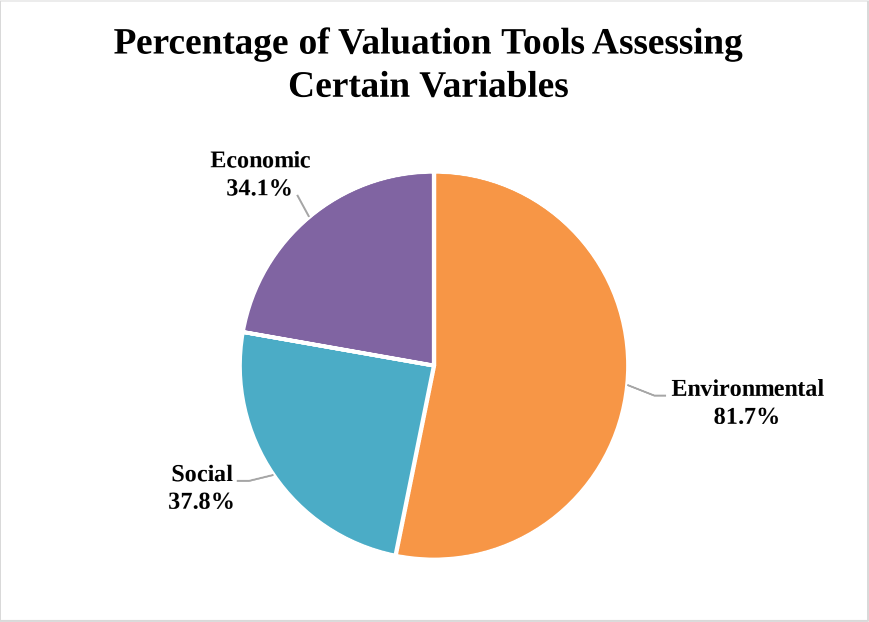

Figure 1.3. Comparison of percentages of the eighty-two valuation tools analyzed in the study that assessed one or more environmental, social, and/or economic variables (total may exceed 100% due to tools assessing more than one variable).

For social variable assessment, thirty-one valuation tools (37.8%) (Figure 1.3) measured one or more variables in this category (Figure 1.5). Fourteen of those tools (45.2%) measured health and well-being benefits, thirteen (41.9%) cultural/social activities/impact, ten (32.3%) pedestrian friendliness and scenic quality, and eight (14.8%) recreational activities (Figure 1.5, Table B-4).

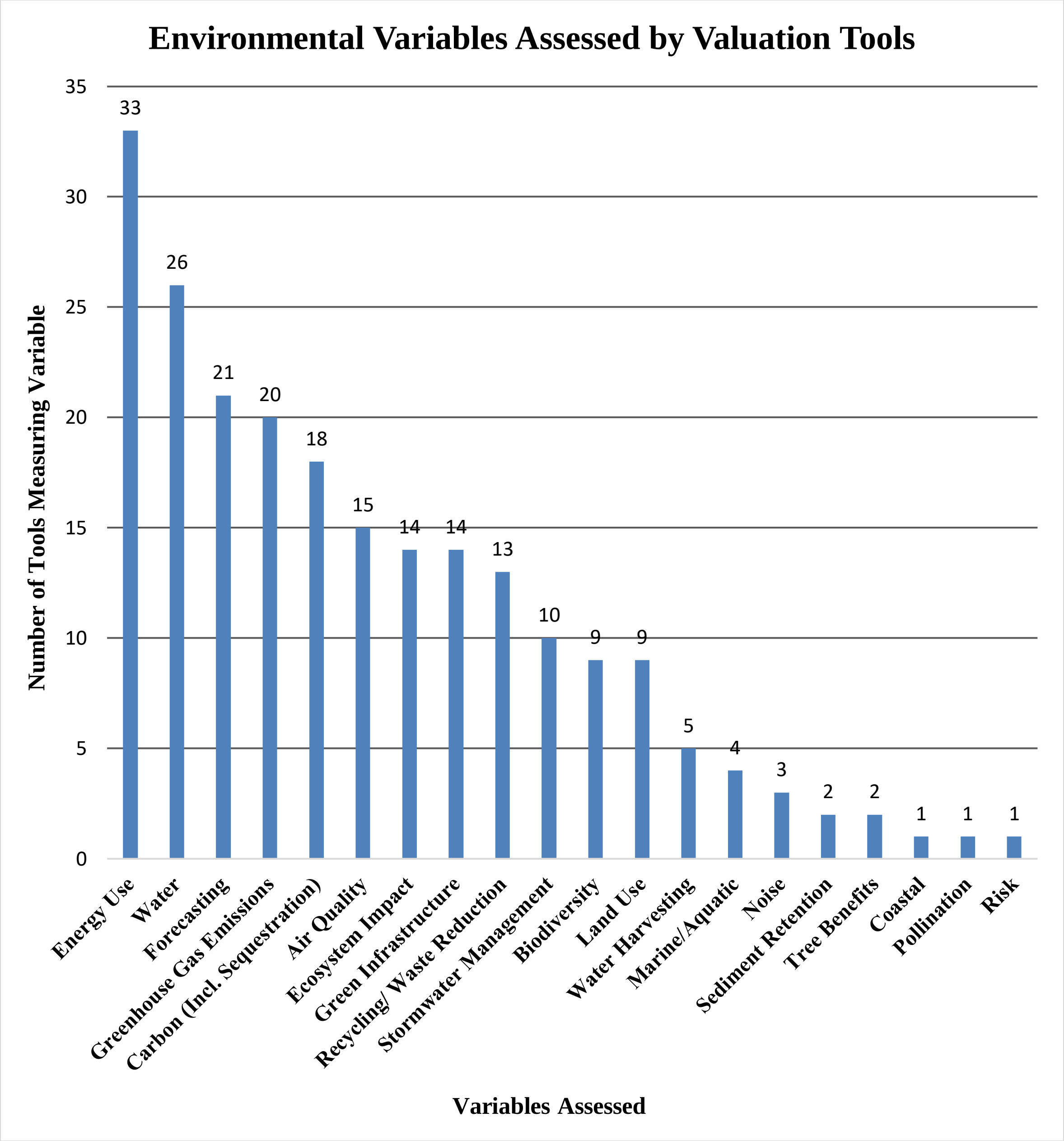

Figure 1.4. Comparison of the frequency of environmental variables that are assessed by sixty-seven valuation tools used to measure environmental impact.

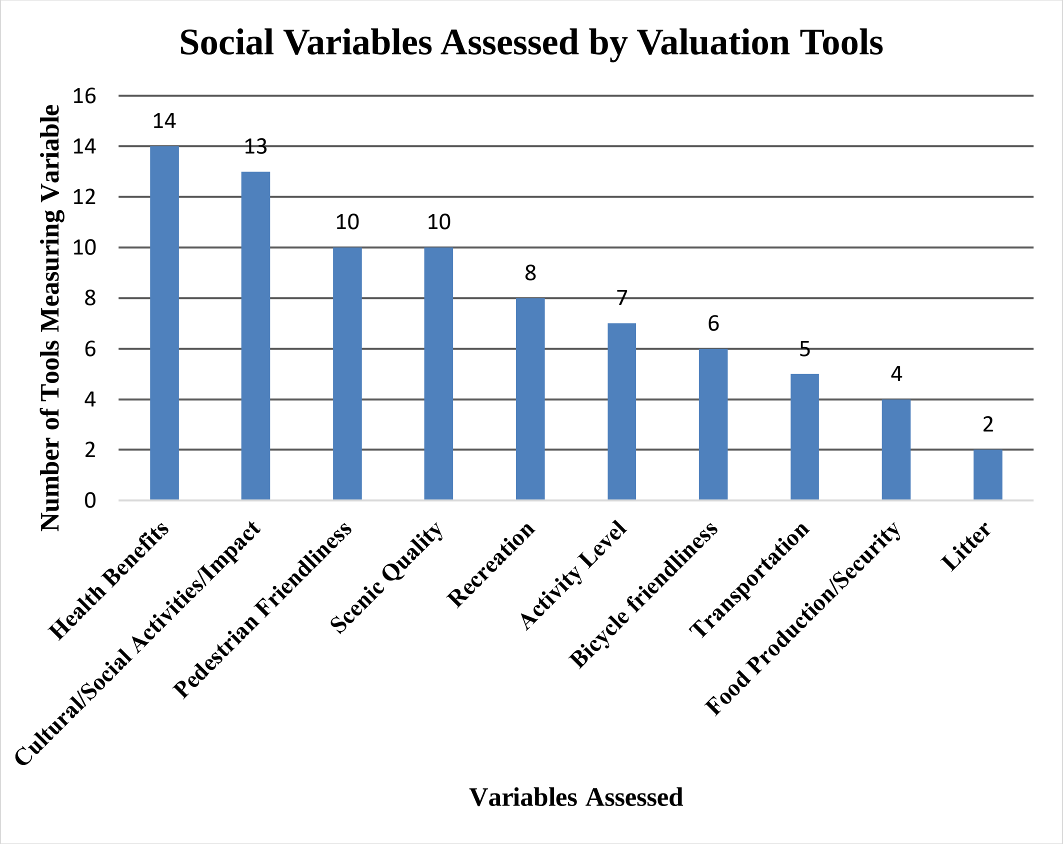

Figure 1.5. Comparison of the frequency of social variables that are assessed by thirty-one valuation tools used to measure social impact.

With respect to economic type of assessments, twenty-eight valuation tools (34.1%) (Figure 1.3) measured economic variables (Figure 1.6) with twenty-seven of those tools (96.4%) including some form of economic assessment component, and only two tools (7.1%) assessed maintenance levels and property value (Figure 1.6, Table B-5).

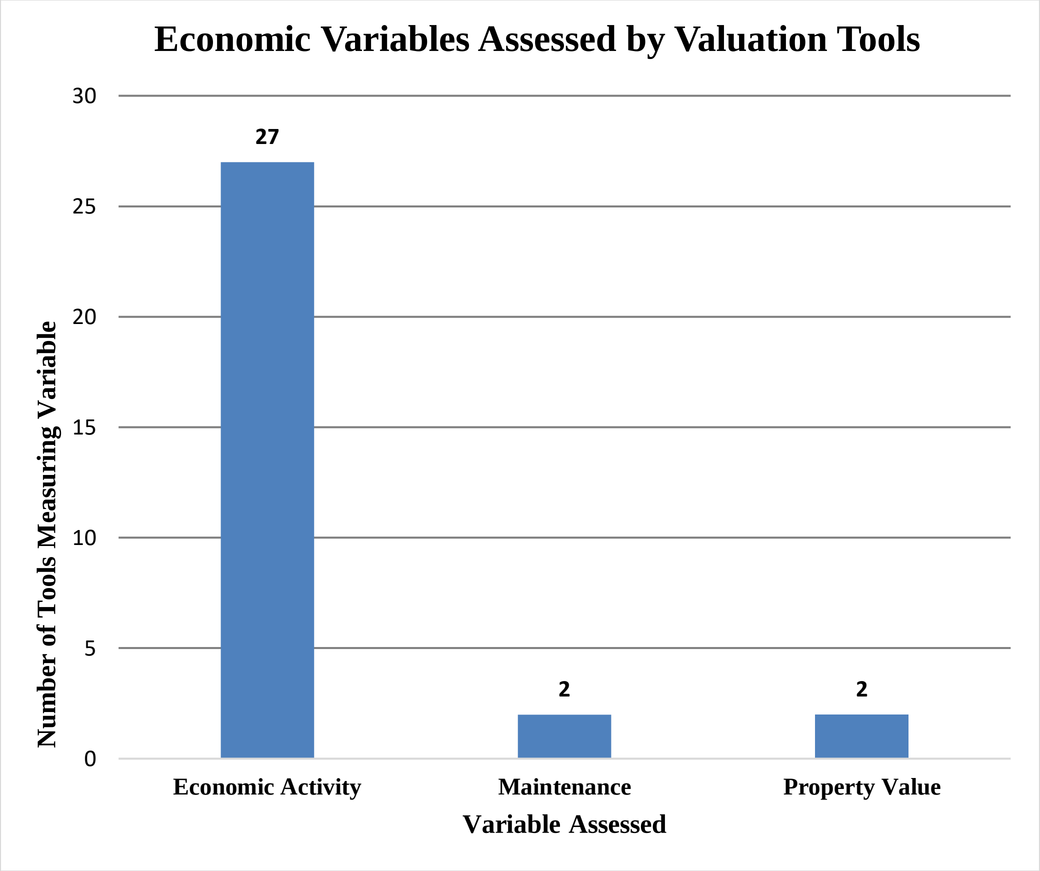

Figure 1.6. Comparison of the frequency of economic variables that are assessed by twenty-eight valuation tools used to measure economic impact.

Fifteen (18.3%) tools assessed only one factor, while the remaining sixty-seven tools (81.7%) assessed two or more variables. Those that measured the most variables overall as well as the greatest promotion of environmental variables included (overall variables measured, environmental variables by each tool measured are included in parentheses): STAR (18, 10); i-Tree (14, 11); Ecological Footprint Calculator (13, 9); Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) (13, 9); and The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits (VGI) (12, 9). Another tool worth noting was the Green Values Stormwater Management Calculator that measured seven environmental variables.

Valuation tools that assessed the greatest proportion of social variables were (number of variables are included in parentheses): Park and Recreation Areas Self-Report Survey (8); Neighborhood Quality of Life Survey (7); STAR (7); Environmental Assessment of Public Recreation Spaces (EAPRS) Tool (6); and Walk Score Professional (5).

Concerning access to the valuation tools, seventy-six (92.7%) were free open source and only six (7.3%) required a purchase to access the tool, three (50.0%) of which were strictly social tools – Social Impact Measurement Toolkit, Volunteering Impact Assessment Toolkit, and Walk Score Professional. Additionally, one open access environmental valuation tool (Automated Geospatial Watershed Assessment - AGWA), requires ArcGIS to run the simulations, which is why it was included in the purchase required category. The other two tools requiring a purchase were Accelerator Pro (a combination tool of the three types of assessment) and ClearPath (an environmental tool).

Based upon the factor analysis, six groupings of tools were revealed: 1.) lifestyle and community aesthetics; 2.) economic impact of green infrastructure on ecosystem services; 3.) impact of trees and pest issues on property values; 4.) habitat and erosion issues for aquatic areas; 5.) economic impact of cultural activities on the ecosystem, habitat, and lifestyles; and 6.) energy and recycling impacts on the environment. Tools that would evaluate lifestyle and community aesthetics include: Accelerator Lite; Accelerator Pro; Environmental Assessment of Public Recreation Spaces (EAPRS) Tool; InVEST; Neighborhood Quality of Life Survey (NQLS); Parks and Recreation Areas Self-Report Survey; STAR; System for Observing Physical Activity and Recreation in Natural Areas (SOPARNA); and Walk Score Professional. Economic impact of ecosystem services is measured by the following valuation tools: Ecological Footprint Calculator; Green Infrastructure Flexible Model (GIFMod); Green Roof Energy Calculator (v. 2.0); Green Values Stormwater Management Calculator; InVEST; i-Tree; Landuse Evolution and Impact Assessment Model (LEAM); Lifecycle Cost Analysis (LCCA); Long-term Hydrologic Impact Analysis Tool (L-THIA); Low Impact Development Rapid Assessment (LIDRA) Model v2; National Stormwater Calculator; STAR; VGI; and Watershed Management Optimization Support Tool (WMOST) v3.0.

Only one tool measures the impact of trees and pest issues on property values – i-Tree – although, the Green Values Stormwater Management Calculator and the National Tree Benefit Calculator also provide estimates for the impact of trees. For habitat and erosion issues in aquatic areas, tools that evaluate these aspects include: Aquatox v3.1; InVEST; i-Tree; and VGI. Tools that measure the economic impact of cultural activities on the ecosystem, habitat, and lifestyles are: Accelerator Lite; Accelerator Pro; Building for Environmental and Economic Sustainability (BEES); Ecological Footprint Calculator; Forest Vegetation Simulator; InVEST; i-Tree; LEAM; STAR; VGI; and WMOST. Finally, energy and recycling impacts on the environment are measured by: AVoided Emissions and GeneRation Tool (AVERT); BEES; Carbon Footprint Calculator; CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool; COMET-Farm; COMET-Energy Tool; COMET-Planner Tool; Ecological Footprint Calculator; Electronics Environmental Benefits Calculator (EEBC) v4; EnviroCalculator; Forest Vegetation Simulator; Green Values Stormwater Management Calculator; Greenhouse Gas Equivalencies Calculator; InVEST; i-Tree; Managing and Transforming Waste Streams Tool; My Environment; National Tree Benefit Calculator; Paper Calculator; PV Watts Calculator; Recycled Content (ReCon) Tool; Recycling and Reusing Landscape Waste Cost Calculator;

Regency Lighting Energy Savings Calculator; STAR; Sustainable Facilities Tool Cost-Effective Upgrades Tool; VGI; and WARM.

## Discussion and Conclusion

The valuation tools in this review provide a broad range of different options for assessing environmental, social, and economic benefits and impacts for public gardens, municipalities, nonprofit organizations, small businesses, and other entities interested in “triple bottom line” or sustainability self-assessments of their organizations. None of the eighty-two valuation tools reviewed in this manuscript assessed all thirty-three variables; however, by matching the choice of tools with desired outcomes (Appendix A), organizations can estimate their environmental, social, and economic impacts upon their communities. For assessments of specific variables, valuation tools that measure one to three variables will most likely be suitable to obtain the appropriate data for informed decisions. For example, to measure pedestrian friendliness, the Pedestrian Environmental Quality Index Tool (PEQI) and/or Walk Score would be good options, while the Rainwater Harvesting Supply Calculator and/or the Water Harvesting Calculator would provide appropriate information for rainwater harvesting assessments.

Valuation tools that measure several variables may be preferable for more comprehensive assessments and longer-range planning, although more research needs to be conducted to make this assessment. STAR, i-Tree, Ecological Footprint Calculator, InVEST, and VGI provide the broadest range of assessment. STAR would likely be optimal for communities that are interested in assessing themselves as diverse and sustainable communities. STAR sets the path toward certification with respect to best management and sustainability practices. InVest utilizes eighteen models that provide a relatively comprehensive and integrated assessment of ecosystem services and urban development. For individuals who desire to learn about their environmental impact, the Ecological Footprint Calculator would provide an estimate based on daily living habits, water and energy usage, and other consumer habit aspects.

Appendix A contains website, developer, and descriptive information about the eighty-two valuation tools that were reviewed. Tables 1.3-1.5 provide a visual overview of the valuation tools and the variables each tool assesses. The following steps are recommended as a guideline for selecting one or more tools that are best suited for the intended assessment purpose:

1) Evaluate the needs and goals of the organization.
2) Determine whether funds are available to purchase one or more assessment tools.
3) Using Tables 1.3-1.5, choose the type of tool (environmental, social, and economic) that best matches the needs and goals of the organization.
4) Choose the tool in Tables 1.3-1.5 that fits the variables of interest for your specific needs and goals.
5) Once a tool has been selected, refer to Appendix A for website and descriptive information.

The tables should provide decision-makers the ability to determine what variables to assess and which valuation tools might be appropriate for the assessments. As stated earlier, the tools were chosen according to their potential relevance to public gardens with limited resources for conducting environmental, social, and economic assessments. It is important to understand that some tools provide only estimates of benefits and value; whereas, others provide reliable and accurate information. Further research needs to be conducted, such as implementing case studies, to determine the scalability, generalizability, time requirements for completing the assessments, training required, level of knowledge required, intended audience, reliability, credibility, accuracy, and validity of each tool.

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# STATE OF THE INDUSTRY SURVEY ON ENVIRONMENTAL, SOCIAL, AND ECONOMIC IMPACT ASSESSMENTS OF PUBLIC GARDENS

In recent years, impact assessment has become increasingly less expensive to conduct making it easier to collect, store, and analyze data (Gugerty & Karlan, 2018). Nonprofit organizations are expected to be more accountable and transparent (Tschirhart & Bielefeld, 2012). Demonstrating effectiveness through impact assessment enhances accountability and transparency efforts, especially given the perception that nonprofit organizations are often seen as ineffective and inefficient (Liket & Maas, 2015). Despite this, nonprofit organizations tend to trivialize the importance of performance and impact assessments because they can be difficult to measure and control (Drucker, 1990), and they do not see the need to quantify and measure their impact (Wood & Leighton, 2010). Sawhill and Williamson (2001) reported that most nonprofit organizations are tracking their performance through activity metrics (outputs), such as number of visitors, membership growth, and funds raised, but are not measuring the real success in achieving the mission of the organization (outcomes). The issue has transcended into the realm of public gardens as well. According to a recent report by Smith and Harvey-Brown (2018), not very many public gardens are measuring the impacts of their programs and services to their community and region.

Resulting from an interest in whether or not public gardens conduct impact assessments, a state of the industry survey of public gardens was conducted in partnership with the American Public Gardens Association (APGA) to determine the occurrences of environmental, social, and economic impact assessments. The primary objective of the survey was to ascertain the number of public gardens that had conducted environmental, social, and economic impact assessments.

Based upon the literature review, it is expected that not many gardens have conducted any impact assessments, and, if they have conducted any, most likely it will have been an economic impact assessment. The second objective was to verify that public gardens collect mostly activity metrics (outputs such as number of visitors, number of students contacted during educational programming, or number of plant collected/maintained) instead of impact metrics (outcomes such as behavioral changes or level of satisfaction). It is hoped that public gardens will reconsider the kinds of data collected and the value of conducting impact assessments.

## Background

What is an impact assessment? From an educational perspective, Fitz-Gibbon (1996) defined impact assessment as any effect of a program or service on individuals. It seeks to provide evidence using qualitative and quantitative research and performance measurement that an intervention was responsible for a change or benefit, the effect on different groups resulted from the intervention, and the impact that would have occurred had the intervention not taken place (Streatfield & Markless, 2009). Impact assessment identifies and evaluates positive and negative changes that are intended or accidental (Streatfield & Markless, 2009; Vanclay, 2003). The essential element is that change is evaluated.

As previously stated, most public gardens measure activity metrics (outputs) such as the number of visitors, but only half measure visitor attitudes (visitor satisfaction) or changes in visitor behavior following a visit (outcomes) (Smith & Harvey-Brown, 2018). Measuring changes in behavior indicates the effectiveness of a program, project, or the organizational mission (Stern, 2010). Dodd and Jones (2010) identified several forces that cause change related to public gardens: The public's increasing detachment from plants (plant blindness); public funding and accountability; policies of social inclusion, well-being, and community cohesion; involvement in wider networks; climate change as a global concern; social justice, equality, and human rights as a global concern; and passion of the professional with increasing accessibility and relevance. Streatfield and Markless (2009) described the behavioral change process as a pyramid road map. The foundation of the pyramid, or the base level where change begins, is the change in knowledge and skills. This leads to the second level of changes in perceptions and confidence, changes in specific behavior at the third level, changes in quality of life at the fourth level, and, ultimately, changes in society and economy (Streatfield & Markless, 2009). Public gardens target all levels of this pyramid, but, ideally, want to affect specific behaviors, such as being more environmentally conscious, that will bring about changes in quality of life, such as a greater appreciation of the benefits of plants and the health and well-being benefits of reconnecting with nature (American Public Gardens Association, 2019; Hamilton & DeMarrais, 2001). It is these and many other environmental, social, and economic values that need to be evaluated by impact assessments.

Impact assessments should be designed to allow modifications to programs based upon the knowledge gained from the assessments (Tschirhart and Bielefeld, 2012). Tschirhart and Bielefeld (2012) continue that outcome and impact goals should be identified when determining how to conduct the impact assessment since these will be used for the outcome evaluation, and activity goals need to be established to monitor internal program activities and process evaluation. The American Alliance of Museums (AAM) (2017) identified three types of impact effects that need to be considered for impact assessments: 1) Direct effect, e.g., economic benefit and activities; 2) indirect effect, e.g., activities that result from other entities; and 3) induced effect, e.g., the impact of employees spending wages on local goods and services. Concerning designing the evaluation, Barrow (1997) stated that all impact assessments share three characteristics: 1) The assessment focuses on effects of a program or project rather than on outputs; 2) it should adopt a proactive direction by engaging stakeholders in the planning process to account for unanticipated effects (positive and negative); and 3) the approach should be methodical, focused, thorough, and interdisciplinary, especially for implementation of policies and projects that may have potentially sensitive implications.

Despite the fact that most public gardens do not conduct impact assessments, there are several reasons why they should. Public gardens structured as nonprofit organizations are often supported by public and private funds. Therefore, they need to prove their merit, and impact assessments are instrumental in such cases as public evaluation (Andreasen & Kotler, 2008). Stakeholders, members of their boards of directors, and funders may require evidence that the gardens are producing an impact, and performing them could generate more support from these groups of people (Smith & Harvey-Brown, 2018; Tschirhart and Bielefeld, 2012). Impact assessments develop stronger evidence-based data and information so that administrators can make better informed decisions (Donovan, 2013) and to advocate for continued support and funding (Smith & Harvey-Brown, 2018; Streatfield & Markless, 2009). Donors want to fund initiatives and programs that demonstrate strong effectiveness (Gugerty & Karlan, 2018). Lastly, public gardens need to be aware of other programs and innovative approaches of institutions that compete for similar funding resources (Andreasen & Kotler, 2008). Impact assessments would reveal some of those innovations that could be utilized in their own institutions.

Public gardens can share best practice approaches for environmental education program effectiveness and document their programs and processes. Greater success would be ensured to positively influence visitors, especially concerning environmental attitudes, conservation, and stewardship (Williams et al., 2015). Dodd and Jones (2010) reported that public gardens are working to broaden their audiences by enhancing their relevance to surrounding communities, by being role models for sustainable behavior, conducting research that has local and global impact, and providing educational programs to provide multi-sensory, high impact learning with plants and landscapes for the public. It continued that the social roles of public gardens would change more quickly if the organizations had evidence of their impact on those visiting the gardens, were more outwardly focused on the community, increased their capacity and skillset among staff, increased their funding, had upper management support, and actively changed attitudes and behavior (Dodd & Jones, 2010).

The Association of Zoos and Aquariums conducted an impact study (Falk et al., 2007) on their member organizations and discovered some interesting facts as a result. Visitors to zoos and aquariums already have an existing knowledge base about ecology and conservation issues. This prompted zoos and aquariums to capitalize on that knowledge base to support and reinforce those values in visitor attitudes. This prior visitor knowledge base also affected how visitors were motivated and impacted how they conveyed themselves so that they would have more meaningful visits to these organizations. Finally, the study revealed that visitors reconsider their roles in environmental issues and conservation efforts after attending zoos and aquariums, gain a stronger connection to nature, and see themselves as part of the solution as a result (Falk et al., 2007). The visitor experience to zoos and aquariums was greatly enhanced due to the discoveries from the impact study.

The American Community Garden Association reported from their impact assessment that areas surrounding community gardens had stabilized neighborhoods with increases in owner-occupied buildings, increase in rent prices, and an attraction of higher income individuals. Social, self-esteem, and safe environment needs were being met and the quality of life benefits increased (Gorham et al., 2009).

The most critical question that needs to be asked is why are public gardens not conducting impact assessments? One reason is that changes in visitor behavior are difficult to attribute to specific programs, even when changes are observed (Andreasen & Kotler, 2008). Cultural ecosystem services are characteristically intangible explaining the difficulty in appraising them (Milcu et al., 2013). Emotional and physical health and well-being benefits are manifested indirectly and subtly making those impacts even more difficult to measure (Anthony et al., 2009; Kenter et al., 2011). Although stated in the context of change inhibitors that prevent botanic gardens from taking a greater social role, Dodd and Jones (2010) listed several valid reasons why public gardens do not conduct impact assessments:

- Historical context: Public gardens never seriously had to consider their public role;
- Lack of capacity and skills: Small number of employees; no employees with appropriate set of skills; community service often given low priority;
- Workforce with limited diversity: Education programs are focused on traditional horticultural topics; do not incorporate educational components that would increase audience diversity because programming only attracts like-minded individuals instead of diversifying the audience; volunteers often represent the same demographics of traditional garden visitors so there is a need to diversify;
- Focus on collections and inwardly-focused: Management may feel that they do not have to justify the importance of the garden; it should be intrinsically understood that plant collections are important; as a result, the garden may appear elitist and inaccessible;

- Hierarchy of management: Garden management tends to be heavily science- and horticulturally-dominated preventing other intellectuals from advancing in the organization; resistance to new ideas because of entrenchment;
- Not aligned with priorities of the board of directors or other governing bodies: Governing bodies may avoid social responsibility or reject that they should have a social responsibility;
- Limited motivation: Do not want to get involved with potentially divisive issues citing scientific objectivity; reluctance to become leaders in issues of environmental stewardship and conservation;
- Limited funding;
- Lack of evidence of impact on users: Lacking profiles of visitors; difficult to pinpoint actual impact of programs; no systematic data collection and analyzation process;
- Distant from wider policy context: Public gardens are not obligated like other public institutions to implement social policies such as community cohesion, active citizenship, social inclusion, and well-being; and
- Politics of climate change: Reluctance to take up controversial issues; risk of losing audience

Dodd and Jones (2010) explained that public gardens have improved historical perceptions by embracing their ever-growing social roles, collaborating with wider networks to reach broader audiences, and advocating for environmental issues. Areas creating the most difficult hurdles to surpass are small workforces and limited funding and workforce diversity resulting in limited skills and capacity to drive greater social roles (Dodd & Jones, 2010).

## Environmental Impact Assessment

Environmental impact assessment (EIA) can be defined as the systematic process that analyzes the consequences of development actions on the environment, preferably before development takes place (Glasson et al., 2012). Munn (1979) defined EIA more broadly as “the need to identify and predict the impact on the environment and on man’s health and well-being of legislative proposals, policies, programs, projects and operational procedures, and to interpret and communicate information about the impacts.” Impact assessments provide quantitative evidence that gardens positively influence environmental attitudes through environmental education (Williams et al, 2015).

This type of assessment deals with ecological restoration, conservation, visitor interactions with nature, urban greening, biotechnology, forestry, pioneering innovative technology, agriculture and horticulture (Smith & Harvey-Brown, 2018). The Public Gardens Sustainability Index (American Public Gardens Association, 2019) includes plant conservation, biodiversity and habitat conservation, sustainable gardening, and landscape methods. These can be measured through plants conserved, scientific and horticultural research, and other direct environmental impacts (Smith & Harvey-Brown, 2018). Unfortunately, EIAs are typically conducted only once and usually late in the planning process; sometimes even after a project has been implemented (Vanclay & Bronstein, 1995). EIAs should be conducted frequently before, during, and after the planning and implementation processes that include strategic EIAs, cumulative impact analyses, risk assessments, social impact studies, public involvement at appropriate and meaningful times, post-project monitoring, and follow-ups to ensure proposed mitigations are being implemented (Vanclay & Bronstein, 1995).

EIAs establish the links between ecosystem services and human well-being and enable the capture of a full range of environmental impacts more systematically (Department of Environment, Food and Rural Affairs, 2007). Other advantages of conducting EIAs include imposing a higher level of precision, accounting for the evaluation of potential trade-offs, and providing credible values that facilitate communication with stakeholders, donors, corporate sponsors, and other affected individuals and groups (Scholes et al., 2010). Environmental valuation is important because the provided services have attributes of public goods which are able to be consumed (enjoyed) by all individuals (National Research Council of the National Academies, 2005).

The Department of Environment, Food and Rural Affairs (DEFRA) (2007) of the United Kingdom provided some key steps to conduct EIAs: 1) Establish a baseline that can be used for future EIAs; 2) conduct qualitative assessments of potential impacts of programs, events, and organizational policies (proposed and existing) on the environment; 3) quantify the impacts of programs, events, and organizational policies identified; 4) measure the effects on human well-being; and 5) determine a value of the changes on the specific environmental aspects as a result of the programs, events, and organizational policies. By following these steps, society's dependence upon the environment's significant contributions to human health and well-being benefits can be recognized and demonstrated.

Several methods can be utilized when conducting EIAs: multi-criteria analysis; cost benefit analysis; cost-effectiveness analysis; hedonic pricing; travel cost; production function approaches; stated preference; benefit transfer; replacement cost; cost of treatment; contingent valuation; contingent choice; and scenario analysis (Daly & Farley, 2011; DEFRA, 2007;

Henrichs et al., 2010; National Research Council of the National Academies, 2005; Simpson & Vira, 2010):

- *Multi-criteria analysis* considers different criteria when making decisions about the desirability of an action and incorporates the views of a diverse group of stakeholders.
- *Cost-benefit analysis* determines a common unit of measurement for different outcomes.
- *Cost-effectiveness analysis* determines the acceptable and reasonable cost in whether a planned intervention, program, or event can be achieved.
- *Hedonic pricing method* estimates values that directly affect the market prices of another good. An example of this is the aesthetic quality of an ecosystem service that affects property value.
- *Travel cost method* looks at values associated with ecosystems used for recreation and how much travel costs people are willing to pay to visit the site. Many national parks and public gardens are considered destination sites and people are willing to incur a certain amount of cost to visit them.
- The *production function or productivity approach* estimates economic values for those products or services that contribute to the production of commercial goods such as plant biomass extraction or a decline in soil quality which affects agricultural production.
- *Stated preference methods* estimate the value of things that may or may not be consumed or used, although this method has received much criticism on its credibility.

- The *benefit transfer method* estimates values by transferring known values from one completed study area to another location or issue. This method is commonly used to assess recreational uses of natural sites.
- *Replacement cost* estimates the cost of replacing ecosystem services, but this method should be used with caution since they are not always accurate.
- *Cost of treatment* evaluates the estimated costs to treat or repair damages to ecosystem services and should be used with caution because of issues with accuracy.
- *Contingent valuation method* provides values for almost any ecosystem service based upon a person's willingness to pay. The stated willingness to pay usually exceeds the actual amount that a person is willing to pay and is generally used for passive use values. An example would be how much a person would be willing to pay in extra taxes to preserve the brown horned owl habitat.
- The *contingent choice method* estimates the tradeoffs people would be willing to pay between a set of ecosystem services. These values are inferred based upon the responses of the people being asked. Examples of this would be habitat protection of the brown horned owl or wetland protection to decrease catastrophic flood events.
- *Scenario analysis* compares situations that are the same for future development or programs and those that are different, it identifies the trade-offs, and then plan of action is created that can be utilized across all scenarios.

The National Research Council of the National Academies (NRCNA) (2005) recommended that EIAs need to be placed in context and assumptions clearly identified. Every effort should be made to break down institutional barriers that may prevent effective assessments from occurring. Be aware that implementation of the results can be costly to protect, conserve, and restore ecosystem services. Identify the trade-offs if economic benefits are sacrificed now or in the future (NRCNA, 2005). The NRCNA (2005) also posed three sets of questions about ecosystem valuation that should be considered during the EIA process:

- “What is meant by the value of ecosystem services? What components of value are being measured?
- Why is it important to quantify the value of ecosystem services? How will the values that are estimated be used?
- How should these values be measured? What methods are available for quantifying values, and what are their advantages and disadvantages?”

DEFRA (2007) posited that environmental valuation can be complex and that impacts should be presented in quantifiable monetary terms if possible. If not, then potential impacts should be qualitatively assessed. Lastly, the NRCNA (2005) acknowledged that there is no perfect answer to these questions and to the scope of analysis that needs to be conducted, but that the overall actions that result from EIAs should generate a net positive benefit.

## Social Impact Assessment

Vanclay (2003) defined social impact assessment (SIA) as the analysis, monitoring, and management of social consequences of development. He further elaborated that practitioners who conduct social and environmental research using the methodology of SIA utilize the process to examine the social impacts of planned interventions, programs, and events (Vanclay, 2003). The goal of SIA is to assess social change resulting from interventions, programs, or events that can improve the quality of life in all individuals. The SIA also provides information about social change, social capital, and social institutions that has implications as to the effectiveness of sustainable development efforts (Barrow, 2000).

SIA measures the social value, those soft outcomes, that are the non-financial impacts, such as well-being of individuals and communities, social capital, and the environment (AAM, 2017; Smith & Harvey-Brown, 2018; Wood & Leighton, 2010). Social impact, closely related to social value, can be defined as “the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society…[It] also includes cultural impacts involving changes to the norms, values, and beliefs that guide and rationalize their cognition of themselves and their society” (Burdge, 2004). Due to the complex nature of social value, these aspects are difficult to measure and quantify (Barrow, 2000; Burdge, 2004; Tschirhart and Bielefeld, 2012; Wood & Leighton, 2010). Unfortunately, most SIAs occur after programs, interventions, or events have taken place, but they may be useful for future actions (Barrow, 2000).

Burdge (2004) described several myths about SIAs that factor into why these instruments are avoided. Since social impact is difficult or impossible to measure, then conducting assessments should be ignored. Social values are common sense and everyone should already know what the social impacts are. Social impacts seldom occur so they do not need to be assessed – according to Burdge (2004), they are always occurring. Projects and events deal with costs, not benefits, so the SIA only slows down projects and events – Burdge (2004) states that social change actually brings social costs to some and benefits to others). SIAs only increase the costs of projects and events, and the benefits are not improved. The SIA process is not important (SIAs do provide major benefits in enabling affected populations to understand, participate in, and cope with proposed projects and events. Finally, it is impossible to document all aspects of social impacts because changes beget other changes (this does have an element of truth).

Even though SIAs are difficult to measure and monetize, the evaluation of social services is arguably the most valuable to society. Due to the nebulous nature of SIAs, they can be imperfect (Barrow, 2000). However, they provide snapshots to positive impacts on mental and physical health, educational benefits, and cultural and aesthetic values (Smith & Harvey-Brown, 2018). The AAM (2017) noted that a broader engagement and understanding are required to develop proper methods (and select appropriate tools) for measuring social value of an organization, and to focus on measuring the results of activities (using the selected tools) instead of merely enumerating the actual activities themselves.

Social value can be classified as instrumental, institutional, or intrinsic (Donovan, 2013). Instrumental value arises from cultural activity that indirectly provides social and economic benefit such as health benefits. Those organizational practices that engage the community and create value to the public are institutional value. Instrumental and institutional value can be measured by outputs and objective outcomes. The third type of social value, intrinsic, is that personal, emotional, intellectual, and spiritual experience derived from shared memories, aesthetic properties, spiritual significance, historic importance, symbolic meanings, and many other possible inherent and fundamental reactions of the human experience (Donovan, 2013). Intrinsic value is difficult to measure because of the inability to precisely attribute those experiences to specific interventions, programs, and events.

Major incentives for conducting SIAs include determining recreational and aesthetic impact, effectiveness of formal and informal education, social interaction, provisioning of places of safety and tranquility for visitors to public gardens, and stimulation of creativity and learning (Edelson, 2010; Smith & Harvey-Brown, 2018). The Public Garden Sustainability Index (American Public Gardens Association, 2019) includes refuge from noise, pollution, and stress, physical activity, health promotion, reduction of health issues, plant-induced calmness, relaxation, and therapy, and improved quality of life. Barrow (2000) suggested that a social audit needs to be conducted that evaluates the social impact and the ethical behavior of the organization, program, or event as they relate to objectives and the people involved.

Several methods can be used to analyze social impact (Burdge, 2004). *Comparative research methods* compare the present to future of an action. *Straight-line projections* take an existing trend and project same rate of change into the future. A third method uses *population multiplier methods* where implications from specific increases in population are assigned multiples of other variables. *Scenarios* are simply constructing different models based on hypothetical futures – similar to what-if scenarios. Another method is *utilizing expert judgment*, and, finally, *calculating foregone futures* to determine what options would be sacrificed as a result of implementing a program or event – similar to the concept of opportunity costs.

## Economic Impact Assessment

Economic impact assessment (EcIA) can be defined as the analysis of proposed and existing projects and programs to discover the estimated changes in income, employment, and other business activities (Leistritz, 1995). EcIAs are important for municipalities and other nonprofit organizations because they are monetary-based, easy to work into budget plans and business models, easier to justify spending and investments especially for corporate sponsors and boards of directors, and generally easier to measure the impacts (Smith & Harvey-Brown, 2018).

Economic impact benefits of public gardens include increase property values, improved attractiveness of communities to homebuyers and businesses, increased tax revenues for the local economy via increased tourist sales and other tourist activities, decreased medical costs through increased exercise and improved cardiovascular and respiratory systems, decreased stormwater treatment costs and other ecosystem services such as reduced air pollution, increased oxygen supply via plants, and reduced greenhouse gas emissions, strengthened social capital, and better quality of life (Richman, 2012). The Public Garden Sustainability Index (APGA, 2019) included the following: Public gardens are a major component of tourism industry; capital projects create jobs; partnerships attract tourists; collaborations with local businesses generate more economic benefit; plant conservation enhances biodiversity, air pollution is decreased, water and energy conservation are promoted; and education promotes environmental stewardship.

Lawton and Jones (2010) listed three types of economic impact: direct; indirect; and induced. Direct impacts are those that can be readily identified as having occurred as a result of an action, program, or event. For example, sales from an auction during an annual public garden gala event. Indirect impacts are those that cannot be readily caused by an action, program, or event such as jobs created from construction projects at a public garden. Induced impacts are those that occur as a result of an action such as employees receiving a bonus which leads to more purchases or public gardens creating a dazzling display which inspires visitors to purchase similar materials to recreate the effect at their own homes.

Leistritz (1994) described three types of economic measures: income, value added, and output. Typical economic measures for income include total employment such as additional jobs created) and aggregate personal income, for example, wage increases or more employees hired. Value added is the sum of wage and income profit, but this should be used with caution since it can overestimate values. Thirdly, business output refers to revenue or sales volume and net profit.

Smith and Harvey-Brown (2018) list several methods to measure economic impact. Travel-cost method assesses purchases by tourists on hotel lodging, meals, transportation, and other costs related to the trip to visit the gardens. As employers, public gardens have an impact on the local economy by providing employment to skilled workers who spend their earnings for goods and services and implementing capital projects which provide work for contractors and the need for supplies from local businesses. The increase in property values to the surrounding community as a result of the public garden enhancing the neighborhood can be measured through sales of land and property. As previously described, assessing the contribution of the public garden to the tax structure. Horticultural and scientific research can attract external funding. Finally, the plant collections and other exhibits such as art collections have a financial value.

Despite the plethora of advantages for conducting EcIAs, Simpson and Vira (2010) described some common errors that need to be avoided. Be cautious with marginal versus total values because the economic value is how much of an additional amount of something is worth, not how much something it is worth in total. Value added methods can confuse the source of value. Leistritz (1994) provided an example of the tendency of double-dipping with property values where values may increase as a result of increases in personal income or business investment, but not necessarily because of the proximity of a favorite park or shopping center.

For the substitute method, if alternatives are available, the value of goods and services cannot be greater than the cost of the alternatives. The replacement method may overstate the value of a good or service if there are less expensive ways to produce a good or service instead of replacing it. Avoid double-counting, not to be confused with double-dipping, when checking calculated values against different methods to compare results. This can lead to values being counted twice. Finally, be aware that alternative metrics that measure ecological footprints and other physical measures such as air quality and energy cannot be used in economic valuation since those measures often provide value estimates instead of concrete data.

To conclude this section, Weisbrod and Weisbrod (1997) identified “seven deadly sins” to avoid when conducting EcIAs:

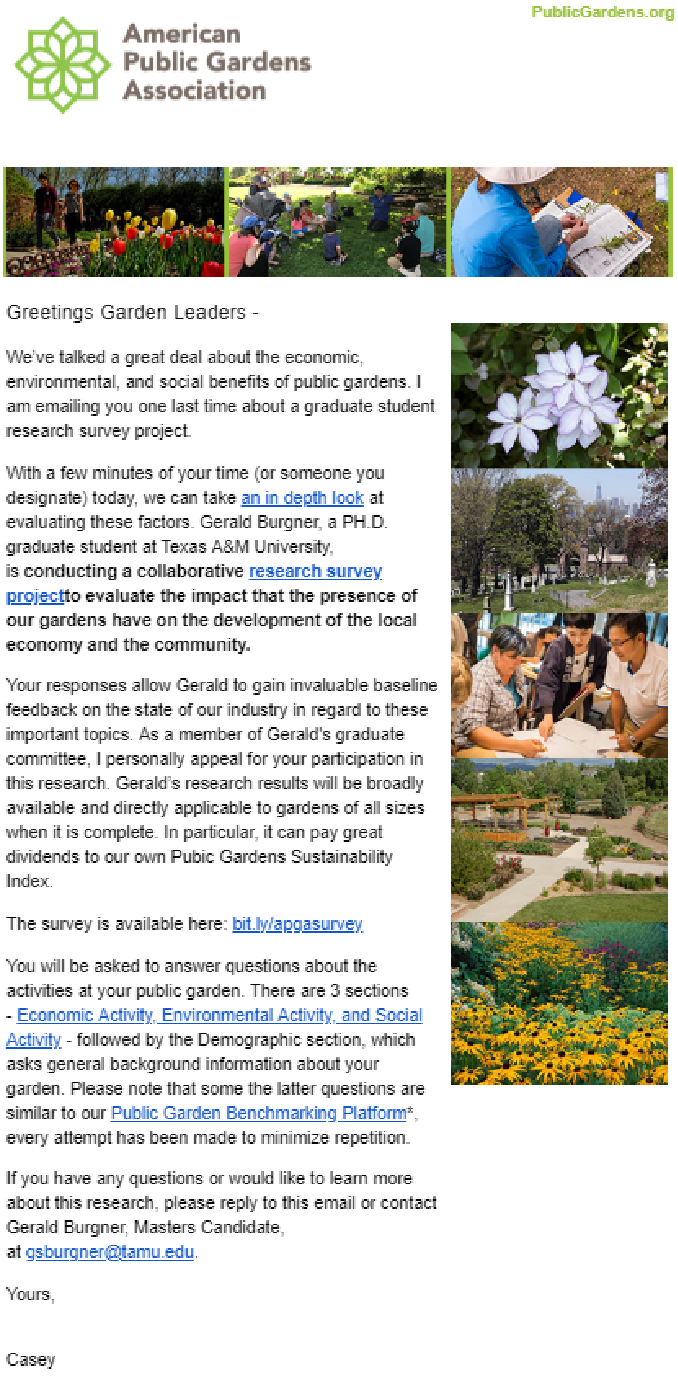
1) “Confusing the economic role or gross effect of a facility or project from its net impact on the economy of an area;
2) Adding together different measures of the same economic change (e.g., changes in business sales and personal income);
3) Confusing study areas (e.g., neighborhood, citywide, state and national effects);
4) Confusing time periods (e.g., immediate and eventual effects on economic growth);
5) Assuming that a facility's capacity and its actual level of activity are the same;
6) Applying multipliers in situations where they do not apply; and
7) Ignoring market effects on wages and land/building costs, which can also affect the economic competitiveness of an area.”

## Materials and Methods

Based upon interviews with survey experts and administrative members of the American Public Garden Association (APGA), a 48-question online survey instrument (Appendix D) was developed according to the survey question methods described in Dillman, Christian, and Smyth (2014) to obtain information about the current environmental social impact, and economic assessment activities at public gardens in the United States. Question formats included a combination of open-ended, closed-ended, and partially closed-ended questions. Certain terms were defined at the beginning of sections as needed to clarify their meanings for purposes of this survey instrument.

A total of 724 potential survey participants were selected from the membership database of the APGA based on the following positions: 1) executive director or chief executive officer; 2) assistant director or manager; or 3) a member of management such as supervisor, curator, or director of a division of the garden. Qualtrics Online Survey Software (Qualtrics, LLC, 2018) was used to administer the survey.

According to response request methods described in Dillman, Christian, and Smyth (2014), each public garden was contacted via email to participate in an online survey estimated to take twenty to twenty-five minutes to complete. Three email prompts (Figure 2.1) were sent by the APGA to garden administrators: the initial email was sent to all 724 potential participants and the response rate was monitored; the second email was sent three weeks later as a reminder to 689 nonrespondents and the response rate continued to be monitored; the third and final email reminder was sent two weeks after the second email to 679 nonrespondents who had yet to participate in the survey. The responses were analyzed using multivariate analysis with Chi-square tests and two-way tables (α = 0.05) using STATA statistical software. Since the response rate was less than 80% (11% response rate), nonresponse issues were handled by comparing key demographic responses of the respondents to those of nonrespondents using a paired t-test analysis (Ary, Jacobs, Sorensen, & Razavieh, 2010; Gall, Gall, & Borg, 2007; Lindner, Murphy, & Briers, 2001; Miller & Smith, 1983). A random sample of twenty nonrespondents were contacted, as suggested by Gall, Gall, and Borg (2007), via email and telephone to participate in the survey. Sixteen of those nonrespondents participated in the survey which was 80% of the nonrespondents contacted, meeting the 75% to 80% expected return from nonrespondents as suggested by Tuckman (1999). The paired t-test analysis (95% confidence level) on thirteen key demographic variables between the respondents and nonrespondents revealed only three variables with significant differences: number of employees, number of visitors, and physical size (Table F-1). Otherwise, there were no significant differences between the results of respondents and nonrespondents.



PublicGardens.org

American
Public Gardens
Association

Greetings Garden Leaders -

We've talked a great deal about the economic, environmental, and social benefits of public gardens. I am emailing you one last time about a graduate student research survey project.

With a few minutes of your time (or someone you designate) today, we can take an in depth look at evaluating these factors. Gerald Burgner, a PH.D. graduate student at Texas A&M University, is **conducting a collaborative research survey projectto evaluate the impact that the presence of our gardens have on the development of the local economy and the community.**

Your responses allow Gerald to gain invaluable baseline feedback on the state of our industry in regard to these important topics. As a member of Gerald's graduate committee, I personally appeal for your participation in this research. Gerald's research results will be broadly available and directly applicable to gardens of all sizes when it is complete. In particular, it can pay great dividends to our own Pubic Gardens Sustainability Index.

The survey is available here: bit.ly/apgasurvey

You will be asked to answer questions about the activities at your public garden. There are 3 sections - Economic Activity, Environmental Activity, and Social Activity - followed by the Demographic section, which asks general background information about your garden. Please note that some the latter questions are similar to our Public Garden Benchmarking Platform*, every attempt has been made to minimize repetition.

If you have any questions or would like to learn more about this research, please reply to this email or contact Gerald Burgner, Masters Candidate, at gsburgner@tamu.edu.

Yours,

Casey

Figure 2.1. Copy of email text that was sent to public garden administrators asking for participation in a state of the industry survey in collaboration with the American Public Gardens Association about environmental, social, and economic impact assessments.

The survey instrument was comprised of eight sections: 1) an informed consent form; 2) background information; 3) economic impact; 4) environmental impact; 5) social impact; 6) demographics; 7) concluding question; and 8) a statement of appreciation. The *informed consent form* contained required information about the researchers, possible risks for participating in the survey, age requirements, anonymous responses, and other preliminary statements mandated by the Internal Review Board of the Texas A&M University Human Subjects Protection Program. The section also included a question asking for confirmation that the participant understands the risks and benefits involved by completing the survey and that the participant is eighteen years of age or older.

Two sections solicit information pertaining to the demographics of the public gardens – one in the beginning to assimilate the participant to the survey environment with simple, relatively easy questions, and the other near the end of the survey instrument. The first demographic section, *background information* (section two of the survey instrument), was created in accordance to methods described by Dillman, Christian, and Smyth (2014). These seven questions were intended to be low-risk, non-challenging, general questions that can be answered rather quickly, including the location of the gardens, visitor demographics, and how visitors learn about and travel to the gardens. The latter section, *demographics* (section six of the survey instrument), consisted of eight questions asking for state location, garden size, organizational status, annual revenue, number of employees, volunteers, and visitors per year.

Sections three, four, and five – *economic impact*, *environmental impact*, and *social impact*, respectively –included similar questions. All three sections asked if and when that particular assessment was conducted, the valuation tools used, level of support from the Board of Directors or Advisory Board, and if information was collected about economic, environmental, and social activities at the gardens. The economic impact section consisted of fourteen questions seeking information about economic conditions in the communities where the gardens are located and the rating of certain economic factors as to their impact on the local economy. The environmental impact and social impact sections will have ten and eleven questions respectively.

The seventh section, *concluding question*, asked about the greatest challenge that faces the gardens. The eighth and final section included a *statement of appreciation* for the responses and time from the participants. They also were asked to leave their contact information if interested in the survey results and/or more information about environmental, social, and economic impact assessments. Participants also had the option to email the researchers or decline further information altogether.

## Results

After all responses were collected (respondents and nonrespondents), ninety-five members of public gardens administration representing thirty-one states, Washington, DC, and three garden administrators outside of the United States participated in the survey. However, eleven participants did not complete relevant information beyond consenting to participate in the study leaving an adjusted total of eighty-four respondents with information that could be evaluated (12% response rate; confidence level = 95%; confidence interval ±10.0). The survey took between 20 to 25 minutes for each participant to complete, and all the responses were optional and anonymous, although respondents could voluntarily provide the name of the organization with which they were employed with certain questions in the survey.

The APGA categorizes each member garden into three divisions depending on the total annual budget of the garden[1]: large (>$2 million), medium ($1 to $2 million), and small (<$1 million) (Moussa, 2014). Based upon this classification, 49.3% of the respondents were from gardens with large budgets (33), 13.4% from medium (9), and 37.3% from small (25) (n = 67) (Figure E-1). A quarter of the gardens (28%) had a budget less than $500,000, and another quarter (28%) had a budget between $2 million and $5 million (Figure E-2). The respondents were grouped according to the geographic region classification system established by the United States Census Bureau (2019). Respondents from the South had the most participants at twenty-three (33%), followed by the West with seventeen (24%), the Midwest fourteen (20%), the Northeast thirteen (19%), and outside of the United States three (4%) (n = 70).

The majority of the respondents worked for a public garden with 501(c)(3) nonprofit status (60%), followed by city or county owned gardens (24%), college or university gardens (23%), and public/private partnership (13%) (Figure E-3). Forty-seven percent of the gardens surveyed were located in urban areas compared to 25% in suburban and 15% in rural areas (Figure E-4). The oldest public garden was established in 1820 and the most recently established was in 2011, while the majority of gardens were established in the 1980s (18%) (Figure E-5). Most gardens employed less than 50 people (59%) (n = 72) (Figure E-6), had over 100 volunteers (55%) (n = 73) (Figure E-7), were over 100 acres (54%) in size (n = 72) (Figure E-8), and had over 50,000 visitors annually (67%) (n = 70) (Figure E-9). Each respondent was asked to list their visitor percentages by age group. Averaging all the results of the respondents, the largest age group was 55-70 years old (31%), followed by 35-54 (24%), 18-34 (18%), <18

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[1] Suzanne Moussa, email message to author, December 5, 2014.

(15%), and >70 (11%) (n = 49) (Figure E-10). Most visitors used personal automobiles or trucks to travel to the gardens (84%) (Figure E-11). Eight public gardens (10%) listed walking/bicycle as the most utilized method of traveling to gardens, which happened to be located in denser urban areas, residential areas, or on/near a college or university. One garden listed public transportation as the primary travel method and was located within a large populated city with a well-established public transportation system. When asked about public transportation access, forty-seven respondents (59%) indicated that it was available to the public garden (n = 79).

Among the marketing strategies used to promote the garden, the internet (96%) and printed materials (92%) were the most used methods. Social media was third (90%), followed by mass media publicity (72%), nonprint materials (65%), paid advertising (65%) and public service announcements (18%) (n = 78) (Figure 2.2). When asked about the greatest challenge besides funding facing their public garden, respondents listed the following: increasing attendance numbers (16%); infrastructure (16%); increasing membership (13%); maintaining plant collections (10%); finding qualified/skilled employees (10%); facilities management (7%); funding (7%) (this was listed despite the instructions); increasing audience diversity (6%); support from board of directors/advisory committee (6%); community support (4%); staff management (1%); educational programming (1%); increasing quality of visit (1%); remaining relevant (1%); and capacity (1%) (n = 71) (Figure 2.3).

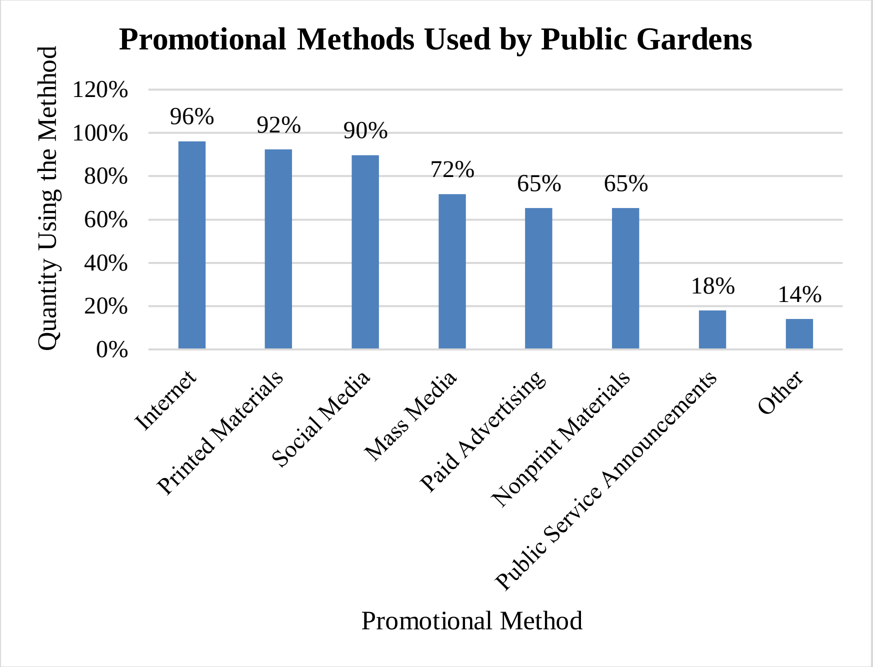

Figure 2.2. Percentage of public garden respondents from a state of the industry survey of public gardens about environmental, social, and economic impact assessments indicating the methods utilized for promoting the public garden (n = 78).

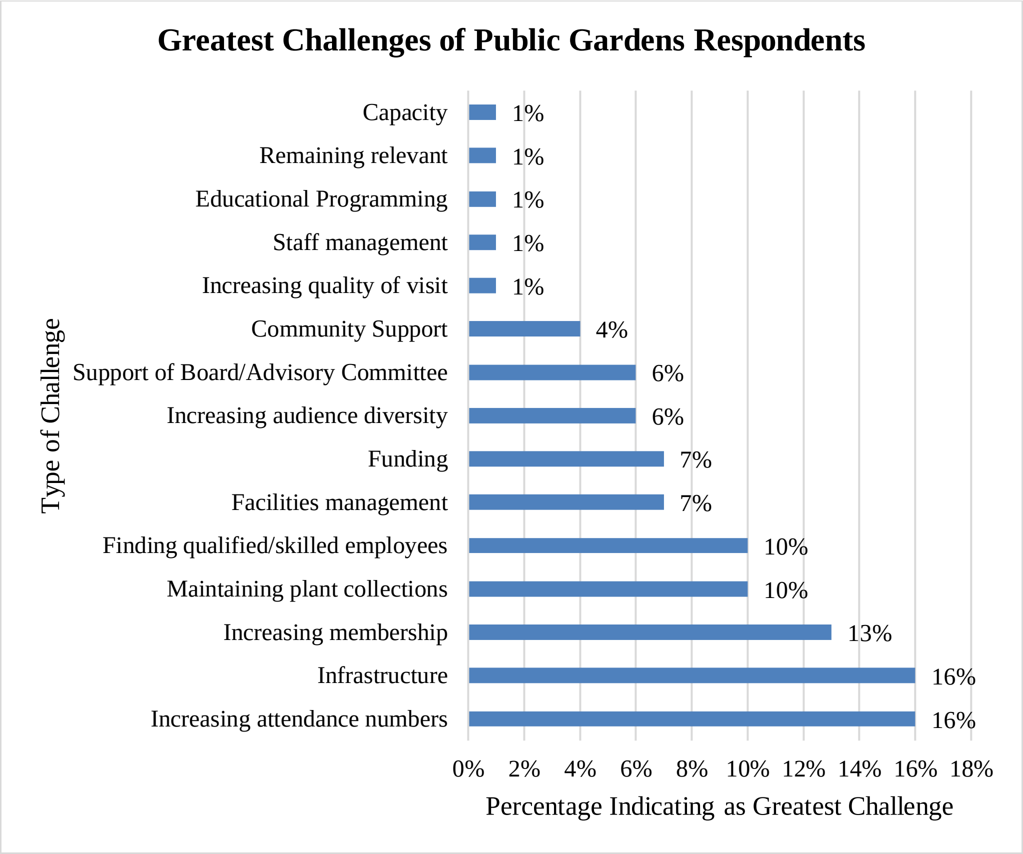

Figure 2.3. Percentage of public garden respondents from a state of the industry survey of public gardens about environmental, social, and economic impact assessments indicating the greatest challenge for the public garden (n = 71).

Nine respondents (12%) reported that their gardens had conducted an environmental impact assessment (n = 76) with most of those assessments being conducted over three years ago (56%) (n = 9) (Table E-1). All of those respondents (100%) stated that the assessment was useful, recommendations would be implemented, and the boards of directors had a strong level of support for the assessment. Valuation tools used for the assessment, if known, were the Environmental Benefits Calculator, InVEST, the National Stormwater Calculator, and the Public Gardens Sustainability Index. Twenty-nine of the respondents (39%) reported that their gardens did not collect any environmental information (n = 74), but thirteen of those (45%) had plans to begin collecting data. For those gardens where it was collected, environmental information included water conservation (35%); environmental stewardship/conservation (32%); stormwater management (28%); recycling costs and/or returns (23%); ecological integrity (22%); waste reduction/diversion costs and/or returns (22%); building/property carbon footprint (11%); air quality/pollution levels (4%); and carbon sequestration (1%) (Figure 2.4).

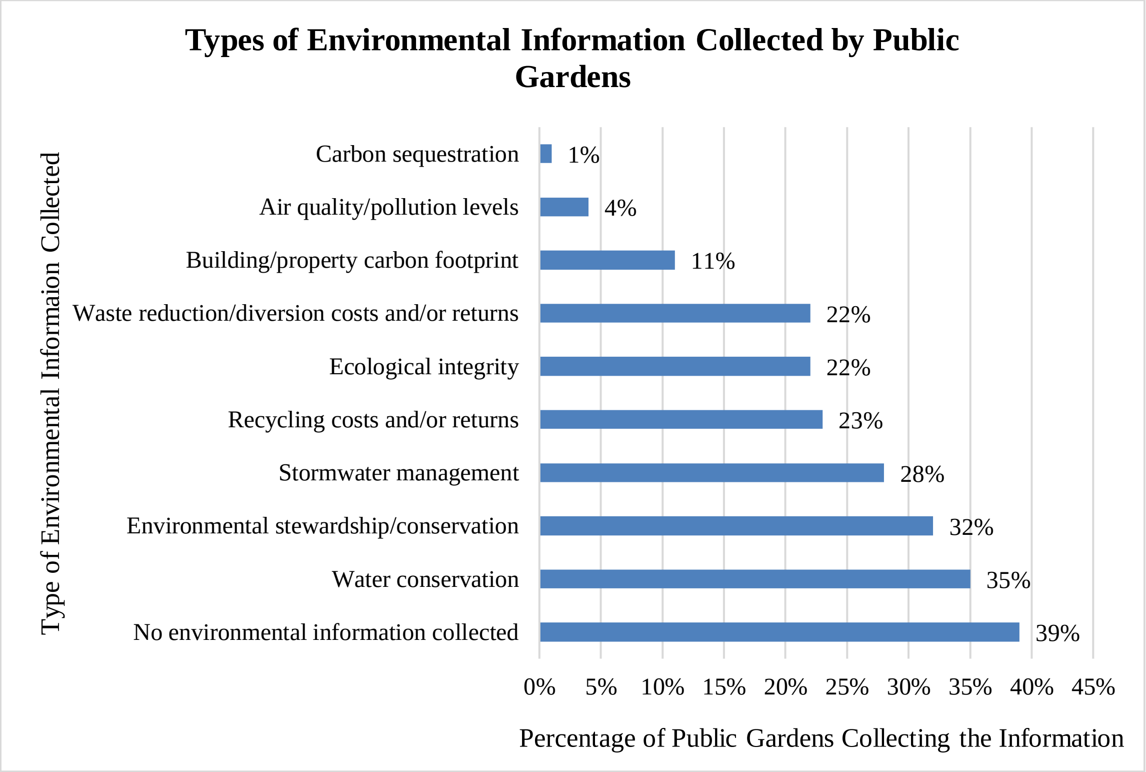

Figure 2.4. Percentage of public garden respondents from a state of the industry survey of public gardens about environmental, social, and economic impact assessments indicating the types of environmental information collected by the public garden (n = 74).

Seven respondents (10%) reported that their gardens had conducted a social impact assessment (n = 73) with most of those assessments being conducted within the last three years (71%) (n = 7) (Table E-1). Six of those respondents (86%) stated that the assessment was useful, recommendations would be implemented, and the boards of directors had a moderate level of support for the assessment. Valuation tools used for the assessment, if known, were the Housing and Transportation Affordability Index, Pedestrian Environmental Quality Index Tool, Public Gardens Sustainability Index, System for Observing Physical Activity and Recreation in Natural Areas, on-site questionnaire, or a contracted data collector. Twenty-one of the respondents (29%) reported that their gardens did not collect any social information (n = 72), and only two of those (11%) had plans to begin collecting data. For those gardens where it was collected, social information included reason for visiting (57%); satisfaction level with the garden and its services (51%); how often the person visits the garden (43%); inspiration from the garden (19%); garden mission awareness level (18%); accessibility (inclusivity) (15%); behavioral adjustments (e.g., more aware of sustainability, environmental stewardship, etc.) (15%); zip code (4%); basic demographics (3%); how visitors heard about garden (3%); visitor surveys (3%); health impact (1%); age range (1%); membership status (1%); home city and state (1%); general comments from social media (1%); and contact info (1%) (Figure 2.5). The majority of the respondents (72%) had not conducted a social return on investment (SROI), and 22% did not know if one had been conducted or did not know what an SROI was (n = 72). Only 3% conducted an SROI regularly.

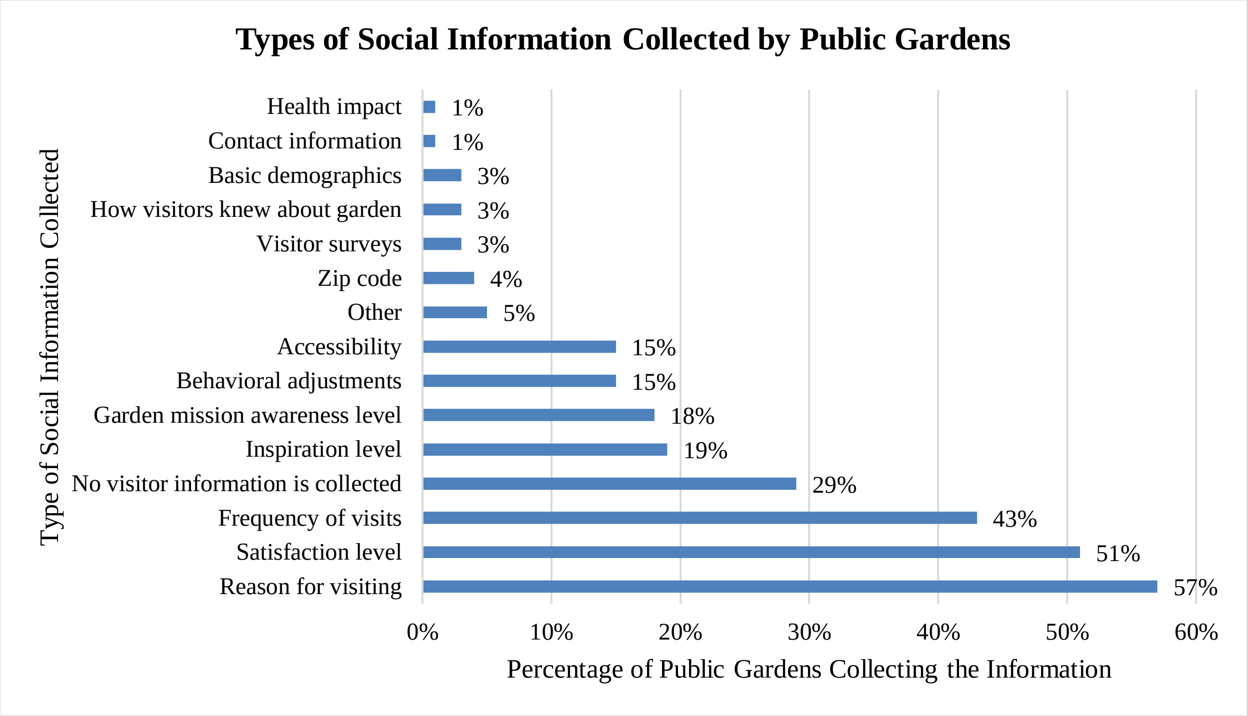

Figure 2.5. Percentage of public garden respondents from a state of the industry survey of public gardens about environmental, social, and economic impact assessments indicating the types of social information collected by the public garden (n = 72).

Fourteen respondents (18%) reported that their gardens had conducted an economic impact assessment (n = 78) with half of those assessments being conducted within the last three years (50%) (n = 14) (Table E-1). Most of those respondents (62%) stated that the assessment was useful and that recommendations would be implemented; however, about half (56%) of the boards of directors had a strong level of support for the assessment with the remainder reporting low to moderate support. Valuation tools used for the assessment, if known, were Lifecycle Cost Analysis, Public Gardens Benchmarking Platform, state Department of Tourism economic impact multiplier, website research and data aggregation, combination of factors (hotel rack cards, auto tag surveys, etc.), Real Estate Value Analysis, Rent Cost Analysis, Tax Revenue

Analysis, Earned Income Analysis, and Hotel/Motel Stay Analysis. Nineteen of the respondents (25%) reported that their gardens did not collect any economic information (n = 75), but five of those (28%) had plans to begin collecting data. For those gardens where it was collected, economic information included energy costs/savings/efficiency (47%); return on investments (45%); waste reduction costs and/or returns (20%); Lifecycle Cost Analysis (19%); recycling costs and/or returns (17%); direct revenue and expenditures (17%) (Figure 2.6).

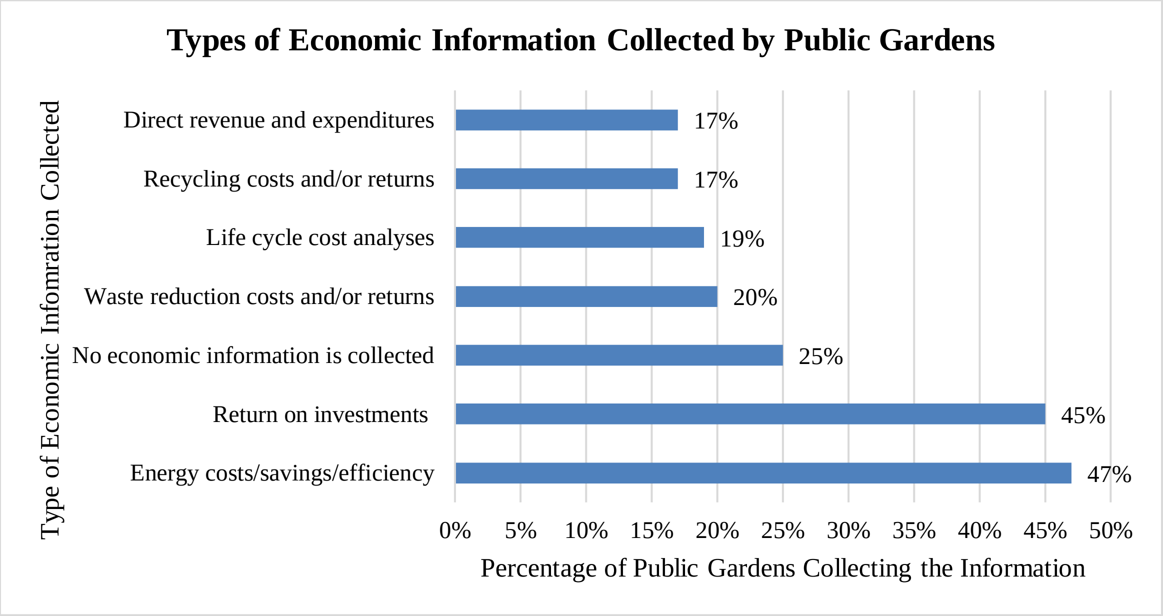

Figure 2.6. Percentage of public garden respondents from a state of the industry survey of public gardens about environmental, social, and economic impact assessments indicating the types of economic information collected by the public garden (n = 75).

**Significant relationships**

Several significant relationships were discovered using multivariate Chi-square analysis and Fisher's exact test. Using guidelines suggested by Fisher (1950), significant relationships are defined with p-values as follows: strong is less than 0.02; moderate is between 0.02 and 0.04; weak is between 0.04 and 0.05; none is greater than 0.05. The governing structure of the garden had significant relationships with the total annual operating budget. A weak significant relationship was discovered with the budget and a city or county governance structure ($\chi^2 = 6.0136$, $p = 0.049$, Fisher's exact = 0.046), and stronger significant relationships with independent nonprofit organizational structure ($\chi^2 = 7.7873$, $p = 0.020$, Fisher's exact = 0.021), and other nonprofit governance structures ($\chi^2 = 7.9526$, $p = 0.019$, Fisher's exact = 0.011). The location of the garden had very strong significant relationships with the availability of public transportation ($\chi^2 = 35.1294$, $p = 0.000$, Fisher's exact = 0.000) – thirty-three gardens with access to public transportation were located in urban areas; twenty-five were in suburban and rural areas without access to public transportation – and the method visitors utilized to attend the gardens ($\chi^2 = 76.2589$, $p = 0.000$, Fisher's exact = 0.001) – fifty-seven gardens were located in urban (29), suburban (16), and rural areas where visitors primarily attended the gardens via automobile or truck. A moderately significant relationship existed between the location of the garden and the physical size of the garden ($\chi^2 = 34.1594$, $p = 0.035$, Fisher's exact = 0.022) – twenty-one out of twenty-nine gardens located in urban areas were less than fifty acres in size which suggests that land acquisition or zoning may be restricting factors for physical size in urban areas. A weak significant relationship was found between the location of the garden and the total annual operating budget ($\chi^2 = 12.5905$, $p = 0.050$, Fisher's exact = 0.117) – twenty-nine gardens were located in urban areas and seventeen gardens with large budgets were located in suburban or rural areas. The state in which the garden was located and the method utilized by visitors to attend the gardens ($\chi^2 = 21.6750$, $p = 0.006$, Fisher's exact = 0.336) had a very strong relationship as well – considering all regions, fifty-six of the sixty-four gardens were located in urban areas with the south having the greatest number of gardens in urban areas (18). The state in which the garden was located and the physical size of the garden had a weak significant relationship ($\chi^2 = 42.3254$, $p = 0.040$, Fisher's exact = 0.009) – twenty gardens were located in the south and sixteen from the west; thirty-three of those ranged in size from 20 to 250 acres suggesting that land may be less expensive in those regions for the creation of larger gardens and that the availability of land may be greater in those regions.

As would be expected, strong relationships existed between the total annual operating budget and the number of employees ($\chi^2 = 63.7176$, $p = 0.000$, Fisher's exact = 0.000) – twenty-two gardens with the most employees also had large total annual budgets; eighteen gardens with small budgets had less than ten employees (n = 60) – and the number of visitors ($\chi^2 = 30.2951$, $p = 0.007$, Fisher's exact = 0.001) – gardens with large budgets had greater numbers of visitors and gardens with small budgets had fewer visitors. Although not as strong, there was a significant relationship between the total annual operating budget and number of volunteers ($\chi^2 = 28.6356$, $p = 0.027$, Fisher's exact = 0.015) – those with larger annual budgets had slightly more volunteers than the gardens with small and medium budgets and those with small budgets generally had 10 to 100 volunteers. However, there was no significant relationship between the annual operating budget and the year the garden was established ($\chi^2 = 7.1565$, $p = 0.520$, Fisher's exact = 0.465), nor the year the garden was established and the number of visitors attending ($\chi^2 = 36.2709$, $p = 0.136$, Fisher's exact = 0.058) suggesting that newer organizations have equal opportunities for success in comparison with gardens founded much earlier.

The number of employees had very strong relationships with the number of volunteers ($\chi^2 = 104.6588$, $p = 0.000$, Fisher's exact = 0.021) and the number of visitors ($\chi^2 = 84.0879$, $p = 0.001$, Fisher's exact = 0.001) as did the number of volunteers and the number of visitors ($\chi^2 = 97.3182$, $p = 0.001$, Fisher's exact = 0.000) – one garden which had the most employees (over five hundred) also had the greatest number of visitors (over one million); generally, the greater the number of visitors indicated a greater number of employees and volunteers indicating that more services and programs were offered requiring more employees and volunteers or more financial resources were available to provide a greater number of services and programs. The number of volunteers had a weaker significant relationship with the year the garden was established ($\chi^2 = 50.0677$, $p = 0.022$, Fisher's exact = 0.250) – fourteen of the thirty-eight gardens established between 1950 and 2000 had between 100 and 250 volunteers – and the state in which the garden was located ($\chi^2 = 49.2551$, $p = 0.026$, Fisher's exact = 0.061) – thirty-six gardens of the south and west had greater numbers of volunteers and fourteen of those had between 100 and 250 volunteers which is unusual considering the south ranks low in the number of volunteers when compared to other states (Corporation for National and Community Service, 2019); this number could have been affected by the larger number of respondents from those regions. The year the garden was established was significantly related to the number of employees ($\chi^2 = 47.0762$, $p = 0.013$, Fisher's exact = 0.031) – seventeen of thirty-one gardens with between 20 and 250 employees were established between 1950 and 2000.

Strong significant relationships existed between the year the garden was established and if the garden had conducted an environmental impact assessment ($\chi^2 = 13.6091$, $p = 0.018$, Fisher's exact = 0.068) – thirty-five gardens established between 1950 and 2000 did not conduct an environmental impact assessment and three did – a social impact assessment ($\chi^2 = 13.0855$, $p = 0.011$, Fisher's exact = 0.168) – thirty-five gardens established between 1950 and 2000 did not conduct a social impact assessment and three did – or an economic impact assessment ($\chi^2 = 68.4042$, $p = 0.000$, Fisher's exact = 0.067) – thirty-four gardens established between 1950 and 2000 did not conduct an environmental impact assessment and four did.

No significant relationships were found between the total annual budget and if the garden had conducted an environmental impact assessment ($\chi^2 = 0.9890$, $p = 0.610$, Fisher's exact = 1.000), a social impact assessment ($\chi^2 = 2.8707$, $p = 0.238$, Fisher's exact = 0.272), or an economic impact assessment ($\chi^2 = 4.5930$, $p = 0.101$, Fisher's exact = 0.071) suggesting that the size of the budget was not an indicator to whether or not an impact assessment was conducted.

Three gardens conducted an environmental and economic impact assessment ($\chi^2 = 8.6306$, $p = 0.013$, Fisher's exact = 0.028) while fifty-six gardens did not conduct either one. Six gardens that found the environmental impact assessment useful also conducted return on investment (ROI) assessments ($\chi^2 = 5.1820$, $p = 0.023$, Fisher's exact = 0.072, 1-sided Fisher's exact = 0.045). Fifty-five gardens (n = 73) did not collect information on recycling costs and/or returns or waste reduction ($\chi^2 = 41.1949$, $p = 0.000$, Fisher's exact = 0.000, 1-sided Fisher's exact = 0.000). Eleven gardens (n = 72) that did not conduct an environmental impact assessment did collect information about ecological integrity ($\chi^2 = 4.6421$, $p = 0.031$, Fisher's exact = 0.053, 1-sided Fisher's exact = 0.053), recycling costs and/or returns ($\chi^2 = 13.1775$, $p = 0.000$, Fisher's exact = 0.002, 1-sided Fisher's exact = 0.002), and/or waste reduction ($\chi^2$ = 13.1775, *p* = 0.000, Fisher's exact = 0.002, 1-sided Fisher's exact = 0.002).

Three gardens that conducted a social impact assessment also conducted a SROI, whereas, four that conducted a social impact assessment did not conduct a SROI (n = 71) ($\chi^2$ = 29.4533, *p* = 0.000, Fisher's exact = 0.001). Thirty-two gardens collected information about visitor satisfaction levels and the reason for attending (n = 72) ($\chi^2$ = 27.0936, *p* = 0.000, Fisher's exact = 0.000, 1-sided Fisher's exact = 0.000). Twenty-eight gardens collected information about how frequently visitors attend the garden and the reason for attending (n = 72) ($\chi^2$ = 24.7374, *p* = 0.000, Fisher's exact = 0.000, 1-sided Fisher's exact = 0.000). Twenty-five gardens collected information about visitor satisfaction levels and how frequently visitors attend the garden (n = 72) ($\chi^2$ = 18.6528, *p* = 0.000, Fisher's exact = 0.000, 1-sided Fisher's exact = 0.000). Twelve gardens (n = 72) collected information about visitor satisfaction levels and visitor inspiration levels ($\chi^2$ = 10.6332, *p* = 0.001, Fisher's exact = 0.001, 1-sided Fisher's exact = 0.001), reason for attending and visitor inspiration levels ($\chi^2$ = 8.0918, *p* = 0.004, Fisher's exact = 0.005, 1-sided Fisher's exact = 0.004), and reason for attending and awareness level of the garden mission ($\chi^2$ = 8.0918, *p* = 0.004, Fisher's exact = 0.005, 1-sided Fisher's exact = 0.004). Eleven gardens (n = 72) collected information about visitor satisfaction levels and awareness level of the garden mission ($\chi^2$ = 7.0111, *p* = 0.008, Fisher's exact = 0.013, 1-sided Fisher's exact = 0.008), reason for attending and accessibility (inclusivity) ($\chi^2$ = 9.8169, *p* = 0.002, Fisher's exact = 0.002, 1-sided Fisher's exact = 0.001), and accessibility (inclusivity) and how frequently visitors attend the garden ($\chi^2$ = 17.1719, *p* = 0.000, Fisher's exact = 0.000, 1-sided Fisher's exact = 0.000).

Ten gardens (n = 72) collected information about inspiration levels and how frequently visitors attend the garden ($\chi^2 = 7.4218$, $p = 0.006$, Fisher's exact = 0.011, 1-sided Fisher's exact = 0.008). Nine gardens (n = 72) collected information about the awareness level of the garden mission and how frequently visitors attend the garden ($\chi^2 = 4.4333$, $p = 0.035$, Fisher's exact = 0.061, 1-sided Fisher's exact = 0.037), visitor satisfaction levels and behavioral adjustments ($\chi^2 = 4.8125$, $p = 0.028$, Fisher's exact = 0.047, 1-sided Fisher's exact = 0.029), and behavioral adjustments and how frequently visitors attend the garden ($\chi^2 = 7.9569$, $p = 0.005$, Fisher's exact = 0.007, 1-sided Fisher's exact = 0.006). Six gardens (n = 72) collected information about visitor inspiration levels and awareness level of the garden mission ($\chi^2 = 8.4655$, $p = 0.004$, Fisher's exact = 0.009, 1-sided Fisher's exact = 0.009), visitor inspiration level and accessibility (inclusivity) ($\chi^2 = 11.6845$, $p = 0.001$, Fisher's exact = 0.003, 1-sided Fisher's exact = 0.003), visitor inspiration levels and behavioral adjustments ($\chi^2 = 6.5877$, $p = 0.010$, Fisher's exact = 0.022, 1-sided Fisher's exact = 0.022), and awareness level of the garden and accessibility (inclusivity) ($\chi^2 = 11.6845$, $p = 0.001$, Fisher's exact = 0.003, 1-sided Fisher's exact = 0.003). Five gardens (n = 72) collected information about awareness level of the garden mission and behavioral adjustments ($\chi^2 = 6.5877$, $p = 0.010$, Fisher's exact = 0.022, 1-sided Fisher's exact = 0.022), and four gardens (n = 72) collected information about accessibility (inclusivity) and behavioral adjustments ($\chi^2 = 4.4599$, $p = 0.035$, Fisher's exact = 0.057, 1-sided Fisher's exact = 0.057).

A significant relationship was discovered between the total annual budget and SROI ($\chi^2 = 13.7267$, $p = 0.033$, Fisher's exact = 0.098) with one garden with a small budget conducting a SROI regularly, two gardens with medium budgets having conducted a SROI over three years ago, forty-four gardens that had not conducted an SROI, and thirteen that did not know if a SROI had been conducted (n = 60). Mostly gardens with large budgets (fourteen of nineteen) collected water conservation information ($\chi^2 = 8.4065$, $p = 0.015$, Fisher's exact = 0.013). Eight gardens with large budgets and one with a small budget (n = 60) conducted a Lifecycle Cost Analysis ($\chi^2 = 7.6799$, $p = 0.021$, Fisher's exact = 0.028). Eleven gardens with small budgets and five with large budgets did not collect any economic information ($\chi^2 = 9.6497$, $p = 0.008$, Fisher's exact = 0.007). Twenty-three gardens with large budgets and ten with small budgets (n = 61) used paid advertising as a marketing strategy ($\chi^2 = 7.9919$, $p = 0.018$, Fisher's exact = 0.022).

Refer to Table F-2 for the remainder of significant relationships found after the analysis.

## Discussion

In response to interest in public gardens conducting impact assessments, a state of the industry survey of public gardens was conducted in partnership with the APGA to ascertain the incidences and frequencies of environmental, social, and economic impact assessments. As reported by others (Borsch & Lohne, 2014; Drucker, 1990; Primack & Miller-Rushing, 2009; Smith & Harvey-Brown, 2018), the survey revealed that most public gardens, as with most nonprofit organizations, do not conduct any impact assessments, and a quarter to over one-third do not collect any information about environmental, social, or economic practices. Overall, public gardens are collecting key metrics, but they are not measuring impact, which agrees with the studies by Smith and Harvey-Brown (2018) and Sawhill and Williamson (2001). However, more gardens are planning to collect environmental information in the future compared to those planning to collect social and economic information.

The size of the budget was not a factor in whether or not a garden conducted impact assessments, indicating that any garden, regardless of budget size, can conduct them. Nevertheless, gardens with larger budgets generally have more visitors, more employees, and more volunteers than those with smaller budgets which enables them to deliver more educational programming, special events, benefits for employees, promotional campaigns, garden maintenance and plant collection maintenance, and several other activities and benefits that smaller gardens cannot provide as well as afford the cost of impact assessments conducted by third-parties. For those gardens where assessments were completed, environmental impact assessments had not been conducted within the last three years suggesting that this type of assessment may be viewed as a one-time process as observed by Vanclay and Bronstein (1995). Social and economic impact assessments, however, had been conducted more recently within the last three years. Since the fewest gardens conducted social impact assessments, the results seem to confirm the study by Wood and Leighton (2010) that organizations do not value the importance of quantifying and measuring social impact, or it is possible that administrators do not know how to conduct them.

More gardens had conducted economic impact assessments than environmental and social impact assessments, possibly due to economic information being more readily available and less difficult to analyze. For gardens conducting impact assessments, support from the board of directors was mixed with economic impact assessments, potentially attributed to more board members having business backgrounds and disagreeing with the results. According to Streatfield and Markless (2009), evidence-based decision making may not always be accepted by everyone. Support from the board of directors was strong for gardens conducting environmental and/or social impact assessments.

In addition to broad support from the board of directors, strengths of public gardens lie in educational programming, community support, high quality visitor experiences, and relevance. These results are related to the report by Smith and Harvey-Brown (2017) which stated that public gardens excel at plant conservation, scientific research, horticultural expertise, public engagement, education, sustainability (environmental efforts), and business management. The same study also reported that 87% of the gardens in their survey measure number of visitors, 57% visitor satisfaction, and 51% visitor attitude or behavioral changes. This compares to 97% measure number of visitors, 51% visitor satisfaction, and 14% visitor attitude or behavioral changes in this study.

Public gardens employ several methods for promoting the gardens. The internet was the most used method. Statistics tracking and gauging visitor responses about internet use related to the garden are recommended for evaluating the effectiveness of this promotional medium. Mass media, social media, and printed and nonprinted materials offer a blend of traditional and nontraditional promotional methods. Social media and internet continue to rank high as promotional methods, which can be attributed to lower costs for marketing, the ability to reach a greater number of people, and the reduction or elimination of printed materials. Public service announcements were the least used promotional method, possibly related to the randomness when the announcements are made and the lack of effective target marketing efforts. Concerning challenges, garden administrators listed their top concerns, besides funding, as increasing attendance numbers, improving infrastructure, and increasing membership. Interestingly, increasing audience diversity and mission directive were not mentioned as challenges as they were in a survey conducted by Burgner et al. (2015), even though that has been a high priority of the APGA (2019). Surprisingly, the smallest age group that attended gardens were over 70 years of age. The age groups less than 18 years of age and 18 to 34 years were also not as prevalent at attending gardens. This may be a result of the persistent perception that public gardens are only for the elite, older, middle class people (Williams et al, 2015). Conducting impact assessments may reveal gaps to address reasons why these groups are not attending in greater numbers and to offer programs that would attract those groups. Utilizing social media and the internet targeted at the younger age groups have been shown to factor into attracting these groups to venues such as public gardens (Barton, 2017), especially with the implementation of mobile application tools and augmented reality programs to supplement the visitor experience at public gardens.

Since most public gardens were located in urban areas, in agreement with Smith and Harvey-Brown (2018), and had access to public transportation, partnering with public transportation authorities could be a method to increase attendance numbers and memberships and reduce infrastructure issues related to parking. Research conducted by the American Public Transportation Association (Clark, 2017) indicated that 87% of trips using public transportation have a direct impact on the local economy, and 51% of the riders use public transportation for purposes other than work, such as shopping, recreational purposes, and other uses. Public gardens could utilize day passes in conjunction with a transit pass medium to pay fares, enabling more convenient access to the gardens.

## Conclusion

Impact assessments demonstrate the effectiveness of programs through evaluation. Accountability and transparency are increased so that the perceptions of ineffectiveness and inefficiency are reduced (Liket & Maas, 2015). With decreasing costs to conduct impact assessments, data collection is easier to collect, store, and analyze (Gugerty & Karlan, 2018). Cause-and-effect relationships of program evaluations can be determined to ideally support the continuance of key change programs, or the evaluation will allow modifications to programs to enhance outcomes and impact (Tschirhart & Bielefeld, 2012)

However, it should be noted that impact assessments need not be conducted for the sake of conducting them. Poor impact assessments could provide misleading or incorrect information which would lead to improper decision-making by administrators (Gugerty & Karlan, 2018). Additionally, impact assessments should not be conducted for justifying the advocacy of certain issues (Streatfield & Markless, 2009). Positive and negative aspects of the evaluations need to be considered so that proper program adjustments can be based upon true assessments. Gugerty & Karlan (2018) recommend using the principles of the CART method to conduct proper impact assessments:

- **C**redible: The evaluation should be reliable, valid, and appropriately analyzed; understand when measurements of impact need to occur
- **A**ctionable: Collect only data that will be used
- **R**esponsible: The benefits of collecting the data should outweigh the costs of conducting the assessments
- **T**ransportable: Collect data that generates knowledge to be used for other programs as well, especially to other public gardens

This study provides a baseline for future research about environmental, social, and economic impact assessments in public gardens. More information needs to be collected about why public gardens are not conducting impact assessments, would they conduct more impact assessments if staff were trained to use valuation tools that measure these aspects, and what other barriers exist for impact assessments. Reasons younger people are not attending public gardens needs to be researched to determine what measures need to be taken to increase their attendance numbers. Information gleaned from the following questions adapted from the Association of Zoos and Aquariums (Falk et al., 2007) would be also be valuable in determining the impact of public gardens:

- How do gardens contribute to people’s understanding and perceptions of plants and their conservation?
- How do gardens contribute to people’s personal and emotional connections to nature and its conservation?
- How do gardens contribute to the ways people act and behave toward nature?
- How do gardens increase these impacts? What do gardens do that is successful?
- Who are the gardens’ visitors?

With appropriate impact assessments, public gardens can develop stronger evidence-based information for donors and other financial providers (Donovan, 2013) Based upon their understanding of environmental issues and their extensive plant collections, public gardens have a great opportunity to provide leadership in climate change research and education and enhance their role in sustainable development and plant conservation (Borsch & Lohne, 2014; Primack & Miller-Rushing, 2009).

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# AN ANALYSIS OF ENVIRONMENTAL, SOCIAL, AND ECONOMIC DECISION-SUPPORT TOOLS: A MULTIPLE-CASE STUDY OF SIX PARKS OF THE CITY OF COLLEGE STATION, TEXAS, US

One of the issues with which public garden administrators and park directors struggle is the justification for budget allocations to urban green spaces (Crompton, 2007, 2009; Harnik & Crompton, 2014; Schmolke et al., 2010). Elected officials and members of the boards of directors often desire evidence-based information to make decisions for fund appropriations (Crompton, 2007). Urban green spaces frequently are viewed as costly investments based strictly upon the capital outlay required to create new spaces (Crompton, 2001). Municipality and nonprofit leaders tend to focus only on economic measures, failing to account for the environmental and social benefits of urban green spaces (Crompton, 2001). Urban green spaces are mistakenly perceived as invisible assets which diminishes their importance and results in these spaces being undervalued and overlooked (Harnik & Crompton, 2014). However, decision-makers can promote green space value to communities by utilizing decision-support tools that can assist with realizing and understanding their benefits and impacts (Christie et al., 2012; Schmolke et al., 2010; Singh et al., 2012). Decision-support tool assessments enable the recognition of urban green spaces as visible assets by framing them in economic terms, and they provide a starting point for quantifying the financial value of physical assets (Harnik & Crompton, 2014).

Crompton (2009) urged employing techniques that demonstrate the benefits of public green spaces, even for those who may not use the spaces, by increasing awareness of off-site benefits to receive additional financial resources. Decision-support tools would more likely garner allocation of resources by demonstrating how urban green spaces meet one of three public benefits, similar to those stated by Young (2004), that are typically supported by a community: 1) economic development; 2) alleviating social issues; or 3) environmental stewardship (Crompton, 2009). Urban green spaces enhance economic development by attracting tourists, businesses, and retirees to the area, increasing sales of recreational equipment, and contributing to proximate real estate values which lead to increased tax revenue (Crompton, 2001). Urban green spaces are important for incidental spending in the community surrounding the public area which impacts economic revenue from increased sales and accommodation taxes to the government, individual businesses which provide the incidental services, and, ultimately, the community due to the influx of more money in the economy (Harnik & Crompton, 2014). Social issues can be alleviated by preventing deviant behavior among youth, promoting healthy lifestyles, reducing psychological and physiological environmental stress, and offsetting less-than-ideal working conditions for those who may be un- or underemployed by providing environments of leisure (Crompton, 2009). The third public benefit, environmental stewardship, can be realized through historic preservation, preserving the natural environment, stormwater runoff retention and other green infrastructure systems, and reduction in energy usage and costs attributed to trees and other plants (Crompton, 2009; Harnik & Crompton, 2014).

Young (2004) stated that urban green spaces were originally established as a public amenity based on four social ideals: democratic equality; social coherence; public health; and economic value. Democratic equality can be achieved by providing healthy recreational activities and eliminating class barriers by promoting public interaction and well-being. Social cohesion and local pride are strengthened in the community to provide social coherence. Public spaces provide fresh air, improving air quality and public health. Lastly, urban green spaces increase economic value by providing places to relax, recuperate, and rejuvenate for those who work, attracting tourists and others from outside the local vicinity of the green spaces, and increase the proximate values of property closer to the green spaces (Crompton, 2007; Young, 2004).

Based upon the ideals set forth by Crompton (2009) and Young (2004), case studies of six parks located in College Station, TX, were conducted to assess decision-support tools that measured environmental, social, and economic benefits of urban green spaces to determine an economic value for the parks. The research questions evaluated in the case studies were:

1) How do valuation tools perform in analyzing public horticultural spaces?
2) How fully are environmental, social, and economic benefits and impacts assessed?

The objectives of the case studies were to:

1) determine an economic value of environmental and social benefits provided by the parks;
2) determine the amount of time required to understand and implement the decision-support tools;
3) determine the skillset and level of knowledge required for the decision-support tools;
4) determine the quantifiability, credibility, replicability, flexibility, and affordability of the decision-support tools; and
5) provide recommendations for the use of decision-support tools

## Case Study Method

The multiple-case study method can be used to predict similar results via literal replication, and it is considered a robust and reliable research method (Baxter & Jack, 2008; Rowley, 2002; Zucker, 2009). This method also utilizes a deductive approach which provides a firmer foundation for validity and structuring data collection and analysis (Baxter & Jack, 2008). Rowley (2002) listed four tests to establish the quality of this type of research:

1) Construct validity – establishing correct measures, reducing subjectivity, and linking the data collection questions to research questions and propositions;
2) Internal validity – during the data analysis, understanding underlying relationships that lead to other situations;
3) External validity – determining the generalizability of the study based on replication logic during the research design and data collection phases; and
4) Reliability – establishing that the data collection can be replicated with the same results which can be achieved through meticulous documentation of records and procedures used.

Five components are necessary to ensure effective case study research design: 1) Research questions; 2) research propositions; 3) unit of analysis; 4) linking the data to the propositions; and 5) establishing the criteria for interpreting the findings (Miles & Huberman, 1994; Rowley; 2002; Yin, 2009). Zucker (2009) recommended that a similar protocol to guide the methodology be used in case study research:

- The purpose and rationale for the study should be clearly stated to establish significance and ensure appropriate research questions are developed.

- The case study should be designed based on the unit of analysis and research purpose.
- Data collection techniques that should be utilized include field methods, mapping major concepts, transcribing notes and interviews, building typologies, and checking the case study participants regularly.
- Describe the case study in full detail.
- The analysis should be focused on ideas that are associated with the purpose and unit of analysis of the case studies.
- The results should be analyzed based on the rationale, purpose, and research questions from disciplinary and case perspectives, comparisons across cases, and narratives from the case studies.
- The rigor of the methodology should establish transferability, credibility, dependability, and confirmability.

Concerning research questions, the case study approach is useful when research studies seek to answer “how” and “why” questions and to examine the contextual settings relevant to the objective of the case study participant (Baxter & Jack, 2008; Rowley, 2002; Stake, 1995; Yin, 2009). The types of case studies are closely linked to the types of research questions being asked. Stake (2006) and Yin (2009) list six different types of case studies: 1) explanatory; 2) exploratory; 3) descriptive; 4) intrinsic; 5) instrumental; and 6) collective. An explanatory case study attempts to establish links to real-life interventions. Second, an exploratory case study does not have any clear, single set of outcomes yet defined. The third type of case study, descriptive, attempts to illustrate the object being studied in real-life context. An intrinsic case study is a situation where the primary focus or interest lies in the subject itself; not necessarily the research questions being asked. The instrumental case study seeks to facilitate the understanding of an idea, program, or other object of focus; thus, providing a better insight into how valuation tools work. Lastly, the collective case study provides a set of research questions that guide each individual study of the case, but are usually for one location (i.e., multiple studies being conducted at one site).

## Materials and Methods

Prior to conducting the case studies for this research, the decision-support tools for ecosystem services that assess environmental, social, and economic impacts were inventoried using resources such as the United States Environmental Protection Agency search tool GIWiz (United States Environmental Protection Agency, 2016), the Sustainability Toolkit of the American Society of Landscape Architects (American Society of Landscape Architects, 2016), and the Landscape Performance Series Benefits Toolkit (Landscape Architecture Foundation, 2016) (Appendix A). A survey of valuation tools based upon evaluative criteria (Table 3.1) provides a brief description of each tool, similar to the methods described by Bagstad, Semmens, Waage, & Winthrop (2013) and Harrison et al. (2017). The valuation tools were chosen according to the methods described by Bagstad, Semmens, Waage, & Winthrop (2013) that assess, value, quantify, model, and/or map ecosystem services and that provide assessments that are quantifiable, credible, flexible, replicable, and affordable. Although the primary goal of this research is to provide guidelines and recommendations relevant for public gardens, they could also be relevant to municipalities and other organizations such as small businesses, nonprofit organizations, or other entities.

Table 3.1. Description of eighty-two decision-support tools against key evaluative criteria in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **Accelerator Lite** | Qualitative | Medium | Yes | Fully developed and documented | N/A | High | No valuation component | Mostly used for training in sustainable development programs |
| **Accelerator Pro** | Qualitative | N/A | Yes | Fully developed and documented | N/A | High | No valuation component | Mostly used for training in sustainable development programs; consultative support provided by developer for a fee |
| **Aquatox v3.1** | Quantitative, uncertainty through varying inputs | N/A | Yes | Fully developed and documented | Watershed scale | High | Biophysical values, can be monetized | Extensive knowledge of aquatic ecosystems required |
| **Automated Geospatial Watershed Assessment (AGWA)** | Qualitative & quantitative | N/A | Yes, assuming user has access to ArcGIS | Fully developed and documented | Watershed scale | High | Biophysical values, can be monetized | Designed for use by experts in hydrology |
| **AVoided Emissions and GeneRation Tool (AVERT)** | Quantitative | Medium | Yes | Fully developed and documented | Landscape scale | Place-specific | Biophysical values, can be monetized | Available as web-based tool or downloadable spreadsheet |
| **Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) v4.1** | Qualitative & quantitative | N/A | Yes | Fully developed and documented | Watershed scale | Place-specific | Biophysical values, can be monetized | Can be used in conjunction with Aquatox, SWMM, WASP, and other EPA tools |
| **Bicycle Level of Service (BLOS) and Pedestrian Level of Service (PLOS)** | Qualitative | Low | Yes, online | Fully developed and documented | Site scale | Place-specific | No valuation component | Web-based tool; more appropriate for roadways instead of parks and trails |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **Bikeability Checklist** | Qualitative | Medium | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Downloadable questionnaire |
| **Bioaccumulation and Aquatic System Simulator (BASS)** | Quantitative, uncertainty through varying inputs | N/A | Yes | Fully developed and documented | Watershed scale | High | Biophysical values, can be monetized | Uses FORTRAN simulation |
| **Building for Environmental and Economic Sustainability (BEES)** | Quantitative | Low | Yes, online | Fully developed and documented | Site scale | Place-specific | Biophysical values, can be monetized | Available as web-based tool or downloadable spreadsheet using lifecycle assessment |
| **Carbon Footprint Calculator** | Qualitative & quantitative | Low | Yes, online | Documentation unavailable | Site scale | Place-specific | Biophysical values, can be monetized | Available as web-based tool or downloadable spreadsheet |
| **ClearPath** | Qualitative & quantitative | N/A | Yes, online | Documentation unavailable | Site scale | Place-specific | Unknown | Only for member municipalities |
| **CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool** | Quantitative | Low | Yes | Fully developed and documented | Multiple scales | High | Biophysical values, can be monetized | Serves as preliminary screening tool to identify scenarios that warrant further study |
| **COMET-Farm** | Qualitative & quantitative | Medium | Yes, online | Fully developed and partially documented | Site scale | Place-specific | Biophysical values, can be monetized | Can be used with COMET-Energy and COMET-Planner tools |
| **COMET-Energy Tool** | Qualitative & quantitative | Medium | Yes, online | Fully developed and partially documented | Site scale | Place-specific | Biophysical values, can be monetized | Can be used with COMET-Farm and COMET-Planner tools |
| **COMET-Planner Tool** | Qualitative & quantitative | Medium | Yes, online | Fully developed and partially documented | Site scale | Place-specific | Biophysical values, can be monetized | Can be used with COMET-Farm and COMET-Energy tools; under revision at the time of this study |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **Community Multi-scale Air Quality (CMAQ) Modeling System v5.2.1** | Qualitative & quantitative | N/A | Yes | Fully developed and documented | Multiple scales | High | Unknown | Requires Linux operating system and FORTRAN |
| **Construction Carbon Calculator** | Quantitative | Low | Yes, online | Fully developed and documented | Site scale | Place-specific | Biophysical values, can be monetized | Provides general estimate within +/-25% |
| **Decking Cost Calculator** | Quantitative | Low | Yes | Documentation unavailable | Site scale | Place-specific | No valuation component | Downloadable spreadsheet; monetary values have to be converted to current year; archived EPA tool |
| **Ecological Footprint Calculator** | Qualitative | Low | Yes, online | Documentation unavailable | Site scale | Place-specific | No valuation component | Very general estimates of individual impact upon the environment; not recommended for scientific use |
| **Electronics Environmental Benefits Calculator (EEBC) v4** | Qualitative & quantitative | Low | Yes, online | Documentation unavailable | Site scale | Place-specific | Biophysical values, can be monetized | Equivalency table included |
| **Energy Star Cash Flow Opportunity Calculator** | Quantitative | Low | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Downloadable spreadsheet |
| **EnergyPlus v8.9.0** | Quantitative, uncertainty through varying inputs | Medium | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Capable of being used on multiple operating systems |
| **EnviroCalculator** | Qualitative & quantitative | Low | Yes, online | Documentation unavailable | Site scale | Place-specific | Biophysical values, can be monetized | Equivalency table included |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **Environmental Assessment of Public Recreation Spaces (EAPRS) Tool** | Quantitative | High | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Downloadable questionnaire; guidebook and photos guide provided for rating observations; very time-consuming, but thorough |
| **Environmental Benefits Calculator** | Quantitative | Low | Yes, online | Fully developed and partially documented | Site scale | Place-specific | Biophysical values, can be monetized | Tool for estimating energy savings by converting from traditional materials to those made from biological materials |
| **Environmental Benefits Calculator (NEWMOA)** | Quantitative | Low | Yes, online | Fully developed and documented | Site scale | Place-specific | Biophysical values, can be monetized | Geared for the hotel industry, but provides useful information that any organization could utilize related to sustainable practices in offices |
| **Forest Vegetation Simulator** | Quantitative | Medium | Yes | Fully developed and documented | Landscape scale | Medium | No valuation component | Several extensions are available to simulate different ecological scenarios |
| **Green Cleaning Pollution Prevention Calculator** | Qualitative & quantitative | Low | Yes, online | Fully developed and documented | Site scale | Place-specific | Biophysical values, can be monetized | Results can be downloaded to spreadsheet |
| **Green Infrastructure Flexible Model (GIFMod)** | Quantitative, uncertainty through random variation | N/A | Yes | Fully developed and documented | Site to landscape scale | Medium | Biophysical values, can be monetized | Unable to test since it only worked on older Windows operating system and would not convert to the newer version Windows; currently unable to operate in Mac-OS |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **Green Roof Energy Calculator (v. 2.0)** | Quantitative | Low | Yes, online | Fully developed and documented | Site scale | Place-specific | Biophysical values, can be monetized | Utility values used in the calculations are from 2010; only major cities of each state are available for selection to run scenarios |
| **Green Values Stormwater Management Calculator** | Quantitative | Medium | Yes, online | Fully developed and documented | Site scale | Place-specific | Biophysical values, can be monetized | Some limitations to size of site and number of trees making the tool inaccurate for larger sites |
| **Greenhouse Gas Equivalencies Calculator** | Qualitative & quantitative | Low | Yes, online | Fully developed and documented | Site scale | Place-specific | Biophysical values, can be monetized | Equivalency table included |
| **Home Heating Cost Calculator** | Quantitative | Low | Yes | Fully developed and partially documented | Site scale | Place-specific | No valuation component | Available as web-based tool or downloadable spreadsheet; primarily for Maine, but provides comparison of different heating costs methods |
| **Housing and Transportation Affordability Index** | Quantitative | Low | Yes, online | Fully developed and documented | Multiple scales | Low | Biophysical values, can be monetized | Output provides overview of location efficiency and affordability conditions |
| **Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) v3.4.4** | Quantitative, uncertainty through varying inputs | High | Yes | Fully developed and documented | Watershed or landscape scale | High | Biophysical values, can be monetized | Available as web-based tool or downloadable software; requires GIS skills; extensive knowledge required |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **i-Tree** | Quantitative | Medium to high | Yes | Fully developed and documented | Multiple scales | High | Biophysical values, can be monetized | Provides a suite of tools that assess various landscape, hydrological, and ecological scenarios |
| **Landuse Evolution and Impact Assessment Model (LEAM)** | Quantitative, uncertainty through varying inputs | N/A | Yes | Fully developed and partially documented | Landscape scale | Medium | No valuation component | Mainly for municipalities for understanding projections of potential development |
| **Lifecycle Cost Analysis (LCCA)** | Quantitative, uncertainty through sensitivity analysis or breakeven analysis | Medium | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Generally does not account for environmental costs |
| **Local Greenhouse Gas Inventory Tool** | Quantitative | Medium | Yes | Fully developed and documented | Site scale | Low | Biophysical values, can be monetized | Downloadable spreadsheet; primarily for communities and local government entities |
| **Long-term Hydrologic Impact Analysis Tool (L-THIA)** | Quantitative, uncertainty through Monte Carlo sampling of random values | Low | Yes, online | Fully developed and documented | Site scale | Low | Biophysical values, can be monetized | Provides printable results of scenarios; very few cities from which to select to test different green infrastructure and low impact development technologies |
| **Low Impact Development Rapid Assessment (LIDRA) Model v2** | Quantitative | Medium | Yes, online | Fully developed and documented | Landscape scale | Medium | Biophysical values, can be monetized | Limited selection of climate data locations |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **Managing and Transforming Waste Streams Tool** | Qualitative | Medium | Yes | Fully developed and documented | Site scale | High | No valuation component | Available as web-based tool or downloadable spreadsheet; primarily for municipalities and communities |
| **Microscale Audit of Pedestrian Streetscapes (MAPS)** | Qualitative | High | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Downloadable questionnaire |
| **My Environment** | Qualitative & quantitative | Low | Yes, online | Fully developed and documented | Landscape scale | Low | No valuation component | Will not provide results if scale is too small |
| **National Stormwater Calculator** | Qualitative & quantitative | Low | Yes | Fully developed and documented | Site to landscape scale | Medium | Biophysical values, can be monetized | Available as web-based tool or downloadable spreadsheet |
| **National Tree Benefit Calculator** | Quantitative | Low | Yes, online | Fully developed and documented | Site scale | Medium | Biophysical values, can be monetized | Powered by i-Tree tools; limited to one tree per calculation |
| **Neighborhood Quality of Life Survey (NQLS)** | Qualitative | High | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Downloadable questionnaire |
| **Office Emissions Calculator** | Quantitative | Low | Yes, online | Documentation unavailable | Site scale | Place-specific | Biophysical values, can be monetized | Provides method to offset carbon footprint costs |
| **Paper Calculator** | Quantitative | Low | Yes, online | Fully developed and documented | Site scale | Medium | Biophysical values, can be monetized | Uses lifecycle cost assessment methodology |
| **Parks and Recreation Areas Self-Report Survey** | Qualitative | Medium | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Downloadable questionnaire |
| **Pedestrian Environmental Quality Index Tool (PEQI) v2.0** | Qualitative | Medium | Yes | Fully developed and documented | Site scale | Plase-specific | No valuation component | Downloadable questionnaire |
| **Prove It! Measuring the Effect of Neighborhood Renewal** | Qualitative | N/A | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Questions are missing in manual to include in survey |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **PV Watts Calculator** | Quantitative | Low | Yes, online | Fully developed and partially documented | Site scale | Place-specific | Biophysical values, can be monetized | Measures electricity produced by photovoltaic solar systems |
| **Rainwater Harvesting Supply Calculator** | Quantitative | Low | Yes | Fully developed and documented | Site scale | Place-specific | Biophysical values, can be monetized | Downloadable spreadsheet |
| **Recycled Content (ReCon) Tool** | Quantitative | Medium | Yes, online | Fully developed and partially documented | Site scale | Medium | Biophysical values, can be monetized | Archived EPA tool last updated 2010; values have to be converted to current year |
| **Recycling and Reusing Landscape Waste Cost Calculator** | Quantitative | Low | Yes | Documentation unavailable | Site scale | Place-specific | No valuation component | Downloadable spreadsheet; monetary values have to be converted to current year; archived EPA tool |
| **Regency Lighting Energy Savings Calculator** | Quantitative | Low | Yes, online | Fully developed, documentation unavailable | Site scale | Place-specific | Biophysical values, can be monetized | Provides energy cost savings projection of upgrading to energy-efficient lighting |
| **Residential Environment Assessment Tool (REAT) v2.0** | Qualitative | High | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Available as web-based tool or downloadable questionnaire |
| **Resource Conserving Landscaping Cost Calculator** | Quantitative | Low | Yes | Documentation unavailable | Site scale | Place-specific | No valuation component | Downloadable spreadsheet; monetary values have to be converted to current year; archived EPA tool |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **Resource Stewardship Evaluation** | Qualitative & quantitative | N/A | Yes | Documentation unavailable | Site scale | Place-specific | Unknown | Only Natural Resources Conservation Services can conduct the evaluation |
| **Social Impact Measurement Toolkit** | Qualitative | N/A | Yes | Documented | Site scale | Place-specific | Unknown | Spreadsheet-based tool is being upgraded and unavailable to new customers |
| **Social Return on Investment (SROI)** | Qualitative | Medium to high | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Downloadable spreadsheet |
| **Social Value Self-Assessment Tool** | Qualitative | Low | Yes, online | Fully developed and documented | Site scale | Place-specific | No valuation component | Questionnaire producing strengths and areas needing improvement in social value issues; individual accounts are free, but portfolio accounts with more technical support provided for a fee |
| **SPAW (Soil-Plant-Air-Water) Model** | Quantitative | N/A | Yes, online | Fully developed and documented | Watershed or landscape scale | High | Biophysical values, can be monetized | Extensive knowledge of hydrology required |
| **STAR Community Rating System (STAR)** | Qualitative | High | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Merged with US Green Building Council in 2018; enables communities to be certified as sustainable, livable communities |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **Storm Water Management Model v5.1.013** | Quantitative, uncertainty through varying inputs | Medium | Yes | Fully developed and documented | Watershed scale | Medium | Biophysical values, can be monetized | Knowledge of hydraulics and hydrology required; approved for National Flood Insurance Program studies |
| **Sustainable Facilities Cost-Effective Upgrades Tool** | Quantitative | Low | Yes, online | Fully developed and documented | Site scale | Medium | Biophysical values, can be monetized | Provides rough estimates of building upgrades, but does not replace thorough evaluation with engineers and other professionals |
| **System for Observing Physical Activity and Recreation in Natural Areas (SOPARNA)** | Qualitative | Medium to high | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Downloadable questionnaire |
| **The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits** | Qualitative & quantitative | High | Yes | Fully developed and documented | Site scale | Place-specific | Biophysical values, can be monetized | Extensive time requirement if every tool and calculation was utilized at one time |
| **Universal Floristic Quality Assessment (FQA) Calculator** | Quantitative | Medium to high | Yes, online | Fully developed and documented | Site to landscape scale | Place-specific | No valuation component | Downloadable forms for completing ecological integrity assessments in the field or can be completed online; provides information on the occurrence and abundance of plant species |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **Vegetable Garden Value Calculator** | Quantitative | Low | Yes, online | Documentation unavailable | Site scale | Place-specific | No valuation component | Available as web-based tool or downloadable spreadsheet which still requires internet access; primarily for small operations |
| **Visualizing Ecosystem Land Management Assessments (VELMA) Model v2.0** | Quantitative | Medium | Yes | Fully developed and documented | Watershed scale | High | Biophysical values, can be monetized | Used to compare scenarios of water quality using green infrastructure |
| **Volunteering Impact Assessment Toolkit** | Qualitative | N/A | Yes | Documentation unavailable | Site scale | Place-specific | No valuation component | Purchase required to access toolkit |
| **Walk Score** | Qualitative | Low | Yes | Fully developed and partially documented | Site scale | Place-specific | No valuation component | Also provides Transit Score, Bike Score, Crime Grade, and City & Neighborhood rankings |
| **Walk Score Professional** | Qualitative | N/A | Yes | Fully developed and partially documented | Site scale | Place-specific | No valuation component | Provides same information as Walk Score except it also provides subscription service to track data over time |
| **Walkability Checklist** | Qualitative | Medium | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Downloadable questionnaire |
| **Waste Reduction Model (WARM) v14** | Quantitative | Medium to high | Yes | Fully developed and documented | Site scale | Medium | Biophysical values, can be monetized | Available as web-based tool or downloadable spreadsheet |

Table 3.1 Continued.

| Tool | Quantifiable, approach to uncertainty | Time requirements | Capacity for independent application | Level of development & documentation | Scalability | Generalizability | Nonmonetary & cultural perspectives | Other Insights |
|---|---|---|---|---|---|---|---|---|
| **Water Harvesting Calculator** | Quantitative | Medium | Yes | Fully developed and documented | Site scale | Place-specific | Biophysical values, can be monetized | Downloadable spreadsheet: created for the state of Washington, but applicable to any area by inputting local precipitation values |
| **Water Quality Analysis Simulation Program (WASP)** | Quantitative | Medium to high | Yes | Fully developed and documented | Watershed scale | High | Biophysical values, can be monetized | Can run on Windows, Mac OSX, and Linux operating systems |
| **WaterSense Water Budget Tool** | Quantitative | Low | Yes | Fully developed and documented | Site scale | Place-specific | No valuation component | Downloadable spreadsheet; archived EPA tool |
| **Watershed Management Optimization Support Tool (WMOST) v3.0** | Quantitative | Medium to high | Yes | Fully developed and documented | Watershed scale | High | Biophysical values, can be monetized | Downloadable spreadsheet |

These tools were evaluated based upon the following evaluative criteria established by Bagstad, Semmens, Waage, & Winthrop (2013) (Table 3.1):

1) *Quantification and uncertainty*. Valuation tools were assessed as to whether outputs measured ecosystem service tradeoffs (quantitative) or were better for initial screenings and coarse-ranking processes (qualitative). The tools were also evaluated as to whether they estimated uncertainty which can indicate the level of confidence of the values generated by the tools.

2) *Time requirements.* This criterion was determined by the amount of time required for the user to learn how to use and apply the tool. The more time required for using the tool, the less practical for widespread use of the tool (Table 3.2).

3) *Capacity for independent application.* Some tools were open source, free access while others required purchasing a software license or contracting with academic or consulting groups to utilize the tool.

4) *Level of development and documentation*. Tools were assessed on reliability, replicability, credibility, and documentation of their methods, algorithms, strengths, and limitations.

5) *Scalability.* Some tools may be applied to various spatial scales. Tools were evaluated based upon if they may be applied across multiple scales, making them more attractive to decision-makers by having to learn fewer tools, or if they are more applicable at certain scales, requiring the use of multiple tools for multi-scale assessments.

6) *Generalizability.* Tools may be place-specific, accounting for more localized situations and less generalizable, or broadly generalizable, being more transferable to other settings, but possibly sacrificing detail that can be attained in place-specific tools.

7) *Nonmonetary and cultural perspectives.* Tools were evaluated as to whether they assess cultural perspectives, such as spiritual and cultural values, and multiple valuation systems, including monetary and nonmonetary values.

8) *Other insights.* Tools are more desirable if they can provide additional information that leads to greater cost-effectiveness with existing management and planning protocols.

Table 3.2. Estimated time to complete assessments for thirty-three decision-support tools in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

| **Tool evaluated** | **Estimated person-hours per location** | | **Information provided** | **Additional Comments** |
|---|---|---|---|---|
| | **Pilot study** | **With data archive** | | |
| **Accelerator Lite**[a] | 10.0-15.0 | 2.0-3.0 | Manuals about each module and PowerPoint presentations explaining the concepts of the Accelerator program | Length of time to study the program manuals and prepare training materials will vary; once the initial training program has been developed, the amount of time to prepare the materials will decrease |
| **AVoided Emissions and GeneRation Tool (AVERT)** | 1.0 | 0.5 | Spatially explicit outputs | If required data is readily available, time could be reduced |
| **Bicycle Level of Service (BLOS) and Pedestrian Level of Service (PLOS)** | 0.5 | 0.5 | Qualitative outputs | Very easy to use, but knowledge of roadway measurements required |
| **Bikeability Checklist** | 1.5 | 1.5 | Qualitative review | Time required for field data collection |
| **Carbon Footprint Calculator**[a] | 0.5 | 0.5 | Qualitative and quantitative outputs | Minimal time requirement |
| **COMET-Farm** | 2.0-3.0 | 1.0-1.5 | Spatially explicit outputs | Data collection and understanding how the tool operates consumes greatest amount of time |
| **COMET-Energy Tool** | 0.5 | 0.5 | Quantitative outputs | Minimal time requirement if data is available |
| **COMET-Planner Tool** | 0.5 | 0.5 | Quantitative outputs | Minimal time requirement |
| **Construction Carbon Calculator** | 1.0-1.5 | 1.0 | Quantitative outputs | Information collection about building structure size and composition consume greatest amount of time |
| **Decking Cost Calculator** | 1.0-1.5 | 2.0 | Quantitative outputs | Economic information needed about current decking materials to keep calculator up-to-date since the tool is no longer updated by the EPA |
| **Ecological Footprint Calculator** | 0.5 | 0.5 | Qualitative and quantitative outputs | Minimal time requirement |

[a] Tool was initially evaluated by the Scholars Program team, but was not included in the case studies due to being deemed inappropriate for purposes of the case studies.

Table 3.2 Continued.

| **Tool evaluated** | **Estimated person-hours per location** | | **Information provided** | **Additional Comments** |
|---|---|---|---|---|
| | **Pilot study** | **With data archive** | | |
| **Green Roof Energy Calculator (v. 2.0)**[a] | 1-1.5 | 0.5-1.0 | Spatially explicit outputs | Extensive information about roof characteristics require more time to understand what inputs are needed for the tool |
| **Green Values Stormwater Management Calculator** | 2.0-3.0 | 1.0-2.0 | Spatially explicit outputs | Extensive information about site conditions required for inputs, and extensive outputs provided requiring a greater amount of time to study and understand; more time required to study different scenario combinations and selections |
| **Greenhouse Gas Equivalencies Calculator** | 1.0 | 0.5 | Qualitative and quantitative outputs | Collection of data consumes most of time requirement; use of tool is quick and easy |
| **Home Heating Cost Calculator**[a] | 0.5 | 0.5 | Quantitative outputs | Minimal time requirement |
| **Housing and Transportation Affordability Index** | 0.5 | 0.5 | Quantitative outputs | Minimal time requirement; data retrieved via input of an address; extensive demographic characteristics provided consuming the most amount of time to study |
| **i-Tree** | 1.0-2.0 | 1.0 | Spatially explicit outputs | Most of time consumed by inputting site characteristics data; otherwise, simple and easy to use |
| **Low Impact Development Rapid Assessment (LIDRA) Model v2** | 1.0 | 0.5-1.0 | Spatially explicit outputs | Time requirement for data collection |
| **Managing and Transforming Waste Streams Tool** | 0.5 | 0.5 | Qualitative review | Most of time consumed involves understanding the different policies recommended based upon the user's selections |
| **MyEnvironment** | 0.5 | 0.5 | Spatially explicit outputs | Very simple to use by inputting an address |
| **National Stormwater Calculator** | 1.0-1.5 | 0.5-1.0 | Spatially explicit outputs | Extensive time requirement for gathering and inputting data, but can be reduced with a system for collecting the data for future assessments |
| **National Tree Benefit Calculator** | 0.5 | 0.5 | Spatially explicit outputs | Very easy to use with drop-down menus; time required to convert to multiple trees since the tool provides data for only a single tree |
| **Office Emissions Calculator** | 0.5 | 0.5 | Spatially explicit outputs | Requires having employment and fleet data, but quick and easy to use |
| **Parks and Recreation Areas Self-Report Survey** | 1.5-2.0 | 1.5-2.0 | Qualitative review | Time required for field data collection |
| **PV Watts Calculator** | 0.5 | 0.5 | Quantitative outputs | Most of time consumed involves understanding the terminology, but very easy to use |
| **Rainwater Harvesting Supply Calculator** | 0.5 | 0.5 | Quantitative outputs | Minimal time requirement |
| **Recycling & Reusing Landscape Waste Calculator** | 1.0-2.0 | 1.0-2.0 | Spatially explicit outputs | Extensive time requirement for gathering data, but can be reduced with a system for collecting the data for future assessments |

[a] Tool was initially evaluated by the Scholars Program team, but was not included in the case studies due to being deemed inappropriate for purposes of the case studies.

Table 3.2 Continued.

| **Tool evaluated** | **Estimated person-hours per location** | | **Information provided** | **Additional Comments** |
|---|---|---|---|---|
| | **Pilot study** | **With data archive** | | |
| **Residential Environment Assessment Tool (REAT) v2.0** | 2.0 | 2.0 | Qualitative review | Time required for field data collection; if the downloadable questionnaire is used, then more time is consumed to enter the data online to complete the assessment |
| **Social Value Self-Assessment Tool** | 0.5 | 0.5 | Qualitative review | Based upon results, exensive information about inputs are provided which consumes the most amount of time |
| **Sustainable Facilities Cost-Effective Upgrades Tool** | 0.5 | 0.5 | Quantitative outputs | Very easy to use; most of time requirement is for learning about the different upgrade options |
| **Volunteer Impact Assessment Tool** | 1.0-2.0 | 0.5 | Quantitative outputs | Time required for gathering volunteer information; after extablishing a system of monitoring volunteer activity, time to complete an assessment is greatly reduced |
| **Walk Score** | 0.5 | 0.5 | Qualitative outputs | Very easy to use; calculates values based upon address |
| **Walkability Checklist** | 1.5 | 1.5 | Qualitative review | Time required for field data collection |

[a] Tool was initially evaluated by the Scholars Program team, but was not included in the case studies due to being deemed inappropriate for purposes of the case studies.

After the survey of valuation tools usage was conducted, multiple park spaces were analyzed as case studies to determine the efficiency, reliability, and utilization of valuation tools in actual functioning organizations. The multiple-case study method was adopted because it can be used to predict similar results via literal replication, and it is considered a robust and reliable research method (Baxter & Jack, 2008; Rowley, 2002; Zucker, 2009). This method also utilizes a deductive approach which provides a firmer foundation for validity and structuring data collection and analysis (Baxter & Jack, 2008).

This research can be described by four types of case studies as defined by Stake (2006) and Yin (2009) that are closely linked to the types of research questions being asked: 1) explanatory; 2) exploratory; 3) descriptive; and 4) instrumental. First, it is an explanatory case study since the valuation tools are trying to be linked to real-life interventions, and the study seeks to link tools implementation with effects in the organizations. Second, it is an exploratory case study due to there not being any clear, single set of outcomes yet defined for the different valuation tools in public organizations. It qualifies for the third type, descriptive, because the study is attempting to describe the valuation tools in real-life context. Lastly, the case study is instrumental in that the research is seeking to facilitate the understanding of valuation tools being used in organizations; thus, providing a better insight into how valuation tools work.

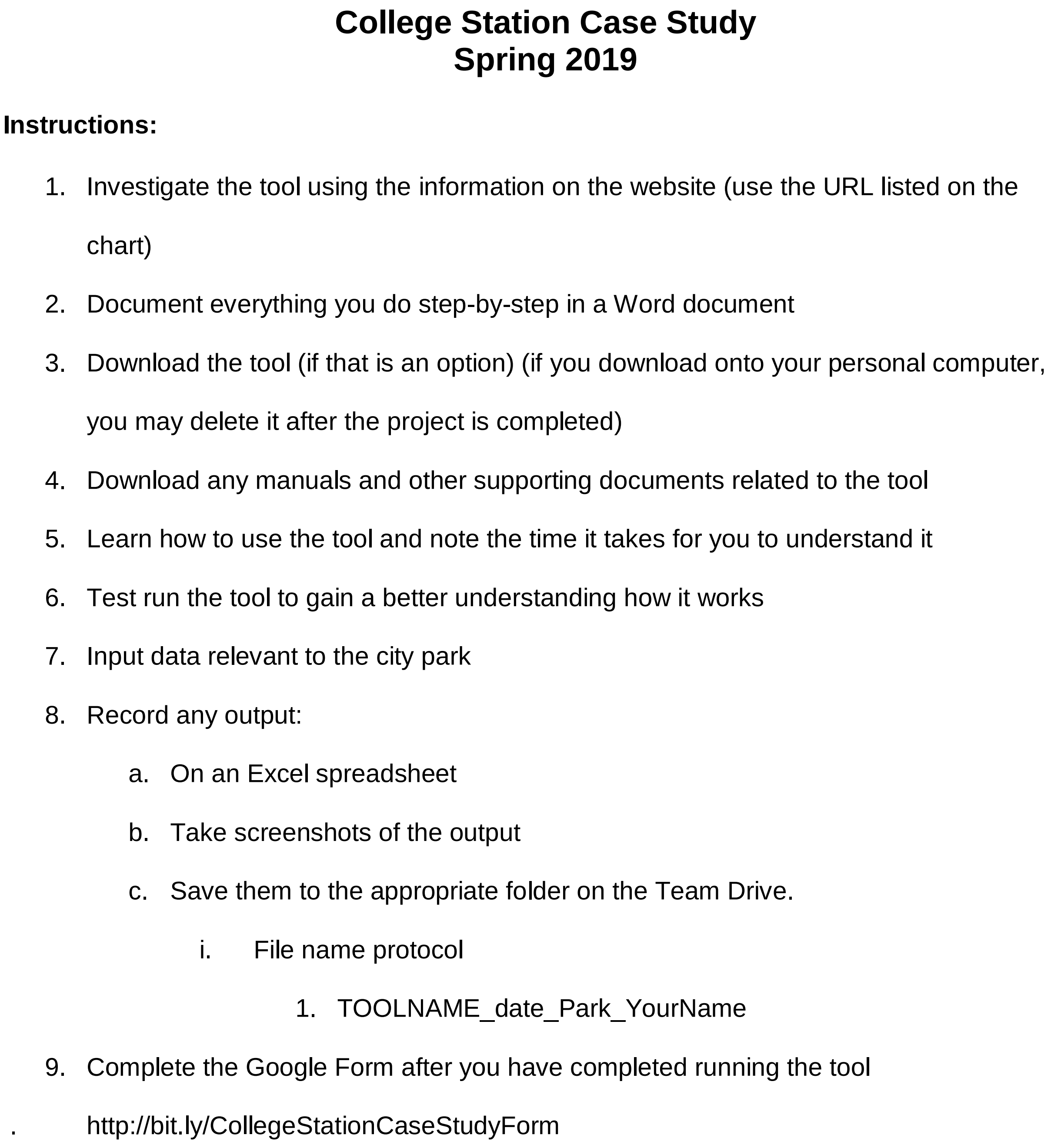
An embedded pilot multiple park case study was conducted according to case study research methods described in Stake (2006) and Yin (2009) with the City of College Station (TX) Department of Parks and Recreation to identify all relevant data collection issues that may be encountered. This organization was chosen due to its accessibility and convenience to the researchers, its availability of documentation and data for its public park areas, and its diverse selection of fifty-seven parks (COCS, 2018c), from which six parks were chosen for the case studies.

Baxter and Jack (2008) suggested that the case studies be properly bound to prevent the study from becoming too broad in scope or having too many objectives. Miles and Huberman (1994) recommended binding the case by definition and context, and Stake (1995) suggested by time and activity. For purposes of this study, six diverse park case studies were conducted (see park descriptions in the following section), and the valuation tools were evaluated according to the eight evaluative criteria. The tools were evaluated over a period of six months, depending upon the availability of information required for the tools, staff assisting with the research, and time required for the Scholars Program team to utilize the valuation tools.

Propositions (instructions) developed enabled all information collected to be linked to the propositions, ensuring that the scope of the study was defined and that the project was more feasible to complete (Figure 3.1). The unit of analysis, which analyzes the process (Baxter & Jack, 2008) is defined as the six parks commissioned as the case studies.

The data were analyzed utilizing techniques described by Baxter and Jack (2008), Miles and Huberman (1995), Rowley (2002), Stake (2006), and Yin (2009) that established validity, reliability, credibility, transferability, and dependability. These techniques included triangulation of data through cross-case comparison (creating internal validity) (comparing the results for each park), creating a chain of evidence through thorough documentation, and comparison with previous results of studies from the literature. Patterns were noted and matched between valuation tools, relationships between the evaluative criteria of the valuation tools were documented, and guidelines were produced based upon how the valuation tools performed in the case studies.

To study the quantifiability, credibility, flexibility, replicability, and affordability of the tools, a team of eight undergraduate students were chosen through the Texas A&M University (TAMU) Aggie Research Scholars Program (hereafter, Scholars Program) for undergraduates. The Scholars Program is a research-intensive community model that enables collaboration between faculty, graduate students (team leaders), and undergraduates on research opportunities and projects (Figure 3.2) (TAMU, 2019). No minimum grade point average or specific discipline was required for the students to participate, and each student worked on the project around their regular coursework (Desai et al., 2008). Students who participated in the Scholars Program for this study were sophomores, juniors, and seniors majoring in accounting, engineering, horticulture, landscape architecture, and psychology. The multi-disciplinary composition of the team was intended to simulate the diversity in life journey and skillsets of staff at public gardens and parks.



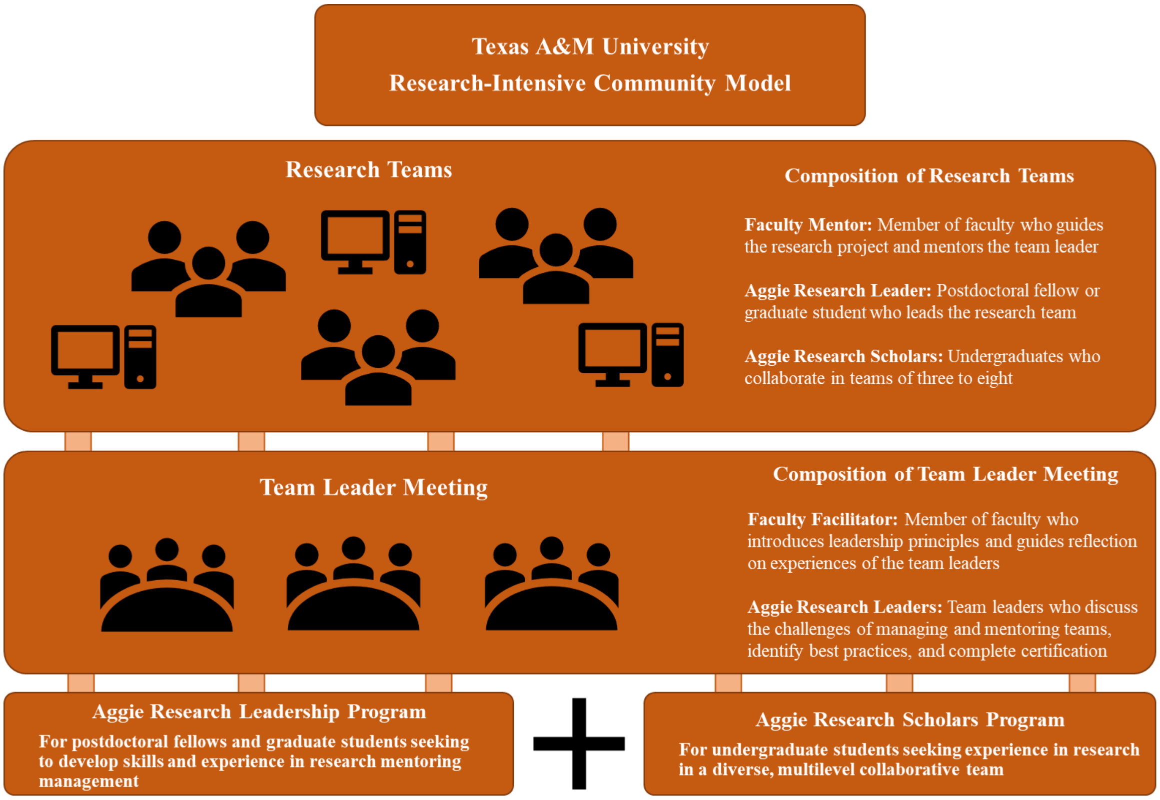
## College Station Case Study
## Spring 2019

**Instructions:**

1. Investigate the tool using the information on the website (use the URL listed on the chart)
2. Document everything you do step-by-step in a Word document
3. Download the tool (if that is an option) (if you download onto your personal computer, you may delete it after the project is completed)
4. Download any manuals and other supporting documents related to the tool
5. Learn how to use the tool and note the time it takes for you to understand it
6. Test run the tool to gain a better understanding how it works
7. Input data relevant to the city park
8. Record any output:
    a. On an Excel spreadsheet
    b. Take screenshots of the output
    c. Save them to the appropriate folder on the Team Drive.
        i. File name protocol
            1. TOOLNAME_date_Park_YourName
9. Complete the Google Form after you have completed running the tool

. http://bit.ly/CollegeStationCaseStudyForm

Figure 3.1. Proposition instructions created to standardize research methods for the Scholars Program team members in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



**Faculty Mentor:** Member of faculty who guides the research project and mentors the team leader

**Aggie Research Leader:** Postdoctoral fellow or graduate student who leads the research team

**Aggie Research Scholars:** Undergraduates who collaborate in teams of three to eight

**Faculty Facilitator:** Member of faculty who introduces leadership principles and guides reflection on experiences of the team leaders

**Aggie Research Leaders:** Team leaders who discuss the challenges of managing and mentoring teams, identify best practices, and complete certification

**For postdoctoral fellows and graduate students seeking to develop skills and experience in research mentoring management**

**For undergraduate students seeking experience in research in a diverse, multilevel collaborative team**

Figure 3.2. Organization of the Aggie Research Scholars Program Research-Intensive Community model, adapted from TAMU (2019), utilized in the multiple-case studies approach for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

Prior to establishing the Scholars Program team, an analysis of each case study park site was conducted for each selected tool to establish a data baseline and to compare the results to those of the Scholars Program team to ascertain inter-rater reliability. Each student was randomly assigned valuation tools, asked to study any available supporting documentation, and required to assess each one based upon the evaluative criteria. To simulate the amount of time, skill, and level of knowledge required to operate the tool and analyze the study area (ease of use) and to reduce rater bias, no information about how to operate the tool program or the expected results were given to the Scholars Program team. However, information such as park descriptions and water, fuel, and energy usage were given for purposes of operating the tool. An ancillary objective of this protocol was to simulate how a public garden or park administrator may have to approach utilizing a tool with no prior information or experience about the instrument. To systematize data collection, a Google Team Drive administered by TAMU was created to house the documentation material and analysis outputs collected about the tools, and an online Google Form was developed for each student to submit the evaluative criteria assessments (Appendix G). After the team members collected the data output, results were compared to the initial baseline data for homogeneity and consensus in the assessments.

### *Park Descriptions*

Six parks operated and maintained by the City of College Station (COCS), TX (Figure 3.3), were selected based upon type of park and primary use of the park to provide a cross-section of different urban settings for assessing the valuation tools: Bee Creek Park and Arboretum (Bee Creek) (Figure H-1), Castlegate Park (Castlegate) (Figure H-2), Lick Creek Park (Lick Creek) (Figure H-3), Stephen C. Beachy Central Park (Central) (Figure H-4), Veterans Park and Athletic Conplex (Veterans) (Figure H-5), and Wolf Pen Creek Park and Amphitheater (Wolf Pen Creek) (Figure H-6). Bee Creek (COCS, 2018a) was acquired by the city in 1946, and also contains the 17-acre D. A. “Andy” Anderson Arboretum, which was acquired in 1975. The 43.5-acre community park contains a gazebo shelter, tennis courts, a swimming pool, play units, softball fields, picnic units, a sand volleyball court, a pavilion, pickleball courts, batting cages, a jogging/walking trail, and an interpretive nature trail (in the

Arboretum). A smaller neighborhood park acquired in 2001, Castlegate (COCS, 2018b), sits on 8.26 acres with tennis courts, fish ponds, picnic units, basketball court, jogging/walking trail, play units, and a gazebo shelter.

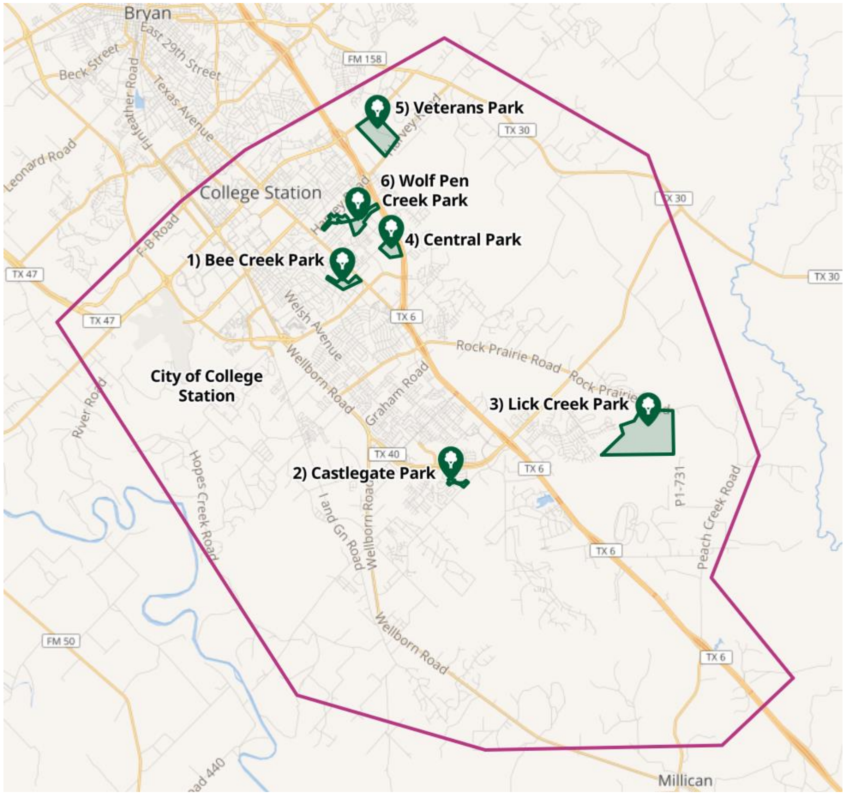


Figure 3.3 Map depicting city boundary and the park locations in the City of College Station, TX, and managed by the Department of Parks and Recreation that were selected for a multiple-case studies approach for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

Acquired in 1987, Lick Creek (COCS, 2018d) is a 515.56-acre regional nature park that contains jogging/walking and nature trails, and the Nature Center. The Nature Center provides an educational facility housing indoor and outdoor classrooms, a monarch butterfly garden, native plant displays, and an amphitheater. Central Park (COCS, 2018e) is a 47.2-acre community park acquired in 1978. Amenities include picnic units, play units, jogging/walking and nature trails, a sand volleyball court, exercise station, fish ponds, softball fields, soccer fields, a basketball court, batting cages, gazebo shelter, pavilion, and tennis court. The College Station Parks and Recreation departmental offices are also housed at this location.

A regional athletic park acquired in 1999, the 150-acre Veterans Park (COCS, 2018f) is a unique blend of a recreational facility as well as a memorial park dedicated to veterans of all military conflicts of the United States, including the Texas War for Independence, containing a Wall of Honor and bronze sculptures memorializing each military conflict along a wooded trail. Amenities include batting cages, play units, picnic units, gazebo shelter, pavilion, softball fields, jogging/walking trail, and athletic fields. Wolf Pen Creek (COCS, 2018g) is a community park that was acquired in two parcels, 1977 and 1991, encompassing 47.17 acres and containing a jogging/walking trail, pond, picnic unit, gazebo shelter, play unit, exercise station, amphitheater, disc golf, and festival site.

### *Selection of Tools*

Eighty-two decision-support tools were selected and assessed according to the evaluative criteria. Twenty-seven tools were utilized for the city park case studies. The remaining fifty-five tools were not selected due to previous assessments by other researchers, purchase or membership required to access the tools, issues with accessing the tools, or the COCS Parks and Recreation department did not have the requested information required for the tools to conduct analyses.

Tools previously studied and not included in the case studies were:

- Lifecycle Cost Analysis (LCCA) (Arditi & Messiha, 1999; Boros et al., 2017; Fuller & Petersen, 1995; Huang et al., 2019; Kulczycka & Smol, 2016; Othoniel et al., 2015);
- Ecological Footprint Calculator (Wackernagel and Rees, 1996);
- Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) (Bagstad, Semmens, Waage, & Winthrop, 2013; Myers, Carney & Whitlow, 2015);
- Green Roof Energy Calculator, Pedestrian Environmental Quality Index (PEQI), The Value of Green Infrastructure (VGI), and Water Harvesting Calculator (Myers, Carney & Whitlow, 2015);
- Microscale Audit of Pedestrian Streetscapes (MAPS) (Cain et al.,2017; Kurka et al., 2016; Millstein et al., 2013);
- Neighborhood Quality of Life Survey (NQLS) (Frank et al., 2010; Sallis et al., 2009);
- System for Observing Physical Activity and Recreation in Natural Areas (SOPARNA) (Martinez-Garcia et al., 2019);
- Universal Floristic Quality Assessment Calculator (Freyman Masters, & Packard, 2016); and
- Social Return on Investment (SROI) (Cooney & Lynch-Cerullo, 2014; Cordes, 2017; Gargani, 2017; Moody, Littlepage, & Paydar, 2015; Nicholls, Mackenzie, & Somers, 2007; Yates & Marra, 2017).

A fee was required to access Accelerator Pro, ClearPath, Social Impact Measurement Toolkit, and Walk Score Professional so these were not included in the case studies. Although the Automated Geospatial Watershed Assessment (AGWA) tool was open source, it required the purchase of ArcGis to conduct the analyses, so it was not selected due not having an available ArcGis program. The Resource Stewardship Evaluation required Natural Resources Conservation Services staff to conduct the assessment, and the STAR Community Rating System (STAR) required membership. The Carbon Footprint Calculator was intended for household use only and it had a limit of five vehicles. The Parks and Recreation department has 110 vehicles and the scale of the tool was not appropriate for the case studies. The Vegetable Garden Value Calculator is primarily for homeowners, small organizations, and micro-producers, and it was not compatible to the purposes of the case studies. The Water Harvesting Calculator was not included since it can only be applied in the state of Washington.

Six tools were not selected since there were issues with downloading or accessing them. The Bioaccumulation and Aquatic System Simulator (BASS) and the Green Infrastructure Flexible Model (GIFMod) functioned only on outdated Windows operating systems rendering them inoperable. The computer operating system failed while attempting to download the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) tool so no further download attempts were risked on that program. The Community Multi-scale Air Quality (CMAQ) Modeling System required a Linux operating system and knowledge of FORTRAN programming, neither of which were available. The Landuse Evolution and Impact Assessment Model (LEAM) could not be accessed. Although Prove It! provided a downloadable manual with procedures for conducting its survey, the required survey questions were missing from the document.

Information required to conduct analyses were unavailable to run twenty-four tools: Aquatox, The Building for Environmental and Economic Stability (BEES), CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA), Electronic Environmental

Benefits Calculator (EEBC), Energy Star Cash Flow Opportunity Calculator, EnergyPlus, EnviroCalculator, Environmental Benefits Calculator by NatureWorks, Environmental Benefits Calculator by Northeast Waste Management Officials' Association (NEWMOA), Forest Vegetation Simulator, Green Cleaning Pollution Prevention Calculator, Home Heating Cost Calculator, Local Greenhouse Gas Inventory Tool, Paper Calculator, Recycled Content (ReCon) Tool, Regency Lighting Energy Savings Calculator, Resource Conserving Landscaping Cost Calculator, Soil-Plant-Air-Water Field and Pond Hydrology Model (SPAW), Storm Water Management Model, Visualizing Ecosystem Land Management Assessments Model (VELMA), Waste Reduction Model (WARM), Water Quality Analysis Simulation Program (WASP), WaterSense Water Budget Tool, and Watershed Management Optimization Support Tool (WMOST).

## Results

### *Analytical and Modeling Approaches of Decision-support Tools (Table 3.1)*

#### *Aspatial sustainability development*

Two tools, Accelerator Lite and Accelerator Pro (Sustainability Accelerator Network, 2018a, 2018b) are a set of three educational tools – Compass; Pyramid; Amoeba – used to enable provide sustainability awareness, training, planning, and implementation for individuals, organizations, suppliers, and other entities. The Lite version is free and intended only for non-commercial, educational use while the Pro version provides technical support, professional training, and assessments on a commercial basis. Although these tools do not provide any valuation procedures, they were included due to the ability to provide organizational staff training utilizing an established set of essential concepts to ease the burden of communicating systems-thinking, collaboration with others, and the ability to enable changes to achieve sustainability.

### *Independently applicable, generalizable, landscape-scale modeling*

Nineteen tools were classified as capable of independent application, mostly generalizable, and generally modelling at the landscape or watershed scale. Eleven tools were developed by the United States Environmental Protection Agency (EPA) (some were developed in collaboration with other organizations) with the other eight tools developed by other federal government agencies, universities, and other groups.

The eleven EPA tools were: Aquatox, AGWA, BASS, COBRA, CMAQ, MyEnvironment, National Stormwater Calculator, Storm Water Management Model (SWMM), VELMA, WASP, and WMOST. Aquatox (EPA, 2018a) is an applied simulation model for performing ecological risk assessments in aquatic ecosystems. Extensive knowledge about types of aquatic life and factors are required to operate this tool. AGWA (EPA, United States Department of Agriculture (USDA) Agricultural Resource Service (ARS), & University of Arizona, 2017) analyzes and manages watershed water quality and quantity using ArcGIS. The open access tool requires the purchase of ArcGIS to run the programs, and is designed for use by experts in hydrology. BASS (EPA, 2018c) is a FORTRAN simulation model that analyzes fish population dynamics and accurately predict chemical bioaccumulation in fish. COBRA (EPA, 2018e) is a preliminary screening model for calculating the beneficial value of clean energy policy scenarios, including economic and health benefits, to identify those policies that warrant further research. CMAQ (EPA, 2018d) is a modeling software application for conducting air quality simulations and to analyze practices that will enable better air quality management. However, this tool requires a Linux computer operating system as well as knowledge of FORTRAN programming.

MyEnvironment (EPA, 2018h) provides information about air quality, water quality, health statistics, and other environmental factors based upon location. It is limited to larger spatial scales, providing no information if the desired area to be studied is too small. The National Stormwater Calculator (EPA, 2018i) is a downloadable desktop application or web-based tool used for estimating annual rainfall amounts and frequency of runoff from specific sites in the United States based on local soil conditions, historic rainfall records, and land cover. Users can select from a list of green infrastructure practices to determine effects from low impact development. Another simulation model, SWMM (EPA, 2018j), provides hydraulic-hydrology water quality for single event or long-term analogies of runoff and pollutant loads. A low-impact development control option allows for analyses using green infrastructure practices. SWMM is also approved for National Flood Insurance Program studies. VELMA (EPA, 2018m) evaluates different green infrastructure options in managing water, toxins, and nutrient loads as well as simulating maintenance and longevity of green infrastructure to predict potential failures based upon contaminant loads, climate change, soil properties, and other factors. WASP (EPA, 2018n) is a versatile simulation model capable of running on Mac OSX, Windows, and Linux computer operating systems that can predict the effects of pollution management policies on water quality responses to anthropogenic pollution and natural occurrences. WMOST (EPA, 2018p), a downloadable spreadsheet, evaluates different water resource management practices based upon fifteen stormwater management practices including traditional, green infrastructure, and low impact development practices.

Three tools created by other federal agencies include the Forest Vegetation Simulator, i-Tree, and SPAW.  Developed by the United States Forest Service (USFS), the Forest Vegetation Simulator (USFS, 2018) provides a system of integrated tools that determine response changes to natural succession, proposed management actions, and disturbances. Certain variants of the simulator can estimate carbon stocks, from dead and live trees, downed dead trees, and forest floor biomass information. A downloadable suite of twelve forest analysis tools, utility software programs, and other assistive programs, i-Tree (USFS et al., 2018) aids in improving management of forests and quantifying environmental services provided by trees and forest structure. The i-Tree core suite includes i-Tree Canopy, Landscape, Eco, Design, and Hydro. Utility tools include i-Tree MyTree, Species, Projects, and Pest. Legacy tools include i-Tree Storm, which assesses damage from widespread severe storms and also has a Hurricane Adaptation extension that can be added, and i-Tree Streets, which enables the assessment of street trees to quantify aesthetic and environmental benefits for urban managers. Lastly, i-Tree Database provides a central location for submitting tree population species and location information. Eco Mobile Data Collection is available for i-Tree Streets and Eco for use with mobile devices such as Smartphones and other web-enabled devices. Another model, SPAW (USDA & Washington State University, 2017) simulates daily hydrologic water budgets for agricultural lands as well as lagoons, ponds, wetlands, and reservoirs.

The last five tools in this section are GIFMod, Housing and Transportation Affordability Index (HTAI), InVEST, Landuse Evolution and Impact Assessment Model (LEAM), and Low

Impact Development Rapid Assessment Model (LIDRA). GIFMod (Massoudieh et al., 2017) is a simulation program used for the evaluation of water quality and hydraulic performance under certain weather scenarios based upon green infrastructure practices. Due to the program requiring an older Windows version to operate, this tool could not be converted to a newer Windows platform, nor was there a version available for Mac operating systems. Based upon location, HTAI (Center for Neighborhood Technology, 2018b) provides the affordability of housing based on housing and transportation costs.

The current release of InVEST software (Bagstad, Semmens, Waage, & Winthrop, 2013; Natural Capital Project, 2018) consists of eighteen models used to determine the value of goods and services provided by nature: nine marine and freshwater and seven terrestrial ecosystem service models (coastal vulnerability, coastal blue carbon, fisheries production, habitat risk assessment, marine fish aquaculture, offshore wind energy, reservoir hydropower production (‘water yield”), nutrient delivery ratio (water purification), wave energy, carbon and storage sequestration, crop pollination, habitat quality, recreation, scenic quality, sediment retention, urban InVEST (in development)). Spatial analyses based on production functions can be conducted at local, regional, or global scales, and it accounts for environmental services and socioeconomic benefits.  This program enables decision-makers in governments, non-profit organizations, and corporations to make informed decisions based on quantified tradeoffs and alternative management choices. LEAM (University of Illinois Design Research Lab, KTH Royal Institute of Technology, & American University of Sharjah, 2016) is a spatial simulation modeling program mainly used by municipalities to discover probable implications of urban policies and investment management decisions in a scenario-based format. The last tool of this section, LIDRA (Drexel University & HDR, 2018), compares how different types of low impact development and green infrastructure are cost effective in the reduction of runoff. However, there is a limited selection of climate data locations available for analysis requiring the user to select the closest location to the study area.

### *Independently applicable, generalizable, site-scale modeling*

Twelve tools were classified as capable of independent application, mostly generalizable, and generally modelling at the site scale. five tools were developed by the EPA with the other seven tools developed by other federal government agencies, universities, and other organizations.

The five EPA tools are Local Greenhouse Gas Inventory Tool, Managing and Transforming Waste Streams Tool, National Stormwater Calculator, ReCon, and WARM. The Local Greenhouse Gas Inventory Tool (EPA, 2018f) is an interactive spreadsheet with two separate modules for community-wide and local government inventories of greenhouse gas emissions from residential, commercial, transportation, and water and waste management. Managing and Transforming Waste Streams Tool (EPA, 2018g) is a web-based or downloadable spreadsheet that estimates the life-cycle impacts of greenhouse gas emissions and energy from various post-consumer recycled content products. The National Stormwater Calculator, described in the previous section, was included here since it can analyze data at the site scale. An online tool, ReCon (EPA, 2017b) evaluates the greenhouse gas benefits by utilizing recycled content of materials. The fifth EPA tool in this section, WARM (EPA, 2018l), compares the benefits of alternative waste management scenarios to typical business practices in determining best waste management practices for an organization.

Three of the seven other tools which were included in the previous section are GIFMod, HTAI, and i-Tree. Each of these has the capability providing data at multiple scales with relative ease. GIFMod can provide conceptual models for green infrastructure such as rain barrels and cisterns at a site scale as well as larger green infrastructure systems at a landscape scale. HTAI is also capable of providing data at a local, regional, or larger scales. Accurate data can be provided even at place-specific site scale given a specific address. This capability enables the study of communities and neighborhoods within municipalities and regions. Thirdly, i-Tree, described in more detail in the previous section, can easily maneuver between site scale to landscape scale.

The last four tools of this section are Long-term Hydrologic Impact Analysis Tool (L-THIA), National Tree Benefit Calculator, Paper Calculator, and Sustainable Facilities Cost-Effective Upgrades Tool. L-THIA (Purdue University, 2015) is an open-access, online tool for assessing water quality impacts due to land use change; estimates recharge, runoff, and nonpoint source pollution. The National Tree Benefit Calculator (Casey Trees, 2018) provides an estimation of annual environmental and economic values provided by trees based upon location, species, and tree size. The Paper Calculator (Environmental Paper Network, 2018) quantifies the impact of paper usage and compares different grades and types of paper with varying levels of recycled content. Finally, the Sustainable Facilities Cost-Effective Upgrades Tool (United States General Services Administration, 2018) is an online tool for businesses and government agencies to determine cost-effective ways of lowering energy costs through certain facilities maintenance practices.

### *Independently applicable, place-specific, landscape-scale modeling*

Three tools were included in this section: AVoided Emissions and geneRation Tool (AVERT), BASINS, and Universal Floristic Quality Assessment Calculator (FQA). Available as an online tool or a downloadable spreadsheet, AVERT (EPA, 2018b) analyzes the emissions benefits of policies and programs for energy efficiency and renewable energy. BASINS (EPA, 2015) is a multipurpose analysis tool that uses GIS to organize spatial information and perform watershed- and water quality-based studies. It integrates environmental data, analysis tools, and watershed and water quality models that can be used in conjunction with Aquatox, SWMM, WASP, and other EPA modelling tools. FQA (Freyman, Masters, & Packard, 2016) is a web-based calculator to assess ecological integrity of an area based on the occurrence and abundance of plant species composition. Downloadable forms can be also be utilized to complete ecological integrity assessments.

### *Independently applicable, place-specific, site-scale modeling*

Fifty tools were classified as capable of independent application, specific to a particular place, and generally modelling at the site scale. Eight tools were developed by the EPA (or in collaboration with another federal agency) with the remaining forty-two tools developed by other federal government agencies, universities, and industry associations, and various other organizations.

The eight EPA tools are Carbon Footprint Calculator, Decking Cost Calculator, EEBC, Energy Star Cash Flow Opportunity Calculator, Greenhouse Gas Equivalencies Calculator, Recycling and Reusing Landscape Waste Cost Calculator, Resource Conserving Landscaping Cost Calculator, and WaterSense Water Budget Tool. The Carbon Footprint Calculator (EPA, 2016a) is an online tool or downloadable spreadsheet used by homeowners and small businesses to assess the carbon footprint based on energy, waste, and water use practices. An archived, downloadable spreadsheet is the Decking Cost Calculator (EPA, 2006) which evaluates the construction cost of a deck using environmentally preferred building materials compared to conventional wood deck materials. Use of this tool requires the values generated to be converted from the last year the tool was updated to the current year. Another online tool, the EEBC (EPA, 2018k), estimates the economic and environmental benefits of purchasing Electronic Product Environmental Assessment Tool (EPEAT)-registered products as well as equipment operation and end-of-life management practices. An equivalency table is also provided. The Energy Star Cash Flow Opportunity Calculator (United States Department of Energy (DOE) & EPA, 2018) is a downloadable spreadsheet that estimates costs of financing new equipment using anticipated savings from energy efficient equipment and if money is being lost by waiting for lower interest rates.

The Greenhouse Gas Equivalencies Calculator (GGEC) (EPA, 2017a) translates annual emissions from automobiles, households, etc., into greenhouse gas equivalencies. Another archived EPA tool, the Recycling and Reusing Landscape Waste Cost Calculator (EPA, 2006), estimates savings by reusing and recycling waste materials generated from landscapes. Use of this tool requires the values generated to be converted from the last year the tool was updated to the current year. Resource Conserving Landscaping Cost Calculator (EPA, 2016b), also an archived EPA tool, compares the cost of using conventional landscape plants with plants that require less irrigation and produce less waste. Use of this tool requires the values generated to be converted from the last year the tool was updated to the current year. The eighth EPA tool in this section, the WaterSense Water Budget Tool (EPA, 2018o), is an archived EPA downloadable spreadsheet that determines the water budget for primarily new home construction based on landscape design specifications. Use of this tool requires the values generated to be converted from the last year the tool was updated to the current year.

Seven tools evaluated pedestrian and bicycle friendliness of communities: Bicycle Level of Service/Pedestrian Level of Service (BLOS/PLOS), Bikeability Checklist, MAPS, PEQI, Walk Score, Walk Score Professional, and Walkability Checklist. The BLOS/PLOS web-based tools (League of Illinois Bicyclists, 2016) determine the level of user comfort based on traffic and road conditions. These tools are more appropriate for roadways instead of parks and trail systems. The Bikeability Checklist (National Highway Traffic Safety Administration, Pedestrian and Bicycle Information Center, & United States Department of Transportation, 2016) is a downloadable survey that individuals can use to rate the ability to travel in an area safely and efficiently. Suggestions to make short- and long-term improvements related to bikeability are also available. Another downloadable survey tool, MAPS (Cain et al., 2012), has three options of complexity used for collecting data on the walkability and pedestrian environment in neighborhoods. PEQI (San Francisco Department of Public Health, 2008) is a downloadable questionnaire utilized during the planning process to prioritize pedestrian infrastructure. Walk Score and Walk Score Professional (Front Seat, 2018) determine the walkability of an address based upon the distance to nearby amenities. The tools also calculate the ease of living a lifestyle with less reliance on automobiles. Walk Score Professional provides a subscription service to track data over time. The Walkability Checklist (Partnership for a Walkable America, Pedestrian and Bicycle Information Center, & United States Department of Transportation, 2018) is a downloadable survey that individuals can use to rate the ability to walk in an area safely and efficiently. Suggestions to make short- and long-term improvements related to walkability are also available.

The following five tools assessed neighborhoods and parks: Environmental Assessment of Public Recreation Spaces Tool (EAPRS), NQLS, Parks and Recreation Areas Self-Report Survey, Residential Environment Assessment Tool (REAT), and SOPARNA. The downloadable EAPRS questionnaire (Saelens, 2006) is an observation tool for assessing parks and playgrounds to evaluate physical aspects in regard to functionality, providing a guidebook and photo guide for standardized rating observations. Another downloadable questionnaire, NQLS (Sallis et al., 2009), surveys residents to assess the relationship between one's neighborhood, quality of life, health, and physical activity. The Parks and Recreation Areas Self-Report Survey (Slater et al., 2012) is a downloadable survey for measuring the presence and condition of features and other amenities of an area, particularly those visited by adolescents. REAT (Cardiff University, 2018), a downloadable questionnaire and web-based tool, was developed in the United Kingdom, and is used to assess neighborhood conditions and natural elements as a means to evaluate various health and quality of life as well as neighborhood quality. SOPARNA (Sasidharan & McKenzie, 2014) observes physical activity in outdoor recreation areas to better understand user behavior and characteristics.

Four tools assess agriculture-related management. COMET-Farm (United States Department of Agriculture Natural Resources Conservation Service (NRCS) & Colorado State University, 2018) is a web-based farm and ranch management tool that compares current practices to simulated scenarios and the effects on greenhouse gas emissions and carbon changes. A parallel online tool to COMET-Farm, COMET-Energy (NRCS & Colorado State University, 2018), estimates greenhouse gas emission reductions based on anticipated fuel usage. Another online planning tool of the COMET series, COMET-Planner (NRCS & Colorado State University, 2018), evaluates carbon and greenhouse gas emissions by adopting NRCS conservation methods. The Resource Stewardship Evaluation (NRCS, 2018) assesses soil management, water quality, water quantity, air quality, and habitat health conservation programs for farm managers and other land managers. This evaluation can only be conducted by trained staff of the NRCS.

Six tools are related to building, infrastructure, and maintenance issues. BEES (National Institute of Standards and Technology, 2016) is a web-based application of downloadable spreadsheet for selecting building products that are cost-effective and perform well environmentally; analyzes lifecycle of products from raw material acquisition, manufacture, transportation, installation, use, to recycling and waste management. Another online tool, the Construction Carbon Calculator (Build Carbon Neutral, 2007) calculates the net amount of carbon for a project's site and structure(s) for developers, architects, builders, and land planners. The Green Cleaning Pollution Prevention Calculator (Responsible Purchasing Network, 2018) determines which green cleaning measures have the greatest impact in hazardous chemicals reduction and in pollution prevention. The results can be downloaded to a spreadsheet. The Green Values Stormwater Management Calculator (Center for Neighborhood Technology, 2018a), an online tool, quantifies the impact of green design features (native landscaping, drainage swales, green roofs, permeable pavers, etc.) and compares those values to conventional systems. It uses the life cycle cost method over a twenty-year life cycle. However, it is limited to smaller size lots and tree quantities making it less useful for larger sites. The Lifecycle Cost Analysis (LCCA) (National Institute of Building Sciences, 2016) estimates overall costs of project alternatives and enables an assessment of the total cost of owning a facility including all costs for acquisition, owning, and disposing of a building/building system. It allows for the lowest overall cost of ownership, but generally does not account for environmental costs. The sixth tool, Office Emissions Calculator (Carbonfund.org Foundation, 2016) determines the amount of carbon an office creates and how much needs to be offset to be carbon neutral.

Eight tools measured energy-related aspects of organizations. EnergyPlus (DOE, 2018) is a whole-building simulation program to model water use and energy consumption for heating, cooling, ventilation, lighting, and plug and process loads in buildings; used in conjunction with OpenStudio software. This tool can be used on multiple operating systems. The EnviroCalculator (Neenah Paper and Packaging, 2018) is similar to the Paper Calculator except it allows for the input of paper produced by wind power and the additional environmental benefits derived by that method. The Environmental Benefits Calculator (NatureWorks, 2018) calculates energy savings by substituting Ingeo biopolymer, a biological material which utilizes carbon stored in plants for traditional oil-based polymers. Another Environmental Benefits Calculator (NEWMOA, 2018) calculates benefits of waste reduction, water conservation, energy use and other conservation measures based on sustainable activity or practice. Although primarily targeted for the hotel industry, the tool provides analyses on the implementation of sustainable practices. Green Roof Energy Calculator (Sailor, Bass, & Peck, 2018) compares annual energy performances of a vegetative green roof to a dark or white roof on a building. However, output calculations are in 2010 utility values, and only major cities in each state are available for scenario analysis. The Home Heating Cost Calculator (Efficiency Maine, 2018), primarily for Maine residents and businesses, compares the estimated annual heating costs of different heating systems based upon current heating systems in place. The PV Watts Calculator (DOE National Renewable Energy

Laboratory, 2018), powered by In My Backyard (IMBY) solar simulation, estimates energy production and energy cost of photovoltaic energy systems (solar powered systems) for small building owners, homeowners, installers, and manufacturers. The Regency Lighting Energy Savings Calculator (Regency Lighting, 2018) calculates the return on investment for total cost of lighting, especially for retrofitting or upgrading existing lighting to energy-efficient lighting options.

ClearPath, STAR, and VGI provide evaluations for communities and municipalities. The proprietary ClearPath (ICLEI Local Governments for Sustainability, 2018) program provides software for the management of energy and emissions and mitigation efforts in local governments and communities. Municipality membership required for this tool. STAR (ICLEI-Local Governments for Sustainability, United States Green Building Council, and Center for American Progress, 2018), another program requiring municipal membership, is a certification program and sustainability framework for communities to address economic, environmental, and social progress. The program recently merged with the United States Green Building Council, and is in the process of being reorganized. The Value of Green Infrastructure (Center for Neighborhood Technology, 2011) is a publication that provides a broad analysis in valuing economic, environmental, and social benefits to aid decision-makers and planners in making informed decisions and provide communities a guide to valuing the benefits of green infrastructure investments.

The next five tools assess aspects of social and cultural impact. Prove It! (New Economics Foundation, 2018) measures the impact of community projects on local people and their quality of life and promotes social capital. The Social Impact Measurement Toolkit (National Disability Services Limited, 2018) is a set of tools that requires minimal technological and technical expertise and used to assess the social impact of programs in non-governmental organizations on people and to maintain consistent outcomes. The spreadsheet-based tool is currently being upgraded, and is unavailable to new clients. Social Return on Investment (SROI) (Social Value UK, 2018) is a downloadable spreadsheet providing a framework that incorporates accounting methods to measure economic, environmental, and social costs and benefits; it focuses on value as opposed to monetary aspects. An online questionnaire, the Social Value Self-Assessment Tool (Social Value UK, 2018), determines how well social value is being measured and reported, and the level of quality of an organization's social value measurement practices. Individual accounts are open access, but a professional service is available with more technical service for portfolio accounts. Another proprietary tool, the Volunteering Impact Assessment Toolkit (National Council for Voluntary Organisations, 2015), provides a set of questionnaires designed for volunteers, the host organization, service users, and the community to ascertain a better understanding of the impact of volunteers.

The last five tools of this section provide various assessments of ecosystem services. The Ecological Footprint Calculator (Global Footprint Network, 2018) is a management and communication tool that determines how much productive land and sea areas are required to support human activities including energy and transportation usage and waste generation from lifestyle traits. Estimated outputs are largely generalized, and not recommended if accurate values are desired. FQA, described in the previous section has the capability to be utilized at the place-specific scale as well as the landscape scale. Another water harvesting calculator, the Rainwater Harvesting Supply Calculator (Texas A&M AgriLife Extension, 2018), is a downloadable spreadsheet that enables the user to correctly size a water harvesting system to determine stored water volume over three years and if supplemental irrigation will be needed.

The Vegetable Garden Value Calculator (PlanGarden, 2018), is a beneficial calculator for small farms, community gardens, or other micro-producer organizations that estimates harvest amounts for vegetables based on square footage. A downloadable spreadsheet is available, but still requires internet access to be utilized. Finally, the last tool, the Water Harvesting Calculator (Washington State Department of Ecology, 2018) estimates the amount of water that could be captured from roofs and parking lots and compares it to the volume of water needed for a building. Unlike the Rainwater Harvesting Calculator, this tool is not generalizable to other areas outside of Washington state.

### *Application of Selected Tools to Six Parks of the City of College Station, TX*

Twenty-seven decision-support valuation tools were applied to six parks managed by the Department of Parks and Recreation in the COCS to determine time requirements to operate the tools, evaluate the responsiveness of the tools to the different characteristics of the parks, and to validate the outputs and inter-rater reliability with other tools utilized in the study.

AVERT (Figure I-1): With each rater entering electrical usage for each park and assuming a 10% decrease in energy use across all hours, the calculator generated an output assessing the impact of displaced energy generation via energy efficient/renewable energy programs. The results for energy generation (MWh) ranged from 10.53% to 10.59%, sulfur dioxide ($SO_2$) emissions (lbs) 7.00% to 7.05%, nitrogen oxide ($NO_x$) emissions (lbs) 9.45% to 9.51%, carbon dioxide ($CO_2$) emissions (tons) 8.65% to 8.71%, and particulate matter less than 2.5 microns ($PM_{2.5}$) emissions (lbs) 7.86% to 7.91%.

Bikeability Checklist (Figure I-2): Each rater had similar results from field observations using a Likert rating system of 1-6 for each question. Questions asked were about a place to bicycle safely, condition of the surface being ridden, ability to proceed through intersections, behavior of drivers, and ease of biking. The overall rating score system was as follows: 5-10 = Poor bikeability; 11-15 = Work needs to be done; 16-20 = Okay, but not ideal; 21-25 = Pretty good; 26-30 = Great for biking. Central ranked highest of the six parks at 26 (great for biking) while the lowest rated park was Wolf Pen Creek at 19 (okay, but not ideal). Castlegate and Lick Creek ranked 25 (pretty good), Bee Creek 22 (pretty good), and Veterans 20 (okay, but not ideal).

BLOS/PLOS (Figure I-3): Each rater entered identical information and received identical output. The rating system was as follows: A <1.50 (extremely high); B 1.51-2.50 (very high); C 2.51-3.50 (medium); D 3.51-5.50 (low); F >5.50 (extremely low). All of the parks except Lick Creek received an A rating (extremely high) for bicycle level-of-service. All of the parks except Lick Creek received a B rating (very high) for pedestrian level-of-service.

Carbon Footprint Calculator (Figure I-4): Raters entered the electric usage for each park and received output about the amount of $CO_2$ produced based on the usage rates. Veterans had the highest annual production of $CO_2$ at 1,152 tons, followed by Central (398 tons), Wolf Pen Creek (231 tons), Bee Creek (60 tons), Lick Creek (56 tons), and Castlegate (7 tons).

COMET-Farm (Figure I-5): Raters entered the property outlines of each park and selected forest management for stands located on parks. Data output projected carbon stock that would be stored from 2019 through 2069. Lick Creek was projected to store the most carbon (132,296.2 tonnes $CO_2$) by 2069 reducing emissions by 698.6 tonnes $CO_2$ per year. Castlegate projected the lowest stored carbon with 916.2 tonnes $CO_2$ and reducing 8.3 tonnes $CO_2$ per year.

Bee Creek projected at storing 7,272.0 tonnes $CO_2$ and reducing 65.8 tonnes $CO_2$ per year, Central 15,680.0 tonnes $CO_2$ and 141.9 tonnes $CO_2$ per year, Veterans 33,389.8 tonnes $CO_2$ and 302.2 tonnes $CO_2$ per year, and Wolf Pen Creek 12,815.9 tonnes $CO_2$ and 116.0 tonnes $CO_2$ per year.

COMET-Plan: Provided conservation plans for selected scenarios, but none were available for Brazos County.

Construction Carbon Calculator (Figure I-6): Raters applied different building scenarios according to the square footage of building structures located at each park and received the same data output concerning the net embodied $CO_2$ levels in the structures. Lick Creek had the most embodied $CO_2$ levels at 30,789 tonnes, followed by Wolf Pen Creek at 5,395 tonnes, Bee Creek at 1,527 tonnes, Central at 1,404 tonnes, Veterans at 784 tonnes, and Castlegate at 540 tonnes.

Decking Cost Calculator (Figure I-7): Raters simulated scenarios for deck sizes of 5,000 square feet, 10,000 square feet, 15,000 square feet, 20,000 square feet, 25,000 square feet, and 30,000 square feet comparing costs of constructing with HDPE plastic, recycled plastic/wood composite, cedar/redwood, and pressure-treated yellow pine. Recycled plastic/wood composite had the lowest cost when comparing 10 year life costs: 22% lower than HDPE plastic, 56% lower than cedar/redwood, and 48% lower than yellow pine.

Ecological Footprint Calculator (Figure I-8): This tool considered a personal lifestyle yielding a lifestyle requiring 2.6 earths to exist, 7.3 tonnes $CO_2$ per year, and 4.4 global hectares of ecological footprint.

GGEC (Figures I-9-I-17): Each rater entered number of vehicles in the Parks and Recreation fleet (110), the fuel consumed annually, and the electrical usage for each park. Data output provides greenhouse gas equivalency results on vehicles and electrical usage in greenhouse gas emissions, $CO_2$ emissions avoided, greenhouse gas emissions avoided, and carbon sequestered. Fuel usage resulted in 195 tonnes of greenhouse gas emissions and the fleet of 110 vehicles resulted in 518 tonnes. For electrical usage, Veterans had the highest emissions at 131 tonnes followed by Central 45.4 tonnes, Wolf Pen Creek 26.4 tonnes, Bee Creek 6.8 tonnes, Lick Creek 6.4 tonnes, and Castlegate 0.755 tonnes.

Green Values Stormwater Management Calculator (Figures I-18-I-19): Each rater entered the scenario of adding an additional 25% tree cover, 20 year life cycle costs, drainage swales instead of conventional infrastructure, and replacing half of lawn areas with native landscaping. Also considered were roof drains to rain gardens from downspouts, porous pavement used on driveway, sidewalk, and other non-street pavement material. Overall, peak stormwater discharge was reduced, and total benefits were increased except for Central. Lick Creek yielded the highest total life benefits (over $3,500,000) and total life cycle costs over twenty years ($27,500,000), and Castlegate had the lowest in benefits ($200,000) and costs (less than $1,000,000).

HTAI (Figures I-20-I-23): Each rater entered the park address to retrieve the results. Castlegate had the highest housing and transportation costs as a percentage of income, and Bee Creek had the lowest. Lick Creek and Veterans had the highest monthly housing cost ($2,168), and Bee Creek had the lowest ($696). Castlegate also had the highest median household income ($98,750) while Wolf Pen Creek had the lowest ($16,875). Castlegate had the highest greenhouse gas emissions per household (11.76 tonnes), and Bee Creek had the lowest (6.13 tonnes).

i-Tree Canopy (Figure I-24): After selecting the park area for “trees” and “not trees,” values of carbon monoxide (CO), $NO_2$, ozone ($O_3$), $PM_{2.5}$, $SO_2$, and $PM_{10}$ removed annually by trees, $CO_2$ sequestered annually, and $CO_2$ stored were provided. Lick Creek had the greatest value at $2,170,931.57, followed by Wolf Pen Creek $183,561.42, Veterans $108,32.60, Bee Creek $84,354.14, Central $73,493.17, and Castlegate $10,849.58.

LEAM (Figure I-25): Since the tool would not allow for specific locations, two scenarios for changing land use from forest and grass/pasture to low density residential and commercial were entered as follows: current land use of 75% Forest: 25% grass/pasture, changing the land use to 75% low density residential: 25% commercial in Scenario 1 and 25% low density residential: 75% commercial in Scenario 2. The output yielded estimates of runoff and nonpoint source pollutants. The current scenario had 2 lbs. nitrogen levels which would change to 126 lbs. nitrogen in Scenario 1 and 287 lbs. in Scenario 2. Phosphorus levels would increase from 0.036 lbs. to 31 lbs. and 68 lbs., respectively, while suspended solids would increase from 2 lbs. to 4,597 and 11,698 lbs., respectively.

Long-term Hydrologic Impact Analysis Tool: There were very few cities from which to select to test different green infrastructure and low impact development technologies, mostly from the northeast United States and Hong Kong. No scenarios were conducted for COCS.

Managing and Transforming Waste Streams Tool (Figure I-26): This tool provides a method of policy/program selection. A sample selection of zero waste policies are highlighted in Figure D-27 and provide impact ratings (high, medium, low), diversion potential (h/m/l), types of material or products affected by the policies, difficulty of community led initiative efforts for the policies, how much authority would be required to implement the policy, level of staff knowledge required, sectors affected, and the receptivity level of the policies.

MyEnvironment (Figures I-27-I-31): Raters entered the address for each park, but the results were only at the state and county level. Energy information was provided only at the state level. Low birth rate, mortality, and cancer risk data were given at the county level.

National Stormwater Calculator (Figures I-32-I-56): Different green infrastructure calculations were provided based on different scenarios. Data output also provided soil type, soil drainage, topography, precipitation and evaporation data, and low impact development control options and scenarios (water harvesting, rain gardens, infiltration basins) yielding capture ratios, cistern sizes, and basin sizes.

National Tree Benefit Calculator (Figures I-57-I-61): Raters entered a tree type and size into the calculator. The calculator provided the annual amount of stormwater intercepted by trees, the amount of atmospheric carbon reduced, energy conserved, and property value increase because of the trees. Lick Creek had the highest tree benefit value at $2,795,682, followed by Veterans $106,552, Wolf Pen Creek $97,424, Central $92,750, Bee Creek $67,078, and Castlegate $10,602.

Office Emissions Calculator: This calculator estimates business travel, employee commute, and office impacts. The Parks and Recreation fleet of 110 vehicles yielded 1,485.18 tonnes $CO_2$ (fleet footprint) and an office footprint of 65 employees yielded 109.66 tonnes $CO_2$. No data was available for employee commute.

Parks and Recreation Self Reporting Survey (Table I-1): This survey revealed that exercise was a reason to visit at all parks. Other reasons included swimming (Bee Creek), sports (Central and Veterans), be with friends and family (Castlegate and Veterans), walk a dog (Central, Lick Creek, Veterans), have a picnic (Castlegate, Lick Creek, Wolf Pen Creek), and to relax and read (Lick Creek). The instrument asked to assess the condition of the following if present: playground equipment, baseball diamond, open grassy areas, tennis courts, volleyball courts, basketball courts, soccer fields, paths/trails, skate park, football fields, water playground, indoor gymnasium, outdoor/indoor swimming pool, lake/pond where swimming is allowed. All equipment was listed as in good condition except for the basketball courts at Central Park. Other amenities at the parks to be assessed, if present, were as follows: restrooms, drinking fountains, shelter/shade, picnic facilities, parking lot, and bike racks. All parks except for Bee Creek were rated as good condition if the amenity was present. All of the amenities at Bee Creek were rated as poor/bad condition. The instrument also asked about the availability of classes, day camps, or after school programs offered at the parks. All of the parks were either no or did not know based upon visual observation only. The appearance of each park was to be rated according to enough lighting (all except Castlegate was “yes”), and litter, broken glass, spray paint, graffiti, or tagging (all parks were marked “not present”). For safety aspects, questions were asked about feeling safe while at the park or on the way to and from the park (all parks were marked “yes/agree” except Bee Creek) and if there were any mean or threatening people, gang members, or bullying (all parks were marked as “disagree: except Bee Creek). Responses for an open-ended question for amenities desired were as follows: soccer fields (Bee Creek) security (Bee Creek, Veterans), restrooms (Castlegate), football field (Central), sports complex (Lick Creek, Wolf Pen Creek), and bike racks (Veterans).

PV Watts Calculator (Figure I-62): Standard default scenario was conducted for each park address. The results were very similar for each park, ranging in value from $518 to $523 for 5,776 kWh per year to 5,813 kWh per year.

Rainwater Harvesting Supply Calculator (Figures I-63-I-64): Scenarios for two tank sizes were conducted: Scenario 1 was 3,000 square feet catchment area, a 1,000-gallon tank, and a 7,000-gallon water demand; and Scenario 2 was 5,000 square feet catchment area, a 3,000-gallon tank, and a 9,000-gallon water demand. Scenario 1 required more supplemental water with no irrigation requirement, whereas, Scenario 2 required less supplemental water.

Recycling & Reusing Landscape Waste Calculator (Figures I-65-I-71): Since data was not available, the rater conducted a scenario assuming 60 cubic yards of green waste annually, 10 cubic yards compost used annually over ten years, 10 cubic yards mulch used annually over ten years, 1,000 linear feet of lumber removed annually, 500 linear feet of lumber used per year, 1,000 bricks removed annually, 500 bricks used annually, 1 ton concrete waste annually, and 1 ton asphalt waste annually. The recycling cost was $15.00 per unit. Assuming maximum reuse, then recycle, and landfill the remaining waste program, this results in an annual hardscape and landscape waste disposition of $200 per year as opposed to $1,000 if all material was disposed in a landfill. Over ten years, disposition costs for landfilling all waste would incur approximately $10,000, whereas, maximum reuse, then recycle, landfill remaining waste would cost less than $2,000 over ten years. Maximum reuse, then recycle, landfill remaining waste and recycling all waste where facilities exist would conserve 325 gallons of water and avoid 10,000 pounds of greenhouse gas emissions and 8,500 MJ of energy annually over ten years. Over ten years, landscape waste materials recycled or reused would be 350,000 tons of waste compared to only 175,000 tons of waste recycled if maximum reuse and landfill the remaining waste.

REAT (Figures I-72-I-90): One rater conducted the assessment with the downloadable questionnaire and recorded the results online. The second rater completed the assessment entirely online. Without consulting each other, both raters reached with same conclusions. For the assessment of neighborhood conditions, a higher score indicates a better condition of the neighborhood. The highest rated park was Veterans (6.67), followed by Central (6.14), Castlegate and Lick Creek (6.10), Wolf Pen Creek (5.50), and Bee Creek (4.19).

Social Value Self-Assessment Tool Results (Figures I-91-I-93, Table I-2): The rater answered questions about the following seven principles: Principle One: involve stakeholders; Principle Two: understand what changes; Principle Three: value things that matter; Principle Four: only include what is material; Principle 5: avoid overclaiming; Principle Six: be transparent; Principle Seven: verify the result. After completing the questions, the output provides score results based upon the responses to the questions and provides information concerning how to improve the scores, useful resources, and benchmarking information. The total COCS social value score (19%) was low compared to the benchmark value for culture and recreation (24%) and the United States (27%).

Sustainable Facilities Tool Cost-Effective Upgrades Tool (Figures I-94-I-97): Hypothetical scenarios were conducted for building sizes of 5,000 square feet, 10,000 square feet, 25,000 square feet, and 50,000 square feet building. Data output provides the number of years to realize the return on an upgrade investment (payback), approximate capital cost, annual energy savings (kBtu per square foot and kBtu per year), and annual cost savings. Approximate cost-effective upgrade costs ranged from $900 for the 5,000 square-foot building to $250,000 for the 50,000 square-foot building with the payback ranging from zero to one year up to eight to ten years for all scenarios. Annual energy savings ranged from 2.0 kBtu per square foot to 39.9 kBtu per square foot or $0.06 to $0.78 per square foot resulting in annual energy savings of 10,000 kBtu per year to 2,000,000 kBtu per year.

Volunteer Impact Assessment Tool (Figures I-98-I-102): Volunteer data was provided for Wolf Pen Creek and Central, and other events that occurred at several park locations. The volunteer impact value for Wolf Pen Creek was $10,336, Central $13,056, Senior Games $8,864, Games of Texas $7,808, and other volunteer events (Easter, Halloween, and Christmas events)

$5,280. The total value of volunteers was $45,344 with 1,417 volunteers and 5,668 hours, or the equivalent of 2.7 FTEs.

Walk Score (Figure I-103): There were no differences between the raters since the results were based upon the park address. Castlegate, Central, Lick Creek, Veterans ranked as having low walkability while Bee Creek and Wolf Pen Creek were considered walkable. Bee Creek, Central, and Wolf Pen Creek were very bikeable, Castlegate and Veterans were somewhat bikeable, and Lick Creek was not bikeable.

Walkability Checklist (Figure I-104): Each rater had similar results from field observations using a Likert rating system of 1-6 for each question. Questions asked were about room to walk, driver behavior, ease of crossing streets, safety rules easy to follow, and pleasantness of walk. The overall rating score system was as follows: 5-10 = Poor walkability; 11-15 = Work needs to be done; 16-20 = Okay, but not ideal; 21-25 = Pretty good; 26-30 = Great for walking. Lick Creek rated the highest at 28 (great for walking) while Veterans was the lowest at 22 (pretty good). Castlegate rated 26 (great for walking), and Bee Creek, Central, and Wolf Pen Creek rated 24 (pretty good).

## Discussion

After surveying eighty-two decision-support tools, twenty-seven tools were selected for evaluation to determine the economic value of environmental and social benefits of six COCS parks. The tools were selected based upon the potential to measure the benefits and ideals set forth by Crompton (2009) and Young (2004) for economic development, social impact, public health, and environmental stewardship. The AVERT tool revealed that Veterans park had the highest impact. Of the six parks, Veterans was the second largest park to Lick Creek, and Veterans also had the greatest energy demand which can be attributed to its being primarily a sports complex with numerous night activities requiring lighting. Castlegate had the least impact, which can be attributed to it being the smallest park at eight acres and requiring the least energy demand. Although hypothetical scenarios were conducted, LIDRA demonstrated the impact that development has on land management decisions. Changing the land management from forest and grass/pasture to low density residential and commercial significantly increases nitrogen and phosphorus levels as well as suspended solids and other heavy metals found in nonpoint source pollutants. This tool would be useful for understanding the potential environmental impacts of future development decisions within the park system. The Green Values Stormwater Management Calculator provided benefit data as well as other financial and hydrological data. However, the National Stormwater Calculator was not as detailed nor as easy to use as the Green Values Stormwater Management Calculator. Similar to LIDRA, the Green Values Stormwater Management Calculator and the National Stormwater Calculator would be useful for determining the potential benefits of low impact development and green infrastructure.

The Carbon Footprint Calculator results were based on electric usage and $CO_2$ per year, whereas, the HTAI provided greenhouse gas values only for auto emissions per household so the values between the tools differed. The Ecological Footprint Calculator provided one generic greenhouse gas value (7.3 tonnes $CO_2$ per year), but it was near the average of all six parks (8.53 tonnes $CO_2$ per year per household). The GGEC values differed from the Carbon Footprint Calculator values even though identical electric usage was entered into the tools.

For the HTAI tool, some of the values had insignificant differences between the raters which could be attributed to the time difference between when the raters conducted the samples.

Based upon the results, Bee Creek had the lowest housing and transportation costs which can be attributed to the residents of that area being mostly college students. Having mostly student residents also can attribute to Bee Creek having the lowest monthly housing costs. The high density housing comprised mainly of college students can also be attributed to Central and Wolf Pen Creek areas having the lowest median household annual incomes since most college students are not employed full-time. Lick Creek had the lowest greenhouse gas per household due to it being a large park area and fewer residents living in the area. Castlegate had the highest median income indicating a more affluent neighborhood compared to other park areas. Lick Creek, Veterans, and Castlegate had the highest monthly housing costs indicating the areas are comprised of low density housing and career-oriented families residing there. Overall, HTAI is a very useful tool for evaluating the demographic characteristics of different neighborhoods so that park programming can be more easily adjusted to the needs of each community.

The Parks and Recreation Areas Self Report Survey was limited by a small sample of twelve observations so the results may not be accurate. The instrument is highly prone to subjective rating on condition of equipment and facilities since photo rating guides were not provided as they were for SOPARNA and EAPRS. As a result, inter-rater reliability is not as strong. However, it is a useful tool for gaining an overall assessment of each park provided a standardized rating system is given to each rater. The Rainwater Harvesting Calculator is useful for determining water needs and considerations for water harvesting systems. Unfortunately, no instructions were given about how to use the calculator, so it required some trial and error and additional external research to understand how to use the tool. The Social Value Self-Assessment Tool is subjective, but it does provide useful information for being more transparent, involving stakeholders, verifying reports and policies through feedback from within the organization.

The Recycling & Reusing Landscape Waste Calculator provided an overall assessment of maximum reuse, then recycle, landfill remaining waste and recycling all waste where facilities exist. Although, in theory, this would be ideal, but not every municipality, public garden, or park has access to recycling facilities, nor is it feasible to recycle all materials due to lack of other projects or lack of storage for later use elsewhere. The tool increases awareness to the need for more recycling and reusing landscape waste, especially organic material that can be composted, or shredded and composted. Landscape waste such as concrete, broken brick, and deteriorating lumber that has been treated are sometimes more difficult to reuse and recycle.

The assessments of the BLOS/PLOS tool differ from the assessments provided by the Walk Score, but they were similar to the Walkability Checklist. The Walk Score ranked Castlegate, Central, Lick Creek, Veterans as low walkability, but BLOS/PLOS ranked the same parks as very high, very high, extremely high and very high, respectively, in walkability. Both tools assessed Bee Creek and Wolf Pen Creek as walkable. Concerning bikeability, both BLOS/PLOS and Walk Score considered Lick Creek not bikeable, and the other five parks as bikeable. Although, BLOS assessed Castlegate and Veterans as somewhat bikeable instead of very bikeable according to the Walk Score. The Bikeability Checklist rated Bee Creek, Castlegate, Central, and Lick Creek as pretty good to great for biking compared to the lower score of BLOS/PLOS. The lower scores for bikeability for Wolf Pen Creek, Central and Bee Creek could be attributed to higher traffic volumes. Lick Creek ranked higher on the Bikeability Checklist possibly due to the rater considering the trails of the park, whereas, the other bikeability tools were rated based on the roadways. The BLOS/PLOS tool is primarily targeted for roadways which could explain Lick Creek receiving a low score even though the park has over five miles of bikeable trails. The PLOS values differ from the Walk Score which may be attributed to the PLOS being more specific to a particular site (park), and the Walk Score geared more toward the general area of the given address and not to a specific site. Even though the tools are based upon algorithmic functions, field observations using the Walkability and Bikeability Checklists will probably provide the best assessments.

Probably the most interesting assessments, according to this rater, were the i-Tree Canopy and National Tree Benefit Calculator. These tools provided an economic valuation of the ecosystem services provided by the trees on a particular site based on the amount of $CO_2$ sequestered by trees each year. The National Tree Benefit Calculator only allowed the input of one tree type and size, so the output value had to be converted to the estimated number of trees on the site. However, i-Tree Canopy required the input of data on a GIS map by identifying points randomly selected on the site by the tool as “Tree” or “Not Tree.” Accuracy of the results increases as more random points are identified. For example, selecting one hundred random points is more accurate than only selecting fifty random points. Limitations of i-Tree are required knowledge of tree species for some of the i-Tree modules and data entry can be time consuming, both of which agree with the assessment by Myers, Carney, and Whitlow (2015). The National Tree Benefit Calculator also provided an estimate of proximate property value increase attributed to trees at $1,189,318 and stormwater intercepted annually at 120,593,088 gallons for all six parks (i-Tree Canopy did not provide a value for property value or stormwater intercepted). Remarkably, even though the tree benefit values differed on each tool, both provided a similar economic value (Figure 3.4). The National Tree Benefit Calculator valued the trees at all parks (tree number estimated by the raters) at $3,170,088 compared to i-Tree Canopy at $2,631,502. Assuming the tree stands are similar to the six parks in the case studies, the economic value of the trees for all fifty-seven parks of the COCS would provide between $24,999,269 and $30,115,836 in ecosystem service benefits.

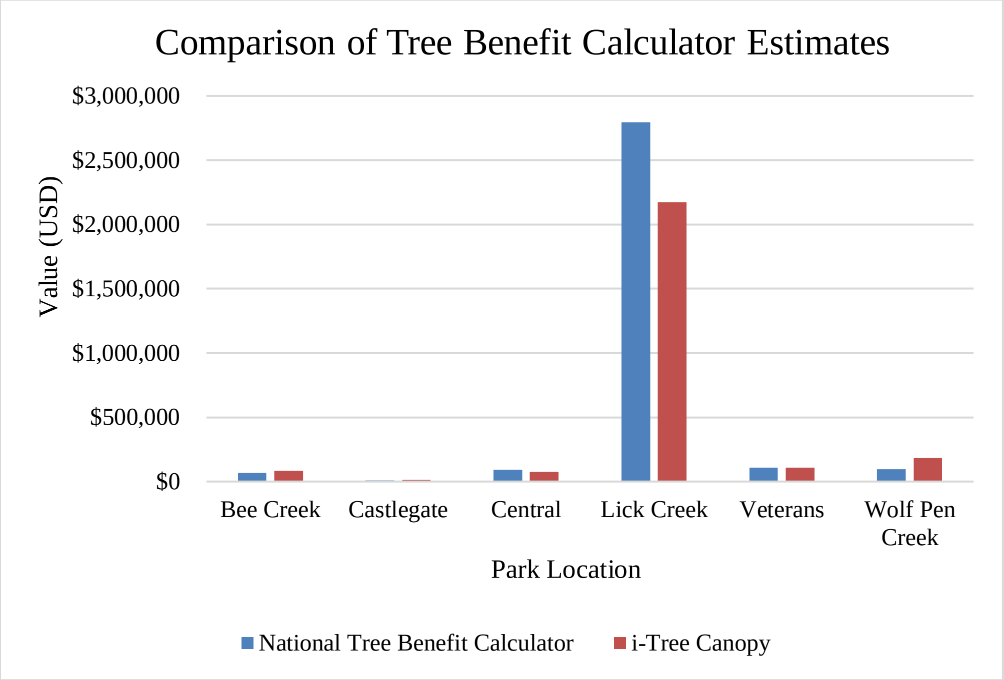


Figure 3.4. Comparison of outputs generated by i-Tree Canopy and the National Tree Benefit Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

## Conclusion

The decision-support tools evaluated in the case studies demonstrated a variety of approaches for assessing environmental benefits and socioeconomic impacts. As expected, some tools were more complicated to understand and learn how to operate, but, overall, most tools were relatively easy to use and required minimal time to implement. The main time requirement was gathering and compiling the data required for the tool, such as electrical usage, quantity of fuel consumed, waste generated, and so on. For the majority of the tools evaluated in the case studies, an extensive knowledge-base and skillset were not needed to implement the tools as demonstrated by the diverse backgrounds, disciplines, and stage in life journeys of the Scholars Program team members. The tools were comparatively intuitive except for those assessing hydrological and aquatic ecosystem services and benefits, which required an extensive knowledge base and more expert skillset. The main limitation of the case studies was the lack of data required for specific tools. The remedy would be to establish a system of collecting the data to be utilized in future tool assessments. Another limitation was the large number of decision-support tools being evaluated at once during a short period of time. Recommended future studies would be to assess tools related to certain topics (e.g., social aspects, landscape waste) and a smaller quantity of tools at once during a longer period of time to gauge reliability of the outputs over time.

Based upon analyses of the decision-support tools from the case studies and the evaluative criteria, lists of recommended tools for specific assessments were generated (Figure 3.5). For stormwater management and green infrastructure assessments, the following tools are recommended based upon ease of use: Green Values Stormwater Management Calculator; Low Impact Development Rapid Assessment; and National Stormwater Calculator. Tools targeted for municipalities that provide extensive environmental, social, and economic impact assessments are: ClearPath; Landuse Evolution and Impact Assessment; STAR Community Rating System; and The Value of Green Infrastructure. Another tool useful for municipalities and communities is the Managing and Transforming Waste Streams Tool which provides policy recommendations. The Housing and Transportation Affordability Index is highly recommended for discovering demographic characteristics of communities as well as greenhouse gas emissions and transportation aspects. This tool is very beneficial for developing appropriate programs for specific communities.

Hydrological and water quality tools that provide scientific outputs (but also require expert knowledge) are the following: Aquatox; Automated Geospatial Watershed Assessment; Better Assessment Science Integrating Point and Nonpoint Sources; Bioaccumulation and Aquatic System Simulator; Integrated Valuation of Ecosystem Services and Tradeoffs; Soil-Plant-Air-Water Model; Storm Water Management Model; Visualizing Ecosystem Land Management Assessments; Water Quality Analysis Simulation; and Watershed Management Optimization Support Tool. Of those, the Integrated Valuation of Ecosystem Services and Tradeoffs tool provides the most comprehensive assessment.

The Bikeability Checklist, the Microscale Audit of Pedestrian Streetscapes, the Pedestrian Environmental Quality Index, and the Walkability Checklist are recommended for assessing bicycling and pedestrian issues. Although the BLOS/PLOS and Walk Score tools were available online and required minimal time to implement, the assessments of the parks were not necessarily accurate compared to the actual field observations. Recommended tools for assessing park conditions and physical activities at the parks are: Environmental Assessment of Public Recreation Spaces Tool; Neighborhood Quality of Life Survey; Parks and Recreation Areas Self-Report Survey; Residential Environment Assessment Tool; and System for Observing Physical Activity and Recreation in Natural Areas. Recommended tools that measure social aspects of an organization are: Neighborhood Quality of Life Survey; Prove It!; Social Return on Investment; Social Value Self-Assessment Tool; and Volunteering Impact Assessment Tool.

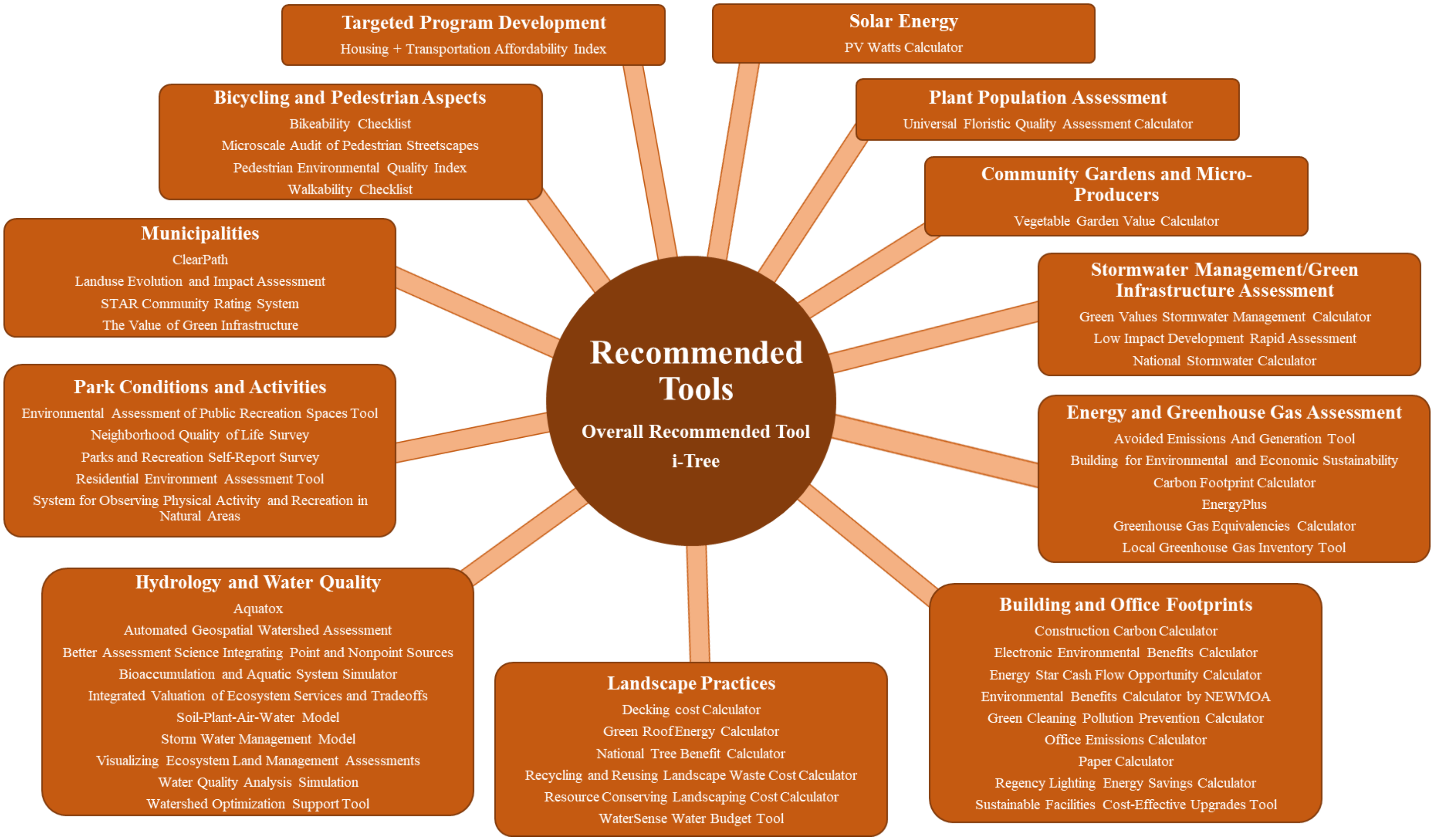


Figure 3.5. Recommended decision-support tools based upon analyses in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

The Universal Floristic Quality Assessment Calculator is recommended for quantifying and assessing plant populations of particular sites. The Vegetable Garden Value Calculator is recommended for small-scale use by community gardens and micro-producers. COMET-Farmand Landuse Evolution and Impact Assessment are recommended for land use management decisions. The Rainwater Harvesting Supply Calculator is recommended for determining tank size needs for harvesting rainwater. For training and educational purposes in sustainability, Accelerator Lite is recommended.

Recommended tools that are beneficial for landscape practices include: Decking Cost Calculator; Green Roof Energy Calculator; National Tree Benefit Calculator; Recycling and Reusing Landscape Waste Cost Calculator; Resource Conserving Landscaping Cost Calculator; and the WaterSense Water Budget Tool. Recommended tools pertaining to building and office footprints are: Construction Carbon Calculator; Electronic Environmental Benefits Calculator; Energy Star Cash Flow Opportunity Calculator; Environmental Benefits Calculator by NEWMOA; Green Cleaning Pollution Prevention Calculator; Office Emissions Calculator; Paper Calculator; Regency Lighting Energy Savings Calculator; and Sustainable Facilities Cost-Effective Upgrades Tool.

For energy- and greenhouse gas-related aspects, the following tools are recommended: Avoided Emissions and Generation Tool; Building for Environmental and Economic Sustainability; Carbon Footprint Calculator; EnergyPlus; Greenhouse Gas Equivalencies Calculator; and the Local Greenhouse Gas Inventory Tool. PV Watts is recommended for assessing solar energy costs and values, and it was the only tool in this study that assessed solar energy.

The overall recommended decision-support tool for environmental and economic assessments is the i-Tree suite of tools. The i-Tree tools provide reliable and quantitative outputs, are affordable (open-source), are regularly updated, provide a wide range of ecosystem service and economic assessments, and are not difficult to understand or utilize. For social impact assessments, there was not a particular overall recommended decision-support tool. This area of decision-support tools still requires further extensive research before a recommendation can be made.

It should be noted that the tools evaluated in the case studies provide only estimates for the purpose of initiating conversations about environmental stewardship practices, social impact assessments, and economic development – they do not replace thorough research and evaluation of these impacts (Harnik & Crompton, 2014). For administrators of public gardens and parks, these decision-support tools provide an avenue for increasing the recognition of urban green spaces as important environmental, social, and financial assets to the community (Christie et al., 2012; Schmolke et al., 2010; Singh et al., 2012).

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# CONCLUSION

Further opportunities of this research would be to develop an aggregate level of rating to signify the status of progress for an organization in achieving environmental and socioeconomic goals, or a type of spider diagram representing the various aspects of the tools to indicate where publicly-managed landscapes rank to national levels. An additional study would be to develop environmental and socioeconomic values based on square footage or per acreage/hectare similar to building costs per square foot. Finally, it would be ideal to further study the decision-support tools in various publicly-managed landscapes and communities on a wider scale to confirm the results of this study which was conducted on a relatively small scale.

As expected, not many public gardens conduct impact assessments according to the responses from a state of the industry survey. Although no environmental, social, and economic information is collected at several public gardens, many respondents indicated that they were considering collecting more information in the future, signifying an increasing interest in those areas. Many of the greatest challenges besides funding of public gardens may be potentially mitigated from information gathered from impact assessments.

The decision-support tools assessed in this study provide a range of different options for assessing environmental, social, and economic values and impacts for public gardens, municipalities, nonprofit organizations, small businesses, and other entities interested in self-assessments of their organizations. No individual tool encompasses assessments of all environmental, social, and economic impacts, but by incorporating an appropriate subset of tools on a regular basis, organizations should be able to gain a perspective on their estimated economic, ecosystem services, and health and well-being impacts upon their communities. For specific assessments of certain ecosystem services, those decision-support tools that measure only one to three factors will most likely provide the data needed to make proper decisions. Many of the tools provide initial screening information to provide perspective for estimated environmental and socioeconomic impacts. However, these decision-support tools do not replace in-depth, comprehensive assessments and longer-range planning.

# APPENDIX A

# A LIST OF DECISION-SUPPORT TOOLS ANALYZED IN THIS STUDY WITH THE ORGANIZATION(S) AND/OR INDIVIDUAL(S) WHO DEVELOPED THE TOOLS, THE WEBSITE LINKS TO ACCESS THE TOOLS, AND DESCRIPTIONS ABOUT THE PURPOSE OF THE TOOLS

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| Accelerator Lite | Sustainability Accelerator Network (formerly The Atkisson Group)<br>http://atkisson.com/acceleratorlite/ | Tool used to enable the management of sustainability awareness, training, planning, and implementation for individuals, organizations, suppliers, etc. |
| Accelerator Pro | Sustainability Accelerator Network (formerly The Atkisson Group)<br>http://atkisson.com/tools/ | Although the same as Accelerator Lite, the Pro version provides technical support for using the tools. |
| Aquatox v3.1 | US Environmental Protection Agency<br>https://www.epa.gov/exposure-assessment-models/aquatox | Simulation model for performing ecological risk assessments in aquatic ecosystems. |
| Automated Geospatial Watershed Assessment (AGWA) | US Environmental Protection Agency, US Department of Agriculture, Agricultural Research Service, University of Arizona<br>https://www.epa.gov/water-research/automated-geospatial-watershed-assessment-agwa-tool-hydrologic-modeling-and-watershed | GIS software used for analyzing and managing watershed water quality and quantity. |
| AVoided Emissions and geneRation Tool (AVERT) | US Environmental Protection Agency<br>https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert<br>https://www.epa.gov/statelocalenergy/avert-web-edition | Online tool used to analyze the emissions benefits of policies and programs for energy efficiency and renewable energy. |
| Better Assessment Science Integrating Point and Nonpoint | US Environmental Protection Agency<br>https://www.epa.gov/exposure-assessment-models/basins | A multipurpose analysis tool that uses GIS to organize spatial information and perform watershed- and water quality-based studies; |

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| Sources (BASINS) v4.1 | | integrates environmental data, analysis tools, and watershed and water quality models. |
| Bicycle Level of Service (BLOS) and Pedestrian Level of Service (PLOS) | League of Illinois Bicyclists<br>http://rideillinois.org/blos/blosform.htm<br>http://rideillinois.org/blos/losform.htm | Calculators used to determine the level of user comfort based on traffic and road conditions. |
| Bikeability Checklist | National Highway Traffic Safety Administration, the Pedestrian and Bicycle Information Center, and the U.S. Department of Transportation<br>https://www.epa.gov/smartgrowth/bikeability-checklist<br>https://www.epa.gov/sites/production/files/2014-12/documents/bikabilitychecklist.pdf<br>http://www.pedbikeinfo.org/pdf/community_bikeability_checklist.pdf | Survey that individuals can use to rate the ability to travel in an area safely and efficiently. Suggestions to make short- and long-term improvements related to bikeability are also available. |
| Bioaccumulation and Aquatic System Simulator (BASS) | US Environmental Protection Agency<br>https://www.epa.gov/exposure-assessment-models/bass | Simulation model to analyze fish population dynamics and to accurately predict chemical bioaccumulation in fish. |
| Building for Environmental and Economic Stability (BEES) v4.0 | National Institute of Standards and Technology<br>http://www.nist.gov/el/economics/BEESSoftware.cfm | Software for selecting building products that are cost-effective and perform well environmentally; analyzes lifecycle of products from raw material acquisition, manufacture, transportation, installation, use, to recycling and waste management. |
| Carbon Footprint Calculator | US Environmental Protection Agency<br>https://www3.epa.gov/carbon-footprint-calculator/ | Tool used by homeowners and small businesses to assess the carbon footprint based on energy, waste, and water use practices. |
| ClearPath (formerly Clean Air and | ICLEI Local Governments for Sustainability<br>http://icleiusa.org/clearpath/ | Software for the management of energy and emissions and mitigation efforts in local governments and communities. |

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| Climate Protection) 2009 | | |
| CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool | US Environmental Protection Agency<br>https://www.epa.gov/statelocalenergy/co-benefits-risk-assessment-cobra-health-impacts-screening-and-mapping-tool | Screening model for calculating the beneficial value of clean energy policies, including economic and health benefits. |
| COMET-Farm | United States Department of Agriculture, Natural Resources Conservation Service;<br>Colorado State University<br>http://cometfarm.nrel.colostate.edu/ | A farm and ranch management tool that compares current practices to simulated scenarios and the effects on greenhouse gas emissions and carbon changes. |
| COMET-Energy Tool | United States Department of Agriculture, Natural Resources Conservation Service;<br>Colorado State University<br>http://cometfarm.nrel.colostate.edu/<br>http://cometfarm.nrel.colostate.edu/QuickEnergy | A parallel tool to COMET-Farm that estimates greenhouse gas emission reductions based on anticipated fuel usage. |
| COMET-Planner Tool | United States Department of Agriculture, Natural Resources Conservation Service (NRCS); Colorado State University<br>http://cometfarm.nrel.colostate.edu/<br>http://comet-planner.com/ | Another planning tool of the COMET series used by the NRCS to evaluate carbon and greenhouse gas emissions by adopting NRCS conservation methods. |
| Community Multi-scale Air Quality (CMAQ) Modeling System v5.2.1 | US Environmental Protection Agency<br>https://www.cmascenter.org/cmaq/ & https://www.epa.gov/cmaq<br>https://www.epa.gov/air-research/community-multi-scale-air-quality-cmaq-modeling-system-air-quality-management | Modeling software for conducting air quality simulations and enable better air quality management. |
| Construction Carbon Calculator | Build Carbon Neutral<br>http://buildcarbonneutral.org/ | Tool for developers, architects, builders, and land planners to calculate the net amount of carbon for a project's site and structure(s). |
| Decking Cost Calculator | US Environmental Protection Agency<br>https://archive.epa.gov/wastes/conserve/tools/greenscapes/web/html/index-2.html | Useful tool for evaluating the construction cost of a deck using environmentally preferred building materials compared to conventional wood deck materials. |

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| Ecological Footprint Calculator | Global Footprint Network<br>http://www.footprintcalculator.org/<br>https://www.earthday.org/take-action/footprint-calculator/?gclid=EAIaIQobChMI2vGDqq6B3QIVCZNpCh2LaQUZEAAYAiAAEgKppPD_BwE | A management and communication tool that determines how much productive land and sea areas are required to support human activities including energy and transportation usage and waste generation from lifestyle traits. |
| Electronics Environmental Benefits Calculator (EEBC) v4 | US Environmental Protection Agency<br>https://www.epa.gov/fec/publications-and-resources#acquisition (resources)<br>http://app2.erg.com/EEBC-Computerv4/eebcCalculator.do (LATEST)<br>https://www.epa.gov/fec/using-electronics-environmental-benefits-calculator-eebc-7252012<br>https://www.epa.gov/greenerproducts/electronic-product-environmental-assessment-tool-epeat#tab-5-7 (EPEAT) | Calculator used to estimate the economic and environmental benefits of purchasing Electronic Product Environmental Assessment Tool (EPEAT)-registered products as well as equipment operation and end-of-life management practices. |
| Energy Star Cash Flow Opportunity Calculator | Energy Star by US Department of Energy and US Environmental Protection Agency)<br>https://www.energystar.gov/CFOcalculator<br>https://www.energystar.gov/buildings/tools-and-resources/cash-flow-opportunity-calculator-excel | Excel worksheet that estimates costs of financing new equipment using anticipated savings from energy efficient equipment and if money is being lost by waiting for lower interest rates. |
| EnergyPlus v8.9.0 | US Department of Energy<br>https://energyplus.net/ | Whole building simulation program to model water use and energy consumption for heating, cooling, ventilation, lighting, and plug and process loads in buildings; used in conjunction with OpenStudio software. |
| EnviroCalculator | Neenah, Inc.<br>https://www.neenahpaper.com/resources/calculators/envirocalculator | Tool similar to the Paper Calculator except it allows for the input of paper produced by wind power and the additional environmental benefits derived by that method. |
| Environmental Assessment of Public Recreation | Brian E. Saelens<br>http://activelivingresearch.org/environmental-assessment-public-recreation-spaces-eaprs-tool | Observation tool for assessing parks and playgrounds to evaluate physical aspects in regard to functionality. |

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| Spaces (EAPRS) Tool | | |
| Environmental Benefits Calculator | Nature Works LLC<br>Office of Health, Safety and Security, US Department of Energy<br>https://www.natureworksllc.com/Resources/Environ-Benefits-Calc | Used to calculate energy savings by substituting Ingeo biopolymer for traditional oil-based polymers. |
| Environmental Benefits Calculator | Northeast Waste Management Officials' Association<br>http://www.newmoa.org/prevention/projects/envben/ | Calculates benefits of waste reduction, water conservation, energy use and other conservation measures based on sustainable activity or practice. |
| Forest Vegetation Simulator | US Forest Service<br>https://www.fs.fed.us/fvs/whatis/index.shtml<br>https://www.fs.fed.us/fvs/software/complete.php | System of integrated tools that determine response changes to natural succession, proposed management actions, and disturbances. Certain variants of the simulator can estimate carbon stocks, from dead and live trees, downed dead trees, and forest floor biomass information. |
| Green Cleaning Pollution Prevention Calculator | Responsible Purchasing Network<br>http://www.responsiblepurchasing.org/janitor/buildinginfo.asp | Calculator that determines which green cleaning measures have the greatest impact in hazardous chemicals reduction and in pollution prevention. |
| Green Infrastructure Flexible Model (GIFMod) | US Environmental Protection Agency<br>http://gifmod.com/ | Simulation program used for the evaluation of water quality and hydraulic performance under certain weather scenarios based upon green infrastructure practices. |
| Green Roof Energy Calculator v2.0 | US Green Building Council, Green Roofs for Healthy Cities, David Sailor, Brad Bass, University of Toronto, Portland State University, Environment and Climate Change Canada<br>Maintained by the Urban Climate Research Center, Arizona State University | Calculator that compares annual energy performances of a vegetative green roof to a dark or white roof on a building. |

| Valuation Tool | Developer | Purpose/Description |
|---|---|---|
| | https://sustainability.asu.edu/urban-climate/green-roof-calculator/ | |
| Green Values Stormwater Management Calculator | Center for Neighborhood Technology<br>http://greenvalues.cnt.org/calculator/calculator.php | Quantifies impact of green design features (native landscaping, drainage swales, green roofs, permeable pavers, etc.) and compares those values to conventional systems. |
| Greenhouse Gas Equivalencies Calculator | US Environmental Protection Agency<br>https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator | A calculator to translate annual emissions from automobiles, households, etc., into greenhouse gas equivalencies. |
| Home Heating Cost Calculator | Efficiency Maine<br>http://www.efficiencymaine.com/at-home/home-energy-savings-program/heating-cost-comparison/ | Compares the estimated annual heating costs of different heating systems based upon current heating systems in place. |
| Housing and Transportation Affordability Index | Center for Neighborhood Technology<br>http://htaindex.cnt.org/map/ | Based upon location, this tool provides the affordability of housing based on housing and transportation costs. |
| Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) v3.3.1 | Natural Capital Project<br>http://www.naturalcapitalproject.org/invest/ | Software that consists of 18 models used to determine the value of goods and services provided by nature; used to help decision makers in governments, non-profit organizations, and corporations to make informed decisions based on quantified tradeoffs and alternative management choices. |
| i-Tree | US Department of Agriculture Forest Service, Davey Tree Expert Company, National Arbor Day Foundation, Society of Municipal Forests, International Society of Arboriculture, Casey Trees<br>http://www.itreetools.org/about.php | Software that consists of 11 forest analysis tools/utility programs; used to aid in improving management of forests and quantifying environmental services provided by trees and forest structure. |
| Landuse Evolution and Impact | University of Illinois Design Research Lab, KTH Royal Institute of Technology, American University of Sharjah | Spatial simulation modeling that is used to discover probable implications of urban |

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| Assessment Model (LEAM) | http://www.leam.uiuc.edu/<br>http://portal.leam.illinois.edu/chicago2017/model.html (MODEL LOCATION FOR CHICAGO) | policies and investment management decisions in a scenario-based format. |
| Lifecycle Cost Analysis (LCCA) | Whole Building Design Guide (National Institute of Building Sciences) http://www.wbdg.org/resources/lcca.php | Estimates overall costs of project alternatives; enables an assessment of the total cost of owning a facility including all costs for acquisition, owning, and disposing of a building/building system; allows for lowest overall cost of ownership. |
| Local Greenhouse Gas Inventory Tool | US Environmental Protection Agency<br>https://www.epa.gov/statelocalenergy/local-greenhouse-gas-inventory-tool | Interactive spreadsheet with two separate modules for community-wide and local government inventories of greenhouse gas emissions from residential, commercial, transportation, and water and waste management. |
| Long-term Hydrologic Impact Analysis Tool | Purdue University<br>https://engineering.purdue.edu/mapserve/LTHIA7/lthianew/tool.php | Open-access, online tool for assessing water quality impacts due to land use change; estimates recharge, runoff, and nonpoint source pollution. |
| Low Impact Development Rapid Assessment (LIDRA) Model v2 | Drexel University, HDR, Inc.<br>http://www.lidratool.org/ | Compares how different types of low impact development and green infrastructure are cost effective in the reduction of runoff. |
| Managing and Transforming Waste Streams Tool | US Environmental Protection Agency<br>https://www.epa.gov/transforming-waste-tool/managing-and-transforming-waste-streams-tool | Web-based or as an Excel worksheet, this tool estimates the life-cycle impacts of greenhouse gas emissions and energy from various post-consumer recycled content products. |
| Microscale Audit of Pedestrian Streetscapes (MAPS) | James F. Sallis, University of California, San Diego<br>http://sallis.ucsd.edu/measure_maps.html | Survey with three options of complexity used for collecting data on the walkability and pedestrian environment in neighborhoods. |

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| | | |
| My Environment | US Environmental Protection Agency<br>https://www3.epa.gov/enviro/myenviro/ | Provides information about air quality, water quality, health statistics, and other environmental factors based upon location. |
| National Stormwater Calculator | US Environmental Protection Agency<br>https://www.epa.gov/water-research/national-stormwater-calculator | Desktop application used for estimating annual rainfall amounts and frequency of runoff from specific sites in the United States based on local soil conditions, historic rainfall records, and land cover; users can select from a list of green infrastructure practices to determine effects from low impact development. |
| National Tree Benefit Calculator | Casey Trees<br>http://www.treebenefits.com/calculator/<br>https://www.arborday.org/calculator/ | Estimation of annual environmental and economic values provided by trees based upon location, species, and tree size. |
| Neighborhood Quality of Life Survey (NQLS) | James F. Sallis<br>http://sallis.ucsd.edu/measure_nqls.html | This instrument surveys residents to assess the relationship between one's neighborhood, quality of life, health, and physical activity. |
| Office Emissions Calculator | Carbonfund.org Foundation<br>https://carbonfund.org/business-calculator/ | Tool for determining the amount of carbon an office creates and how much needs to be offset to be carbon neutral. |
| Paper Calculator | Environmental Paper Network<br>http://c.environmentalpaper.org/home | Tool used for quantifying the impact of paper usage and to compare different grades and types of paper with varying levels of recycled content. |
| Parks and Recreation Areas Self-Report Survey | Sandy Slater, Kelsie Full, Marian Fitzgibbon, and Myron Floyd, University of Illinois at Chicago<br>http://activelivingresearch.org/parks-and-recreation-areas-self-report-survey | Tool used for measuring the presence and condition of features and other amenities of an area, particularly those visited by adolescents. |
| Pedestrian Environmental | San Francisco Department of Health<br>https://nacto.org/wp-content/uploads/2015/04/Pedestrian-Environmental-Quality-Index-Part-I.pdf | Tool utilized during the planning process to prioritize pedestrian infrastructure. |

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| Quality Index Tool (PEQI) v2.0 | | |
| Prove It! Measuring the Effect of Neighborhood Renewal | New Economics Foundation<br>https://neweconomics.org/2000/05/prove-it | Tool for measuring the impact of community projects on local people and their quality of life; promotes social capital. |
| PV Watts Calculator | National Renewable Energy Laboratory (US Department of Energy)<br>http://pvwatts.nrel.gov/ | Estimates energy production and energy cost of photovoltaic energy systems for small building owners, homeowners, installers, and manufacturers; In My Backyard (IMBY) solar simulation tool was incorporated into this calculator. |
| Rainwater Harvesting Supply Calculator | Texas A&M AgriLife Extension<br>http://rainwaterharvesting.tamu.edu/calculators/ | Excel worksheet that enables the user correctly size a water harvesting system to determine stored water volume over three years and if supplemental irrigation will be needed. |
| Recycled Content (ReCon) Tool | US Environmental Protection Agency<br>https://19january2017snapshot.epa.gov/www3/epawaste/conserve/tools/warm/ReCon_Online.html | Online tool that evaluates the greenhouse gas benefits by utilizing recycled content of materials. |
| Recycling and Reusing Hardscapes and Landscape Waste Cost Calculator | US Environmental Protection Agency<br>https://archive.epa.gov/wastes/conserve/tools/greenscapes/web/html/index-2.html | Calculator that estimates savings by reusing and recycling waste materials generated from landscapes. |
| Regency Lighting Energy Savings Calculator | Regency Lighting<br>https://www.regencylighting.com/lighting-resources/energy-savings-calculator/ | Calculates the return on investment for total cost of lighting, especially for retrofitting or upgrading existing lighting. |
| Residential Environment | Cardiff University<br>http://reat.cardiff.ac.uk/ (ONLINE VERSION) | Paper and web-based tool developed in the United Kingdom used to assess |

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| Assessment Tool (REAT) v2.0 | http://reat.cardiff.ac.uk/downloads/Appendix-7-REAT-2.0-Audit-Tool-Final-(18.1.16).pdf | neighborhood conditions and natural elements as a means to evaluate various health and quality of life as well as neighborhood quality. |
| Resource Conserving Landscaping Cost Calculator | US Environmental Protection Agency<br>https://archive.epa.gov/wastes/conserve/tools/greenscapes/web/html/index-2.html | Calculator that compares the cost of using conventional landscape plants with plants that require less irrigation and produce less waste. |
| Resource Stewardship Evaluation | United States Department of Agriculture, Natural Resources Conservation Service;<br>file:///C:/Users/gbsha/Downloads/RSE_Fact_Sheet_November_2017.pdf | Evaluation that assesses soil management, water quality, water quantity, air quality, and habitat health conservation programs for farm managers and other land managers. |
| Social Impact Measurement Toolkit | National Disability Services (Australia)<br>https://www.nds.org.au/resources/social-impact-measurement-toolkit-simt | A set of tools that require minimal technological and technical expertise and used to assess the social impact of programs in non-governmental organizations on people and to maintain consistent outcomes. |
| Social Return on Investment (SROI) | Original: Roberts Enterprise Development Fund<br>Revision: Social Value UK<br>http://www.socialvalueuk.org/ | A framework that incorporates accounting methods to measure economic, environmental, and social costs and benefits; it focuses on value as opposed to monetary aspects. |
| Social Value Self Assessment Tool | Social Value UK<br>http://www.socialvalueuk.org/what-is-social-value/sroi-self-assessment-tool/ | Online questionnaire that helps determine how well social value is being measured and reported, and the level of quality of an organization’s social value measurement practices. |
| Soil-Plant-Air-Water (SPAW) Field and Pond Hydrology Model | US Department of Agriculture, Washington State University<br>http://hydrolab.arsusda.gov/SPAW/Index.htm<br>https://hrsl.ba.ars.usda.gov/SPAW/Index.htm | Model simulation of daily hydrologic water budgets for agricultural lands as well as lagoons, ponds, wetlands, and reservoirs. |

| Valuation Tool | Developer | Purpose/Description |
|---|---|---|
| STAR Community Rating System (STAR) | STAR Communities<br>http://www.starcommunities.org/ | A certification program and sustainability framework for communities to address economic, environmental, and social progress. |
| Storm Water Management Model (SWMM) v5.1.013 | US Environmental Protection Agency<br>https://www.epa.gov/water-research/storm-water-management-model-swmm | Simulation model for hydraulic-hydrology water quality for single event or long-term analogies of runoff and pollutant loads; a low-impact development control option allows for analyses using green infrastructure practices. |
| Sustainable Facilities Tool Cost-Effective Upgrades Tool | US General Services Administration<br>https://sftool.gov/plan/upgrades/selections | Online tool for businesses and government agencies to determine cost-effective ways of lowering energy costs through certain facilities maintenance practices. |
| System for Observing Physical Activity and Recreation in Natural Areas (SOPARNA) | Vinod Sasidharan and Thomas L. McKenzie, San Diego State University<br>https://activelivingresearch.org/soparna-system-observing-physical-activity-and-recreation-natural-areas<br>http://activelivingresearch.org/sites/default/files/SOPARNA_Protocols_04.30.14_0.pdf | Tool for measuring by observation physical activity in outdoor recreation areas to better understand user behavior and characteristics. |
| The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits | Center for Neighborhood Technology<br>http://www.cnt.org/publications/the-value-of-green-infrastructure-a-guide-to-recognizing-its-economic-environmental-and | Publication that provides a broad analysis in valuing economic, environmental, and social benefits to aid decision-makers and planners in making informed decisions and provide communities a guide to valuing the benefits of green infrastructure investments. |
| Universal Floristic Quality Assessment (FQA) Calculator | William A. Freyman, Openlands<br>http://universalfqa.org/about | Web-based calculator to assess ecological integrity of an area based on plant species composition. |

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| Vegetable Garden Value Calculator | PlanGarden<br>http://www.plangarden.com/app/vegetable_value/ | Calculator to estimate harvest amounts for vegetables. |
| Visualizing Ecosystem Land Management Assessments (VELMA) Model v2.0 | US Environmental Protection Agency<br>https://www.epa.gov/water-research/visualizing-ecosystem-land-management-assessments-velma-model-20 | Tool for evaluating different green infrastructure options in managing water, toxins, and nutrient loads as well as simulating maintenance and longevity of green infrastructure to predict potential failures based upon contaminant loads, climate change, soil properties, and other factors. |
| Volunteering Impact Assessment Toolkit | The National Council for Voluntary Organisations<br>https://www.ncvo.org.uk/component/redshop/1-publications/P78-volunteering-impact-assessment-toolkit | A set of questionnaires designed for volunteers, the host organization, service users, and the community to ascertain a better understanding of the impact of volunteers. |
| Walk Score and Walk Score Professional | Walk Score<br>https://www.walkscore.com/<br>https://www.walkscore.com/professional/research.php | Calculator that determines the walkability of an address based upon the distance to nearby amenities; based upon the characteristics of a neighborhood or community, the tool calculates the ease of living a lifestyle with less reliance on automobiles; Walk Score API software technology also available. |
| Walkability Checklist | Partnership for a Walkable America, the Pedestrian and Bicycle Information Center, and the U.S. Department of Transportation<br>https://www.epa.gov/smartgrowth/walkability-checklist<br>https://www.epa.gov/sites/production/files/2014-03/documents/checklist_walkability_0.pdf<br>http://www.pedbikeinfo.org/pdf/community_walkability_checklist.pdf | Survey that individuals can use to rate the ability to walk in an area safely and efficiently. Suggestions to make short- and long-term improvements related to walkability are also available. |
| Waste Reduction Model (WARM) v14 | US Environmental Protection Agency<br>https://www.epa.gov/warm/versions-waste-reduction-model-warm#WARM Tool V14 | Compares the benefits of alternative waste management scenarios to typical business practices in determining best waste management practices for an organization. |

| **Valuation Tool** | **Developer** | **Purpose/Description** |
|---|---|---|
| Water Harvesting Calculator | Washington State Department of Ecology<br>https://ecology.wa.gov/Water-Shorelines/Water-supply/Water-recovery-solutions/Rainwater-collection | Calculator to estimate the amount of water that could be captured from roofs and parking lots and compares it to the volume of water needed for a building. |
| Water Quality Analysis Simulation Program (WASP) | US Environmental Protection Agency<br>https://www.epa.gov/ceam/water-quality-analysis-simulation-program-wasp | Simulation model that predicts the effects of pollution management policies on water quality responses to anthropogenic pollution and natural occurrences. |
| WaterSense Water Budget Tool | US Environmental Protection Agency<br>https://www.epa.gov/watersense/water-budget-tool (home page)<br>https://www.epa.gov/watersense/water-budget-data-finder (for use with Excel tool) | Calculator that determines the water budget for primarily new home construction based on landscape design specifications. |
| Watershed Management Optimization Support Tool (WMOST) v3.0 | US Environmental Protection Agency<br>https://www.epa.gov/ceam/wmost<br>https://www.epa.gov/ceam/wmost-30-download-page | Tool that evaluates different water resource management practices based upon fifteen stormwater management practices including traditional, green infrastructure, and low impact development practices. |

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# APPENDIX B

## RESULTS FROM ANALYSES OF ENVIRONMENTAL, SOCIAL, AND ECONOMIC VARIABLES USED TO ANALYZE EIGHTY-TWO DECISION-SUPPORT TOOLS

Table B-1. A list of eighty-two valuation tools analyzed in the study with the number of environmental, social, and/or economic variables assessed and the type of accessibility (free, open source) for each valuation tool indicated by a bullet (•) in the table.

| | **Type of assessment** | | | **Access** |
|---|---|---|---|---|
| **Valuation tool** | **Environmental** | **Social** | **Economic** | **Free (open source)** |
| Accelerator Lite | 4 | 3 | 1 | • |
| Accelerator Pro | 4 | 3 | 1 | |
| Aquatox v3.1 | 6 | 0 | 0 | • |
| Automated Geospatial Watershed Assessment (AGWA) | 2 | 0 | 0 | |
| AVoided Emissions and GeneRation Tool (AVERT) | 3 | 0 | 0 | • |
| Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) v4.1 | 3 | 1 | 0 | • |
| Bicycle Level of Service (BLOS) and Pedestrian Level of Service (PLOS) | 0 | 2 | 0 | • |
| Bikeability Checklist | 0 | 1 | 0 | • |
| Bioaccumulation and Aquatic System Simulator (BASS) | 2 | 0 | 0 | • |
| Building for Environmental and Economic Sustainability (BEES) | 6 | 0 | 2 | • |
| Carbon Footprint Calculator | 5 | 0 | 1 | • |
| ClearPath | 3 | 0 | 0 | |
| CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool | 2 | 1 | 1 | • |
| COMET-Farm | 3 | 0 | 0 | • |
| COMET-Energy Tool | 4 | 0 | 0 | • |

Table B-1 Continued.

| | Type of assessment | | | Access |
|---|---|---|---|---|
| **Valuation tool** | **Environmental** | **Social** | **Economic** | **Free (open source)** |
| COMET-Planner Tool | 5 | 0 | 0 | • |
| Community Multi-scale Air Quality (CMAQ) Modeling System v5.2.1 | 2 | 0 | 0 | • |
| Construction Carbon Calculator | 1 | 0 | 0 | • |
| Decking Cost Calculator | 1 | 0 | 0 | • |
| Ecological Footprint Calculator | 9 | 3 | 1 | • |
| Electronics Environmental Benefits Calculator (EEBC) v4 | 2 | 0 | 1 | • |
| Energy Star Cash Flow Opportunity Calculator | 2 | 0 | 1 | • |
| EnergyPlus v8.9.0 | 2 | 0 | 0 | • |
| EnviroCalculator | 4 | 0 | 0 | • |
| Environmental Assessment of Public Recreation Spaces (EAPRS) Tool | 0 | 6 | 0 | • |
| Environmental Benefits Calculator | 2 | 0 | 0 | • |
| Environmental Benefits Calculator (NEWMOA) | 2 | 0 | 0 | • |
| Forest Vegetation Simulator | 4 | 0 | 1 | • |
| Green Cleaning Pollution Prevention Calculator | 3 | 0 | 0 | • |
| Green Infrastructure Flexible Model (GIFMod) | 3 | 0 | 0 | • |
| Green Roof Energy Calculator (v. 2.0) | 2 | 0 | 1 | • |
| Green Values Stormwater Management Calculator | 7 | 1 | 1 | • |
| Greenhouse Gas Equivalencies Calculator | 4 | 0 | 0 | • |
| Home Heating Cost Calculator | 1 | 0 | 1 | • |
| Housing and Transportation Affordability Index | 1 | 1 | 1 | • |
| Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) v3.4.4 | 9 | 3 | 1 | • |

Table B-1 Continued.

| Valuation tool | Type of assessment | | | Access |
|---|---|---|---|---|
| | Environmental | Social | Economic | Free (open source) |
| i-Tree | 11 | 1 | 2 | • |
| Landuse Evolution and Impact Assessment Model (LEAM) | 6 | 1 | 1 | • |
| Lifecycle Cost Analysis (LCCA) | 3 | 0 | 2 | • |
| Local Greenhouse Gas Inventory Tool | 1 | 0 | 0 | • |
| Long-term Hydrologic Impact Analysis Tool (L-THIA) | 4 | 0 | 0 | • |
| Low Impact Development Rapid Assessment (LIDRA) Model v2 | 3 | 0 | 0 | • |
| Managing and Transforming Waste Streams Tool | 1 | 0 | 0 | • |
| Microscale Audit of Pedestrian Streetscapes (MAPS) | 0 | 1 | 0 | • |
| My Environment | 5 | 0 | 0 | • |
| National Stormwater Calculator | 4 | 0 | 0 | • |
| National Tree Benefit Calculator | 4 | 0 | 1 | • |
| Neighborhood Quality of Life Survey (NQLS) | 0 | 7 | 0 | • |
| Office Emissions Calculator | 1 | 0 | 0 | • |
| Paper Calculator | 6 | 0 | 0 | • |
| Parks and Recreation Areas Self-Report Survey | 0 | 8 | 0 | • |
| Pedestrian Environmental Quality Index Tool (PEQI) v2.0 | 3 | 3 | 0 | • |
| Prove It! Measuring the Effect of Neighborhood Renewal | 0 | 2 | 0 | • |
| PV Watts Calculator | 1 | 0 | 1 | • |
| Rainwater Harvesting Supply Calculator | 1 | 0 | 0 | • |
| Recycled Content (ReCon) Tool | 2 | 0 | 0 | • |
| Recycling and Reusing Landscape Waste Cost Calculator | 2 | 1 | 1 | • |
| Regency Lighting Energy Savings Calculator | 1 | 0 | 1 | • |

Table B-1 Continued.

| Valuation tool | Type of assessment | | | Access |
|---|---|---|---|---|
| | Environmental | Social | Economic | Free (open source) |
| Residential Environment Assessment Tool (REAT) v2.0 | 0 | 4 | 0 | • |
| Resource Conserving Landscaping Cost Calculator | 1 | 0 | 1 | • |
| Resource Stewardship Evaluation | 3 | 0 | 0 | • |
| Social Impact Measurement Toolkit | 0 | 2 | 0 | |
| Social Return on Investment (SROI) | 1 | 1 | 1 | • |
| Social Value Self-Assessment Tool | 0 | 1 | 0 | • |
| SPAW (Soil-Plant-Air-Water) Model | 2 | 0 | 0 | • |
| STAR Community Rating System (STAR) | 10 | 7 | 1 | • |
| Storm Water Management Model v5.1.013 | 2 | 0 | 0 | • |
| Sustainable Facilities Tool Cost-Effective Upgrades Tool | 2 | 0 | 1 | • |
| System for Observing Physical Activity and Recreation in Natural Areas (SOPARNA) | 0 | 4 | 0 | • |
| The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits | 9 | 2 | 1 | • |
| Universal Floristic Quality Assessment (FQA) Calculator | 3 | 0 | 0 | • |
| Vegetable Garden Value Calculator | 0 | 1 | 0 | • |
| Visualizing Ecosystem Land Management Assessments (VELMA) Model v2.0 | 3 | 0 | 0 | • |
| Volunteering Impact Assessment Toolkit | 0 | 1 | 1 | |
| Walk Score | 0 | 1 | 0 | • |
| Walk Score Professional | 1 | 5 | 0 | |
| Walkability Checklist | 0 | 1 | 0 | • |
| Waste Reduction Model (WARM) v14 | 4 | 0 | 0 | • |
| Water Harvesting Calculator | 1 | 0 | 0 | • |
| Water Quality Analysis Simulation Program (WASP) | 1 | 0 | 0 | • |

Table B-1 Continued.

| Valuation tool | Type of assessment |  |  | Access |
|---|---|---|---|---|
|  | Environmental | Social | Economic | Free (open source) |
| WaterSense Water Budget Tool | 1 | 0 | 0 | • |
| Watershed Management Optimization Support Tool (WMOST) v3.0 | 5 | 0 | 1 | • |

Table B-2. The eighty-two valuation tools were analyzed according to thirty-three variables grouped into environmental, social, and economic categories based upon criteria established by the European Commission (2009) and the Organisation for Economic Co-operation and Development (2010).

| Environmental | Social | Economic |
|---|---|---|
| Air quality | Activity level | Economic activity |
| Biodiversity | Bicycle friendliness | Maintenance |
| Carbon (incl. sequestration) | Cultural/social activities/impact | Property value |
| Coastal aspects | Food production/security | |
| Ecosystem impact | Health benefits | |
| Energy use | Litter | |
| Forecasting | Pedestrian friendliness | |
| Green infrastructure | Recreation | |
| Greenhouse gas emissions | Scenic quality | |
| Land use | Transportation | |
| Marine/aquatic | | |
| Noise | | |
| Pollination | | |
| Recycling/waste reduction | | |
| Risk | | |
| Sediment retention | | |
| Stormwater management | | |
| Tree benefits | | |
| Water | | |
| Water harvesting | | |

Table B-3. Sixty-seven valuation tools categorized according to environmental variables assessed by each tool indicated by a bullet (•) in the table.

| Valuation Tool | Air quality | Biodiversity | Carbon (incl. sequestration) | Coastal | Ecosystem impact | Energy use | Forecasting | Green infrastructure | Greenhouse gas emissions | Land use | Marine/aquatic | Noise | Pollination | Recycling/ waste reduction | Risk | Sediment retention | Stormwater management | Tree benefits | Water | Water harvesting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Accelerator Lite |  | • |  |  | • | • |  |  |  |  |  |  |  |  |  |  |  |  | • |  |
| Accelerator Pro |  | • |  |  | • | • |  |  |  |  |  |  |  |  |  |  |  |  | • |  |
| Aquatox v3.1 |  | • |  |  | • |  | • |  |  |  | • |  |  |  |  | • |  |  | • |  |
| Automated Geospatial Watershed Assessment (AGWA) |  |  |  |  |  |  | • |  |  |  |  |  |  |  |  |  |  |  | • |  |
| AVoided Emissions and GeneRation Tool (AVERT) | • |  |  |  |  | • |  |  | • |  |  |  |  |  |  |  |  |  |  |  |
| Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) v4.1 | • |  |  |  |  |  |  |  |  |  | • |  |  |  |  |  |  |  | • |  |
| Bioaccumulation and Aquatic System Simulator (BASS) |  |  |  |  |  |  | • |  |  |  | • |  |  |  |  |  |  |  |  |  |
| Building for Environmental and Economic Sustainability (BEES) | • |  | • |  | • | • |  |  | • |  |  |  |  | • |  |  |  |  |  |  |
| Carbon Footprint Calculator |  |  | • |  |  | • | • |  | • |  |  |  |  | • |  |  |  |  |  |  |
| ClearPath |  |  |  |  |  | • | • |  | • |  |  |  |  |  |  |  |  |  |  |  |

Table B-3 Continued.

| **Valuation Tool** | **Air quality** | **Biodiversity** | **Carbon (incl. sequestration)** | **Coastal** | **Ecosystem impact** | **Energy use** | **Forecasting** | **Green infrastructure** | **Greenhouse gas emissions** | **Land use** | **Marine/aquatic** | **Noise** | **Pollination** | **Recycling/ waste reduction** | **Risk** | **Sediment retention** | **Stormwater management** | **Tree benefits** | **Water** | **Water harvesting** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool | • | | | | | • | | | | | | | | | | | | | | |
| COMET-Farm | | | • | | | □ | | | • | • | | | | | | | | | | |
| COMET-Energy Tool | • | | • | | | • | | | • | | | | | | | | | | | |
| COMET-Planner Tool | • | | • | | | • | • | | • | | | | | | | | | | | |
| Community Multi-scale Air Quality (CMAQ) Modeling System v5.2.1 | • | | | | | | | | • | | | | | | | | | | | |
| Construction Carbon Calculator | | | • | | | | | | | | | | | | | | | | | |
| Decking Cost Calculator | | | □ | | | | | | | | | | | • | | | | | | |
| Ecological Footprint Calculator | • | | • | | • | | • | • | • | • | | | | • | | | □ | | • | |
| Electronics Environmental Benefits Calculator (EEBC) v4 | | | | | | • | | | | | | | | • | | | | | | |
| Energy Star Cash Flow Opportunity Calculator | | | | | | • | • | | | | | | | | | | | | | |
| EnergyPlus v8.9.0 | | | | | | • | | | | | | | | | | | | | • | |
| EnviroCalculator | | | • | | | • | | | • | | | | | • | | | | | | |

Table B-3 Continued.

| **Valuation Tool** | **Air quality** | **Biodiversity** | **Carbon (incl. sequestration)** | **Coastal** | **Ecosystem impact** | **Energy use** | **Forecasting** | **Green infrastructure** | **Greenhouse gas emissions** | **Land use** | **Marine/aquatic** | **Noise** | **Pollination** | **Recycling/ waste reduction** | **Risk** | **Sediment retention** | **Stormwater management** | **Tree benefits** | **Water** | **Water harvesting** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Environmental Benefits Calculator | | | | | | • | | | • | | | | | | | | | | | |
| Environmental Benefits Calculator (NEWMOA) | | | | | | • | | | • | | | | | | | | | | | |
| Forest Vegetation Simulator | | | • | | • | | • | | | • | | | | | | | | | | |
| Green Cleaning Pollution Prevention Calculator | | | | | • | • | | | | | | | | • | | | | | | |
| Green Infrastructure Flexible Model (GIFMod) | | | | | □ | | | • | | | | | | | | | • | | • | |
| Green Roof Energy Calculator (v. 2.0) | | | | | | • | | • | | | | | | | | | | | | |
| Green Values Stormwater Management Calculator | • | | • | | | | • | • | | | | | | | | | • | • | • | □ |
| Greenhouse Gas Equivalencies Calculator | | | • | | | • | | | • | | | | | • | | | | | | |
| Home Heating Cost Calculator | | | | | | • | | | | | | | | | | | | | | |
| Housing and Transportation Affordability Index | | | | | | | | | • | | | | | | | | | | | |

Table B-3 Continued.

| **Valuation Tool** | **Air quality** | **Biodiversity** | **Carbon (incl. sequestration)** | **Coastal** | **Ecosystem impact** | **Energy use** | **Forecasting** | **Green infrastructure** | **Greenhouse gas emissions** | **Land use** | **Marine/aquatic** | **Noise** | **Pollination** | **Recycling/ waste reduction** | **Risk** | **Sediment retention** | **Stormwater management** | **Tree benefits** | **Water** | **Water harvesting** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) v3.4.4 | | • | • | • | □ | • | | • | | | • | | • | | | • | | | • | |
| i-Tree | • | • | • | | • | • | • | • | | □ | | | | | • | | • | • | • | |
| Landuse Evolution and Impact Assessment Model (LEAM) | | | | | • | | • | • | | • | | | | | | | • | | • | |
| Lifecycle Cost Analysis (LCCA) | | | | | | • | • | | | | | | | | | | | | • | |
| Local Greenhouse Gas Inventory Tool | | | | | | | | | • | | | | | | | | | | | |
| Long-term Hydrologic Impact Analysis Tool (L-THIA) | | | | | | | • | | | • | | | | | | | • | | • | |
| Low Impact Development Rapid Assessment (LIDRA) Model v2 | | | | | | | • | • | | □ | | | | | | | | | • | |
| Managing and Transforming Waste Streams Tool | | | | | | | | | | | | | | • | | | | | | |
| My Environment | • | | • | | | • | | | • | | | | | | | | | | • | |
| National Stormwater Calculator | | | | | | | • | • | | | | | | | | | • | | | • |
| National Tree Benefit Calculator | • | | • | | | • | | | | | | | | | | | • | | | |

Table B-3 Continued.

| **Valuation Tool** | **Air quality** | **Biodiversity** | **Carbon (incl. sequestration)** | **Coastal** | **Ecosystem impact** | **Energy use** | **Forecasting** | **Green infrastructure** | **Greenhouse gas emissions** | **Land use** | **Marine/aquatic** | **Noise** | **Pollination** | **Recycling/ waste reduction** | **Risk** | **Sediment retention** | **Stormwater management** | **Tree benefits** | **Water** | **Water harvesting** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office Emissions Calculator | | | • | | | | | | | | | | | | | | | | | |
| Paper Calculator | • | | | | • | • | | | • | | | | | • | | | | | • | |
| Pedestrian Environmental Quality Index Tool (PEQI) v2.0 | | | | | | | | | | • | | • | | | | | | | | • |
| PV Watts Calculator | | | | | | • | | | | | | | | | | | | | | |
| Rainwater Harvesting Supply Calculator | | | | | | | | | | | | | | | | | | | | • |
| Recycled Content (ReCon) Tool | | | | | | • | | | • | | | | | | | | | | | ☐ |
| Recycling and Reusing Landscape Waste Cost Calculator | | | | | | • | | | ☐ | | | | | • | | | | | | ☐ |
| Regency Lighting Energy Savings Calculator | | | | | | • | | | | | | | | | | | | | | |
| Resource Conserving Landscaping Cost Calculator | | | | | | | | | | | | | | | | | | | • | |
| Resource Stewardship Evaluation | | • | | | | | | | | • | | | | | | | | | • | |
| Social Return on Investment (SROI) | | | | | ☐ | | • | | | | | | | | | | | | | |

Table B-3 Continued.

| Valuation Tool | Air quality | Biodiversity | Carbon (incl. sequestration) | Coastal | Ecosystem impact | Energy use | Forecasting | Green infrastructure | Greenhouse gas emissions | Land use | Marine/aquatic | Noise | Pollination | Recycling/ waste reduction | Risk | Sediment retention | Stormwater management | Tree benefits | Water | Water harvesting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPAW (Soil-Plant-Air-Water) Model | | | | | | | • | | | | | | | | | | | | • | |
| STAR Community Rating System (STAR) | • | • | | | • | • | | • | • | • | | • | | • | | | | | • | |
| Storm Water Management Model v5.1.013 | | | | | | | | • | | | | | | | | | • | | | |
| Sustainable Facilities Tool Cost-Effective Upgrades Tool | | | | | | • | • | ☐ | | | | | | | | | ☐ | | | |
| The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits | • | • | • | | | • | | • | | | | • | | | | | • | | • | • |
| Universal Floristic Quality Assessment (FQA) Calculator | | • | | | • | | | | | • | | | | | | | | | | |
| Visualizing Ecosystem Land Management Assessments (VELMA) Model v2.0 | | | | | • | | | • | | | | | | | | | | | • | |
| Walk Score Professional | | | | | | | • | | | | | | | | | | | | | |
| Waste Reduction Model (WARM) v14 | | | • | | | • | | | • | | | | | • | | | | | | |

Table B-3 Continued.

| Valuation Tool | Air quality | Biodiversity | Carbon (incl. sequestration) | Coastal | Ecosystem impact | Energy use | Forecasting | Green infrastructure | Greenhouse gas emissions | Land use | Marine/aquatic | Noise | Pollination | Recycling/ waste reduction | Risk | Sediment retention | Stormwater management | Tree benefits | Water | Water harvesting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water Harvesting Calculator | | | ☐ | | | ☐ | | | ☐ | | | | | ☐ | | | | | | • |
| Water Quality Analysis Simulation Program (WASP) | | | | | | | | | | | | | | | | | | | • | ☐ |
| WaterSense Water Budget Tool | | | | | | | | | | | | | | | | | | | • | ☐ |
| Watershed Management Optimization Support Tool (WMOST) v3.0 | | | | | • | | • | • | | | | | | | | | • | | • | ☐ |
| **Number measuring factor:** | 15 | 9 | 18 | 1 | 14 | 33 | 21 | 14 | 20 | 9 | 4 | 3 | 1 | 13 | 1 | 2 | 10 | 2 | 26 | 5 |
| **Percentage:** | 22.4% | 13.4% | 26.9% | 1.5% | 20.9% | 49.3% | 31.3% | 20.9% | 29.9% | 13.4% | 6.0% | 4.5% | 1.5% | 19.4% | 1.5% | 3.0% | 14.9% | 3.0% | 38.8% | 7.5% |

Table B-4. Thirty-one valuation tools categorized according to social variables assessed by each tool indicated by a bullet (•) in the table.

| | Social Variables Assessed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Valuation Tool | Activity Level | Bicycle friendliness | Cultural/social activities/impact | Food production/security | Health benefits | Litter | Pedestrian friendliness | Recreation | Scenic quality | Transportation |
| Accelerator Lite | • | | • | | • | | | | | |
| Accelerator Pro | • | | • | | • | | | | | |
| Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) v4.1 | | | | | • | | | | | |
| Bicycle Level of Service (BLOS) and Pedestrian Level of Service (PLOS) | | • | | | | | • | | | |
| Bikeability Checklist | | • | | | | | | | | |
| CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool | | | | | • | | | | | |
| Ecological Footprint Calculator | | | • | • | | | | | | • |
| Environmental Assessment of Public Recreation Spaces (EAPRS) Tool | • | • | • | | | | • | • | • | |
| Green Values Stormwater Management Calculator | | | | | • | | | | | |
| Housing and Transportation Affordability Index | | | | | | | | | | • |
| Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) v3.4.4 | | | | | • | | | • | • | |
| i-Tree | | | | | | | | | • | |
| Landuse Evolution and Impact Assessment Model (LEAM) | | | • | | | | | | | |
| Microscale Audit of Pedestrian Streetscapes (MAPS) | | | | | | | • | | | |
| Neighborhood Quality of Life Survey (NQLS) | • | | • | | • | | • | • | • | • |
| Parks and Recreation Areas Self-Report Survey | • | • | • | | • | • | • | • | • | |
| Pedestrian Environmental Quality Index Tool (PEQI) v2.0 | | • | | | | | • | | • | |
| Prove It! Measuring the Effect of Neighborhood Renewal | | | • | | • | | | | | |
| Recycling and Reusing Landscape Waste Cost Calculator | | | | | • | | | | | |
| Residential Environment Assessment Tool (REAT) v2.0 | | | | | • | • | | • | • | |
| Social Impact Measurement Toolkit | | | • | | • | | | | | |
| Social Return on Investment (SROI) | | | • | | | | | | | |
| Social Value Self-Assessment Tool | | | • | | | | | | | |
| STAR Community Rating System (STAR) | • | | • | • | • | | • | | • | • |
| System for Observing Physical Activity and Recreation in Natural Areas (SOPARNA) | • | | | | • | | | • | • | |
| The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits | | | | | | | | • | • | |
| Vegetable Garden Value Calculator | | | | • | | | | | | |
| Volunteering Impact Assessment Toolkit | | | • | | | | | | | |
| Walk Score | | | | | | | • | | | |
| Walk Score Professional | | • | | • | | | • | • | | • |
| Walkability Checklist | | | | | | | • | | | |
| Number measuring factor: | 7 | 6 | 13 | 4 | 14 | 2 | 10 | 8 | 10 | 5 |
| Percentage: | 22.6% | 19.4% | 41.9% | 12.9% | 45.2% | 6.5% | 32.3% | 25.8% | 32.3% | 16.1% |

Table B-5. Twenty-eight valuation tools categorized according to economic variables assessed by each tool indicated by a bullet (•) in the table.

| | Economic Variables Assessed | | |
|---|---|---|---|
| Valuation Tool | Economic activity | Maintenance | Property Value |
| Accelerator Lite | • | | |
| Accelerator Pro | • | | |
| Building for Environmental and Economic Sustainability (BEES) | • | • | |
| Carbon Footprint Calculator | • | | |
| CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool | • | | |
| Ecological Footprint Calculator | • | | |
| Electronics Environmental Benefits Calculator (EEBC) v4 | • | | |
| Energy Star Cash Flow Opportunity Calculator | • | | |
| Forest Vegetation Simulator | • | | |
| Green Roof Energy Calculator (v. 2.0) | • | | |
| Green Values Stormwater Management Calculator | • | | |
| Home Heating Cost Calculator | • | | |
| Housing and Transportation Affordability Index | • | | |
| Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) v3.4.4 | • | | |
| i-Tree | • | | • |
| Landuse Evolution and Impact Assessment Model (LEAM) | • | | |
| Lifecycle Cost Analysis (LCCA) | • | • | |
| National Tree Benefit Calculator | | | • |
| PV Watts Calculator | • | | |
| Recycling and Reusing Landscape Waste Cost Calculator | • | | |
| Regency Lighting Energy Savings Calculator | • | | |
| Resource Conserving Landscaping Cost Calculator | • | | |
| Social Return on Investment (SROI) | • | | |
| STAR Community Rating System (STAR) | • | | |
| Sustainable Facilities Tool Cost-Effective Upgrades Tool | • | | |
| The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits | • | | |
| Volunteering Impact Assessment Toolkit | • | | |
| Watershed Management Optimization Support Tool (WMOST) v3.0 | • | | |
| Number measuring factor: | 27 | 2 | 2 |
| Percentage: | 96.4% | 7.1% | 7.1% |

# APPENDIX C

# RESULTS FROM STATISTICAL ANALYSES OF ENVIRONMENTAL, SOCIAL, AND ECONOMIC VARIABLES USED TO ANALYZE EIGHTY-TWO DECISION-SUPPORT TOOLS USING PRINCIPAL COMPONENT ANALYSIS, HORN'S PARALLEL ANALYSIS, AND FACTOR ANALYSIS

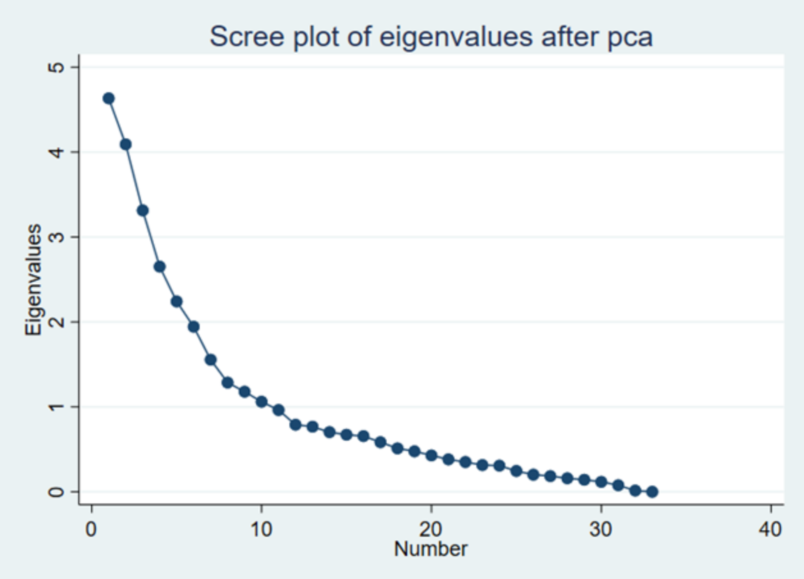


Figure C-1. Scree plot of Iteration A used to determine the retention of components for principal component analysis of the thirty-three environmental, social, and economic variables used to analyze eighty-two valuation tools.

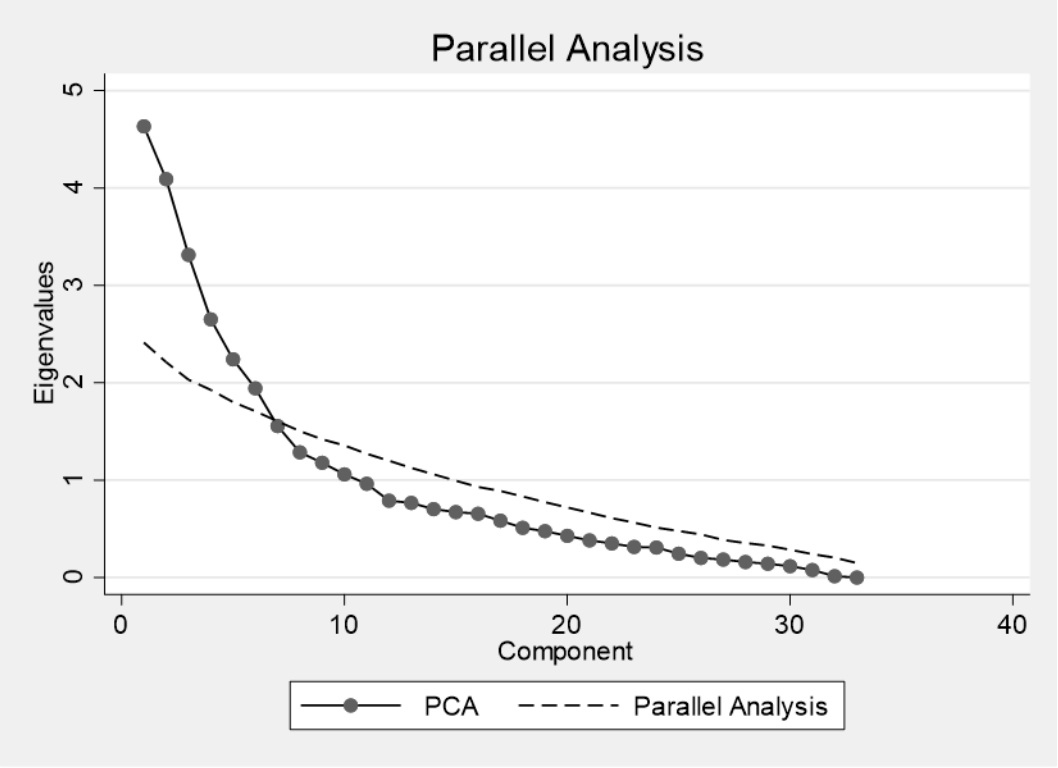


Figure C-2. Scree plot of Horn’s parallel analysis for Iteration A used to determine the retention of components for principal component analysis of the thirty-three environmental, social, and economic variables used to analyze eighty-two valuation tools.

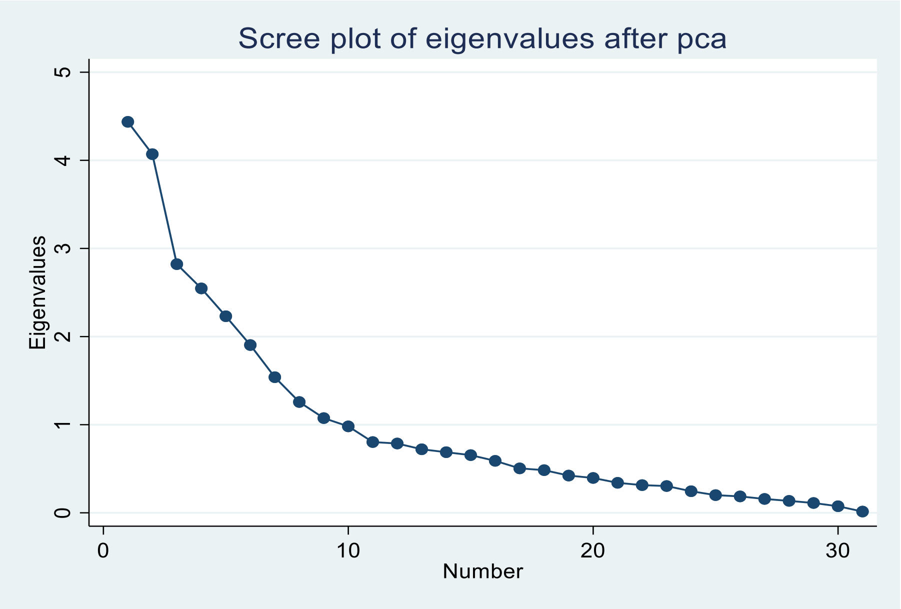


Figure C-3. Scree plot of Iteration C used to determine the retention of components for principal component analysis of the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.

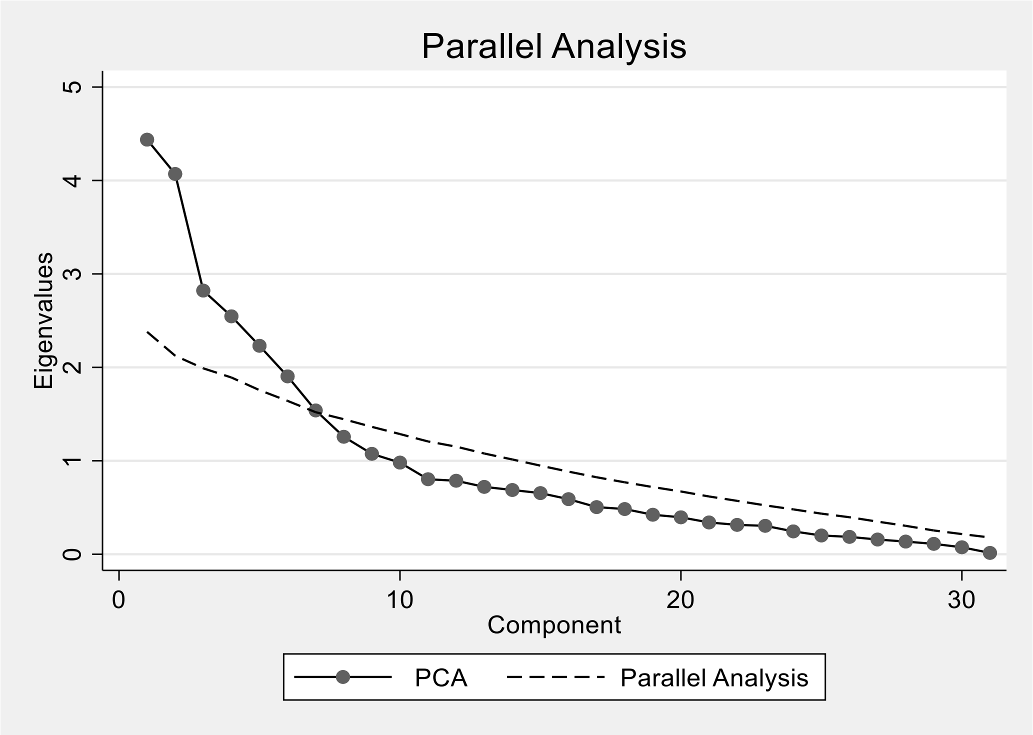


Figure C-4. Scree plot of Horn’s parallel analysis for Iteration C used to determine the retention of components for principal component analysis of the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.

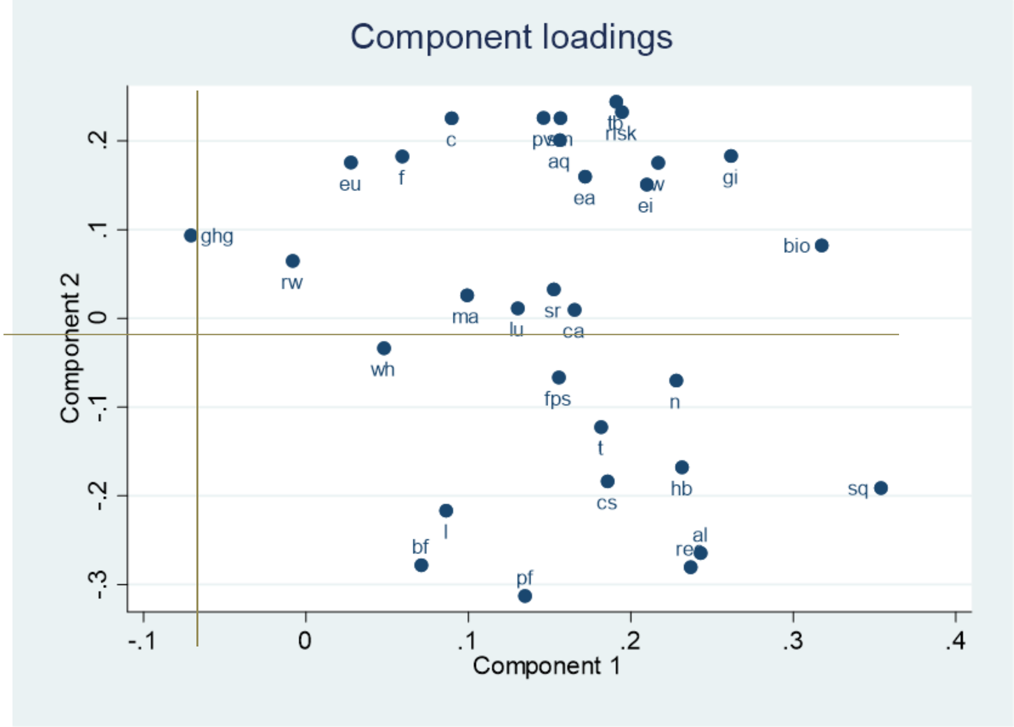


Figure C-5. Principal component analysis component loadings for Iteration C of the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools after orthogonal varimax and oblique promax rotations.

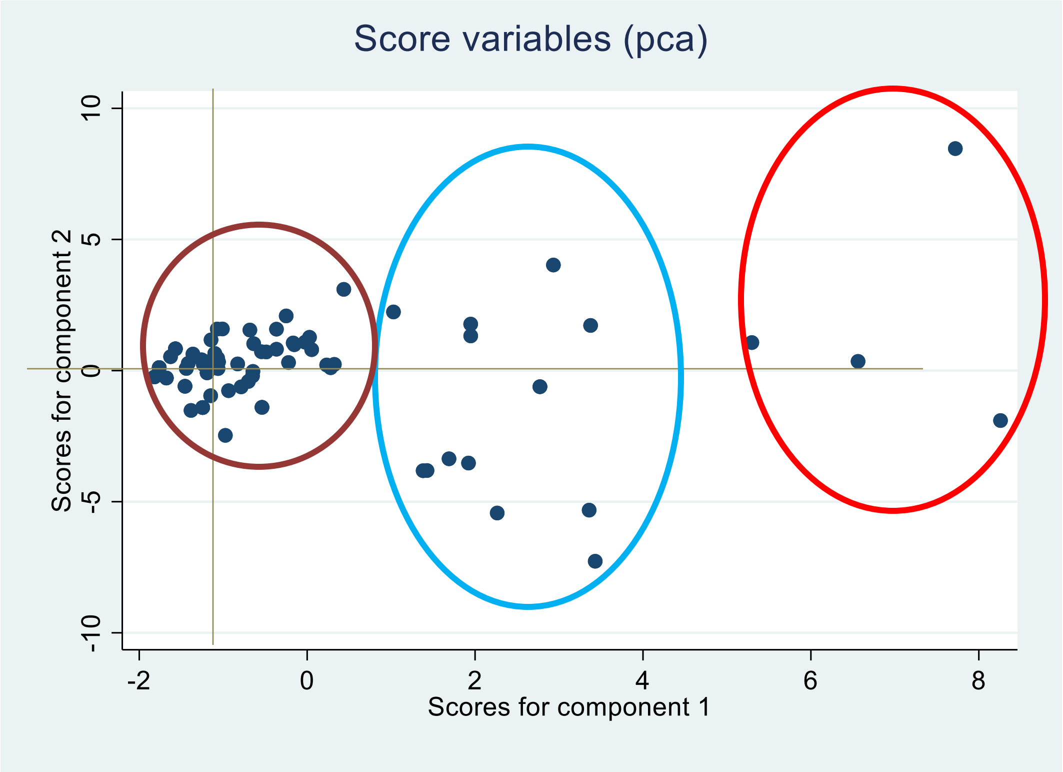


Figure C-6. Principal component analysis score plot depicting three clusters for Iteration C of the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools after orthogonal varimax and oblique promax rotations.

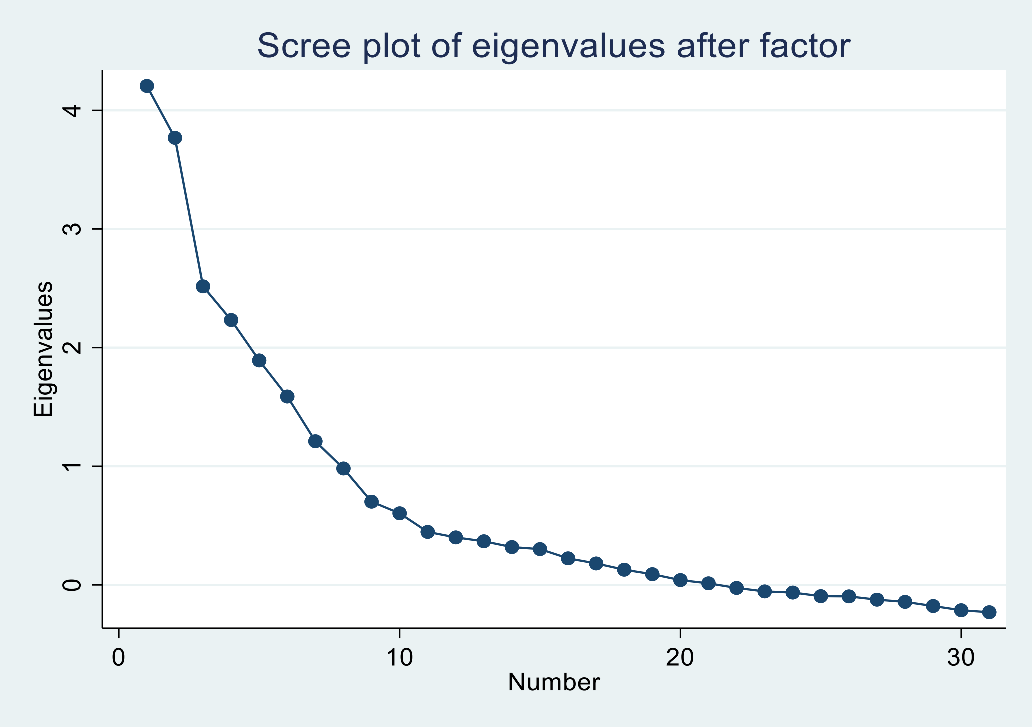


Figure C-7. Scree plot of Iteration C used to determine the retention of factors for factor analysis of the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.

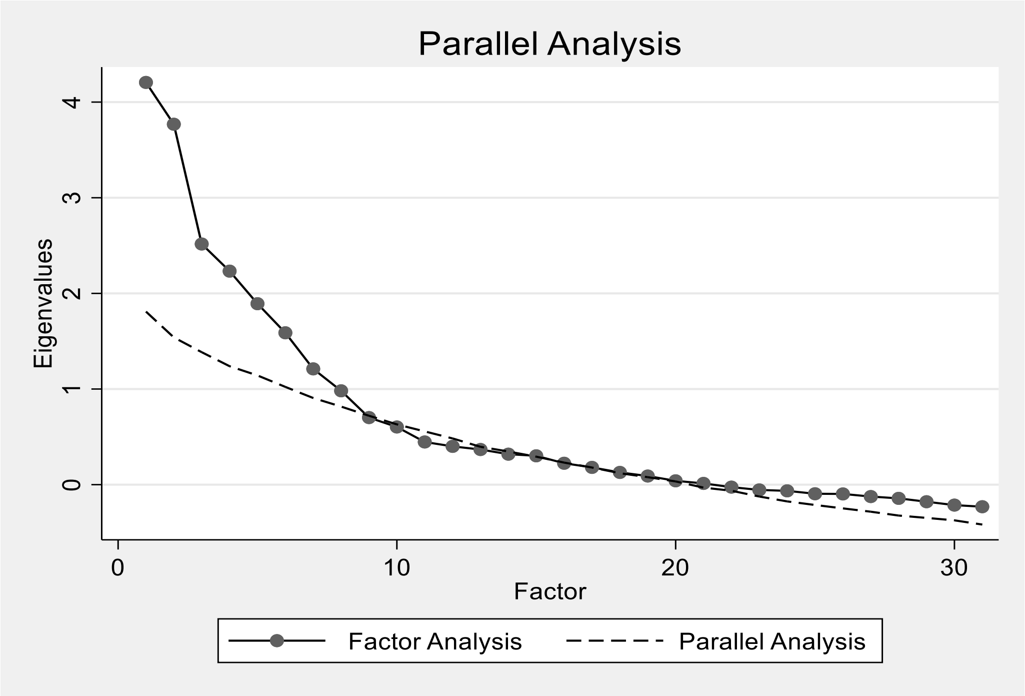


Figure C-8. Scree plot of Horn’s parallel analysis for Iteration C used to determine the retention of factors for factor analysis of the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.

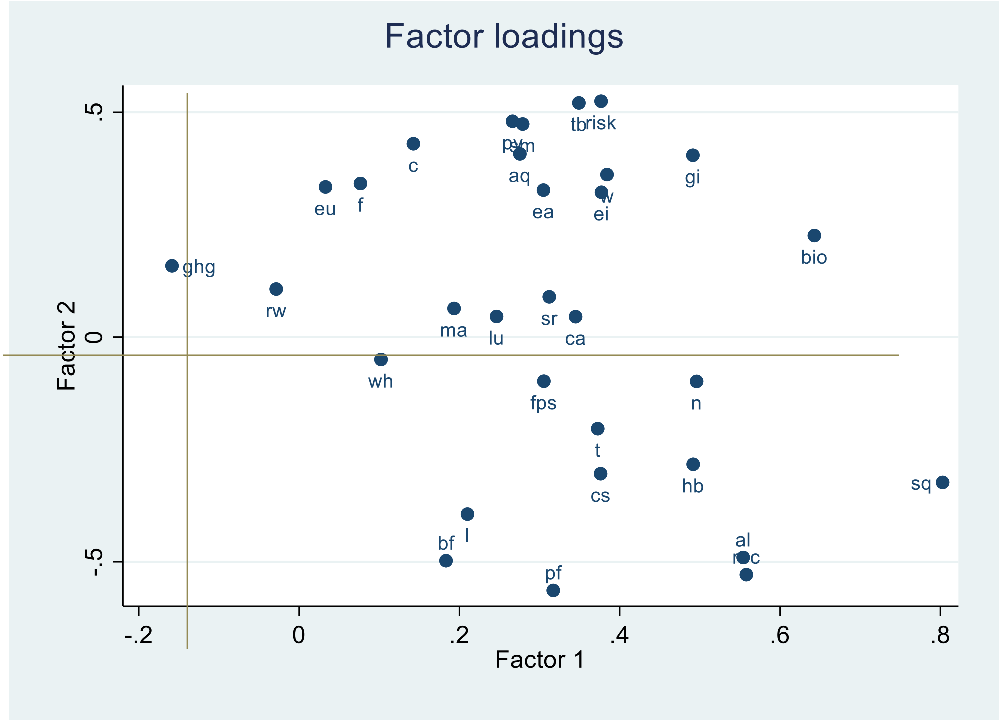


Figure C-9. Factor analysis factor loadings for Iteration C of the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools after orthogonal varimax and oblique promax rotations.

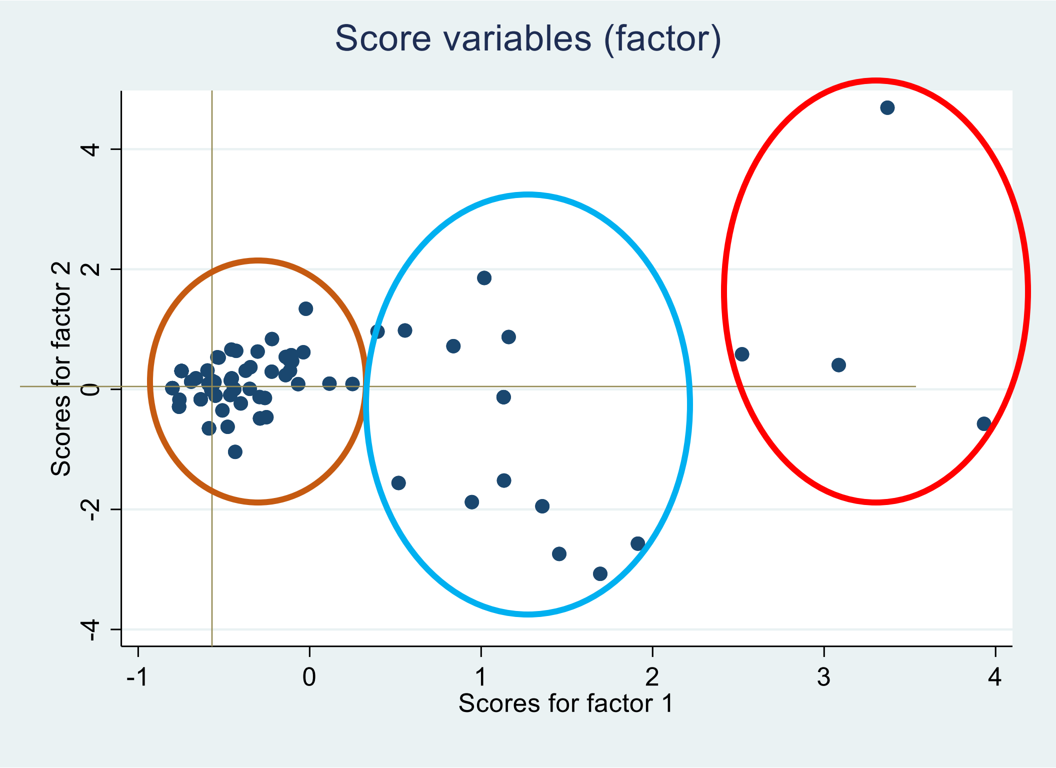
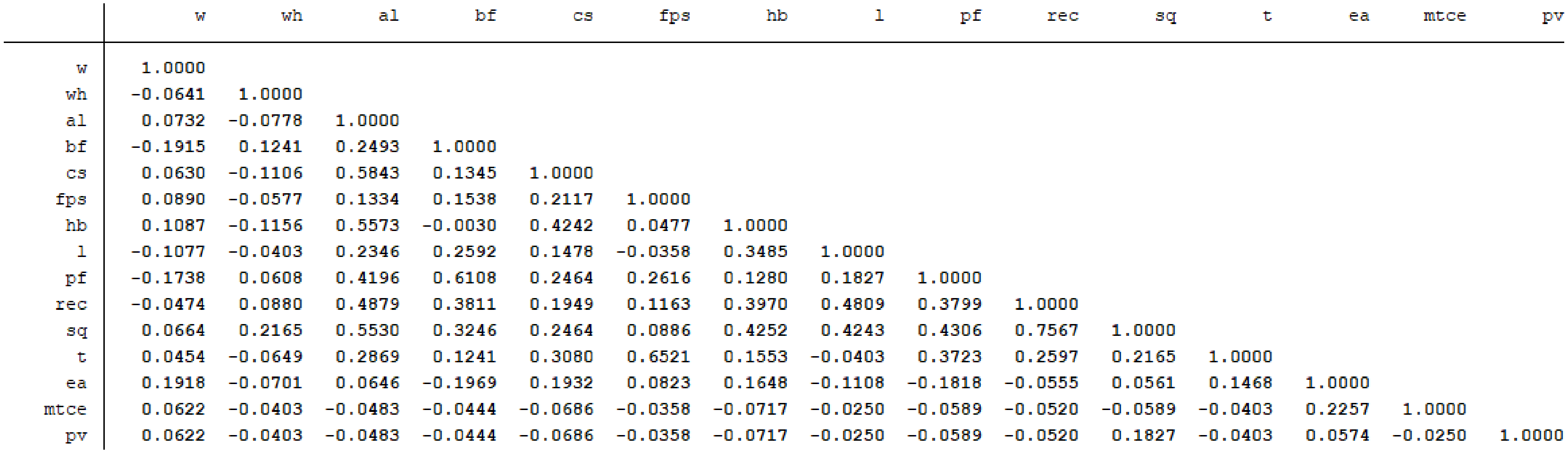


Figure C-10. Factor analysis score plot depicting three clusters for Iteration C of the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools after orthogonal varimax and oblique promax rotations.

Table C-1. Correlation matrix from Iteration A for the thirty-three environmental, social, and economic variables used to analyze eighty-two valuation tools.

| | aq | bio | c | ca | ei | eu | f | gi | ghg | lu | ma | n | p | rw | risk | sr | sm | tb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| aq | 1.0000 | | | | | | | | | | | | | | | | | |
| bio | 0.1366 | 1.0000 | | | | | | | | | | | | | | | | |
| c | 0.4349 | 0.0966 | 1.0000 | | | | | | | | | | | | | | | |
| ca | -0.0526 | 0.3164 | 0.2095 | 1.0000 | | | | | | | | | | | | | | |
| ei | 0.2045 | 0.4628 | 0.0726 | -0.0504 | 1.0000 | | | | | | | | | | | | | |
| eu | 0.3193 | 0.1892 | 0.2857 | 0.1354 | 0.0903 | 1.0000 | | | | | | | | | | | | |
| f | 0.0115 | -0.0273 | 0.0938 | -0.0652 | 0.1793 | -0.0827 | 1.0000 | | | | | | | | | | | |
| gi | 0.2045 | 0.2554 | 0.1509 | 0.2449 | 0.3109 | -0.0419 | 0.2536 | 1.0000 | | | | | | | | | | |
| ghg | 0.3924 | -0.1086 | 0.3849 | -0.0631 | 0.0442 | 0.4025 | -0.0730 | -0.1068 | 1.0000 | | | | | | | | | |
| lu | 0.0357 | 0.2511 | 0.0966 | -0.0390 | 0.3591 | -0.2086 | 0.1515 | 0.1517 | 0.0731 | 1.0000 | | | | | | | | |
| ma | 0.0393 | 0.2827 | 0.0167 | 0.4907 | 0.0477 | -0.0704 | 0.1265 | 0.0477 | -0.1286 | -0.0795 | 1.0000 | | | | | | | |
| n | 0.2438 | 0.3472 | 0.0536 | -0.0217 | 0.0842 | 0.1050 | -0.1143 | 0.2568 | 0.0406 | 0.3472 | -0.0441 | 1.0000 | | | | | | |
| p | -0.0526 | 0.3164 | 0.2095 | 1.0000 | -0.0504 | 0.1354 | -0.0652 | 0.2449 | -0.0631 | -0.0390 | 0.4907 | -0.0217 | 1.0000 | | | | | |
| rw | 0.1401 | -0.0456 | 0.2538 | -0.0482 | 0.2467 | 0.3247 | -0.1017 | -0.0195 | 0.3755 | 0.0612 | -0.0983 | 0.0933 | -0.0482 | 1.0000 | | | | |
| risk | 0.2348 | 0.3164 | 0.2095 | -0.0123 | 0.2449 | 0.1354 | 0.1894 | 0.2449 | -0.0631 | -0.0390 | -0.0252 | -0.0217 | -0.0123 | -0.0482 | 1.0000 | | | |
| sr | -0.0748 | 0.4503 | 0.1071 | 0.7027 | 0.1384 | 0.0315 | 0.0884 | 0.1384 | -0.0898 | -0.0555 | 0.6982 | -0.0308 | 0.7027 | -0.0686 | -0.0176 | 1.0000 | | |
| sm | 0.2093 | 0.1076 | 0.1625 | -0.0414 | 0.1280 | -0.0778 | 0.2936 | 0.6233 | -0.2117 | 0.1076 | -0.0844 | 0.1259 | -0.0414 | -0.1618 | 0.2981 | -0.0589 | 1.0000 | |
| tb | 0.3342 | 0.1974 | 0.2981 | -0.0176 | 0.1384 | 0.0315 | 0.2695 | 0.3485 | -0.0898 | -0.0555 | -0.0358 | -0.0308 | -0.0176 | -0.0686 | 0.7027 | -0.0250 | 0.4243 | 1.0000 |
| w | 0.2199 | 0.4315 | 0.0185 | 0.1631 | 0.3873 | -0.0248 | 0.2607 | 0.4570 | -0.1429 | 0.1799 | 0.2107 | 0.1464 | 0.1631 | -0.0805 | 0.1631 | 0.2320 | 0.3067 | 0.2320 |
| wh | 0.0113 | 0.0736 | -0.0120 | -0.0283 | -0.1156 | -0.1052 | -0.0328 | 0.1553 | -0.1447 | 0.0736 | -0.0577 | 0.4933 | -0.0283 | -0.1106 | -0.0283 | -0.0403 | 0.2165 | -0.0403 |
| al | -0.0317 | 0.3116 | -0.1620 | -0.0339 | 0.2093 | 0.0163 | -0.1793 | -0.0226 | -0.0719 | 0.0324 | -0.0692 | 0.1729 | -0.0339 | -0.0131 | -0.0339 | -0.0483 | -0.1139 | -0.0483 |
| bf | -0.1329 | -0.0987 | -0.1490 | -0.0312 | -0.1275 | -0.2306 | -0.0576 | -0.1275 | -0.1596 | 0.0512 | -0.0636 | 0.1947 | -0.0312 | -0.1220 | -0.0312 | -0.0444 | -0.1047 | -0.0444 |
| cs | -0.0326 | 0.1680 | -0.1495 | -0.0482 | 0.2467 | -0.1519 | -0.0252 | 0.0693 | -0.0910 | 0.1680 | -0.0983 | 0.0933 | -0.0482 | -0.0056 | -0.0482 | -0.0686 | -0.0597 | -0.0686 |
| fps | 0.1857 | 0.1016 | 0.0167 | -0.0252 | 0.1982 | -0.0704 | 0.1265 | 0.1982 | 0.1350 | 0.2827 | -0.0513 | 0.2574 | -0.0252 | 0.2117 | -0.0252 | -0.0358 | -0.0844 | -0.0358 |
| hb | 0.1206 | 0.2554 | -0.0840 | 0.2449 | 0.0525 | 0.0242 | -0.1920 | 0.0525 | -0.1822 | -0.0556 | 0.1982 | 0.0842 | 0.2449 | -0.0195 | -0.0504 | 0.1384 | -0.0701 | 0.1384 |
| l | -0.0748 | -0.0555 | -0.0839 | -0.0176 | -0.0717 | -0.1298 | -0.0928 | -0.0717 | -0.0898 | -0.0555 | -0.0358 | -0.0308 | -0.0176 | -0.0686 | -0.0176 | -0.0250 | -0.0589 | -0.0250 |
| pf | -0.0799 | -0.0116 | -0.1976 | -0.0414 | -0.0701 | -0.2298 | -0.1333 | -0.0701 | -0.1249 | 0.1076 | -0.0844 | 0.3244 | -0.0414 | -0.0597 | -0.0414 | -0.0589 | -0.1389 | -0.0589 |
| rec | -0.0493 | 0.1475 | 0.0242 | 0.3379 | -0.1492 | -0.1022 | -0.0988 | 0.0693 | -0.1867 | -0.1154 | 0.1163 | 0.1548 | 0.3379 | -0.1427 | -0.0365 | 0.2144 | 0.0031 | -0.0520 |
| sq | 0.1129 | 0.3460 | 0.0725 | 0.2981 | 0.0290 | -0.0019 | -0.1333 | 0.2271 | -0.1249 | 0.1076 | 0.0886 | 0.5229 | 0.2981 | -0.0597 | 0.2981 | 0.1827 | 0.0889 | 0.1827 |
| t | 0.1431 | 0.0736 | -0.0120 | -0.0283 | 0.1553 | -0.1052 | 0.0840 | 0.1553 | 0.2113 | 0.2366 | -0.0577 | 0.2218 | -0.0283 | 0.1685 | -0.0283 | -0.0403 | -0.0950 | -0.0403 |
| ea | 0.1383 | 0.2521 | 0.1300 | 0.1586 | 0.3028 | 0.3775 | 0.2429 | 0.3028 | -0.0958 | 0.0861 | -0.0382 | 0.1399 | 0.1586 | 0.1222 | 0.1586 | 0.0574 | 0.1354 | 0.2257 |
| mtce | 0.1297 | -0.0555 | 0.1071 | -0.0176 | 0.1384 | 0.1927 | 0.0884 | -0.0717 | 0.0943 | -0.0555 | -0.0358 | -0.0308 | -0.0176 | 0.1478 | -0.0176 | -0.0250 | -0.0589 | -0.0250 |
| pv | 0.3342 | 0.1974 | 0.2981 | -0.0176 | 0.1384 | 0.1927 | 0.0884 | 0.1384 | -0.0898 | -0.0555 | -0.0358 | -0.0308 | -0.0176 | -0.0686 | 0.7027 | -0.0250 | 0.4243 | 0.4875 |

Table C-1 Continued.



| | w | wh | al | bf | cs | fps | hb | l | pf | rec | sq | t | ea | mtce | pv |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| w | 1.0000 | | | | | | | | | | | | | | |
| wh | -0.0641 | 1.0000 | | | | | | | | | | | | | |
| al | 0.0732 | -0.0778 | 1.0000 | | | | | | | | | | | | |
| bf | -0.1915 | 0.1241 | 0.2493 | 1.0000 | | | | | | | | | | | |
| cs | 0.0630 | -0.1106 | 0.5843 | 0.1345 | 1.0000 | | | | | | | | | | |
| fps | 0.0890 | -0.0577 | 0.1334 | 0.1538 | 0.2117 | 1.0000 | | | | | | | | | |
| hb | 0.1087 | -0.1156 | 0.5573 | -0.0030 | 0.4242 | 0.0477 | 1.0000 | | | | | | | | |
| l | -0.1077 | -0.0403 | 0.2346 | 0.2592 | 0.1478 | -0.0358 | 0.3485 | 1.0000 | | | | | | | |
| pf | -0.1738 | 0.0608 | 0.4196 | 0.6108 | 0.2464 | 0.2616 | 0.1280 | 0.1827 | 1.0000 | | | | | | |
| rec | -0.0474 | 0.0880 | 0.4879 | 0.3811 | 0.1949 | 0.1163 | 0.3970 | 0.4809 | 0.3799 | 1.0000 | | | | | |
| sq | 0.0664 | 0.2165 | 0.5530 | 0.3246 | 0.2464 | 0.0886 | 0.4252 | 0.4243 | 0.4306 | 0.7567 | 1.0000 | | | | |
| t | 0.0454 | -0.0649 | 0.2869 | 0.1241 | 0.3080 | 0.6521 | 0.1553 | -0.0403 | 0.3723 | 0.2597 | 0.2165 | 1.0000 | | | |
| ea | 0.1918 | -0.0701 | 0.0646 | -0.1969 | 0.1932 | 0.0823 | 0.1648 | -0.1108 | -0.1818 | -0.0555 | 0.0561 | 0.1468 | 1.0000 | | |
| mtce | 0.0622 | -0.0403 | -0.0483 | -0.0444 | -0.0686 | -0.0358 | -0.0717 | -0.0250 | -0.0589 | -0.0520 | -0.0589 | -0.0403 | 0.2257 | 1.0000 | |
| pv | 0.0622 | -0.0403 | -0.0483 | -0.0444 | -0.0686 | -0.0358 | -0.0717 | -0.0250 | -0.0589 | -0.0520 | 0.1827 | -0.0403 | 0.0574 | -0.0250 | 1.0000 |

Table C-2. Total variance explained using principal component analysis in Iteration A for the thirty-three environmental, social, and economic variables to analyze eighty-two valuation tools.

| Variable | Initial eigenvalues | | | Extraction sums of squared loadings | | | Rotation sums of squared loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % |
| 1 | 4.63315 | 14.04 | 14.04 | 4.63315 | 14.04 | 14.04 | 3.6836 | 11.16 | 11.16 |
| 2 | 4.09106 | 12.40 | 26.44 | 4.09106 | 12.40 | 26.44 | 3.44253 | 10.43 | 21.59 |
| 3 | 3.31354 | 10.04 | 36.48 | 3.31354 | 10.04 | 36.48 | 3.35072 | 10.15 | 31.75 |
| 4 | 2.65157 | 8.04 | 44.51 | 2.65157 | 8.04 | 44.51 | 3.05728 | 9.26 | 41.01 |
| 5 | 2.24128 | 6.79 | 51.30 | 2.24128 | 6.79 | 51.30 | 2.70757 | 8.20 | 49.22 |
| 6 | 1.94361 | 5.89 | 57.19 | 1.94361 | 5.89 | 57.19 | 2.63252 | 7.98 | 57.19 |
| 7 | 1.5585 | 4.71 | 61.91 | 1.5585 | 4.71 | 61.91 | | | |
| 8 | 1.28597 | 3.90 | 65.81 | 1.28597 | 3.90 | 65.81 | | | |
| 9 | 1.17856 | 3.57 | 69.38 | 1.17856 | 3.57 | 69.38 | | | |
| 10 | 1.06025 | 3.21 | 72.59 | 1.06025 | 3.21 | 72.59 | | | |
| 11: | 0.962694 | 2.92 | 75.51 | | | | | | |
| 33 | 0.00 | 0.00 | 100.00 | | | | | | |

Extraction method: principal component analysis, Horn’s parallel analysis, varimax rotation

Table C-3. Horn's parallel analysis of Iteration A conducted after the initial principal component analysis for principal components with eigenvalues averaged over ten replications with the first ten components shown for the thirty-three environmental, social, and economic variables used to analyze eighty-two valuation tools.

| | PCA | PA | Difference |
|---|---|---|---|
| 1 | 4.63315 | 2.41335 | 2.219807 |
| 2 | 4.09106 | 2.21205 | 1.87901 |
| 3 | 3.31354 | 2.03181 | 1.28173 |
| 4 | 2.65157 | 1.92716 | 0.72441 |
| 5 | 2.24128 | 1.80211 | 0.43917 |
| 6 | 1.94361 | 1.70832 | 0.23529 |
| 7 | 1.55586 | 1.60416 | -0.04831 |
| 8 | 1.28597 | 1.50403 | -0.21806 |
| 9 | 1.17856 | 1.41977 | -0.24120 |
| 10 | 1.06025 | 1.35684 | -0.29659 |

Table C-4. Total variance explained using principal component analysis in Iteration C for the thirty-one environmental, social, and economic variables to analyze eighty-two valuation tools.

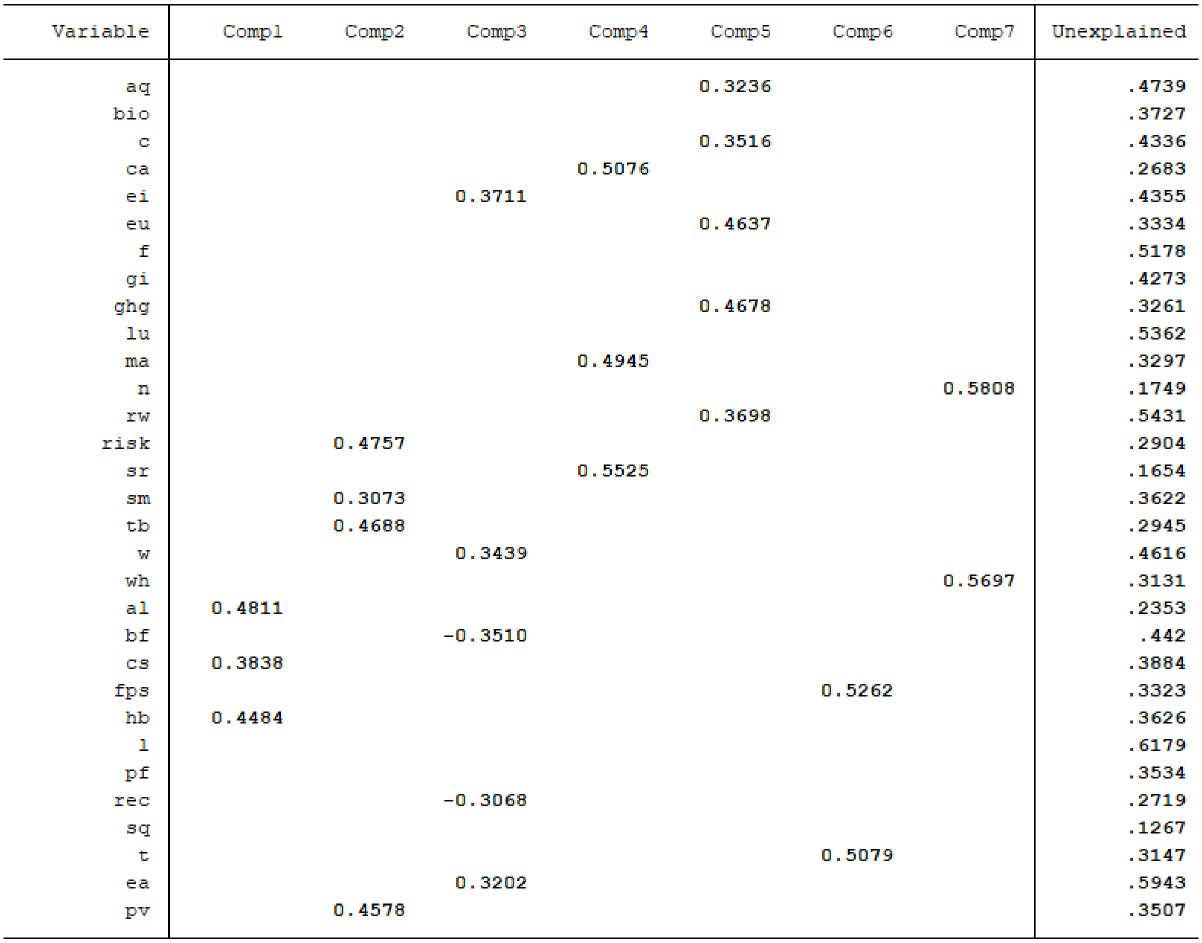
| Variable | Initial eigenvalues | | | Extraction sums of squared loadings | | | Rotation sums of squared loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % |
| 1 | 4.43701 | 14.31 | 14.31 | 4.43701 | 14.31 | 14.31 | 3.28037 | 10.58 | 10.58 |
| 2 | 4.07022 | 13.13 | 27.44 | 4.07022 | 13.13 | 27.44 | 3.2565 | 10.50 | 21.08 |
| 3 | 2.82188 | 9.10 | 36.55 | 2.82188 | 9.10 | 36.55 | 3.02715 | 9.76 | 30.84 |
| 4 | 2.5466 | 8.21 | 44.76 | 2.5466 | 8.21 | 44.76 | 2.79917 | 9.03 | 39.87 |
| 5 | 2.23095 | 7.20 | 51.96 | 2.23095 | 7.20 | 51.96 | 2.65246 | 8.56 | 48.43 |
| 6 | 1.90409 | 6.14 | 58.10 | 1.90409 | 6.14 | 58.10 | 2.5198 | 8.13 | 56.56 |
| 7 | 1.53929 | 4.97 | 63.06 | 1.53929 | 4.97 | 63.06 | 2.16365 | 6.98 | 63.54 |
| 8 | 1.25741 | 4.06 | 67.12 | 1.25741 | 4.06 | 67.12 | | | |
| 9 | 1.07487 | 3.47 | 70.59 | 1.07487 | 3.47 | 70.59 | | | |
| 10: | 0.981095 | 3.16 | 73.75 | | | | | | |
| 31 | 0.143801 | 0.05 | 100.00 | | | | | | |

Extraction method: principal component analysis, promax rotation

Table C-5. Horn's parallel analysis of Iteration C conducted after the initial principal component analysis for principal components with eigenvalues averaged over ten replications with the first ten components shown for the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.

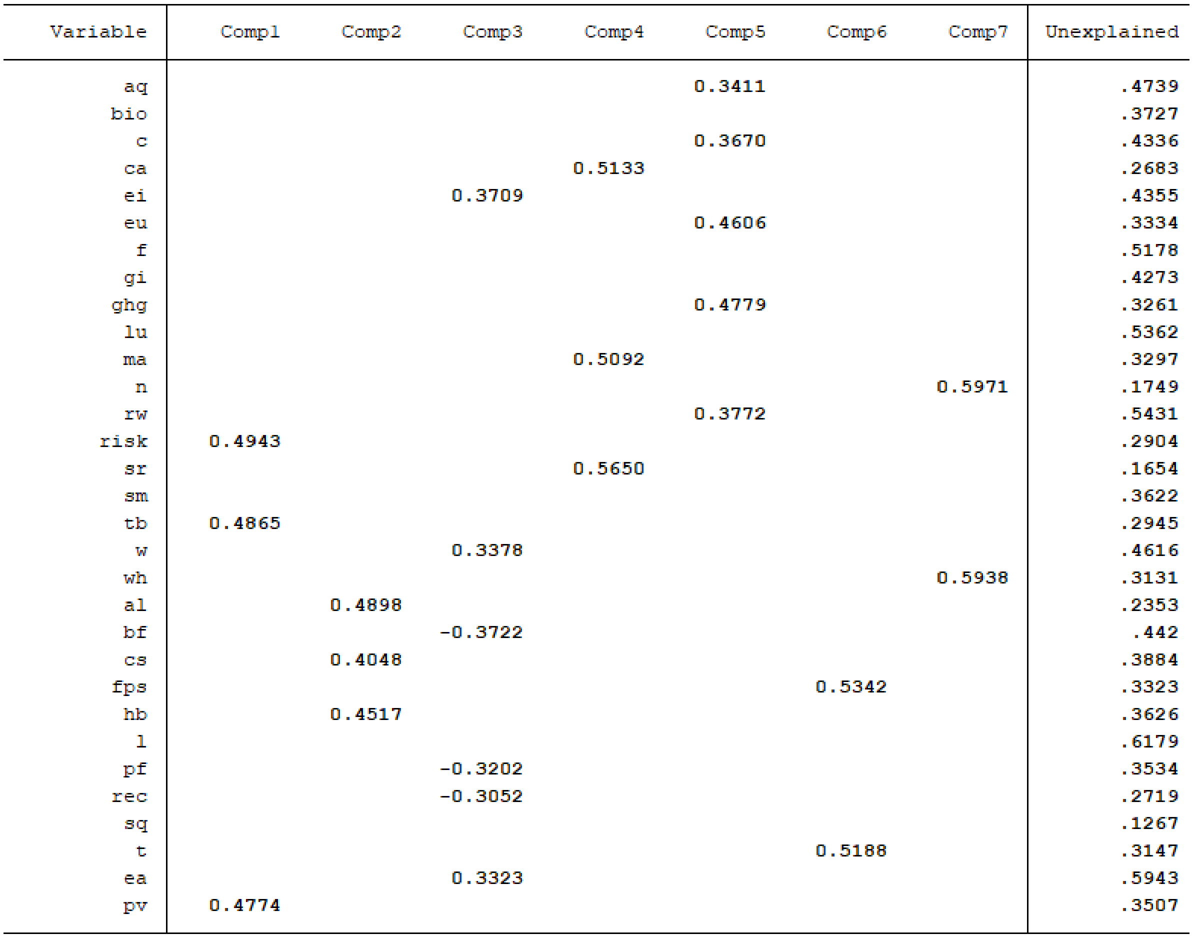
| | PCA | PA | Difference |
|---|---|---|---|
| 1 | 4.43701 | 2.38022 | 2.05679 |
| 2 | 4.07022 | 2.12461 | 1.94561 |
| 3 | 2.82188 | 1.98986 | 0.83202 |
| 4 | 2.54660 | 1.89186 | 0.65475 |
| 5 | 2.23095 | 1.75637 | 0.47459 |
| 6 | 1.90410 | 1.64157 | 0.26253 |
| 7 | 1.53929 | 1.52027 | 0.01902 |
| 8 | 1.25741 | 1.44568 | -0.18827 |
| 9 | 1.07487 | 1.36393 | -0.28905 |
| 10 | 0.98110 | 1.28646 | -0.30536 |

Table C-6. Principal component analysis component loadings >0.3 for orthogonal varimax rotation of Iteration C for the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.



| Variable | Comp1 | Comp2 | Comp3 | Comp4 | Comp5 | Comp6 | Comp7 | Unexplained |
|---|---|---|---|---|---|---|---|---|
| aq | | | | | 0.3236 | | | .4739 |
| bio | | | | | | | | .3727 |
| c | | | | | 0.3516 | | | .4336 |
| ca | | | | 0.5076 | | | | .2683 |
| ei | | | 0.3711 | | | | | .4355 |
| eu | | | | | 0.4637 | | | .3334 |
| f | | | | | | | | .5178 |
| gi | | | | | | | | .4273 |
| ghg | | | | | 0.4678 | | | .3261 |
| lu | | | | | | | | .5362 |
| ma | | | | 0.4945 | | | | .3297 |
| n | | | | | | | 0.5808 | .1749 |
| rw | | | | | 0.3698 | | | .5431 |
| risk | | 0.4757 | | | | | | .2904 |
| sr | | | | 0.5525 | | | | .1654 |
| sm | | 0.3073 | | | | | | .3622 |
| tb | | 0.4688 | | | | | | .2945 |
| w | | | 0.3439 | | | | | .4616 |
| wh | | | | | | | 0.5697 | .3131 |
| al | 0.4811 | | | | | | | .2353 |
| bf | | | -0.3510 | | | | | .442 |
| cs | 0.3838 | | | | | | | .3884 |
| fps | | | | | | 0.5262 | | .3323 |
| hb | 0.4484 | | | | | | | .3626 |
| l | | | | | | | | .6179 |
| pf | | | | | | | | .3534 |
| rec | | | -0.3068 | | | | | .2719 |
| sq | | | | | | | | .1267 |
| t | | | | | | 0.5079 | | .3147 |
| ea | | | 0.3202 | | | | | .5943 |
| pv | | 0.4578 | | | | | | .3507 |

Table C-7. Principal component analysis component loadings >0.3 for oblique promax rotation of Iteration C for the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.



| Variable | Comp1 | Comp2 | Comp3 | Comp4 | Comp5 | Comp6 | Comp7 | Unexplained |
|---|---|---|---|---|---|---|---|---|
| aq | | | | | 0.3411 | | | .4739 |
| bio | | | | | | | | .3727 |
| c | | | | | 0.3670 | | | .4336 |
| ca | | | | 0.5133 | | | | .2683 |
| ei | | | 0.3709 | | | | | .4355 |
| eu | | | | | 0.4606 | | | .3334 |
| f | | | | | | | | .5178 |
| gi | | | | | | | | .4273 |
| ghg | | | | | 0.4779 | | | .3261 |
| lu | | | | | | | | .5362 |
| ma | | | | 0.5092 | | | | .3297 |
| n | | | | | | | 0.5971 | .1749 |
| rw | | | | | 0.3772 | | | .5431 |
| risk | 0.4943 | | | | | | | .2904 |
| sr | | | | 0.5650 | | | | .1654 |
| sm | | | | | | | | .3622 |
| tb | 0.4865 | | | | | | | .2945 |
| w | | | 0.3378 | | | | | .4616 |
| wh | | | | | | | 0.5938 | .3131 |
| al | | 0.4898 | | | | | | .2353 |
| bf | | | -0.3722 | | | | | .442 |
| cs | | 0.4048 | | | | | | .3884 |
| fps | | | | | | 0.5342 | | .3323 |
| hb | | 0.4517 | | | | | | .3626 |
| l | | | | | | | | .6179 |
| pf | | | -0.3202 | | | | | .3534 |
| rec | | | -0.3052 | | | | | .2719 |
| sq | | | | | | | | .1267 |
| t | | | | | | 0.5188 | | .3147 |
| ea | | | 0.3323 | | | | | .5943 |
| pv | 0.4774 | | | | | | | .3507 |

Table C-8. Total variance explained using principal factor analysis in Iteration C for the thirty-one environmental, social, and economic variables to analyze eighty-two valuation tools.

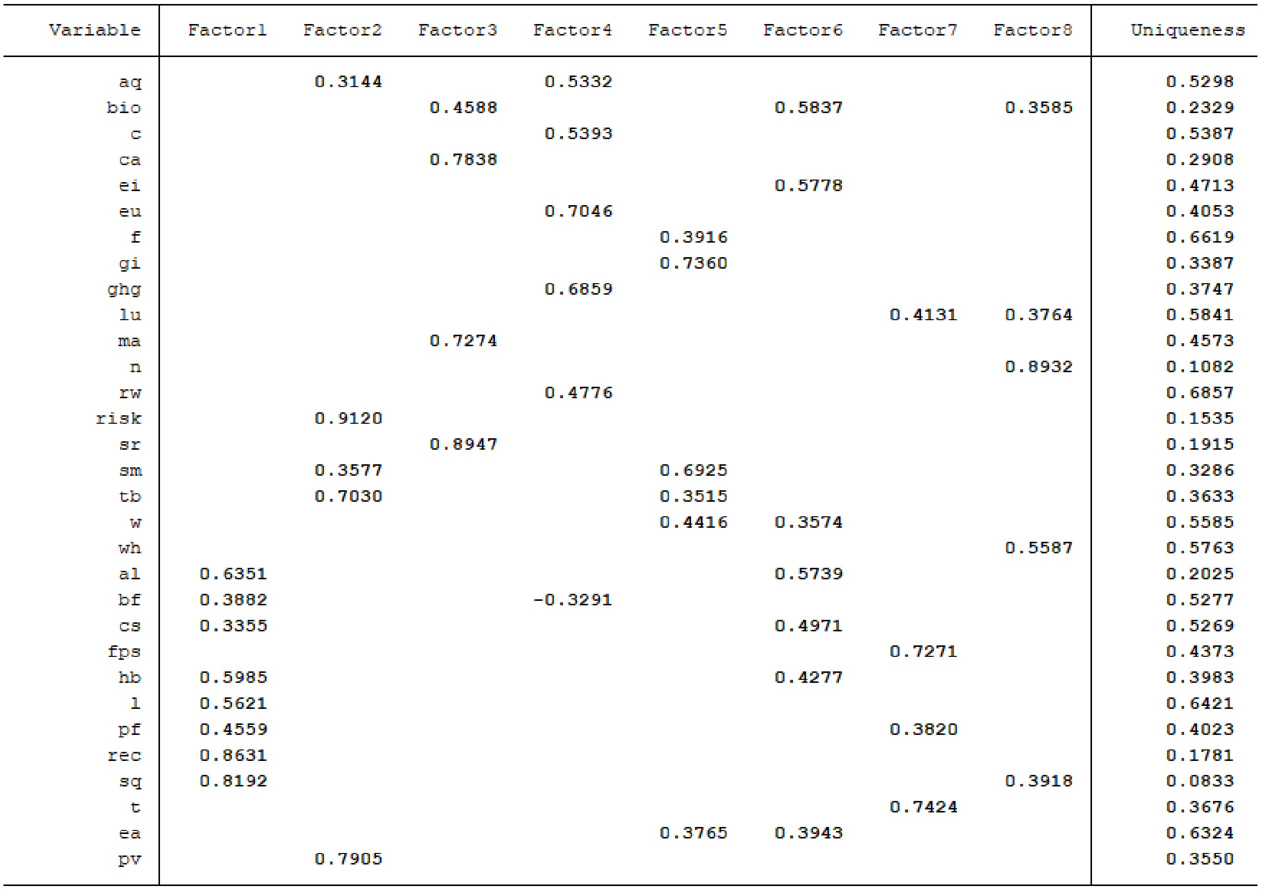
| Variable | Initial eigenvalues | | | Extraction sums of squared loadings | | | Rotation sums of squared loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % |
| 1 | 4.20587 | 20.04 | 20.04 | 4.20587 | 20.04 | 20.04 | 3.32381 | 15.84 | 15.84 |
| 2 | 3.76834 | 17.96 | 38.00 | 3.76834 | 17.96 | 38.00 | 2.92738 | 13.95 | 29.79 |
| 3 | 2.51618 | 11.99 | 49.98 | 2.51618 | 11.99 | 49.98 | 2.76613 | 13.18 | 42.97 |
| 4 | 2.23260 | 10.64 | 60.62 | 2.23260 | 10.64 | 60.62 | 2.58720 | 12.33 | 55.30 |
| 5 | 1.89214 | 9.02 | 69.64 | 1.89214 | 9.02 | 69.64 | 2.46351 | 11.74 | 67.04 |
| 6 | 1.58804 | 7.57 | 77.20 | 1.58804 | 7.57 | 77.20 | 2.45353 | 11.69 | 78.73 |
| 7 | 1.21078 | 5.77 | 82.97 | 1.21078 | 5.77 | 82.97 | 2.24109 | 10.68 | 89.41 |
| 8 | 0.98141 | 4.68 | 87.65 | 0.98141 | 4.68 | 87.65 | 1.98735 | 9.47 | 98.88 |
| 9: | 0.70169 | 3.34 | 90.99 | | | | | | |
| 31 | -0.23028 | -0.0110 | 100.00 | | | | | | |

Extraction method: principal factor analysis, Horn’s parallel analysis, promax rotation

Table C-9. Horn's parallel analysis of Iteration C conducted after the initial factor analysis for principal components with eigenvalues averaged over ten replications with the first ten components shown for the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.

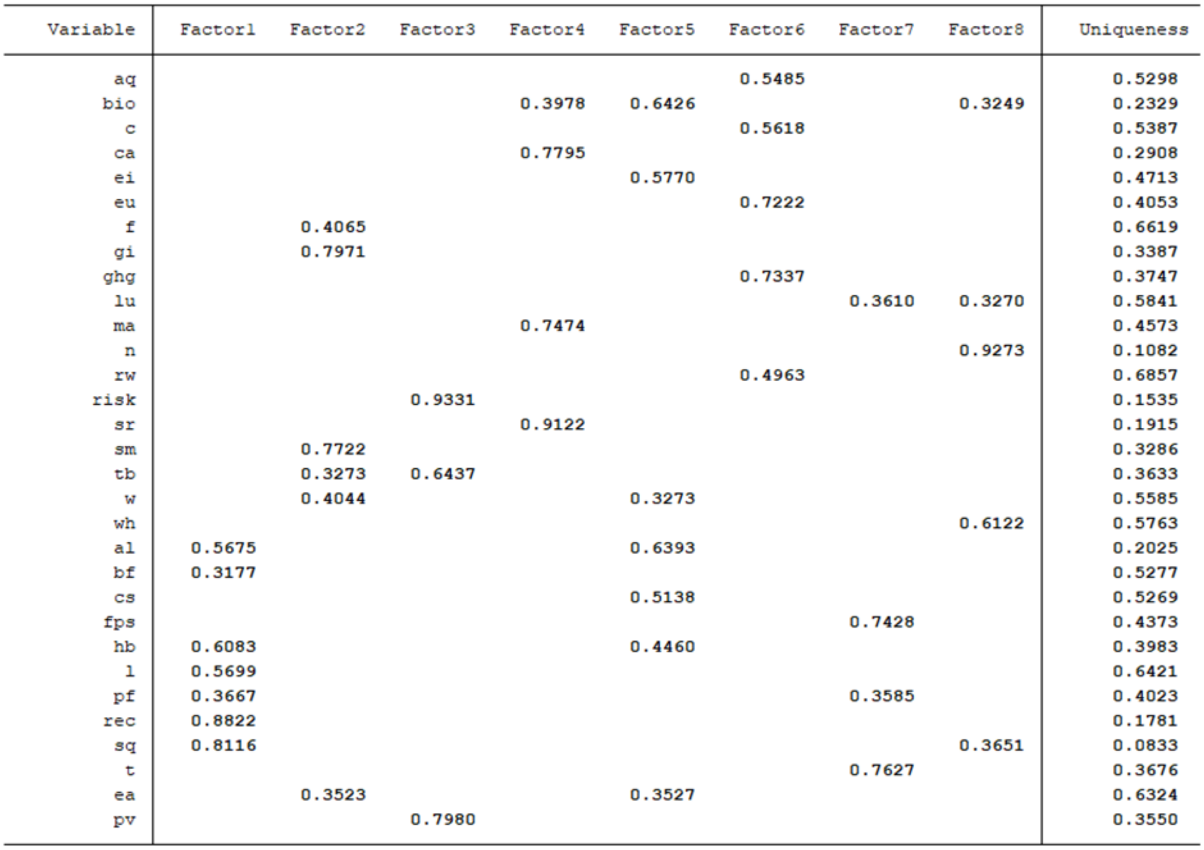
| | FA | PA | Difference |
|---|---|---|---|
| 1 | 4.20587 | 1.80988 | 2.39600 |
| 2 | 3.76834 | 1.53993 | 2.22840 |
| 3 | 2.51618 | 1.38543 | 1.13075 |
| 4 | 2.23260 | 1.23863 | 0.99396 |
| 5 | 1.89214 | 1.14205 | 0.75009 |
| 6 | 1.58804 | 1.02242 | 0.56562 |
| 7 | 1.21078 | 0.90616 | 0.30462 |
| 8 | 0.98141 | 0.81656 | 0.16485 |
| 9 | 0.70169 | 0.72059 | -0.01890 |
| 10 | 0.60334 | 0.63043 | -0.02709 |

Table C-10. Factor analysis factor loadings >0.3 for orthogonal varimax rotation of Iteration C for the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.



| Variable | Factor1 | Factor2 | Factor3 | Factor4 | Factor5 | Factor6 | Factor7 | Factor8 | Uniqueness |
|---|---|---|---|---|---|---|---|---|---|
| aq |  | 0.3144 |  | 0.5332 |  |  |  |  | 0.5298 |
| bio |  |  | 0.4588 |  |  | 0.5837 |  | 0.3585 | 0.2329 |
| c |  |  |  | 0.5393 |  |  |  |  | 0.5387 |
| ca |  |  | 0.7838 |  |  |  |  |  | 0.2908 |
| ei |  |  |  |  |  | 0.5778 |  |  | 0.4713 |
| eu |  |  |  | 0.7046 |  |  |  |  | 0.4053 |
| f |  |  |  |  | 0.3916 |  |  |  | 0.6619 |
| gi |  |  |  |  | 0.7360 |  |  |  | 0.3387 |
| ghg |  |  |  | 0.6859 |  |  |  |  | 0.3747 |
| lu |  |  |  |  |  |  | 0.4131 | 0.3764 | 0.5841 |
| ma |  |  | 0.7274 |  |  |  |  |  | 0.4573 |
| n |  |  |  |  |  |  |  | 0.8932 | 0.1082 |
| rw |  |  |  | 0.4776 |  |  |  |  | 0.6857 |
| risk |  | 0.9120 |  |  |  |  |  |  | 0.1535 |
| sr |  |  | 0.8947 |  |  |  |  |  | 0.1915 |
| sm |  | 0.3577 |  |  | 0.6925 |  |  |  | 0.3286 |
| tb |  | 0.7030 |  |  | 0.3515 |  |  |  | 0.3633 |
| w |  |  |  |  | 0.4416 | 0.3574 |  |  | 0.5585 |
| wh |  |  |  |  |  |  |  | 0.5587 | 0.5763 |
| al | 0.6351 |  |  |  |  | 0.5739 |  |  | 0.2025 |
| bf | 0.3882 |  |  | -0.3291 |  |  |  |  | 0.5277 |
| cs | 0.3355 |  |  |  |  | 0.4971 |  |  | 0.5269 |
| fps |  |  |  |  |  |  | 0.7271 |  | 0.4373 |
| hb | 0.5985 |  |  |  |  | 0.4277 |  |  | 0.3983 |
| l | 0.5621 |  |  |  |  |  |  |  | 0.6421 |
| pf | 0.4559 |  |  |  |  |  | 0.3820 |  | 0.4023 |
| rec | 0.8631 |  |  |  |  |  |  |  | 0.1781 |
| sq | 0.8192 |  |  |  |  |  |  | 0.3918 | 0.0833 |
| t |  |  |  |  |  |  | 0.7424 |  | 0.3676 |
| ea |  |  |  |  | 0.3765 | 0.3943 |  |  | 0.6324 |
| pv |  | 0.7905 |  |  |  |  |  |  | 0.3550 |

Table C-11. Factor analysis factor loadings >0.3 for oblique promax rotation of Iteration C for the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.



| Variable | Factor1 | Factor2 | Factor3 | Factor4 | Factor5 | Factor6 | Factor7 | Factor8 | Uniqueness |
|---|---|---|---|---|---|---|---|---|---|
| aq | | | | | | 0.5485 | | | 0.5298 |
| bio | | | | 0.3978 | 0.6426 | | | 0.3249 | 0.2329 |
| c | | | | | | 0.5618 | | | 0.5387 |
| ca | | | | 0.7795 | | | | | 0.2908 |
| ei | | | | | 0.5770 | | | | 0.4713 |
| eu | | | | | | 0.7222 | | | 0.4053 |
| f | | 0.4065 | | | | | | | 0.6619 |
| gi | | 0.7971 | | | | | | | 0.3387 |
| ghg | | | | | | 0.7337 | | | 0.3747 |
| lu | | | | | | | 0.3610 | 0.3270 | 0.5841 |
| ma | | | | 0.7474 | | | | | 0.4573 |
| n | | | | | | | | 0.9273 | 0.1082 |
| rw | | | | | | 0.4963 | | | 0.6857 |
| risk | | | 0.9331 | | | | | | 0.1535 |
| sr | | | | 0.9122 | | | | | 0.1915 |
| sm | | 0.7722 | | | | | | | 0.3286 |
| tb | | 0.3273 | 0.6437 | | | | | | 0.3633 |
| w | | 0.4044 | | | 0.3273 | | | | 0.5585 |
| wh | | | | | | | | 0.6122 | 0.5763 |
| al | 0.5675 | | | | 0.6393 | | | | 0.2025 |
| bf | 0.3177 | | | | | | | | 0.5277 |
| cs | | | | | 0.5138 | | | | 0.5269 |
| fps | | | | | | | 0.7428 | | 0.4373 |
| hb | 0.6083 | | | | 0.4460 | | | | 0.3983 |
| l | 0.5699 | | | | | | | | 0.6421 |
| pf | 0.3667 | | | | | | 0.3585 | | 0.4023 |
| rec | 0.8822 | | | | | | | | 0.1781 |
| sq | 0.8116 | | | | | | | 0.3651 | 0.0833 |
| t | | | | | | | 0.7627 | | 0.3676 |
| ea | | 0.3523 | | | 0.3527 | | | | 0.6324 |
| pv | | | 0.7980 | | | | | | 0.3550 |

Table C-12. Significant and marginally significant factor groupings discovered after factor analysis using oblique promax rotation of Iteration C for the thirty-one environmental, social, and economic variables used to analyze eighty-two valuation tools.

| Factor | Variables | Number of variables | Average interitem covariance | Scale reliability coefficient |
|---|---|---|---|---|
| 1 | al-bf-hb-l-pf-rec-sq | 7 | 0.03265 | 0.8030 |
| 2 | f-gi-sm-tb-w-ea | 6 | 0.04042 | 0.6851[a] |
| 3 | risk-tb-pv | 3 | 0.01194 | 0.8141 |
| 4 | bio-ca-ma-sr | 4 | 0.01659 | 0.6962[a] |
| 5 | bio-ei-w-al-cs-hb-ea | 7 | 0.03586 | 0.6895[a] |
| 6 | aq-c-eu-ghg-rw | 5 | 0.05888 | 0.7120 |

[a]Denotes factor groupings with marginally significant usefulness.

# APPENDIX D

# THE ONLINE QUALTRICS SURVEY QUESTIONNAIRE, “TOOLS TO VALUATE ECONOMIC, ENVIRONMENTAL, AND SOCIAL IMPACTS OF PUBLIC GARDENS,” THAT ASKED PUBLIC GARDENS ADMINISTRATORS TO PROVIDE INFORMATION RELATED TO ENVIRONMENTAL, SOCIAL, AND IMPACT ASSESSMENTS

**Start of Block: Introduction and Consent Form**

Q1.1 **Informed Consent Form**

Gerald S. Burgner

Dr. Charlie Hall

Texas A&M University

Department of Horticultural Sciences

979-845-5341

gsburgner@tamu.edu

"Tools to Valuate Economic, Environmental, and Social Impacts of Public Gardens”

**Introduction**

You are invited to take part in a collaborative research survey project with the American Public Gardens Association about evaluating the economic, environmental, and social benefits your garden provides, and to determine the impact that the presence of the gardens has on the development of the local economy and the community.

The information gleaned from this survey is not intended to augment or replace the information entered into the Public Gardens Benchmarking Platform. It is also information that may be very similar to the information found in the Public Gardens Sustainability Index. Please check out both of those resources by clicking on the links below:

Public Gardens Benchmarking Platform

Public Gardens Sustainability Index

**Procedures**

You will be asked to answer questions about the activities at your public garden. There are 3 sections - Economic Activity, Environmental Activity, and Social Activity - followed by the Demographic section, which asks general background information about the public garden. Questions are designed to assess what your public garden does that may contribute to local economies and communities. This questionnaire will be conducted with an online Qualtrics-created survey.

**NOTE:** If you feel that you are not the person best qualified to fill out this information on behalf of your organization, please feel free to send it to someone else in your organization who would be able to complete the survey.

### Risks/Discomforts

There are no known risks or discomforts associated with this survey.

### Benefits

There are no direct benefits for participants. However, results obtained from the survey will be used to make recommendations useful for establishing economic policies concerning the value that public space, especially public gardens, have on local economies and communities and for generating social impact assessment information concerning how visitors to public spaces utilize acquired information from their visits.

### Confidentiality

The survey is confidential. The information collected will remain confidential and anonymous, and will not be shared with any third party organizations. Any reports of the data will not be linked with your name or your organization as well as your individual responses. All data obtained will be stored in a secure database. The data collected will be stored in the HIPPA-compliant, Qualtrics-secure database until it has been deleted by the primary investigator.

**Compensation**

There is no direct compensation.

**Participation**

Your participation in this study is completely voluntary. It will take you approximately 20-25 minutes to complete this online survey at your computer. If there are any questions that you prefer not to answer, then you are under no obligation to complete them.

You may complete this survey in one sitting or you may complete it in multiple sittings within 2 weeks of when you begin the survey.

**Questions about the Research and your Rights as Research Participants**

If you have questions or want a copy or summary of this study's results, you may contact **Gerald Burgner (gsburgner@tamu.edu)**. For questions about your rights as a research participant; or if you have questions, complaints, or concerns about the research, you may call the Texas A&M University Human Subjects Protection Program office at 979-458-4067 or irb@tamu.edu.

**By clicking the ">>" button below, you are indicating that you are 18 years of age or older and that you consent to participate in this survey:**

Q1.2 I have read, understood, and printed a copy of (if desired) the above consent form and choose of my own free will to participate in this study.

○ Yes (1)

○ No (2)

*Skip To: End of Survey If I have read, understood, and printed a copy of (if desired) the above consent form and choose of... = No*

**End of Block: Introduction and Consent Form**

**Start of Block: Background Information**

Q2.1 What is the name of your institution (OPTIONAL)?

Q2.2 Please select your garden’s governance structure. Choose all that apply.

☐ City or county owned (1)

☐ College or university (2)

☐ For profit (3)

☐ Independent nonprofit (e.g., 501(c)(3)) (4)

☐ Public/private partnership (5)

☐ Nonprofit (501(c)(3)) (6)

☐ Other (7)

Q2.3 What is your job title?

Q2.4 Where is your public garden located? Choose one answer.

- ○ Urban area (within a city) (1)
- ○ Suburban area (on the outskirts of a city, but not in a rural area) (2)
- ○ Rural area (nearest city is at least 5-10 miles away) (3)
- ○ It's complicated (mixed urban/suburban/rural) (4)
- ○ None of the above (5)

Q2.5 Is public transit available to your public garden (i.e., city bus service, etc.)? Choose one answer.

- ○ Yes (1)
- ○ No (2)

Q2.6 How do most visitors get to your public garden? Choose one answer.

- ○ Automobile/Truck (1)
- ○ Public Transit (2)
- ○ Group bus (chartered, school) (3)
- ○ Walk/bicycle (4)
- ○ Other (5)
- ○ Unknown (6)

Q2.7 How do visitors get information about your public garden? Check all that apply.

- ○ Newsletters, brochures and other printed materials (1)
- ○ Non-print materials (emails, text messaging, CDs, DVDs, etc.) (2)
- ○ Mass media publicity (free television and/or newspaper features, etc.) (3)
- ○ Public service announcements (4)
- ○ Paid advertising (radio, television, newspaper, etc.) (5)
- ○ Social media (Twitter, Facebook, etc.) (6)
- ○ Internet (website) (7)
- ○ Other (please specify): (8)

---

Q2.8 What percentage of your visitors are from the following age groups? Total should equal 100.

Please give your best estimate of your garden's age demographic. If unknown, leave blank.

Under 18 years of age : _______ (1)

18 to 34 years old : _______ (2)

35 to 54 years old : _______ (3)

55 to 70 years old : _______ (4)

Over 70 years old : _______ (5)

Total : ________

**End of Block: Background Information**

---

**Start of Block: Economic Impact**

Q3.1 **In the questions that follow, the terms "economic improvement", "economic development", and "economic impact" are used.**

**For the purpose of this survey, the following key terms apply:**

**Economic improvement:** The overall building up of the economic structure in an area by activities which result in the creation of new jobs.

**Economic development:** The expansion of overall business activity in an area either by physical expansion of existing business, by the location of or creation of new business or by the increased business activity of existing business without their physical expansion.

**Economic impact:** The change in economic activity in a community, city, or region as a result of an event, project, business, or organization, policy, or other activity or program (the contribution of an organization to the economic activity).

Q3.2 Has your garden ever conducted an economic impact assessment? Choose one answer.

- ○ Yes (1)
- ○ No (2)

*Skip To: Q3.8 If Has your garden ever conducted an economic impact assessment? Choose one answer. = No*

Q3.3 When was the last economic impact assessment conducted? Choose one answer.

- ○ Within the last 3 years (1)
- ○ More than 3 years ago (2)

Q3.4 Who conducted the economic impact assessment? Choose one answer.

- ○ Garden staff conducted the economic impact assessment (1)
- ○ A firm/third party was hired to conduct the economic impact assessment (2)
- ○ Other (3)

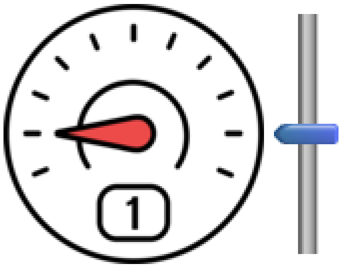
Q3.5 What tools were used to conduct the economic impact assessment? Choose all that apply.

- ○ Public Gardens Benchmarking Platform (1)
- ○ Public Gardens Sustainability Index (2)
- ○ Lifecycle Cost Analysis (LCA) (3)
- ○ Building for Environmental and Economic Sustainability (BEES) (4)
- ○ Green Values National Stormwater Management Calculator (5)
- ○ National Tree Benefit Calculator (6)
- ○ Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) (7)
- ○ STAR Community Rating System (STAR) (8)
- ○ Other (such as Implan) (please list): (9)
- ○ Haven't a clue! (10)

Q3.6 Was the economic impact assessment useful? Choose one answer.

- ○ Yes, results/recommendations/actions are/will be used (1)
- ○ Yes, it was useful, but no further action has been taken (2)
- ○ No, it was not useful (3)

Q3.7 On the sliding scale below, select the number that best describes the level of support that the board of directors/advisory board has provided for the economic impact assessment (0 = no support; 10 = full support)(if there is not a board, select "0"):



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1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

7 (7)

8 (8)

9 (9)

10 (10)

Q3.8 What economic information does your garden collect about its facilities and landscapes? Check all that apply.

○ Energy costs/savings/efficiency (1)

○ Life cycle cost analyses (2)

○ Recycling costs and/or returns (3)

○ Return on investments (capital projects/green infrastructure, educational programs, special events, etc.) (4)

○ Waste reduction costs and/or returns (5)

○ Other (Please list): (6)

○ No economic information is collected (7)

*Skip To: Q3.9 If What economic information does your garden collect about its facilities and landscapes? Check all... = No economic information is collected*

*Display This Question:*

*If What economic information does your garden collect about its facilities and landscapes? Check all... = No economic information is collected*

Q3.9 Does your garden plan to collect economic information about its facilities and landscapes? Choose one answer.

○ Yes (1)

○ No (2)

**End of Block: Economic Impact**

**Start of Block: Environmental Impact**

Q4.1 For purposes of this survey, **environmental impact** is a systematic evaluation designed to identify and forecast good and bad consequences of an action on the environment and potential impacts on human health and well-being which is interpreted and communicated to decision-makers and others who would be affected by any action taken.

Q4.2 Has your garden ever conducted an environmental impact assessment? Choose one answer.

○ Yes (1)

○ No (2)

*Skip To: Q4.8 If Has your garden ever conducted an environmental impact assessment? Choose one answer. = No*

Q4.3 When was the last environmental impact assessment conducted? Choose one answer.

○ Within the last 3 years (1)

○ More than 3 years ago (2)

Q4.4 Who conducted the environmental impact assessment? Choose one answer.

○ Garden staff conducted the environmental impact assessment (1)

○ A firm/third party was hired to conduct the environmental impact assessment (2)

○ Other (3)

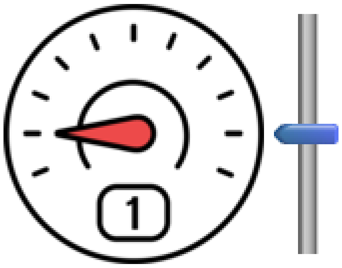
Q4.5 What tools were used to conduct the environmental impact assessment? Choose all that apply.

- ○ Public Gardens Sustainability Index (1)
- ○ Public Gardens Plant Conservation and Biodiversity Benchmarking (2)
- ○ i-Tree (3)
- ○ National Stormwater Calculator (4)
- ○ Environmental Benefits Calculator (5)
- ○ Landuse Evolution and Impact Assessment Model (LEAM) (6)
- ○ Building for Environmental and Economic Sustainability (BEES) (7)
- ○ Green Values National Stormwater Management Calculator (8)
- ○ National Tree Benefit Calculator (9)
- ○ Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) (10)
- ○ STAR Community Rating System (STAR) (11)
- ○ Other (please list): (12)
- ○ Haven't a clue! (13)

Q4.6 Was the environmental impact assessment useful? Choose one answer.

- ○ Yes, results/recommendations/actions are/will be used (1)
- ○ Yes, it was useful, but no further action has been taken (2)
- ○ No, it was not useful (3)

Q4.7 On the sliding scale below, select the number that best describes the level of support that the board of directors/advisory board has provided for the environmental impact assessment (0 = no support; 10 = full support)(if there is not a board, select "0"):



0 (0)
1 (1)
2 (2)
3 (3)
4 (4)
5 (5)
6 (6)
7 (7)
8 (8)
9 (9)
10 (10)

Q4.8 What environmental information does your garden collect about its facilities and landscapes? Check all that apply.

- ○ Building/property carbon footprint (1)
- ○ Water conservation (2)
- ○ Ecological integrity (3)
- ○ Air quality/pollution levels (4)
- ○ Recycling costs and/or returns (5)
- ○ Environmental stewardship/conservation (6)
- ○ Waste reduction/diversion costs and/or returns (7)
- ○ Stormwater management (8)
- ○ Other (Please list): (9)
- ○ No environmental information is collected (10)

*Skip To: Q4.9 If What environmental information does your garden collect about its facilities and landscapes? Chec... = No environmental information is collected*

*Display This Question:*

*If What environmental information does your garden collect about its facilities and landscapes? Chec... = No environmental information is collected*

Q4.9 Does your garden plan to collect environmental information about its facilities and landscapes? Choose one answer.

- ○ Yes (1)
- ○ No (2)

**End of Block: Environmental Impact**

**Start of Block: Social Impact**

Q5.1 For purposes of this survey, **social impact** is the evaluation of potential intended and unintended actions to human populations that may alter the social pattern of people's lives or may change cultural norms and values.

Examples of **social value** are providing a place for relaxation and meditation, social gatherings, recreation, education, etc.

Q5.2 Has your garden ever conducted a social impact assessment? Choose one answer.

○ Yes (1)

○ No (2)

*Skip To: Q5.8 If Has your garden ever conducted a social impact assessment? Choose one answer. = No*

Q5.3 When was the last social impact assessment conducted? Choose one answer.

○ Within the last 3 years (1)

○ More than 3 years ago (2)

Q5.4 Who conducted the social impact assessment? Choose one answer.

○ Garden staff conducted the social impact assessment (1)

○ A firm/third party was hired to conduct the social impact assessment (2)

○ Other (3)

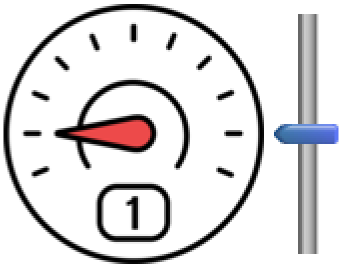
Q5.5 What tools were used to conduct the social impact assessment? Choose all that apply.

- ○ Public Gardens Sustainability Index (1)
- ○ Housing and Transportation Affordability Index (2)
- ○ Microscale Audit of Pedestrian Streetscapes (MAPS) (3)
- ○ Environmental Assessment of Public Recreation Spaces (4)
- ○ Pedestrian Environmental Quality Index Tool (PEQ) (5)
- ○ System for Observing Physical Activity and Recreation in Natural Areas (SOPARNA) (6)
- ○ Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) (7)
- ○ STAR Community Rating System (STAR) (8)
- ○ Other (including internal data/evaluation collection) (please list): (9)
- ○ Haven't a clue! (10)

Q5.6 Was the social impact assessment useful? Choose one answer.

- ○ Yes, results/recommendations/actions are/will be used (1)
- ○ Yes, it was useful, but no further action has been taken (2)
- ○ No, it was not useful (3)

Q5.7 On the sliding scale below, select the number that best describes the level of support that the board of directors/advisory board has provided for the social impact assessment (0 = no support; 10 = full support)(if there is not a board, select "0"):



0 (0)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

7 (7)

8 (8)

9 (9)

10 (10)

Q5.8 **Social return on investment** refers to the social value of your organization by determining the tangible value and intangible value to the community based on the total amount of resources.

In other words, it helps to determine the cost of what would happen if your public garden did not exist.

Does your public garden calculate its social return on investment? Choose one answer.

○ Yes, my public garden regularly conducts a social return on investment (1)

○ Yes, my public garden has conducted social return on investment, but not within the last 3 years (2)

○ No, my garden has not conducted a social return on investment (3)

○ Have no idea what a social return on investment is or if my public garden has ever conducted one (4)

Q5.9 What information does your garden collect from visitors? Check all that apply.

○ Satisfaction level (with the garden and its services) (1)

○ Reason for visiting (2)

○ Inspiration from the gardens (visitors using information) (3)

○ Garden mission awareness level (4)

○ Accessibility (inclusivity) (5)

○ Behavioral adjustments - e.g., more aware of sustainability, environmental stewardship, etc. (6)

○ How often the person visits the garden (7)

○ Other (please list): (8)

○ No visitor information is collected (9)

*Skip To: Q5.10 If What information does your garden collect from visitors? Check all that apply. = No visitor information is collected*

*Display This Question:*

*If What information does your garden collect from visitors? Check all that apply. = No visitor information is collected*

Q5.10 Does your garden plan to collect visitor information (i.e., demographics, diversity, local vs. national, etc.)? Choose one answer.

○ Yes (1)

○ No (2)

**End of Block: Social Impact**

---

**Start of Block: Demographics**

Q6.1 What year was the public garden established?

Q6.2 In which state is the public garden located?

▼ The public garden is not located in the United States (53) ... Wyoming (52)

Q6.4 How many employees work at the public garden (do not include volunteers)? Choose one answer.

○ 1-4 (1)
○ 5-9 (2)
○ 10-19 (3)
○ 20-49 (4)
○ 50-99 (5)
○ 100-249 (6)
○ 250-499 (7)
○ 500-999 (8)
○ 1000 or more (9)

Q6.5 How many volunteers work at the public garden? Choose one answer.

○ None (1)
○ 1-4 (2)
○ 5-9 (3)
○ 10-19 (4)
○ 20-49 (5)
○ 50-99 (6)
○ 100-249 (7)
○ 250-499 (8)
○ 500-999 (9)
○ 1000 or more (10)

Q6.6 What is the physical size of the public garden (list the total amount of property if more than one location is managed by the organization)? Choose one answer.

○ 0-9 acres (1)
○ 10-19 acres (2)
○ 20-49 acres (3)
○ 50-99 acres (4)
○ 100-249 acres (5)
○ 250-499 acres (6)
○ 500-999 acres (7)
○ 1000 or more acres (8)

Q6.7 What is the total annual revenue for your public garden? Choose one answer.

○ $0–$500,000  (1)
○ $500,001–$1,000,000  (2)
○ $1,000,001-$2,000,000  (3)
○ $2,000,001-$5,000,000  (4)
○ $5,000,001-$7,500,000  (5)
○ $7,500,001-$10,000,000  (6)
○ $10,000,001 or greater  (7)

Q6.8 How many visitors attend the public garden each year? Choose one answer.

○ Less than 10,000  (1)
○ 10,000-19,999  (2)
○ 20,000-49,999  (3)
○ 50,000-99,999  (4)
○ 100,000-249,000  (5)
○ 250,000-499,000  (6)
○ 500,000-999,999  (7)
○ 1,000,000 or more  (8)
○ If unsure, list estimated number:  (9)

**End of Block: Demographics**

**Start of Block: Concluding Question**

Q7.1 Besides funding, what is the **greatest** challenge facing your public garden? Choose one answer.

○ Increasing attendance numbers (1)
○ Increasing audience diversity (2)
○ Increasing membership (3)
○ Facilities management (4)
○ Maintaining plant collections (5)
○ Maintaining other collections (art and other exhibits, etc.) (6)
○ Staff management (7)
○ Finding qualified/skilled employees (8)
○ Support from the board of directors/advisory board (9)
○ Educational programming (10)
○ Infrastructure (e.g., parking, stormwater management, etc.) (11)
○ Community support (12)
○ Visitor services (13)
○ Other (please list): (14)

**End of Block: Concluding Question**

---

**Start of Block: Thank You**

Q8.1 If your organization completed a(n) economic, environmental, and/or social impact assessment, would you be willing to share the results? If so, leave your contact information or send an email to Gerald Burgner (gsburgner@tamu.edu) with "APGA Survey" in the subject line.

You may skip this question if your organization did not complete any impact assessments.

○ Yes, we will share the results of our economic, environmental, and/or social impact assessment(s). My contact information is listed below. (1)

○ Yes. we will share the results of our economic, environmental, and/or social impact assessment(s), but we will contact you via email. (2)

○ No, we do not wish to share the results of our economic, environmental, and/or social impact assessment(s). (3)

Q8.2 Thanks for participating in the survey. If you are interested in receiving information about the conclusions drawn from this survey or about valuation tools for conducting economic, environmental, or social impact assessments, enter your email address below or you may email Gerald Burgner at gsburgner@tamu.edu. Results will be available in Spring 2019.

○ I would like to receive information about the conclusions from this survey. Please enter your email address: (1)

○ I would like to receive information about valuation tools for economic, environmental, and/or social impact assessments. Please enter your email address: (2)

○ No, thanks. (3)

**End of Block: Thank You**

# APPENDIX E

# PARTICIPANT RESPONSE RESULTS FROM AN ONLINE QUALTRICS SURVEY QUESTIONNAIRE, “TOOLS TO VALUATE ECONOMIC, ENVIRONMENTAL, AND SOCIAL IMPACTS OF PUBLIC GARDENS,” THAT ASKED PUBLIC GARDENS ADMINISTRATORS TO PROVIDE INFORMATION RELATED TO ENVIRONMENTAL, SOCIAL, AND IMPACT ASSESSMENTS

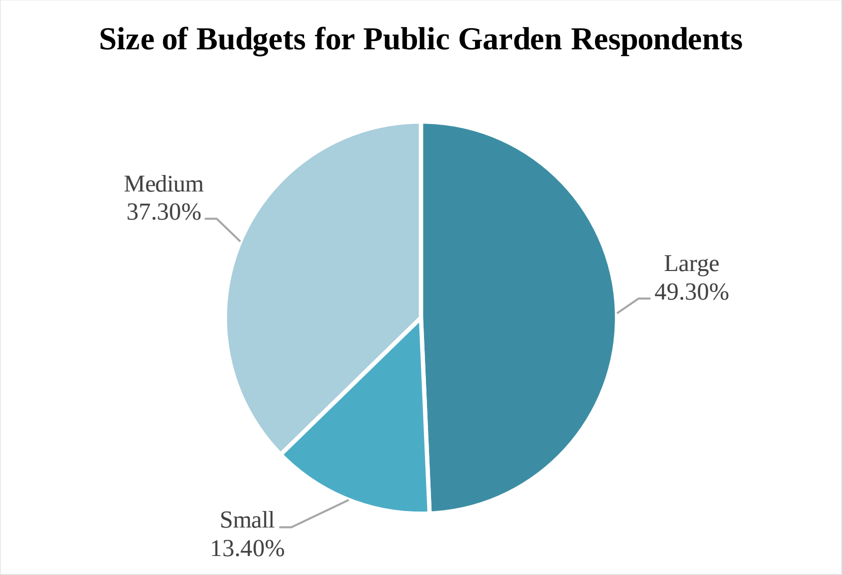


Figure E-1. Size of budgets of public gardens from respondents to a state of the industry survey about environmental, social, and economic impact assessments.

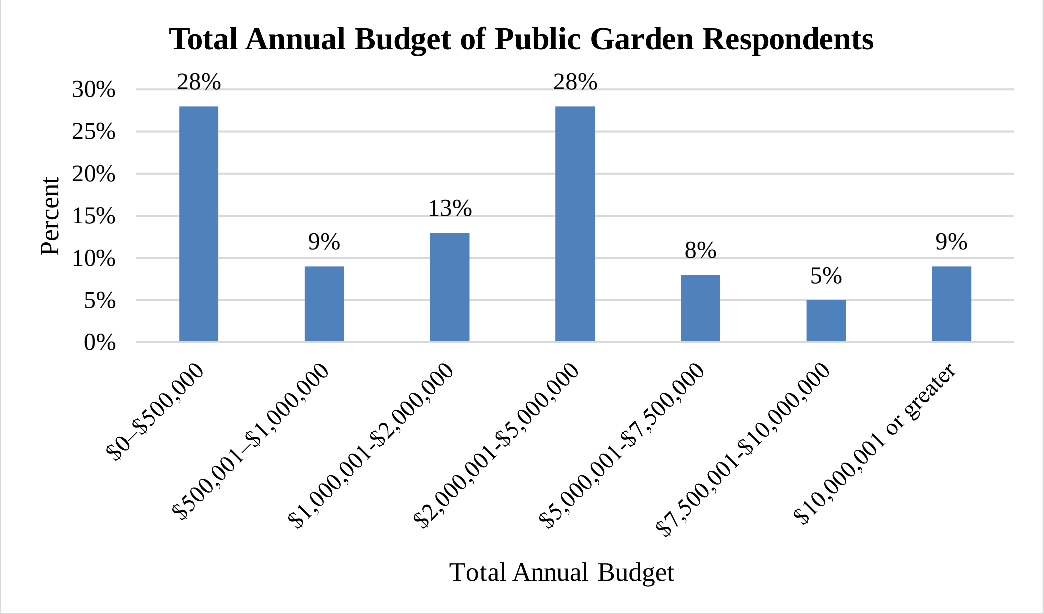


Figure E-2. Total annual budgets of public gardens from respondents to a state of the industry survey about environmental, social, and economic impact assessments.

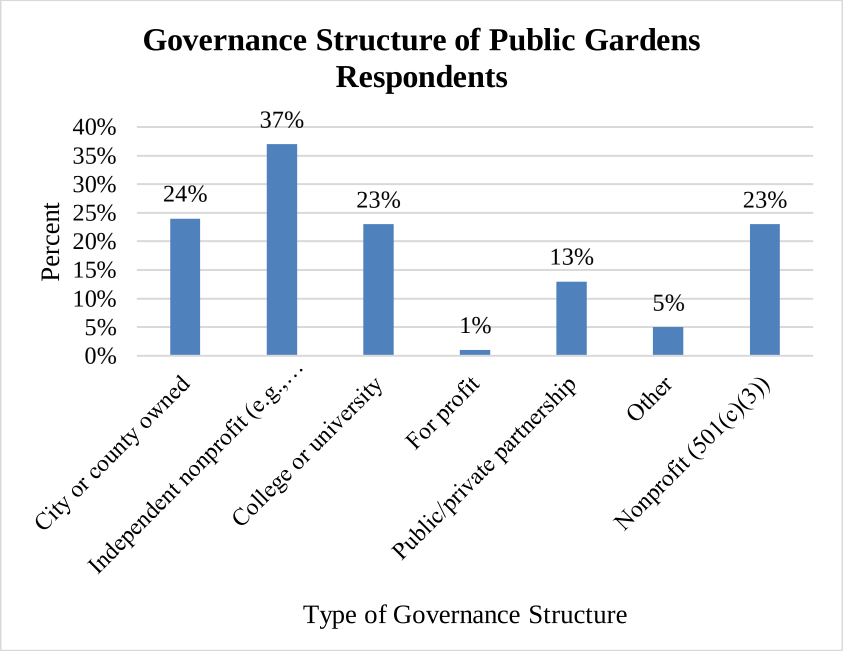


Figure E-3. Percentage of respondents indicating the governance structure types of public gardens in a state of the industry survey about environmental, social, and economic impact assessments.

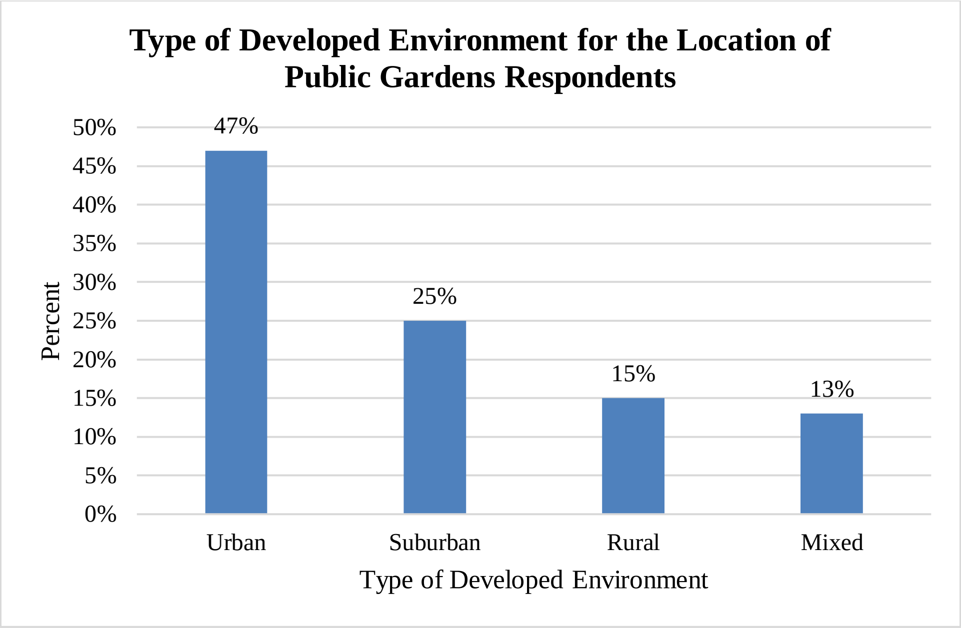


Figure E-4. Percentage of responses for the type of developed environment where public gardens were located from public garden respondents in a state of the industry survey about environmental, social, and economic impact assessments.

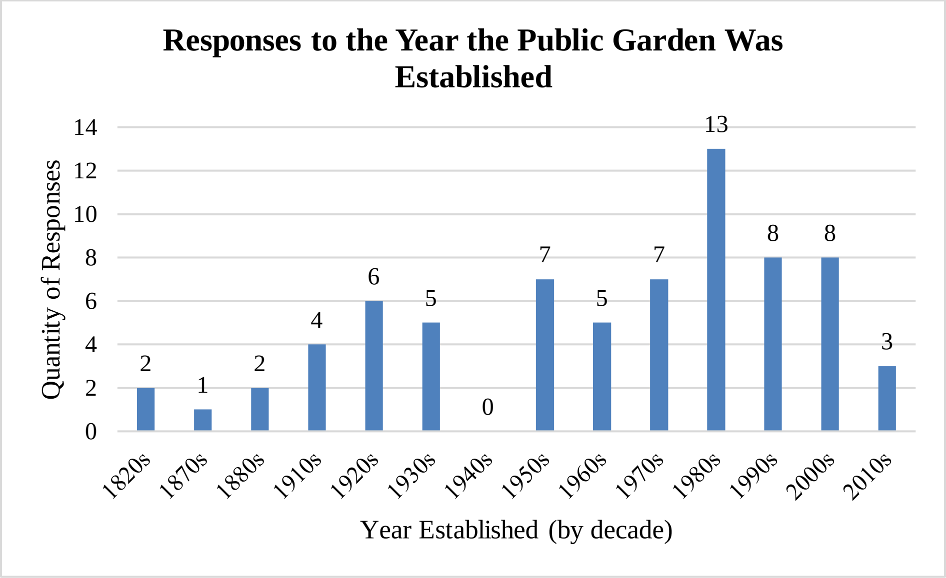


Figure E-5. Responses from a state of the industry survey of public gardens about environmental, social, and economic impact assessments indicating the year the garden was established (by decade).

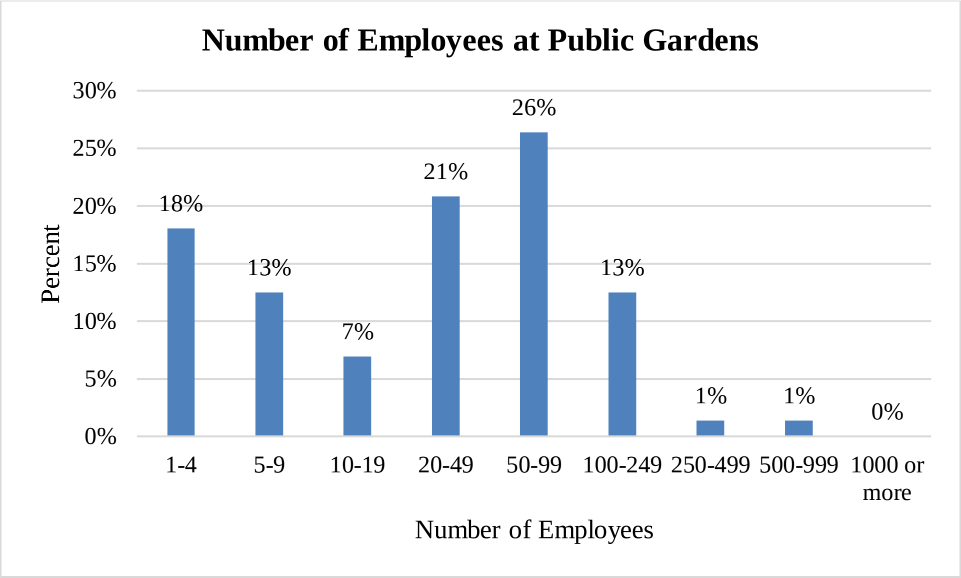


Figure E-6. Percentage of responses from a state of the industry survey of public gardens about environmental, social, and economic impact assessments indicating the number of employees working for the public garden.

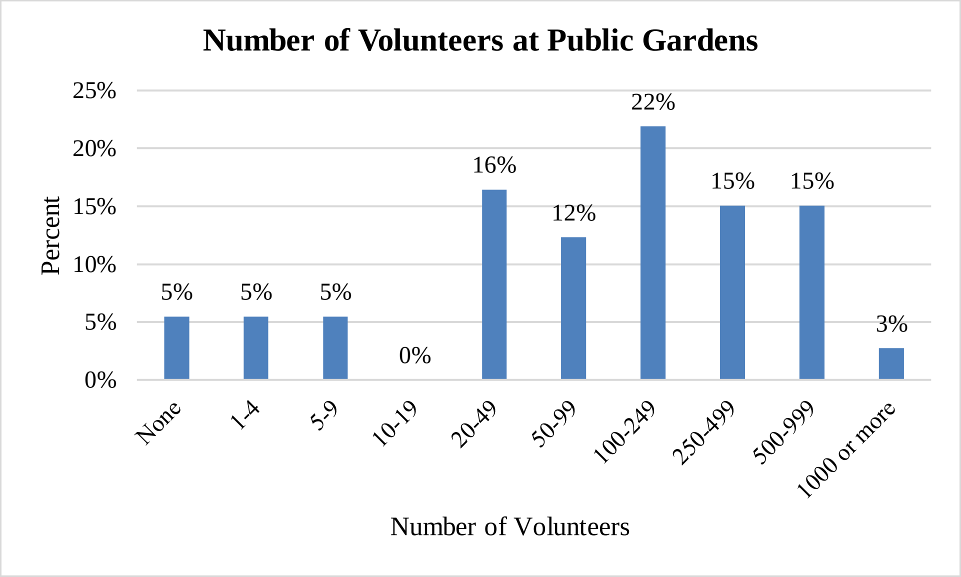


Figure E-7. Percentage of responses from a state of the industry survey of public gardens about environmental, social, and economic impact assessments indicating the number of volunteers working for the public garden.

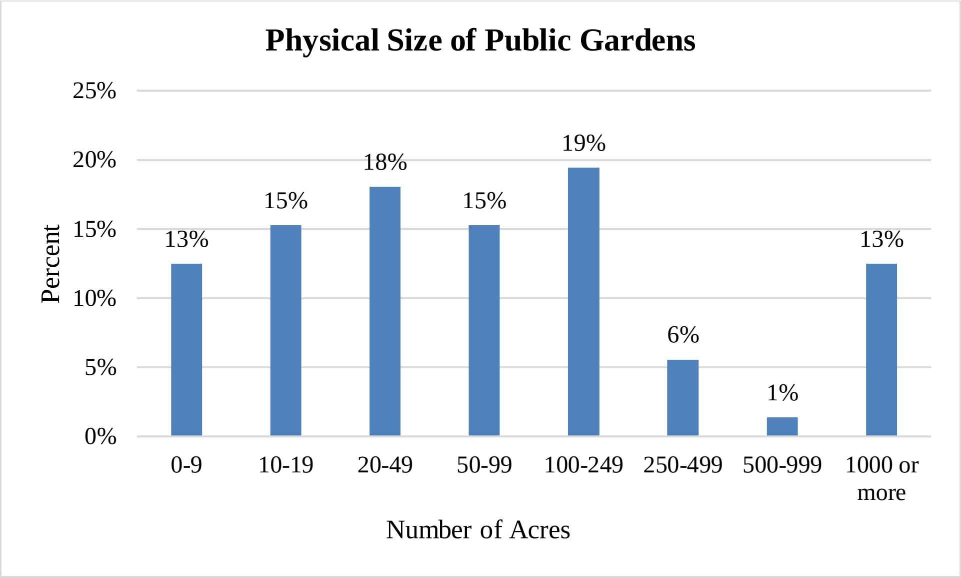


Figure E-8. Percentage of responses from a state of the industry survey of public gardens about environmental, social, and economic impact assessments indicating the physical size (in acres) of the public gardens.

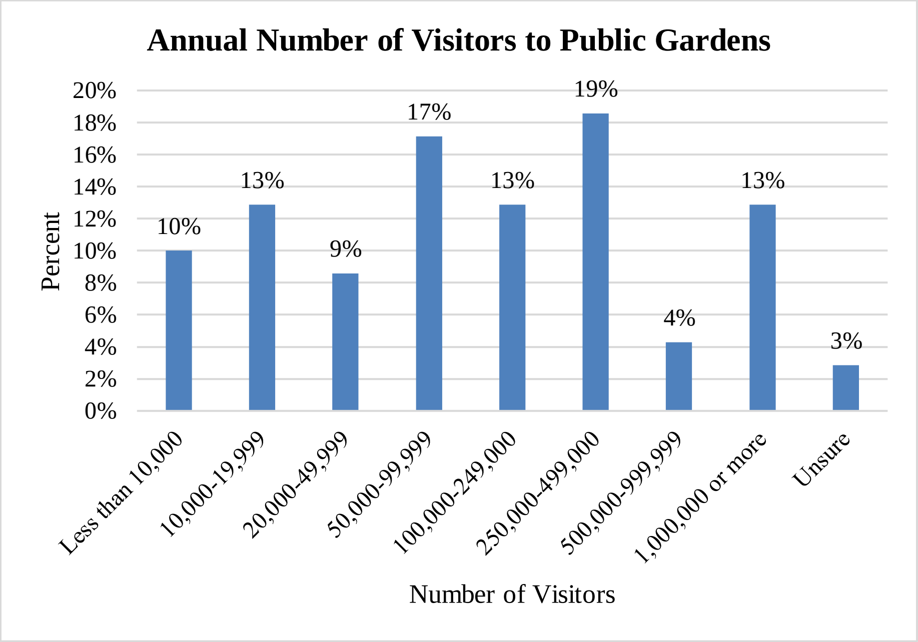


Figure E-9. Percentage of responses from a state of the industry survey of public gardens about environmental, social, and economic impact assessments indicating the annual number of visitors attending public gardens.

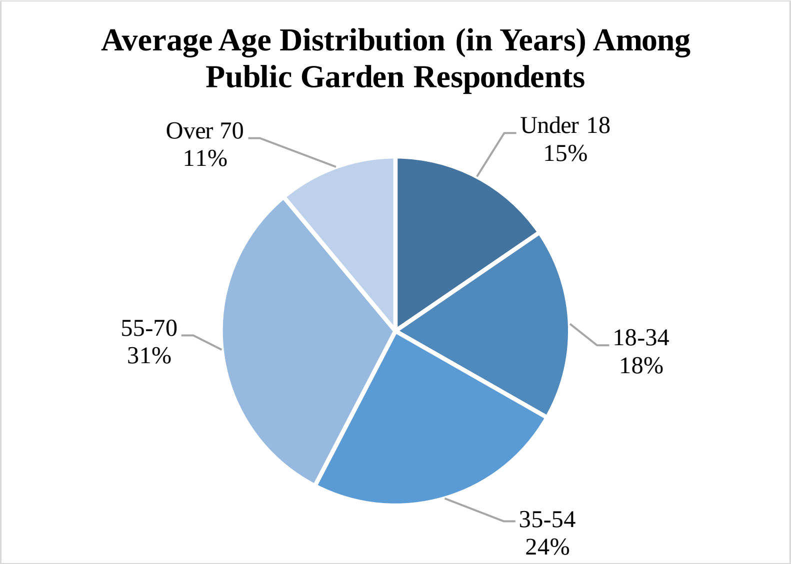


Figure E-10. Average age distribution (in years) of public garden respondents from a state of the industry survey of public gardens about environmental, social, and economic impact assessments.

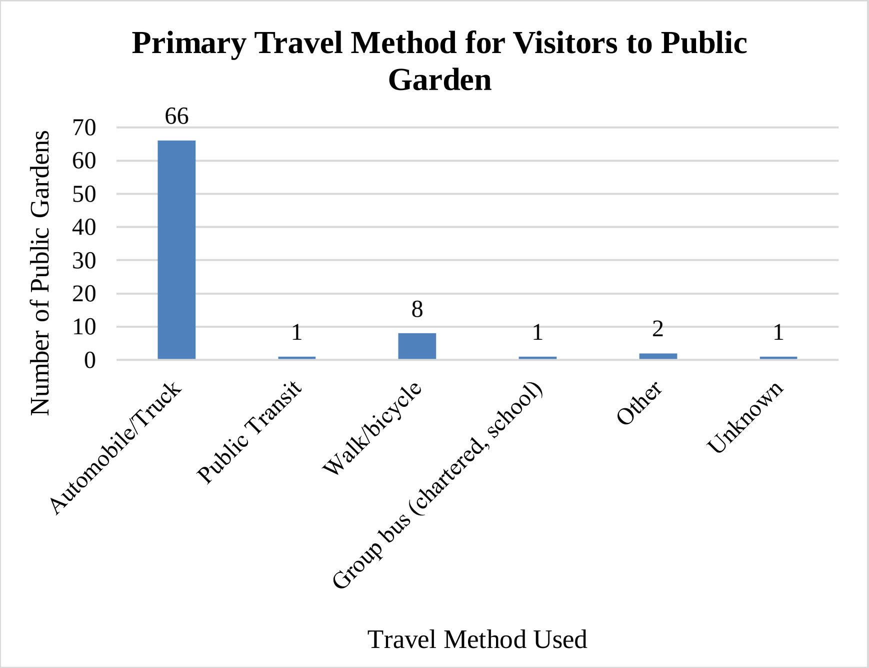


Figure E-11. Primary travel method for visitors attending public gardens as indicated by respondents from a state of the industry survey of public gardens about environmental, social, and economic impact assessments.

Table E-1. Responses to impact assessment information in a state of the industry survey about environmental, social, and economic impact assessments.

| | Environmental | Social | Economic |
|---|---|---|---|
| Gardens that conducted an assessment | 9 (12%)<br>(n = 76) | 7 (10%)<br>(n = 73) | 14 (18%)<br>(n = 78) |
| Assessment conducted within last 3 years | 4 (44%)<br>(n = 9) | 5 (71%)<br>(n = 7) | 7 (50%)<br>(n = 14) |
| Assessment conducted more than 3 years ago | 5 (56%)<br>(n = 9) | 2 (29%)<br>(n = 7) | 6 (43%)<br>(n = 14) |
| Assessment conducted by staff | 3 (33%)<br>(n = 9) | 1 (14%)<br>(n = 7) | 1 (7%)<br>(n = 14) |
| Assessment conducted by 3rd party | 5 (56%)<br>(n = 9) | 5 (51%)<br>(n = 7) | 7 (50%)<br>(n = 14) |
| Assessment conducted by other | 2 (22%)<br>(n = 9) | 2 (29%)<br>(n = 7) | 5 (36%)<br>(n = 14) |
| Assessment was useful, and will be implemented | 8 (100%)<br>(n = 8) | 6 (86%)<br>(n = 7) | 8 (62%)<br>(n = 13) |
| Assessment was useful, but no action will be taken | 0 (0%)<br>(n = 8) | 0 (0%)<br>(n = 7) | 5 (38%)<br>(n = 13) |
| Assessment was not useful | 0 (0%)<br>(n = 8) | 1 (14%)<br>(n = 7) | 0 (0%)<br>(n = 14) |
| Information not collected | 29 (39%)<br>(n = 74) | 21 (29%)<br>(n = 72) | 19 (25%)<br>(n = 75) |
| If no information is collected, is it being considered | 13 (45%)<br>(n = 29) | 2 (11%)<br>(n = 19) | 5 (28%)<br>(n = 18) |

# APPENDIX F

# STATISTICAL ANALYSES FROM AN ONLINE QUALTRICS SURVEY QUESTIONNAIRE, "TOOLS TO VALUATE ECONOMIC, ENVIRONMENTAL, AND SOCIAL IMPACTS OF PUBLIC GARDENS," THAT ASKED PUBLIC GARDENS ADMINISTRATORS TO PROVIDE INFORMATION RELATED TO ENVIRONMENTAL, SOCIAL, AND IMPACT ASSESSMENTS

Table F-1. Comparison of thirteen key demographic variables between respondents and nonrespondents in a state of the industry survey about environmental, social, and economic impact assessments using paired t-tests.

| **Variable** | **Respondents** | **Nonrespondents** | **Difference** | **p value** |
|---|---|---|---|---|
| Location (developed environment) | 1.9603 | 2.0667 | -0.1604 | 0.7921 |
| Availability of public transportation | 1.4444 | 1.2500 | 0.1944 | 0.3332 |
| Method to attend garden | 1.5156 | 1.4667 | 0.0490 | 0.7838 |
| Year established | 3.8246 | 3.5714 | 0.2531 | 0.2123 |
| State location | 2.6842 | 3.0000 | -0.3158 | 0.8619 |
| Number of employees | 3.5172 | 4.7143 | -1.1970 | 0.0120[a] |
| Number of volunteers | 6.3559 | 5.8571 | 0.4988 | 0.5013 |
| Number of visitors | 4.1786 | 5.5714 | -1.3929 | 0.0048[a] |
| Physical size | 3.7241 | 5.0714 | -1.3473 | 0.0218[a] |
| Total annual budget | 2.0727 | 2.3333 | -0.2606 | 0.0889 |
| Environmental impact assessment | 1.9016 | 1.8000 | 0.1016 | 0.3343 |
| Social impact assessment | 1.8852 | 1.9286 | -0.0433 | 0.3356 |
| Economic impact assessment | 1.8548 | 1.7333 | 0.1215 | 0.4332 |

[a] Denotes significant difference between respondents and nonrespondents

Table F-2. Significant relationships between survey information discovered from multivariate Chi-square and Fisher's exact test analyses in a state of the industry survey about environmental, social, and economic impact assessments.

| **Variables with significant relationships** | **Chi-square value ($\chi^2$)** | ***p* value** | **Fisher's exact test** |
|---|---|---|---|
| Governance structure – College or university x independent nonprofit | 11.1946 | 0.011 | 0.002 |
| Governance structure – For profit x independent nonprofit | 47.2250 | 0.000 | 0.021 |
| Governance structure – Independent nonprofit x public/private partnership | 63.0825 | 0.000 | 0.003 |
| Governance structure – Independent nonprofit x standard nonprofit | 208.4979 | 0.000 | 0.000 |
| Governance structure – Public/private partnership x standard nonprofit | 213.3825 | 0.000 | 0.000 |
| Marketing strategy – print x nonprint | 13.1958 | 0.000 | 0.001 |
| Marketing strategy – print x mass media | 7.7122 | 0.005 | 0.010 |
| Marketing strategy – print x paid advertising | 16.0784 | 0.000 | 0.000 |
| Marketing strategy – print x social media | 46.9349 | 0.000 | 0.000 |
| Marketing strategy – print x internet | 25.0772 | 0.000 | 0.000 |
| Marketing strategy – nonprint x paid advertising | 21.9993 | 0.000 | 0.000 |
| Marketing strategy – nonprint x social media | 14.3976 | 0.000 | 0.000 |
| Marketing strategy – nonprint x internet | 7.4712 | 0.006 | 0.011 |
| Marketing strategy – mass media x public service announcement | 7.8382 | 0.005 | 0.004 |
| Marketing strategy – mass media x paid advertising | 8.9758 | 0.003 | 0.004 |
| Marketing strategy – mass media x social media | 14.5866 | 0.000 | 0.000 |
| Marketing strategy – mass media x internet | 10.3090 | 0.001 | 0.004 |
| Marketing strategy – paid advertising x social media | 11.8527 | 0.001 | 0.001 |
| Marketing strategy – paid advertising x internet | 6.1745 | 0.013 | 0.018 |

Table F-2 Continued.

| **Variables with significant relationships** | **Chi-square value ($\chi^2$)** | ***p* value** | **Fisher's exact test** |
|---|---|---|---|
| Marketing strategy – social media x internet | 40.6215 | 0.000 | 0.000 |
| Environment impact assessment (usefulness) x environmental information collected – water conservation | 8.0000 | 0.018 | 0.125 |
| Environment impact assessment (usefulness) x environmental information collected – ecological integrity | 8.0000 | 0.018 | 0.125 |
| Environment impact assessment (usefulness) x environmental information collected – air quality/pollution | 8.0000 | 0.005 | 0.125 |
| Environment impact assessment (usefulness) x environmental information collected – recycling costs and/or returns | 8.0000 | 0.018 | 0.125 |
| Environment impact assessment (usefulness) x environmental information collected – environmental stewardship/conservation | 8.0000 | 0.018 | 0.125 |
| Environment impact assessment (usefulness) x environmental information collected – waste reduction | 8.0000 | 0.018 | 0.125 |
| Environment impact assessment (usefulness) x environmental information collected – stormwater management | 8.0000 | 0.018 | 0.125 |
| Environmental information collected – water conservation x ecological integrity | 90.3755 | 0.000 | 0.000 |
| Environmental information collected – water conservation x air quality/pollution | 74.4289 | 0.000 | 0.009 |
| Environmental information collected – water conservation x recycling costs and/or returns | 90.3506 | 0.000 | 0.000 |
| Environmental information collected – water conservation x environmental stewardship/conservation | 93.9991 | 0.000 | 0.000 |
| Environmental information collected – water conservation x waste reduction | 85.8057 | 0.000 | 0.000 |
| Environmental information collected – water conservation x stormwater management | 98.3949 | 0.000 | 0.000 |
| Environmental information collected – water conservation x plans to collect environmental information in the future | 29.0000 | 0.000 | 0.034 |
| Environmental information collected – ecological integrity x air quality/pollution | 77.0426 | 0.000 | 0.004 |
| Environmental information collected – ecological integrity x recycling costs and/or returns | 82.4093 | 0.000 | 0.000 |
| Environmental information collected – air quality/pollution x recycling costs and/or returns | 76.2622 | 0.000 | 0.004 |

Table F-2 Continued.

| **Variables with significant relationships** | **Chi-square value ($\chi^2$)** | ***p* value** | **Fisher's exact test** |
|---|---|---|---|
| Environmental information collected – air quality/pollution x environmental stewardship/conservation | 74.5870 | 0.000 | 0.008 |
| Environmental information collected – air quality/pollution x stormwater management | 81.2522 | 0.000 | 0.000 |
| Environmental information collected – air quality/pollution x plans to collect environmental information in the future | 29.0000 | 0.000 | 0.034 |
| Environmental information collected – carbon footprint x environmental stewardship/conservation | 7.0313 | 0.008 | 0.014 |
| Environmental information collected – ecological integrity x environmental stewardship/conservation | 104.1211 | 0.000 | 0.000 |
| Environmental information collected – ecological integrity x stormwater management | 82.8422 | 0.000 | 0.000 |
| Environmental information collected – ecological integrity x plans to collect environmental information in the future | 29.0000 | 0.000 | 0.034 |
| Environmental information collected – recycling costs and/or returns x environmental stewardship/conservation | 79.5973 | 0.000 | 0.001 |
| Environmental information collected – ecological integrity x waste reduction | 125.2459 | 0.000 | 0.000 |
| Environmental information collected – ecological integrity x stormwater management | 80.1216 | 0.000 | 0.000 |
| Environmental information collected – ecological integrity x plans to collect environmental information in the future | 29.0000 | 0.000 | 0.034 |
| Environmental information collected – environmental stewardship/conservation x waste reduction | 79.5973 | 0.000 | 0.001 |
| Environmental information collected – environmental stewardship/conservation x stormwater management | 78.9313 | 0.000 | 0.001 |
| Environmental information collected – environmental stewardship/conservation x plans to collect environmental information in the future | 29.0000 | 0.000 | 0.034 |
| Environmental information collected – waste reduction x stormwater management | 83.8404 | 0.000 | 0.000 |
| Environmental information collected – waste reduction x plans to collect environmental information in the future | 29.0000 | 0.000 | 0.034 |
| Environmental information collected – stormwater management x plans to collect environmental information in the future | 29.0000 | 0.000 | 0.034 |

Table F-2 Continued.

| Variables with significant relationships | Chi-square value ($\chi^2$) | *p* value | Fisher's exact test |
|---|---|---|---|
| Environmental information collected – no information collected x plans to collect environmental information in the future | 29.0000 | 0.000 | 0.034 |
| Social impact assessment conducted x last time social impact assessment conducted | 8.0000 | 0.018 | 0.125 |
| Social impact assessment conducted x who conducted social impact assessment conducted | 9.0000 | 0.029 | 0.333 |
| Social impact assessment x social information collected – accessibility (inclusivity) | 10.2891 | 0.001 | 0.009 |
| Social impact assessment x social information collected – reason for attending garden | 5.6822 | 0.017 | 0.018 |
| Social impact assessment x social information collected – awareness level of garden mission | 7.8293 | 0.005 | 0.018 |
| Social impact assessment x social information collected – behavioral adjustments | 21.1028 | 0.000 | 0.000 |
| Social impact assessment x social tool used – EAPRS | 7.0000 | 0.008 | 0.143 |
| SROI x social information collected – behavioral adjustments | 23.4307 | 0.000 | 0.001 |
| SROI x plans to collect social information in the future | 20.4412 | 0.002 | 0.158 |
| Social information collected – satisfaction levels x no social information collected | 24.4957 | 0.000 | 0.000 |
| Social information collected – reason attending garden x no social information collected | 29.7540 | 0.000 | 0.000 |
| Social information collected – inspiration level x no social information collected | 6.0714 | 0.014 | 0.013 |
| Social information collected – awareness level of garden mission x no social information collected | 6.0714 | 0.014 | 0.013 |
| Social information collected – accessibility (inclusivity) x no social information collected | 4.3220 | 0.050 | 0.034 |
| Social information collected – behavioral adjustments x no social information collected | 4.8851 | 0.027 | 0.028 |
| Social information collected – behavioral adjustments x plans to collect social information in the future | 20.0000 | 0.000 | 0.100 |
| Social information collected – number of visitors x no social information collected | 15.3091 | 0.000 | 0.000 |
| Social information collected – no social information collected x plans to collect social information in the future | 20.0000 | 0.000 | 0.100 |

Table F-2 Continued.

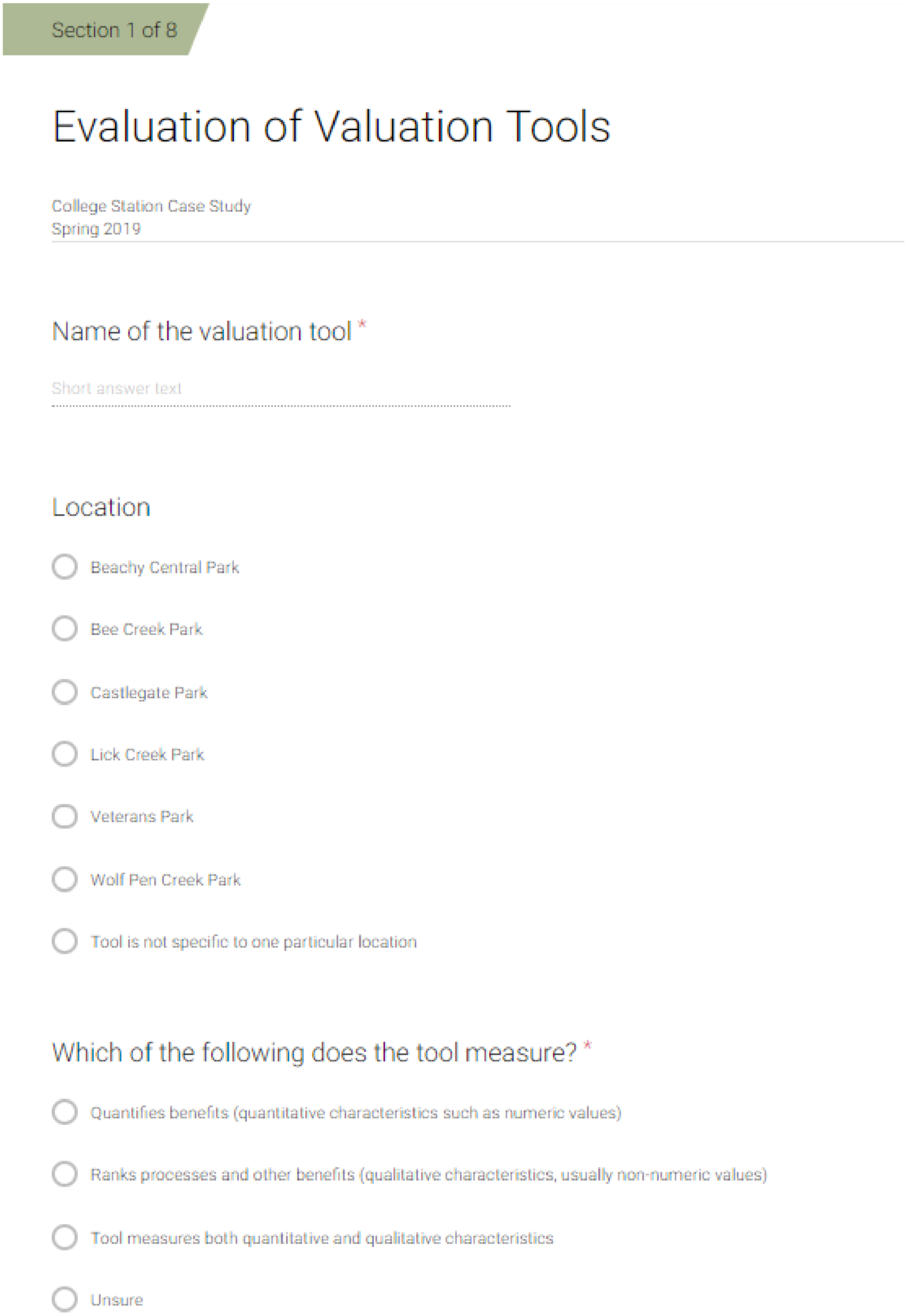
| **Variables with significant relationships** | **Chi-square value ($\chi^2$)** | ***p* value** | **Fisher's exact test** |
|---|---|---|---|
| Social impact assessment last conducted x social tool used – EAPRS | 7.0000 | 0.030 | 0.143 |
| Who conducted last social impact assessment x social tool used – EAPRS | 7.0000 | 0.030 | 0.286 |
| Social tool used – PEQ x SOPARNA | 16.0000 | 0.003 | 0.036 |
| Social tool used – PEQ x InVEST | 8.0000 | 0.018 | 0.250 |
| Social tool used – PEQ x STAR | 7.0000 | 0.030 | 0.286 |
| Social tool used –SOPARNA x InVEST | 8.0000 | 0.018 | 0.250 |
| Social tool used –SOPARNA x STAR | 7.0000 | 0.030 | 0.286 |
| Social tool used – InVEST x STAR | 7.0000 | 0.008 | 0.143 |
| Who conducted economic impact assessment x total annual budget | 14.000 | 0.007 | 0.024 |
| Who conducted economic impact assessment x economic impact assessment last conducted | 6.2857 | 0.043 | 0.061 |
| Economic impact assessment x economic impact assessment last conducted | 14.0000 | 0.001 | 0.071 |
| Economic impact assessment x economic tool used – PGSI | 12.0000 | 0.001 | 0.083 |
| Economic impact assessment x no economic information collected | 4.6999 | 0.030 | 0.031 |
| Economic impact assessment x plans to collect economic information in the future | 19.0000 | 0.000 | 0.053 |
| Economic impact assessment last conducted x economic tool used – PGSI | 12.0000 | 0.002 | 0.083 |
| Economic impact assessment (usefulness) x economic information collected – recycling | 4.2857 | 0.038 | 0.081 |
| Economic information collected – energy use x LCA | 9.5837 | 0.008 | 0.003 |
| Economic information collected – energy use x recycling | 13.9996 | 0.000 | 0.000 |
| Economic information collected – energy use x waste reduction | 22.2476 | 0.000 | 0.000 |

Table F-2 Continued.

| **Variables with significant relationships** | **Chi-square value ($\chi^2$)** | ***p* value** | **Fisher's exact test** |
|---|---|---|---|
| Economic information collected – energy use x no economic information collected | 22.0048 | 0.000 | 0.000 |
| Economic information collected – LCA x recycling | 12.2642 | 0.000 | 0.002 |
| Economic information collected – recycling x ROI | 4.300 | 0.038 | 0.071 |

# APPENDIX G

# GOOGLE FORM QUESTIONNAIRE THAT TEAM MEMBERS OF THE SCHOLARS PROGRAM WERE TO COMPLETE WHEN ASSESSING DECISION-SUPPORT TOOLS FOR A MULTIPLE-CASE STUDIES APPROACH ON SIX PARKS LOCATED IN THE CITY OF COLLEGE STATION, TX, AND MANAGED BY THE DEPARTMENT OF PARKS AND RECREATION FOR THE EVALUATION OF DECISION-SUPPORT TOOLS THAT MEASURE ENVIRONMENTAL AND SOCIOECONOMIC BENEFITS



Section 1 of 8

# Evaluation of Valuation Tools

College Station Case Study
Spring 2019

Name of the valuation tool *

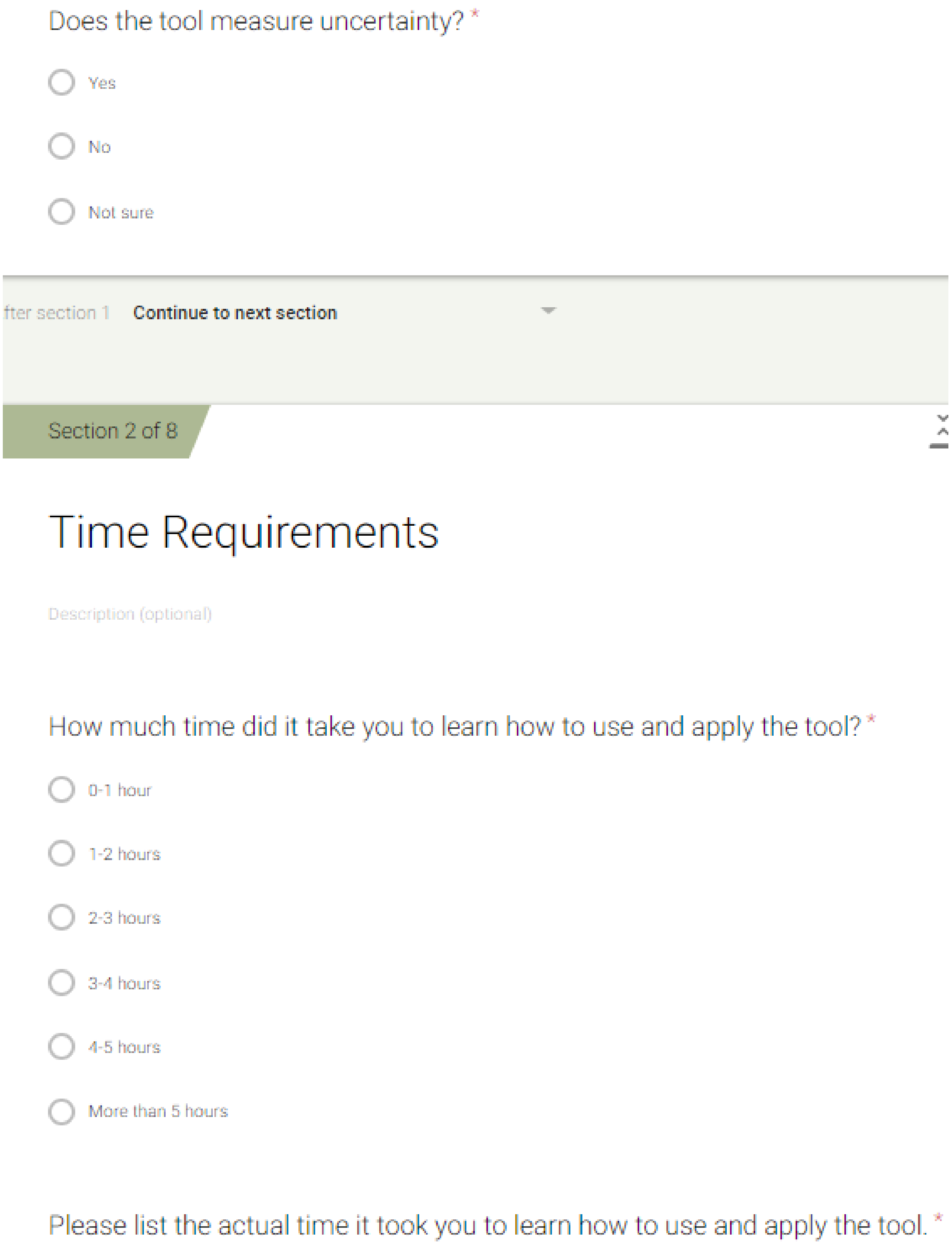
Short answer text

Location

○ Beachy Central Park
○ Bee Creek Park
○ Castlegate Park
○ Lick Creek Park
○ Veterans Park
○ Wolf Pen Creek Park
○ Tool is not specific to one particular location

Which of the following does the tool measure? *

○ Quantifies benefits (quantitative characteristics such as numeric values)
○ Ranks processes and other benefits (qualitative characteristics, usually non-numeric values)
○ Tool measures both quantitative and qualitative characteristics
○ Unsure



Does the tool measure uncertainty? *

○ Yes

○ No

○ Not sure

## Time Requirements

How much time did it take you to learn how to use and apply the tool? *

○ 0-1 hour

○ 1-2 hours

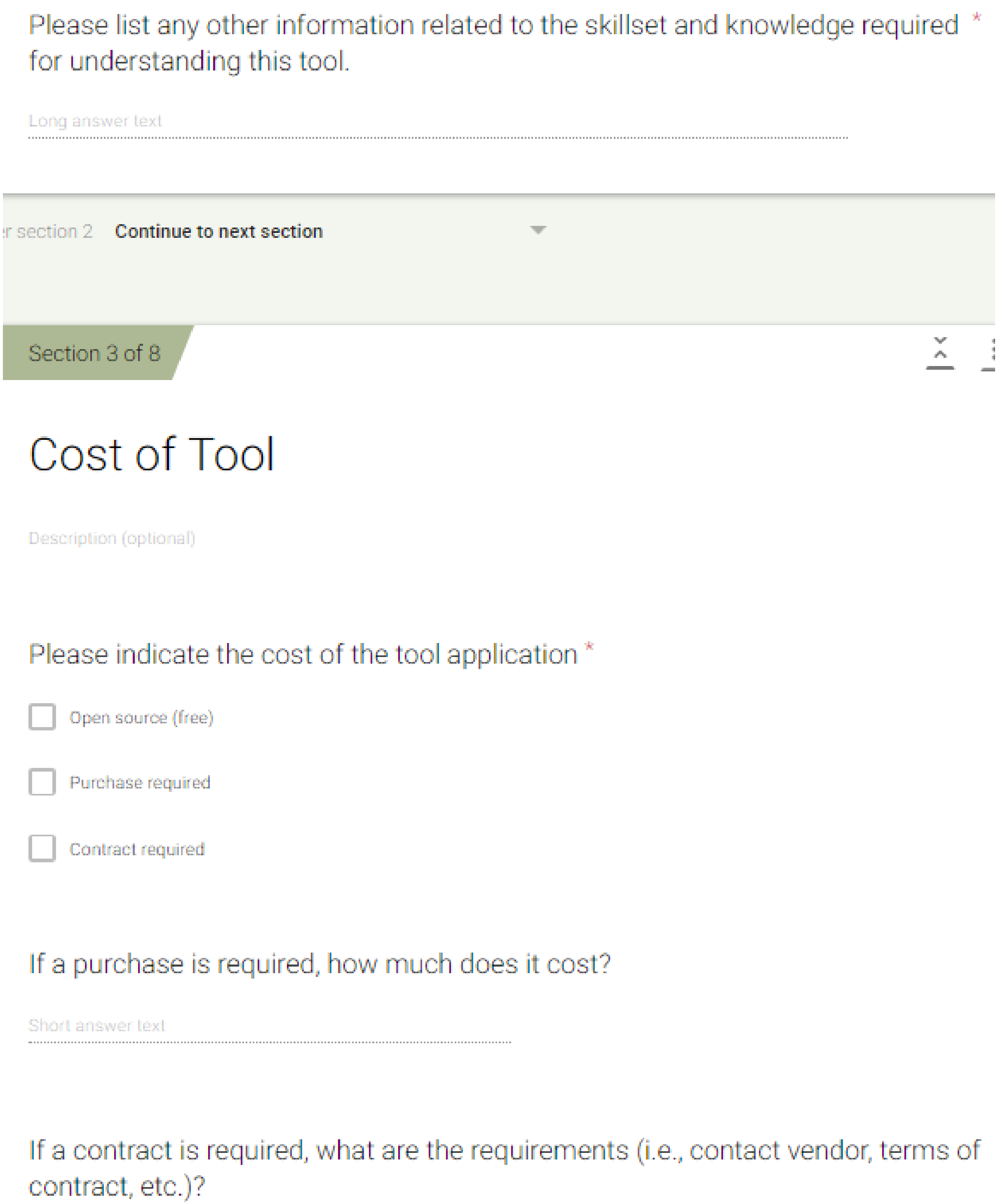
○ 2-3 hours

○ 3-4 hours

○ 4-5 hours

○ More than 5 hours

Please list the actual time it took you to learn how to use and apply the tool. *



Please list any other information related to the skillset and knowledge required * for understanding this tool.

Long answer text

r section 2 **Continue to next section**

Section 3 of 8

## Cost of Tool

Description (optional)

Please indicate the cost of the tool application *

☐ Open source (free)

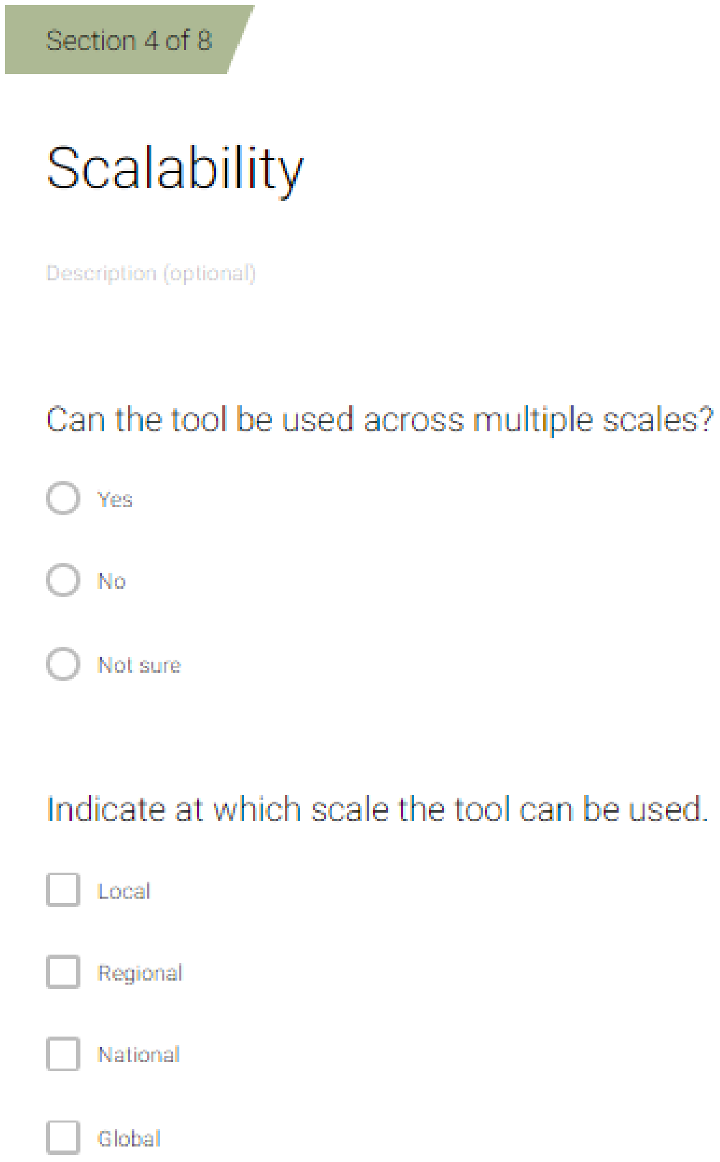
☐ Purchase required

☐ Contract required

If a purchase is required, how much does it cost?

Short answer text

If a contract is required, what are the requirements (i.e., contact vendor, terms of contract, etc.)?



Section 4 of 8

# Scalability

Description (optional)

Can the tool be used across multiple scales?

○ Yes

○ No

○ Not sure

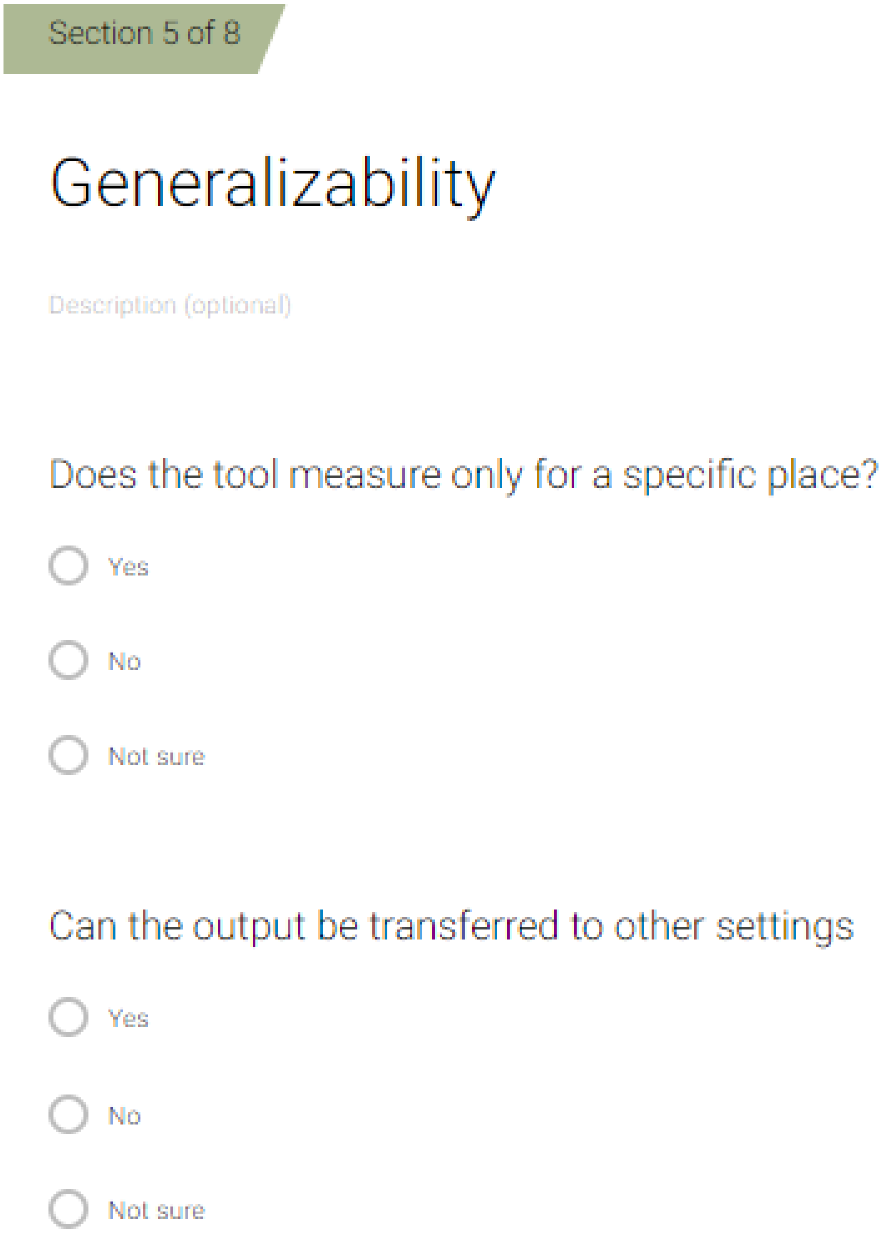
Indicate at which scale the tool can be used.

☐ Local

☐ Regional

☐ National

☐ Global



Section 5 of 8

# Generalizability

Description (optional)

Does the tool measure only for a specific place?

○ Yes

○ No

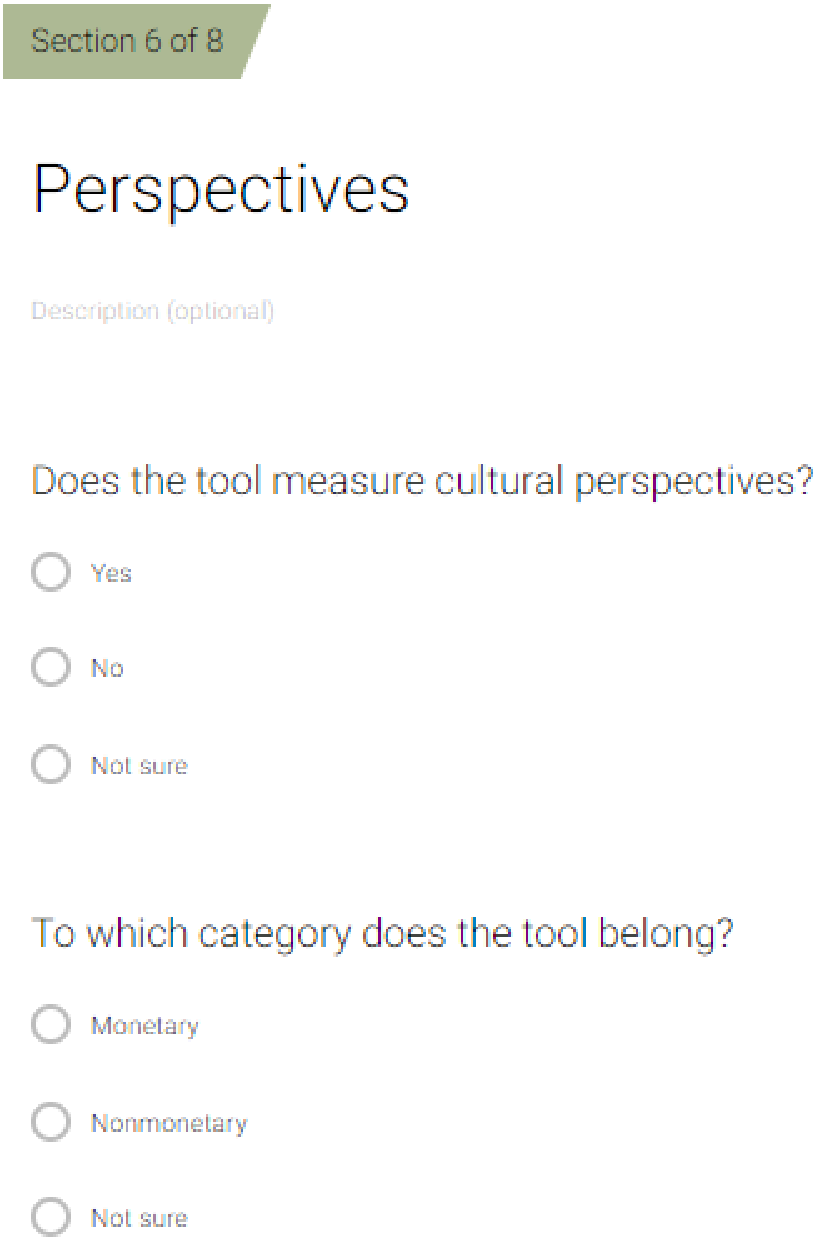
○ Not sure

Can the output be transferred to other settings

○ Yes

○ No

○ Not sure



Section 6 of 8

# Perspectives

Description (optional)

Does the tool measure cultural perspectives?

○ Yes

○ No

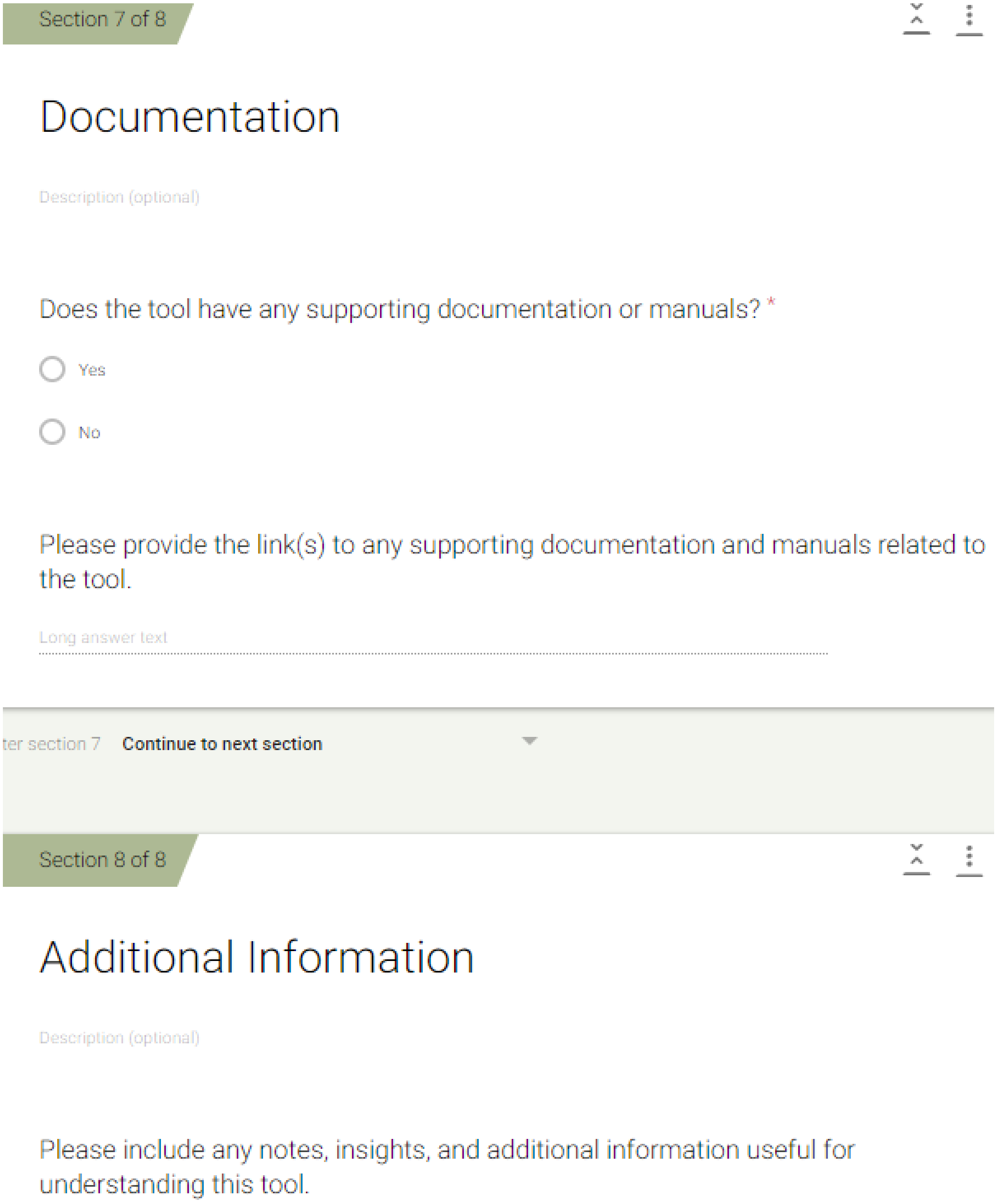
○ Not sure

To which category does the tool belong?

○ Monetary

○ Nonmonetary

○ Not sure



Section 7 of 8

Documentation

Description (optional)

Does the tool have any supporting documentation or manuals? *

○ Yes

○ No

Please provide the link(s) to any supporting documentation and manuals related to the tool.

Long answer text

ter section 7 **Continue to next section**

Section 8 of 8

Additional Information

Description (optional)

Please include any notes, insights, and additional information useful for understanding this tool.

# APPENDIX H

## MAPS OF SIX PARKS LOCATED IN THE CITY OF COLLEGE STATION, TX, AND MANAGED BY THE DEPARTMENT OF PARKS AND RECREATION THAT WERE USED AS CASE STUDIES IN A MULTIPLE-CASE STUDIES APPROACH FOR THE EVALUATION OF DECISION-SUPPORT TOOLS THAT MEASURE ENVIRONMENTAL AND SOCIOECONOMIC BENEFITS

Figure H-1. Map depicting the boundaries of Bee Creek Park located in the City of College Station, TX, and managed by the Department of Parks and Recreation that was selected for a multiple-case studies approach for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

Figure H-2. Map depicting the boundaries of Castlegate Park located in the City of College Station, TX, and managed by the Department of Parks and Recreation that was selected for a multiple-case studies approach for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

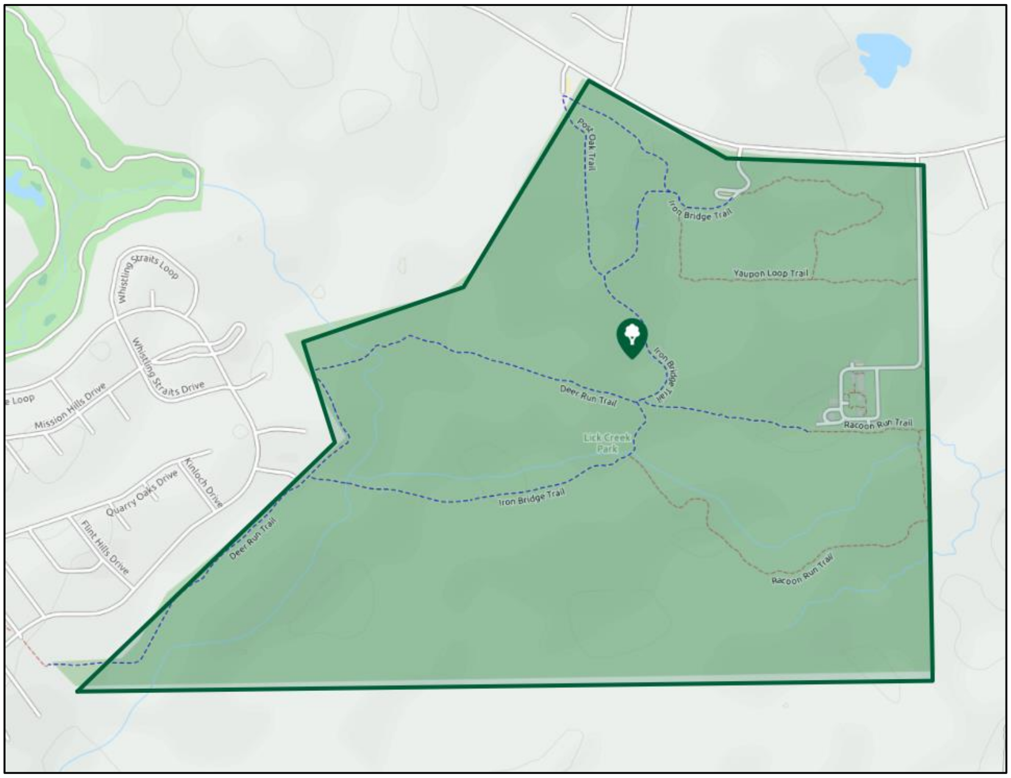


Figure H-3. Map depicting the boundaries of Lick Creek Park located in the City of College Station, TX, and managed by the Department of Parks and Recreation that was selected for a multiple-case studies approach for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

Figure H-4. Map depicting the boundaries of Central Park located in the City of College Station, TX, and managed by the Department of Parks and Recreation that was selected for a multiple-case studies approach for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

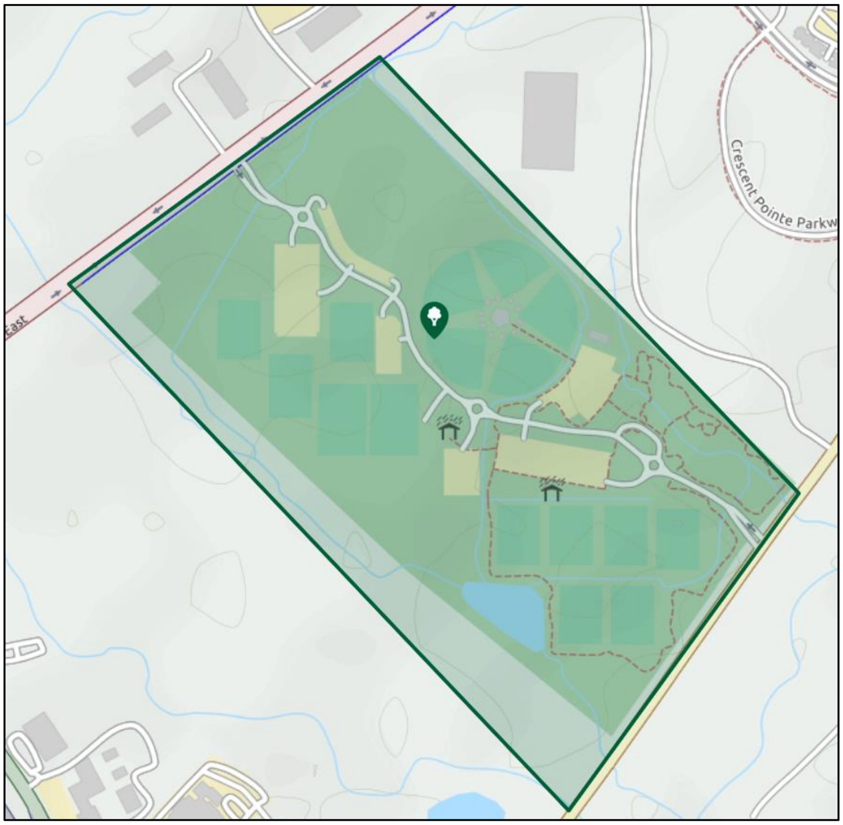


Figure H-5. Map depicting the boundaries of Veterans Park located in the City of College Station, TX, and managed by the Department of Parks and Recreation that was selected for a multiple-case studies approach for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

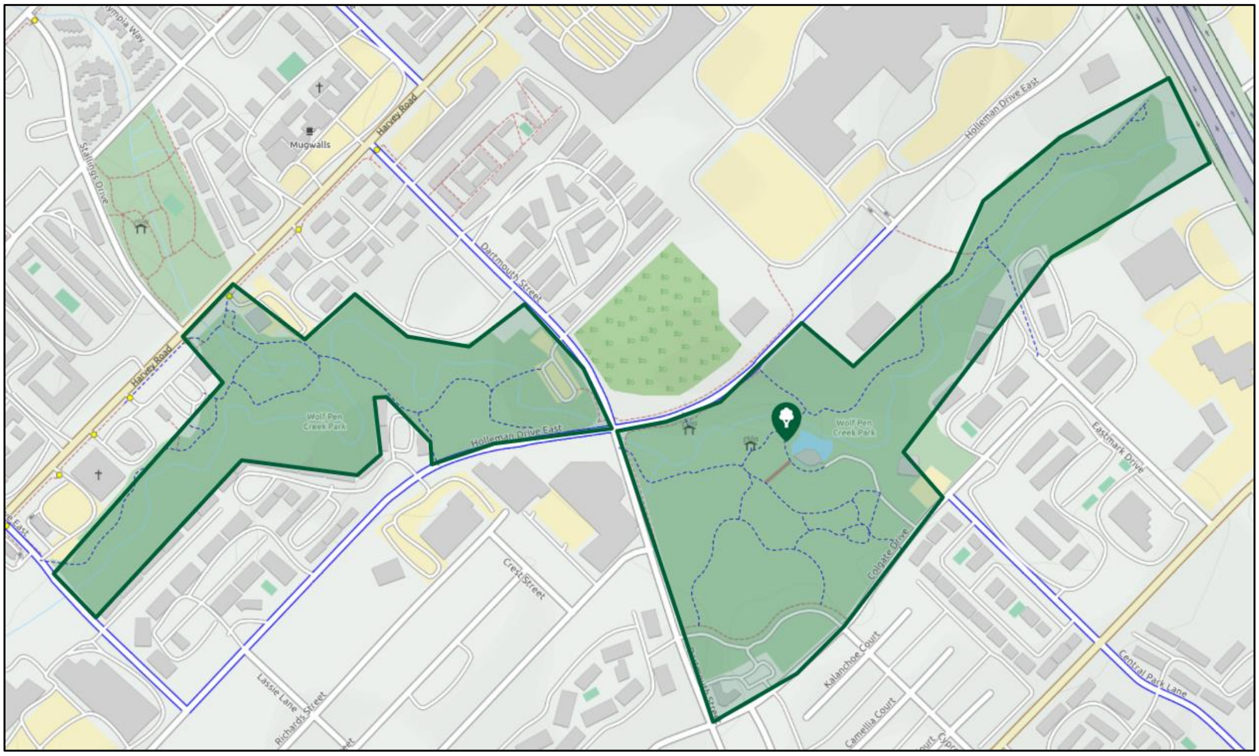


Figure H-6. Map depicting the boundaries of Wolf Pen Creek Park located in the City of College Station, TX, and managed by the Department of Parks and Recreation that was selected for a multiple-case studies approach for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

# APPENDIX I

## OUTPUT RESULTS FROM DECISION-SUPPORT TOOLS ANALYZED IN A MULTIPLE-CASE STUDIES APPROACH ON SIX PARKS LOCATED IN THE CITY OF COLLEGE STATION, TX, AND MANAGED BY THE DEPARTMENT OF PARKS AND RECREATION FOR THE EVALUATION OF DECISION-SUPPORT TOOLS THAT MEASURE ENVIRONMENTAL AND SOCIOECONOMIC BENEFITS

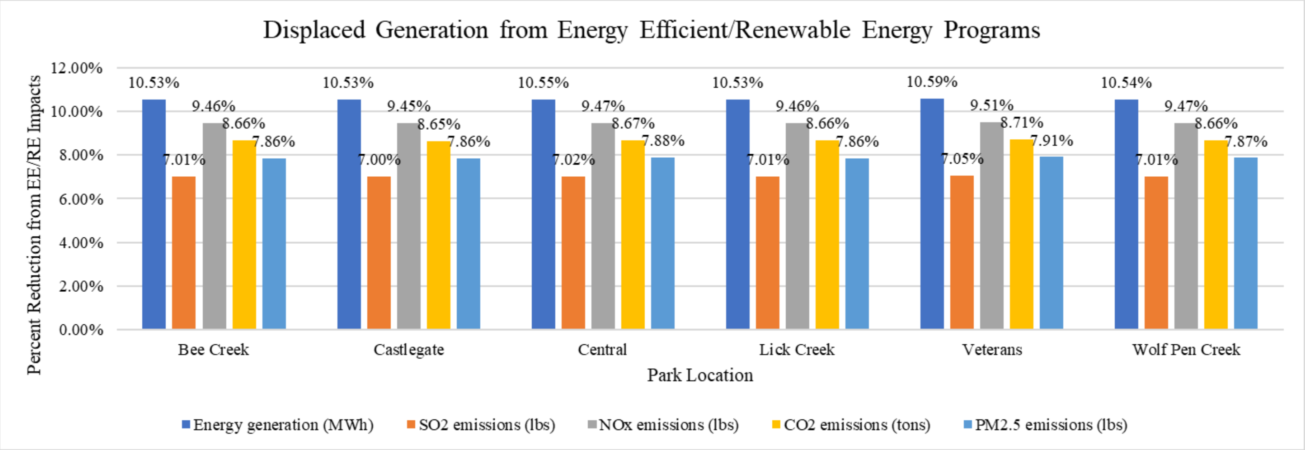


Figure I-1. Output generated by the Avoided Emissions and Generation Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

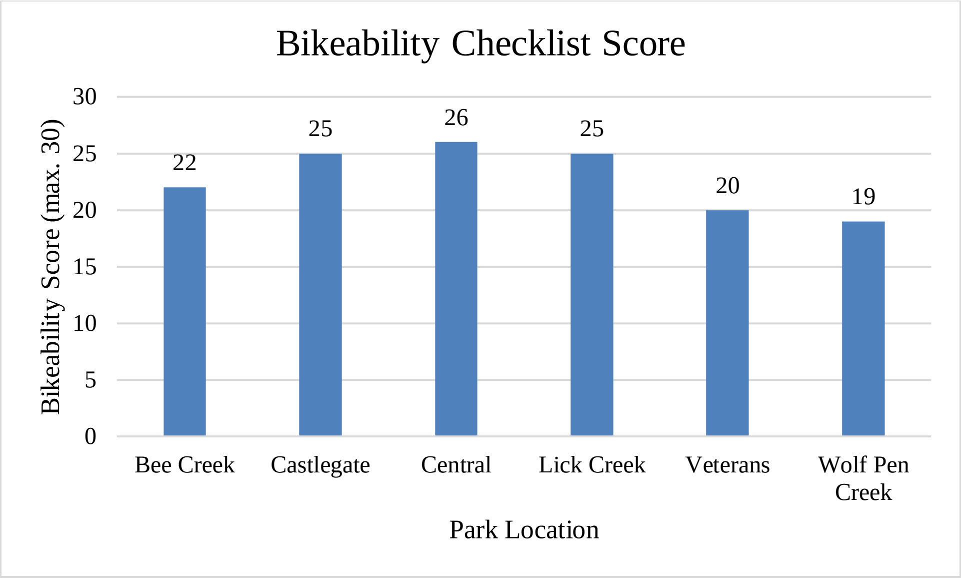


Figure I-2. Output generated by the Bikeability Checklist survey analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

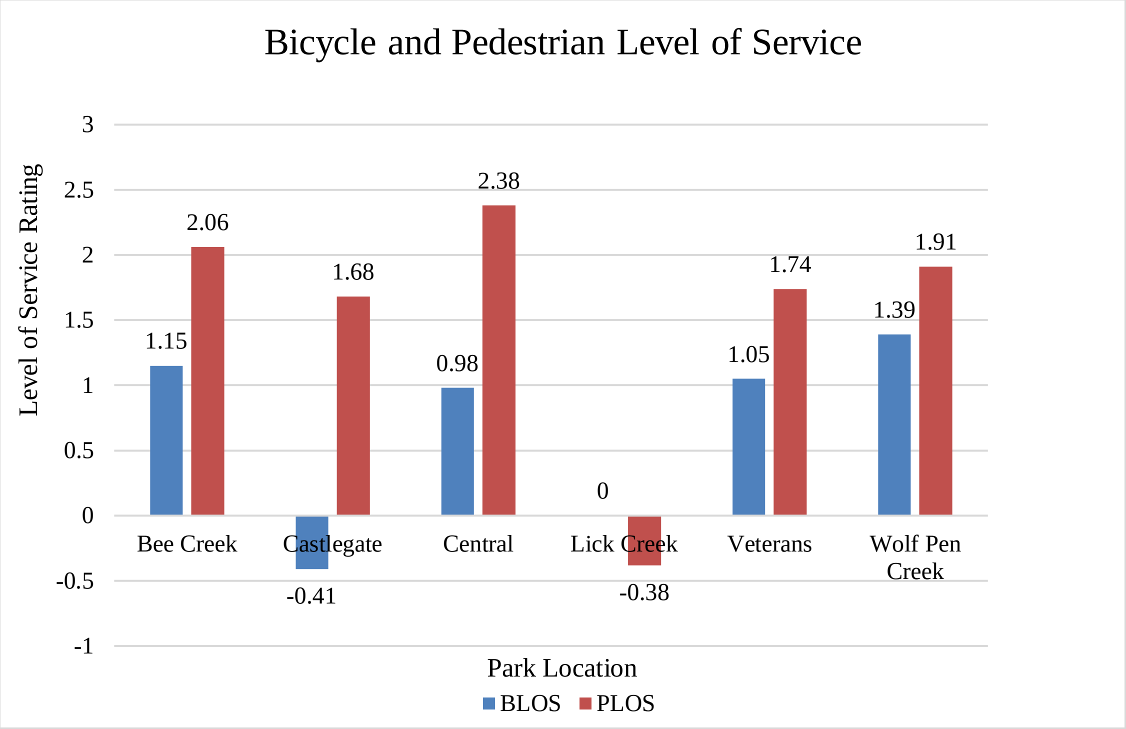


Figure I-3. Output generated by the BLOS/PLOS tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

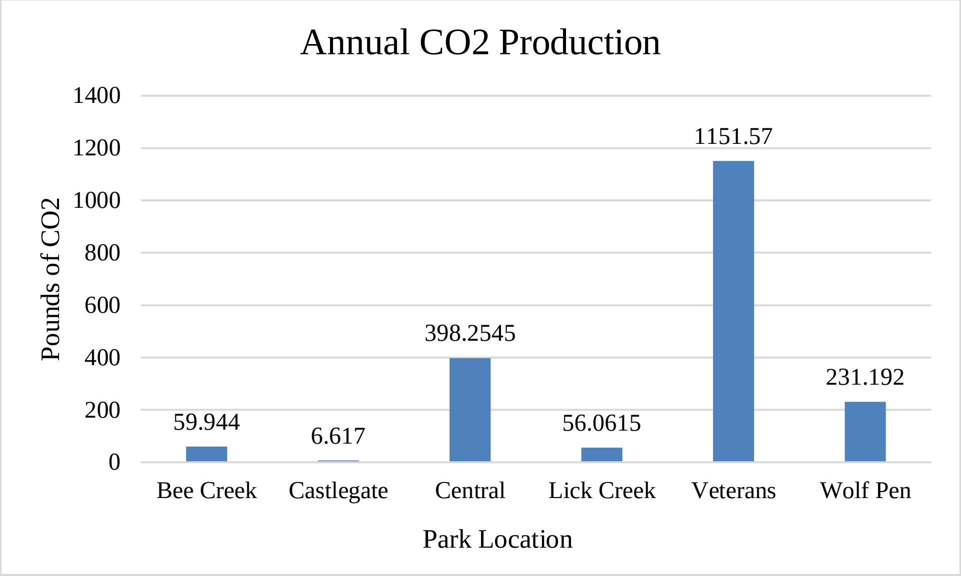


Figure I-4. Output generated by the Carbon Footprint Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

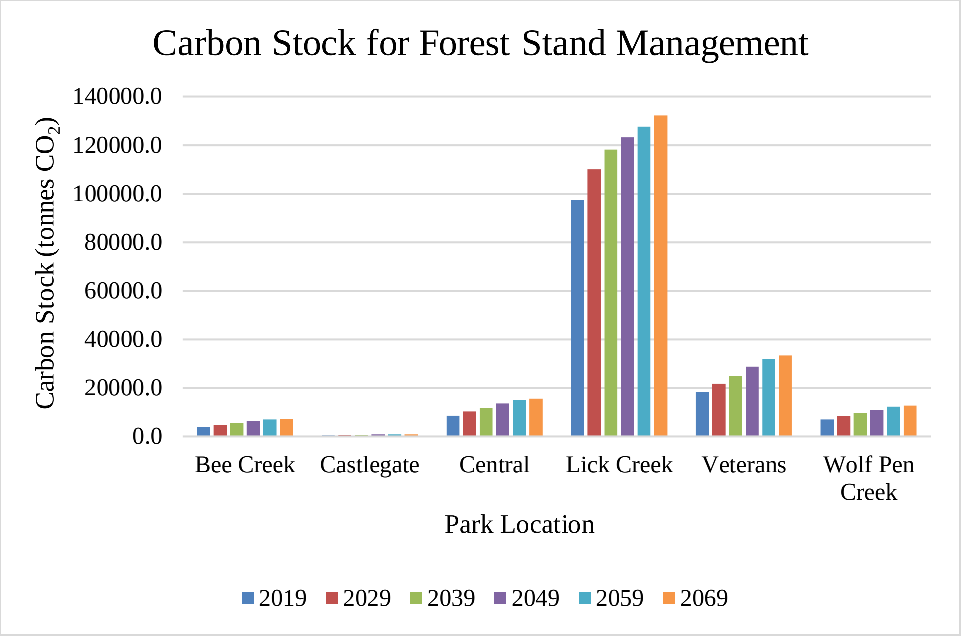


Figure 3. Output generated by the COMET-Farm tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

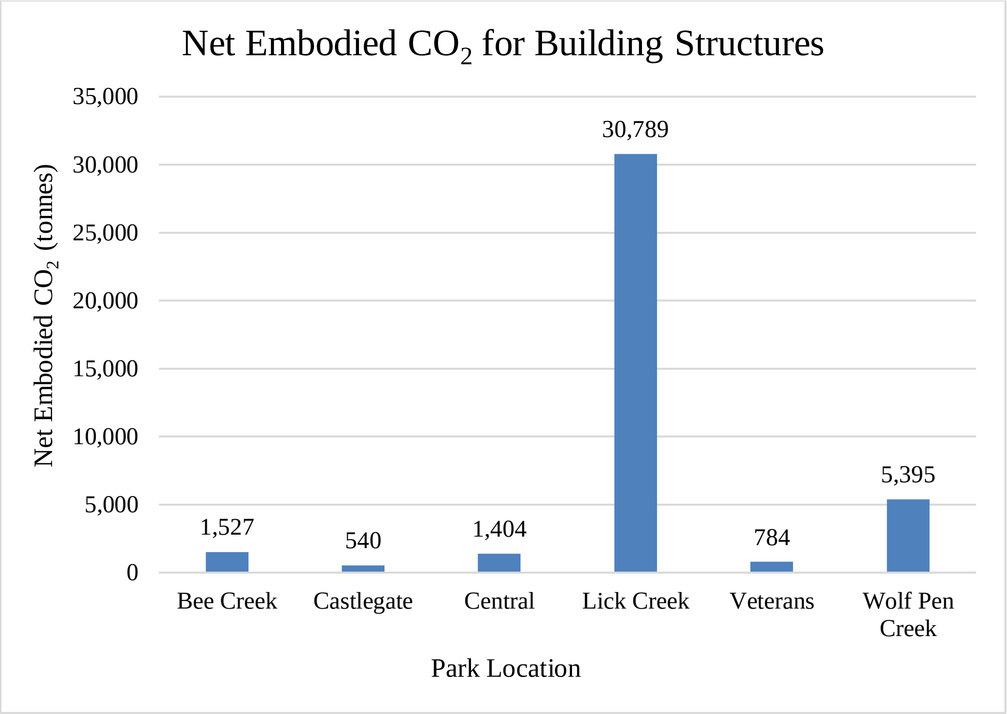


Figure I-6. Output generated by the Construction Cost Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

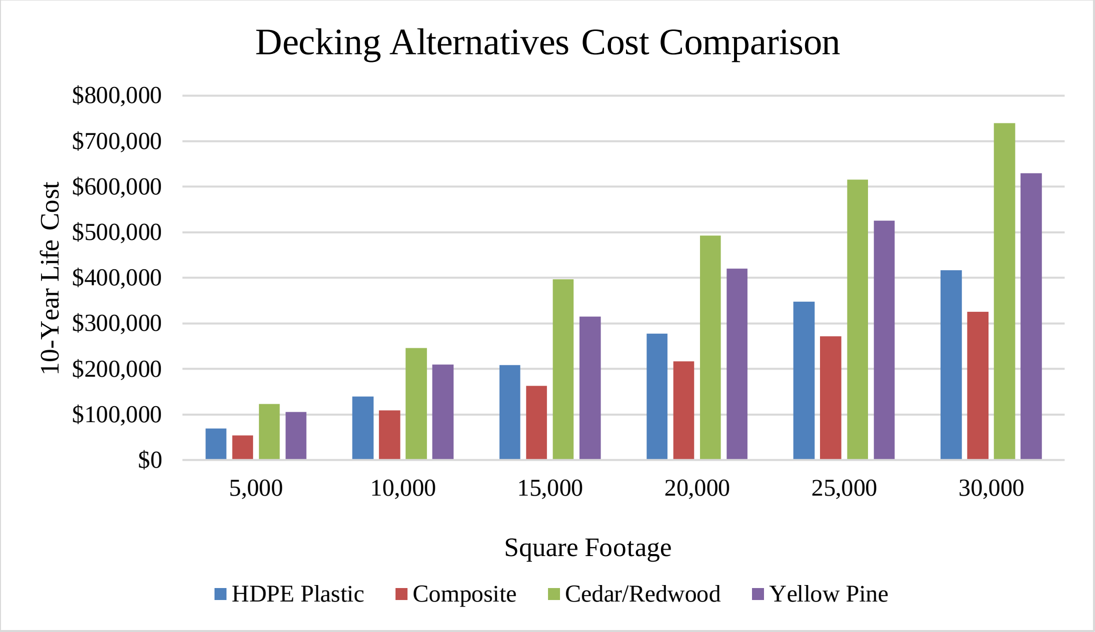
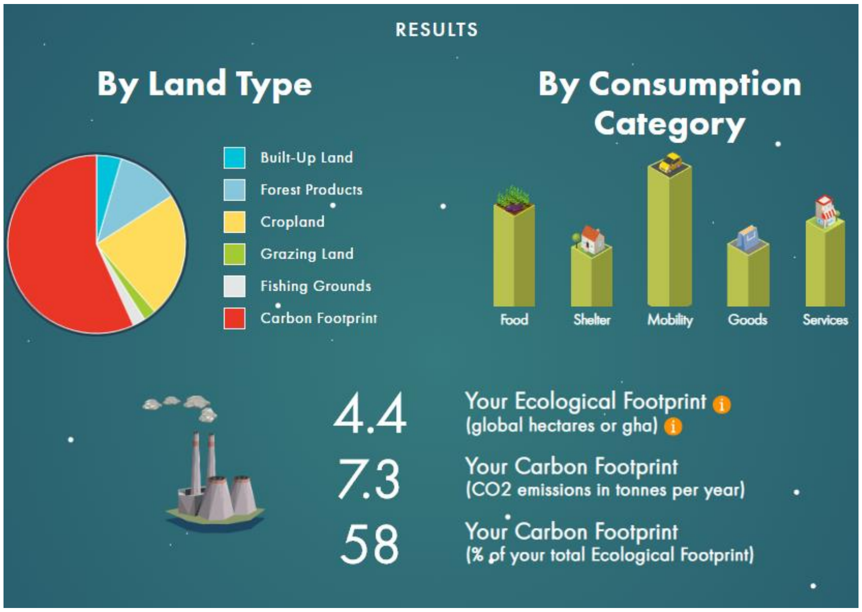


Figure 4. Output generated by the Decking Cost Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



4.4 Your Ecological Footprint (global hectares or gha)

7.3 Your Carbon Footprint (CO2 emissions in tonnes per year)

58 Your Carbon Footprint (% of your total Ecological Footprint)

Figure I-8. Output generated by the Ecological Footprint Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

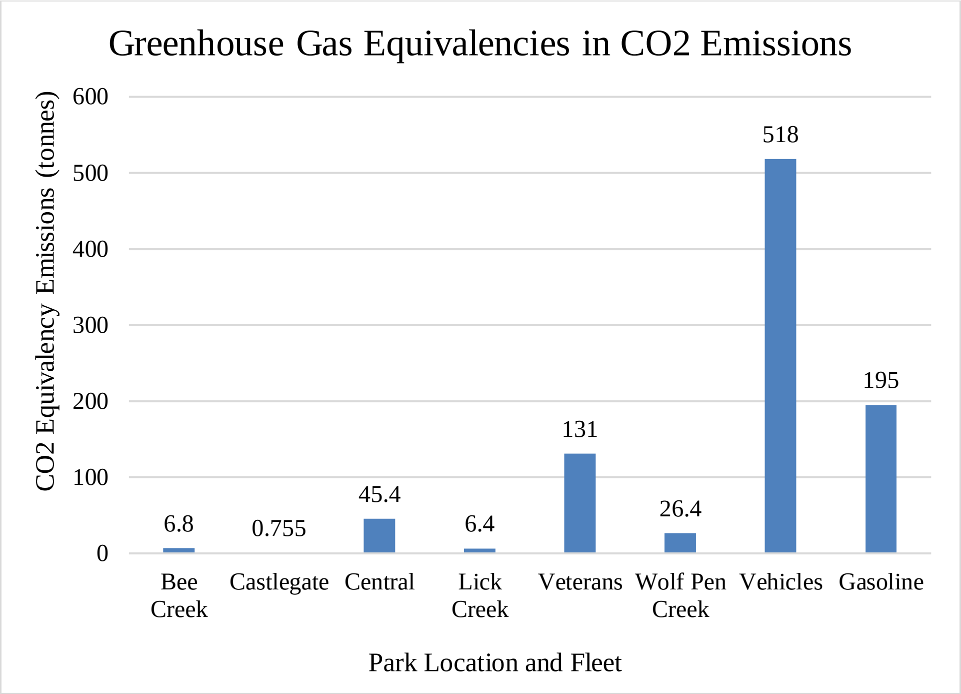


Figure I-9. Output generated by the Greenhouse Gas Equivalencies Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

9666 kilowatt-hours of electricity

**Equivalency Results**

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to: 6.8 Metric Tons

**Greenhouse gas emissions from**

1.5 Passenger vehicles driven for one year -or-
16,712 Miles driven by an average passenger vehicle

**$CO_2$ emissions from**

769 gallons of gasoline consumed -or-
671 gallons of diesel consumed -or-
7,473 Pounds of coal burned -or-
0.09 tanker trucks' worth of gasoline -or-
0.819 homes' energy use for one year -or-
1.2 homes' electricity use for one year -or-
0.037 railcars' worth of coal burned -or-
15.8 barrels of oil consumed -or-
279 propane cylinders used for home barbeques -or-
0 coal-fired power plants in one year -or-
871,588 number of smartphones charged

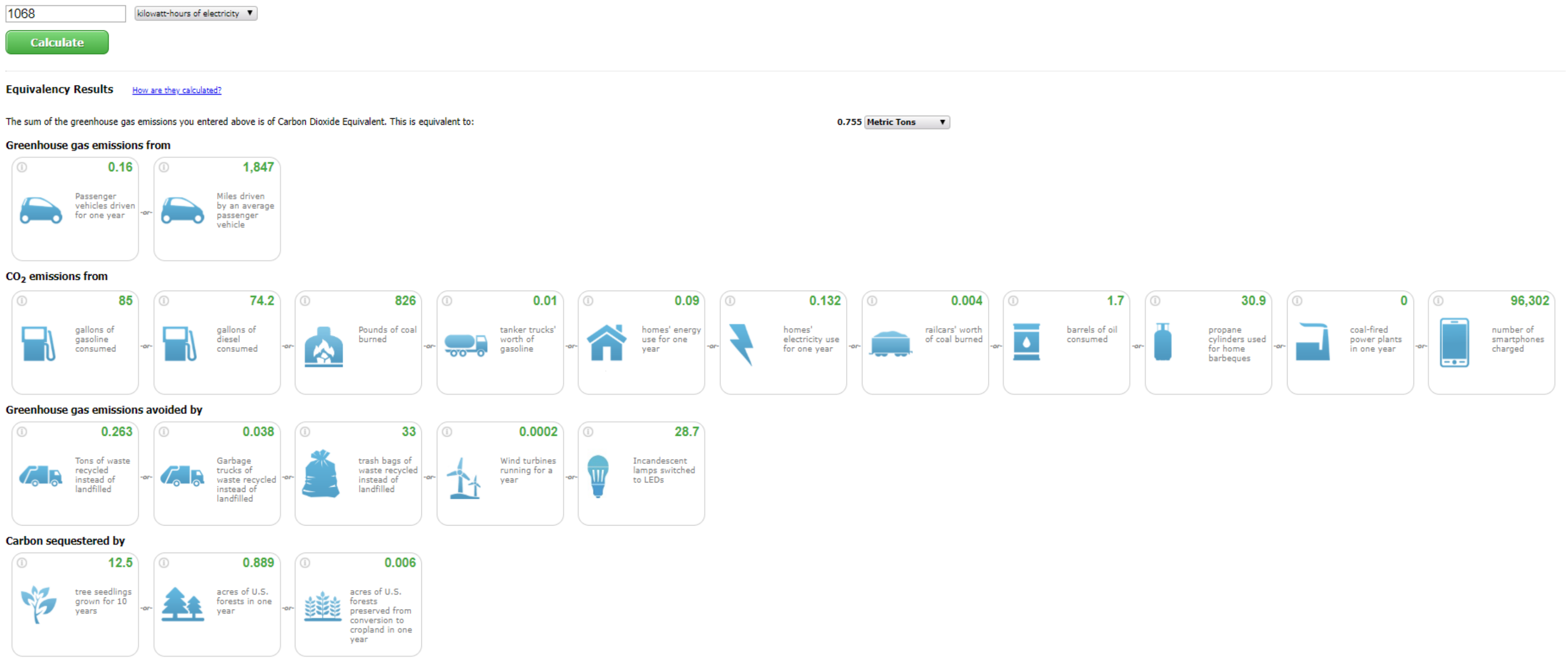
**Greenhouse gas emissions avoided by**

2.4 Tons of waste recycled instead of landfilled -or-
0.341 Garbage trucks of waste recycled instead of landfilled -or-
298 trash bags of waste recycled instead of landfilled -or-
0.001 Wind turbines running for a year -or-
260 Incandescent lamps switched to LEDs

**Carbon sequestered by**

113 tree seedlings grown for 10 years -or-
8 acres of U.S. forests in one year -or-
0.055 acres of U.S. forests preserved from conversion to cropland in one year

Figure I-10. Equivalency output for Bee Creek Park generated by the Greenhouse Gas Equivalencies Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



1068 kilowatt-hours of electricity

**Equivalency Results**

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to: 0.755 Metric Tons

**Greenhouse gas emissions from**

0.16 Passenger vehicles driven for one year
1,847 Miles driven by an average passenger vehicle

**$CO_2$ emissions from**

85 gallons of gasoline consumed
74.2 gallons of diesel consumed
826 Pounds of coal burned
0.01 tanker trucks' worth of gasoline
0.09 homes' energy use for one year
0.132 homes' electricity use for one year
0.004 railcars' worth of coal burned
1.7 barrels of oil consumed
30.9 propane cylinders used for home barbeques
0 coal-fired power plants in one year
96,302 number of smartphones charged

**Greenhouse gas emissions avoided by**

0.263 Tons of waste recycled instead of landfilled
0.038 Garbage trucks of waste recycled instead of landfilled
33 trash bags of waste recycled instead of landfilled
0.0002 Wind turbines running for a year
28.7 Incandescent lamps switched to LEDs

**Carbon sequestered by**

12.5 tree seedlings grown for 10 years
0.889 acres of U.S. forests in one year
0.006 acres of U.S. forests preserved from conversion to cropland in one year

Figure I-11. Equivalency output for Castlegate Park generated by the Greenhouse Gas Equivalencies Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

64219 kilowatt-hours of electricity

**Equivalency Results**

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to: 45.4 Metric Tons

**Greenhouse gas emissions from**

- 9.6 Passenger vehicles driven for one year
- 111,033 Miles driven by an average passenger vehicle

**$CO_2$ emissions from**

- 5,110 gallons of gasoline consumed
- 4,461 gallons of diesel consumed
- 49,646 Pounds of coal burned
- 0.601 tanker trucks' worth of gasoline
- 5.4 homes' energy use for one year
- 7.9 homes' electricity use for one year
- 0.248 railcars' worth of coal burned
- 105 barrels of oil consumed
- 1,856 propane cylinders used for home barbeques
- 0 coal-fired power plants in one year
- 5,790,657 number of smartphones charged

**Greenhouse gas emissions avoided by**

- 15.8 Tons of waste recycled instead of landfilled
- 2.3 Garbage trucks of waste recycled instead of landfilled
- 1,981 trash bags of waste recycled instead of landfilled
- 0.01 Wind turbines running for a year
- 1,725 Incandescent lamps switched to LEDs

**Carbon sequestered by**

- 751 tree seedlings grown for 10 years
- 53.4 acres of U.S. forests in one year
- 0.369 acres of U.S. forests preserved from conversion to cropland in one year

Figure I-12. Equivalency output for Central Park generated by the Greenhouse Gas Equivalencies Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

9040 kilowatt-hours of electricity

**Equivalency Results**

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to: 6.4 Metric Tons

**Greenhouse gas emissions from**

1.4 Passenger vehicles driven for one year
15,630 Miles driven by an average passenger vehicle

**$CO_2$ emissions from**

719 gallons of gasoline consumed
628 gallons of diesel consumed
6,989 Pounds of coal burned
0.085 tanker trucks' worth of gasoline
0.765 homes' energy use for one year
1.1 homes' electricity use for one year
0.035 railcars' worth of coal burned
14.8 barrels of oil consumed
261 propane cylinders used for home barbeques
0 coal-fired power plants in one year
815,141 number of smartphones charged

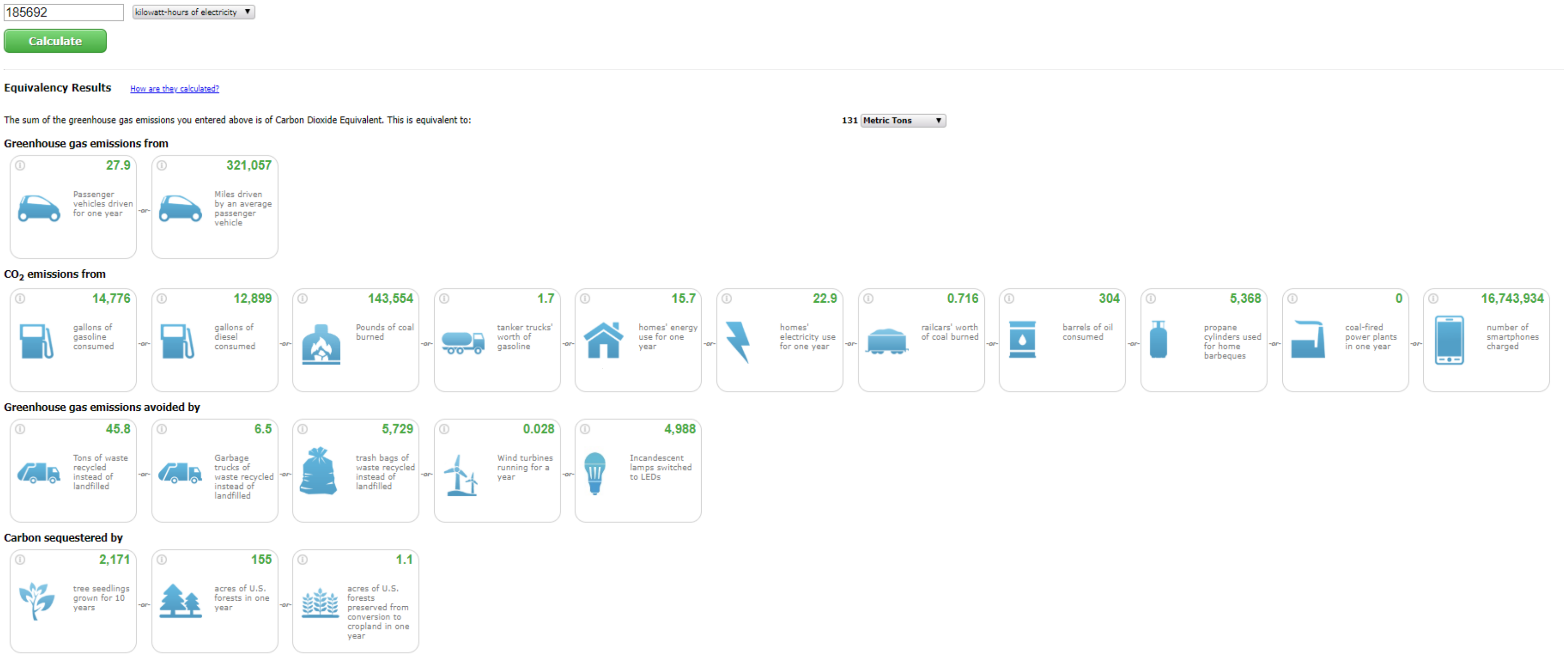
**Greenhouse gas emissions avoided by**

2.2 Tons of waste recycled instead of landfilled
0.319 Garbage trucks of waste recycled instead of landfilled
279 trash bags of waste recycled instead of landfilled
0.001 Wind turbines running for a year
243 Incandescent lamps switched to LEDs

**Carbon sequestered by**

106 tree seedlings grown for 10 years
7.5 acres of U.S. forests in one year
0.052 acres of U.S. forests preserved from conversion to cropland in one year

Figure I-13. Equivalency output for Lick Creek Park generated by the Greenhouse Gas Equivalencies Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



185692 kilowatt-hours of electricity

**Equivalency Results**

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to: 131 Metric Tons

**Greenhouse gas emissions from**

- 27.9 Passenger vehicles driven for one year
- 321,057 Miles driven by an average passenger vehicle

**$CO_2$ emissions from**

- 14,776 gallons of gasoline consumed
- 12,899 gallons of diesel consumed
- 143,554 Pounds of coal burned
- 1.7 tanker trucks' worth of gasoline
- 15.7 homes' energy use for one year
- 22.9 homes' electricity use for one year
- 0.716 railcars' worth of coal burned
- 304 barrels of oil consumed
- 5,368 propane cylinders used for home barbeques
- 0 coal-fired power plants in one year
- 16,743,934 number of smartphones charged

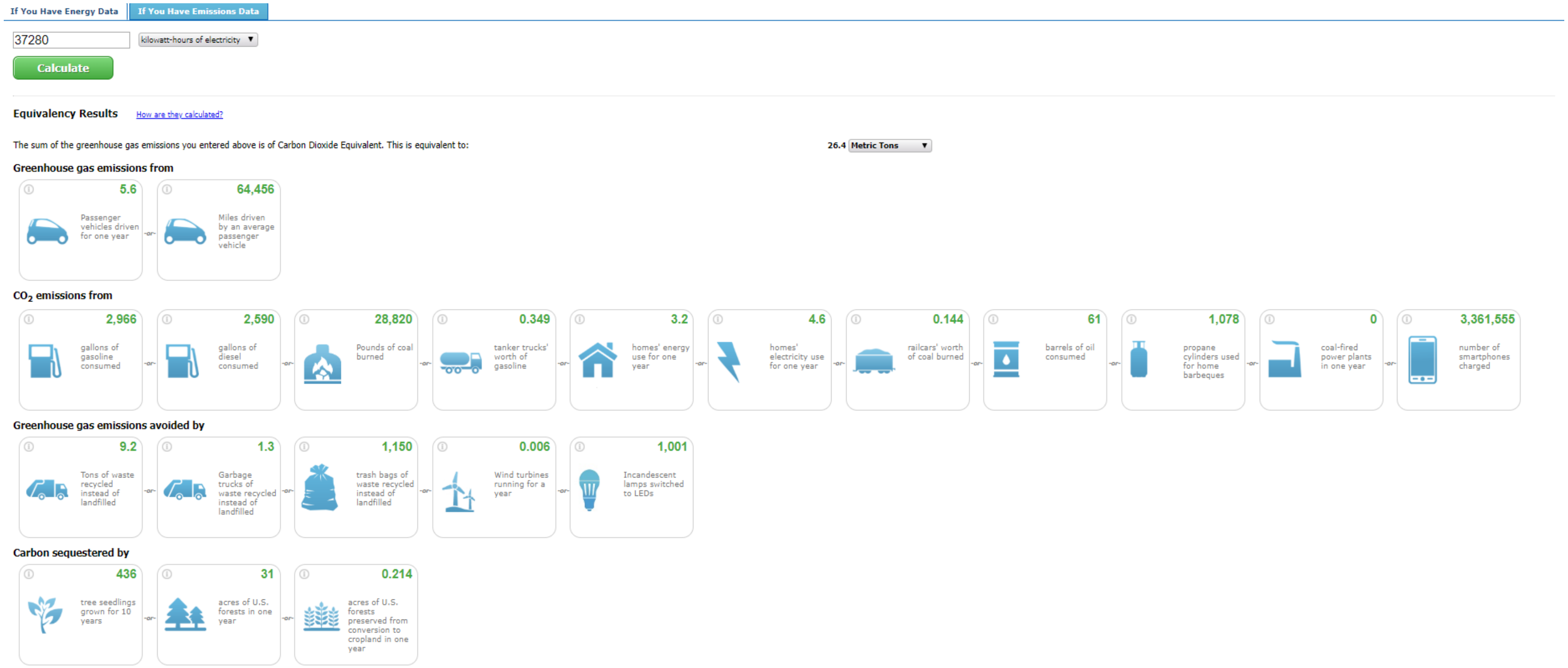
**Greenhouse gas emissions avoided by**

- 45.8 Tons of waste recycled instead of landfilled
- 6.5 Garbage trucks of waste recycled instead of landfilled
- 5,729 trash bags of waste recycled instead of landfilled
- 0.028 Wind turbines running for a year
- 4,988 Incandescent lamps switched to LEDs

**Carbon sequestered by**

- 2,171 tree seedlings grown for 10 years
- 155 acres of U.S. forests in one year
- 1.1 acres of U.S. forests preserved from conversion to cropland in one year

Figure I-14. Equivalency output for Veterans Park generated by the Greenhouse Gas Equivalencies Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



37280 kilowatt-hours of electricity

**Equivalency Results**

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to: 26.4 Metric Tons

**Greenhouse gas emissions from**

5.6 Passenger vehicles driven for one year

64,456 Miles driven by an average passenger vehicle

**$CO_2$ emissions from**

2,966 gallons of gasoline consumed

2,590 gallons of diesel consumed

28,820 Pounds of coal burned

0.349 tanker trucks' worth of gasoline

3.2 homes' energy use for one year

4.6 homes' electricity use for one year

0.144 railcars' worth of coal burned

61 barrels of oil consumed

1,078 propane cylinders used for home barbeques

0 coal-fired power plants in one year

3,361,555 number of smartphones charged

**Greenhouse gas emissions avoided by**

9.2 Tons of waste recycled instead of landfilled

1.3 Garbage trucks of waste recycled instead of landfilled

1,150 trash bags of waste recycled instead of landfilled

0.006 Wind turbines running for a year

1,001 Incandescent lamps switched to LEDs

**Carbon sequestered by**

436 tree seedlings grown for 10 years

31 acres of U.S. forests in one year

0.214 acres of U.S. forests preserved from conversion to cropland in one year

Figure I-15. Equivalency output for Wolf Pen Creek Park generated by the Greenhouse Gas Equivalencies Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

110 passenger vehicles

**Equivalency Results**

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to:

518 Metric Tons

**Greenhouse gas emissions from**

110 Passenger vehicles driven for one year

1,265,757 Miles driven by an average passenger vehicle

**$CO_2$ emissions from**

58,253 gallons of gasoline consumed

50,854 gallons of diesel consumed

565,957 Pounds of coal burned

6.9 tanker trucks' worth of gasoline

62 homes' energy use for one year

90.3 homes' electricity use for one year

2.8 railcars' worth of coal burned

1,199 barrels of oil consumed

21,163 propane cylinders used for home barbeques

0.0001 coal-fired power plants in one year

66,012,445 number of smartphones charged

**Greenhouse gas emissions avoided by**

181 Tons of waste recycled instead of landfilled

25.8 Garbage trucks of waste recycled instead of landfilled

22,588 trash bags of waste recycled instead of landfilled

0.11 Wind turbines running for a year

19,664 Incandescent lamps switched to LEDs

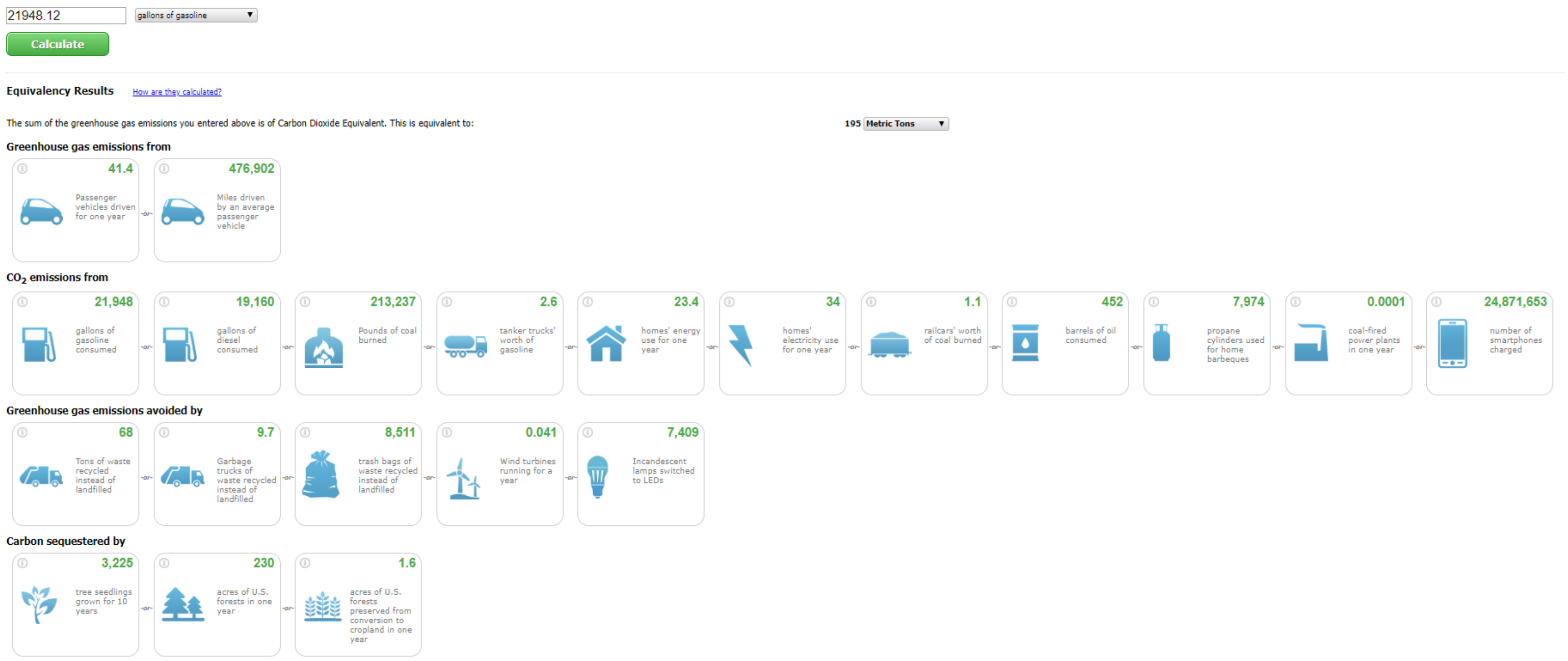
**Carbon sequestered by**

8,560 tree seedlings grown for 10 years

609 acres of U.S. forests in one year

4.2 acres of U.S. forests preserved from conversion to cropland in one year

Figure I-16. Equivalency output for the Department of Parks and Recreation vehicle fleet generated by the Greenhouse Gas Equivalencies Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



21948.12 gallons of gasoline

**Equivalency Results**

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to: 195 Metric Tons

**Greenhouse gas emissions from**

41.4 Passenger vehicles driven for one year

476,902 Miles driven by an average passenger vehicle

**$CO_2$ emissions from**

21,948 gallons of gasoline consumed

19,160 gallons of diesel consumed

213,237 Pounds of coal burned

2.6 tanker trucks' worth of gasoline

23.4 homes' energy use for one year

34 homes' electricity use for one year

1.1 railcars' worth of coal burned

452 barrels of oil consumed

7,974 propane cylinders used for home barbeques

0.0001 coal-fired power plants in one year

24,871,653 number of smartphones charged

**Greenhouse gas emissions avoided by**

68 Tons of waste recycled instead of landfilled

9.7 Garbage trucks of waste recycled instead of landfilled

8,511 trash bags of waste recycled instead of landfilled

0.041 Wind turbines running for a year

7,409 Incandescent lamps switched to LEDs

**Carbon sequestered by**

3,225 tree seedlings grown for 10 years

230 acres of U.S. forests in one year

1.6 acres of U.S. forests preserved from conversion to cropland in one year

Figure I-17. Equivalency output for the Department of Parks and Recreation fuel consumption generated by the Greenhouse Gas Equivalencies Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

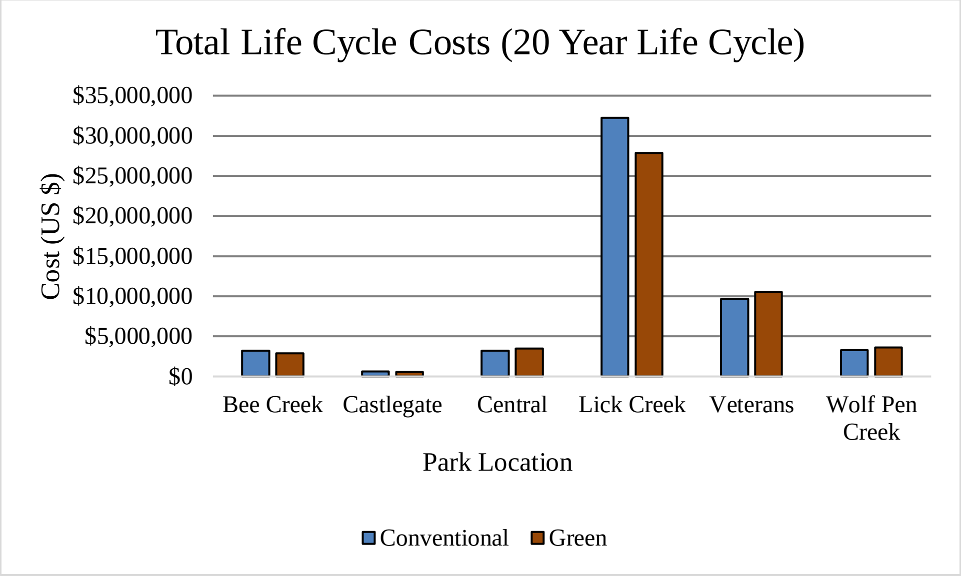


Figure I-18. Life cycle costs output generated by the Green Values Stormwater Management Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

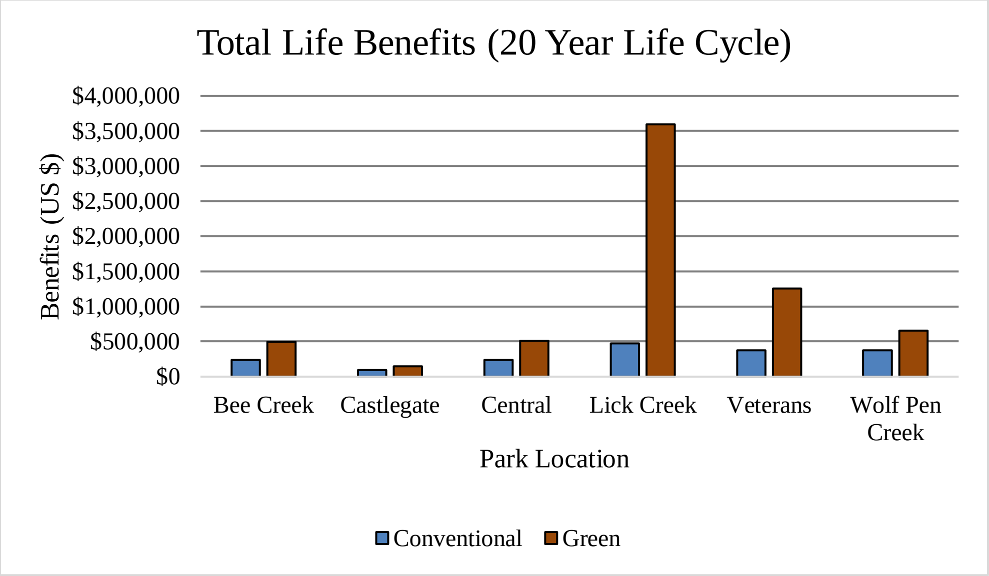


Figure I-19. Life benefits output generated by the Green Values Stormwater Management Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

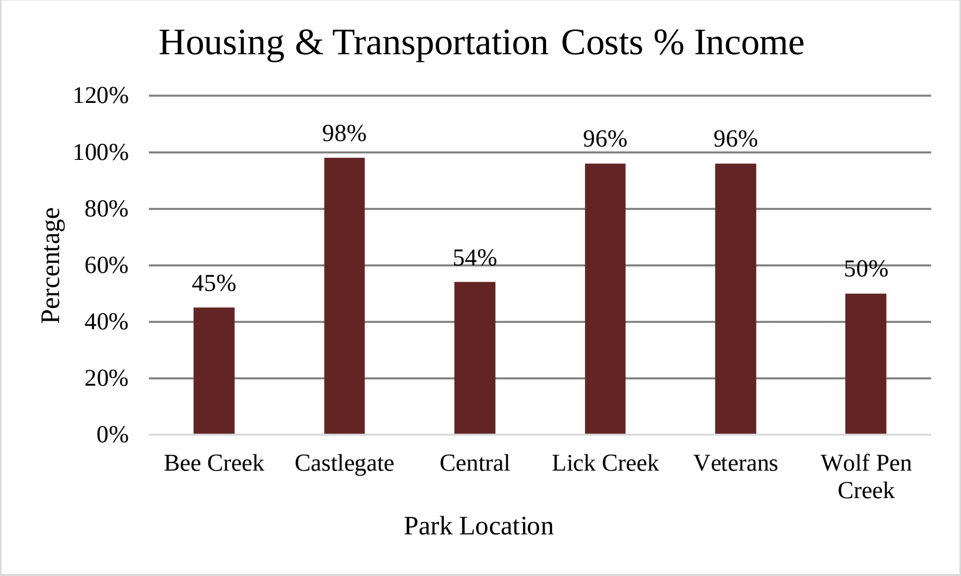


Figure I-20. Output for housing and transportation costs as a percentage of household income generated by the Housing and Transportation Affordability Index analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

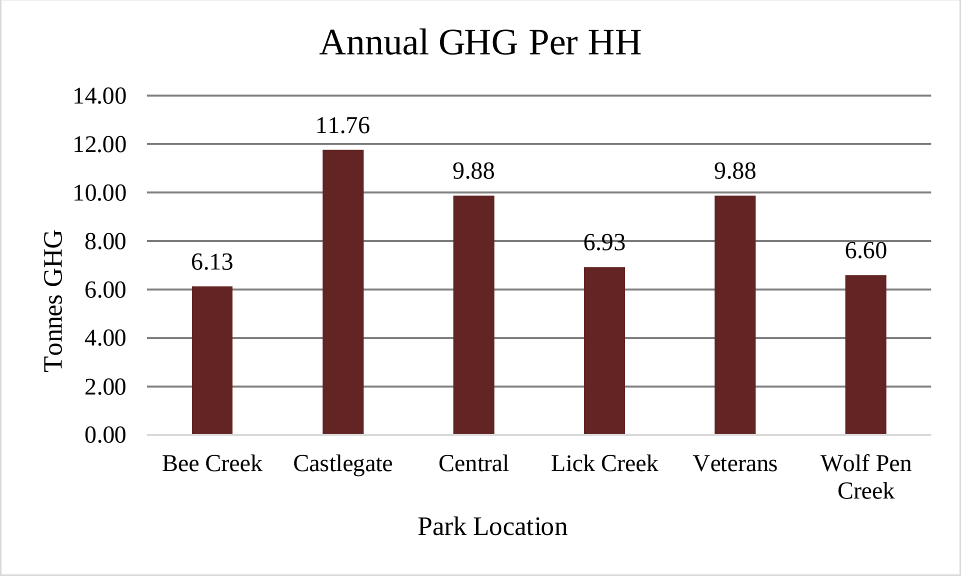


Figure I-21. Output for annual generation of greenhouse gas emissions per household generated by the Housing and Transportation Affordability Index analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

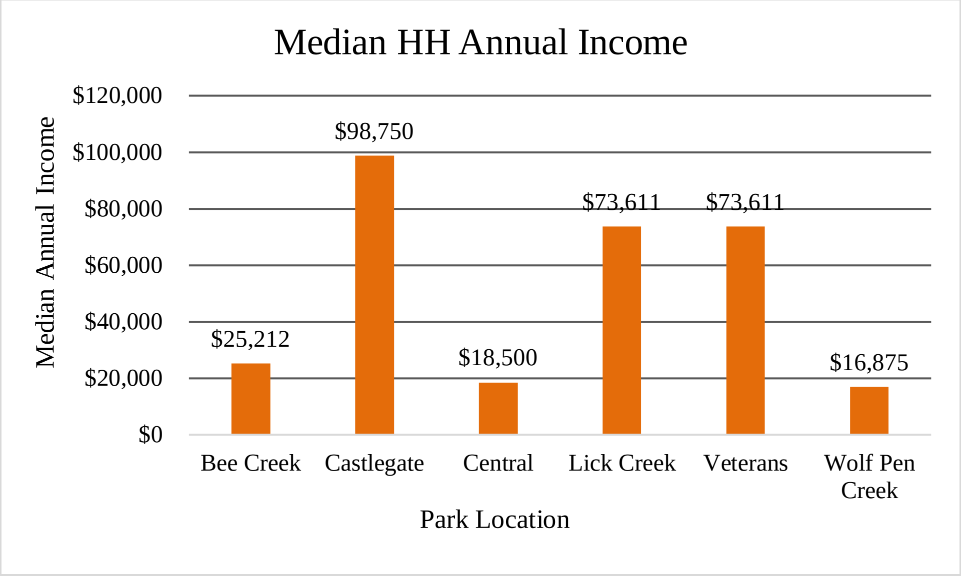


Figure I-22. Output for median household annual income generated by the Housing and Transportation Affordability Index analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

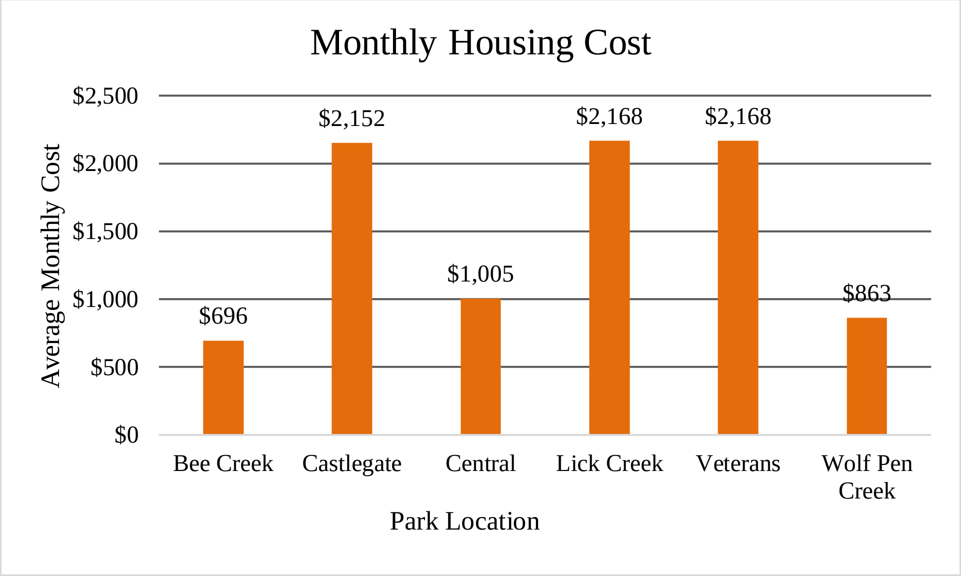


Figure I-23. Output for average monthly housing cost per household generated by the Housing and Transportation Affordability Index analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

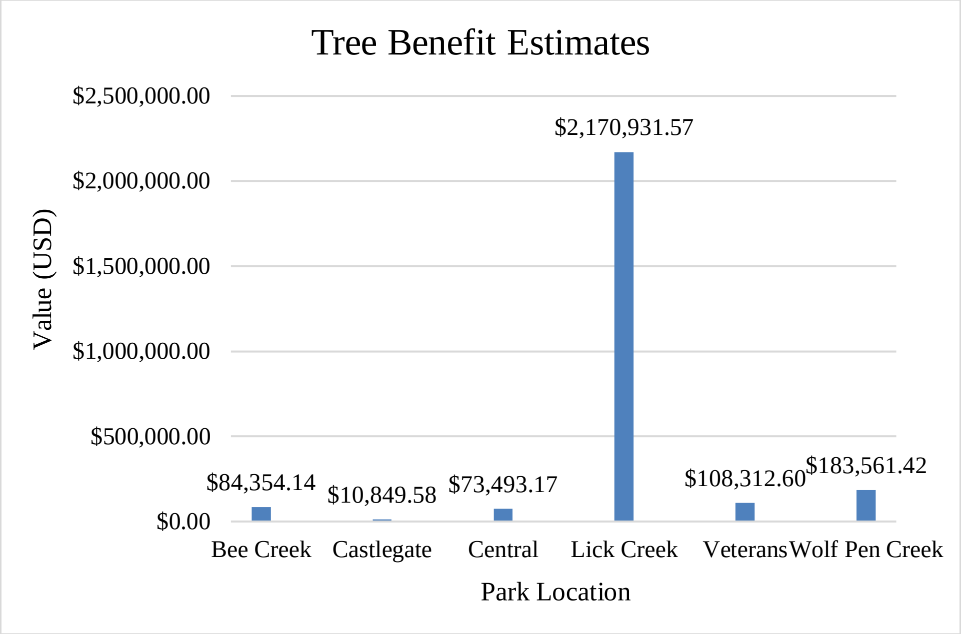
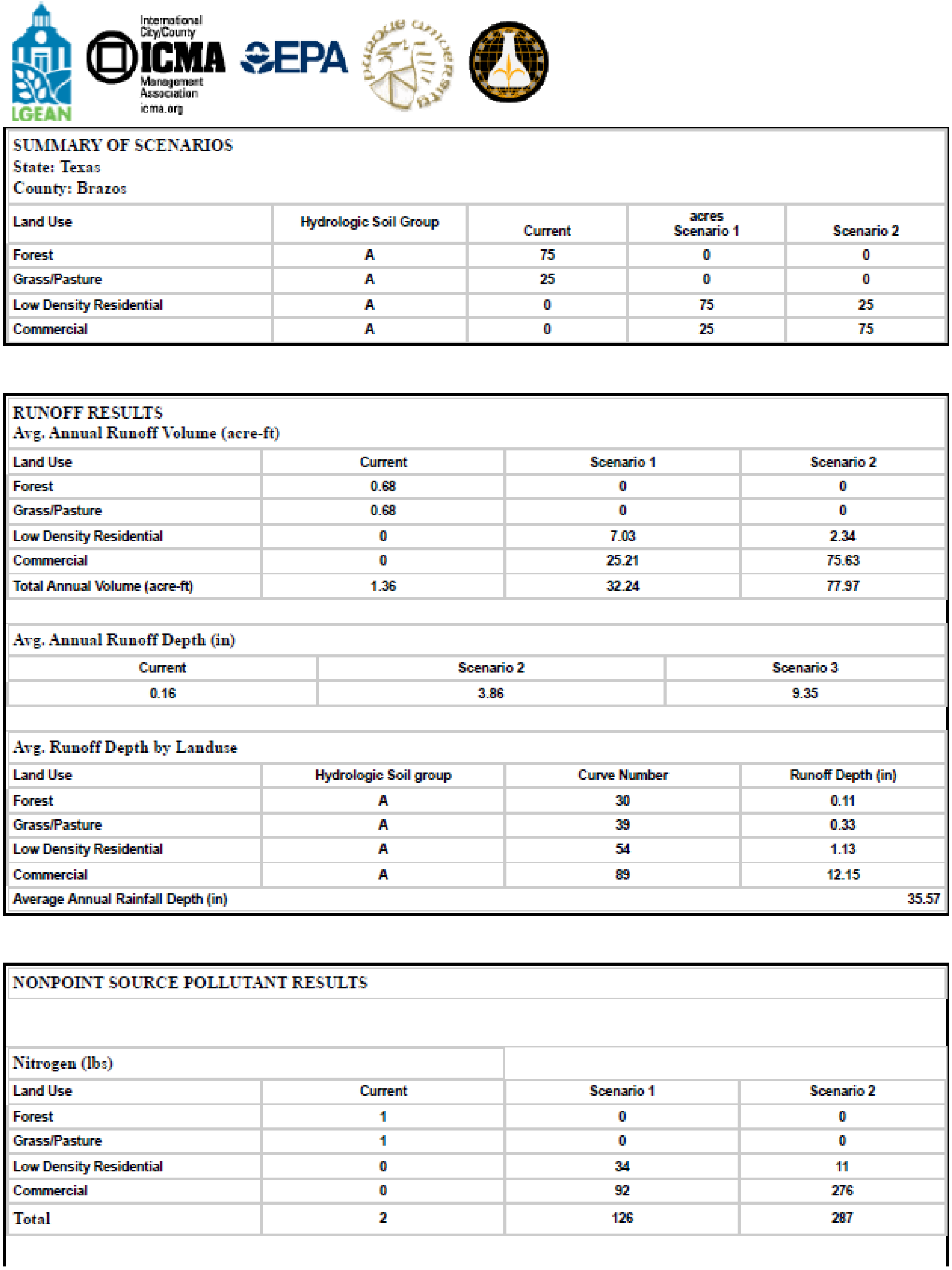


Figure I-24. Output generated by i-Tree Canopy analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



SUMMARY OF SCENARIOS
State: Texas
County: Brazos

| Land Use | Hydrologic Soil Group | Current | acres<br>Scenario 1 | Scenario 2 |
|---|---|---|---|---|
| Forest | A | 75 | 0 | 0 |
| Grass/Pasture | A | 25 | 0 | 0 |
| Low Density Residential | A | 0 | 75 | 25 |
| Commercial | A | 0 | 25 | 75 |

RUNOFF RESULTS
Avg. Annual Runoff Volume (acre-ft)

| Land Use | Current | Scenario 1 | Scenario 2 |
|---|---|---|---|
| Forest | 0.68 | 0 | 0 |
| Grass/Pasture | 0.68 | 0 | 0 |
| Low Density Residential | 0 | 7.03 | 2.34 |
| Commercial | 0 | 25.21 | 75.63 |
| Total Annual Volume (acre-ft) | 1.36 | 32.24 | 77.97 |

Avg. Annual Runoff Depth (in)

| Current | Scenario 2 | Scenario 3 |
|---|---|---|
| 0.16 | 3.86 | 9.35 |

Avg. Runoff Depth by Landuse

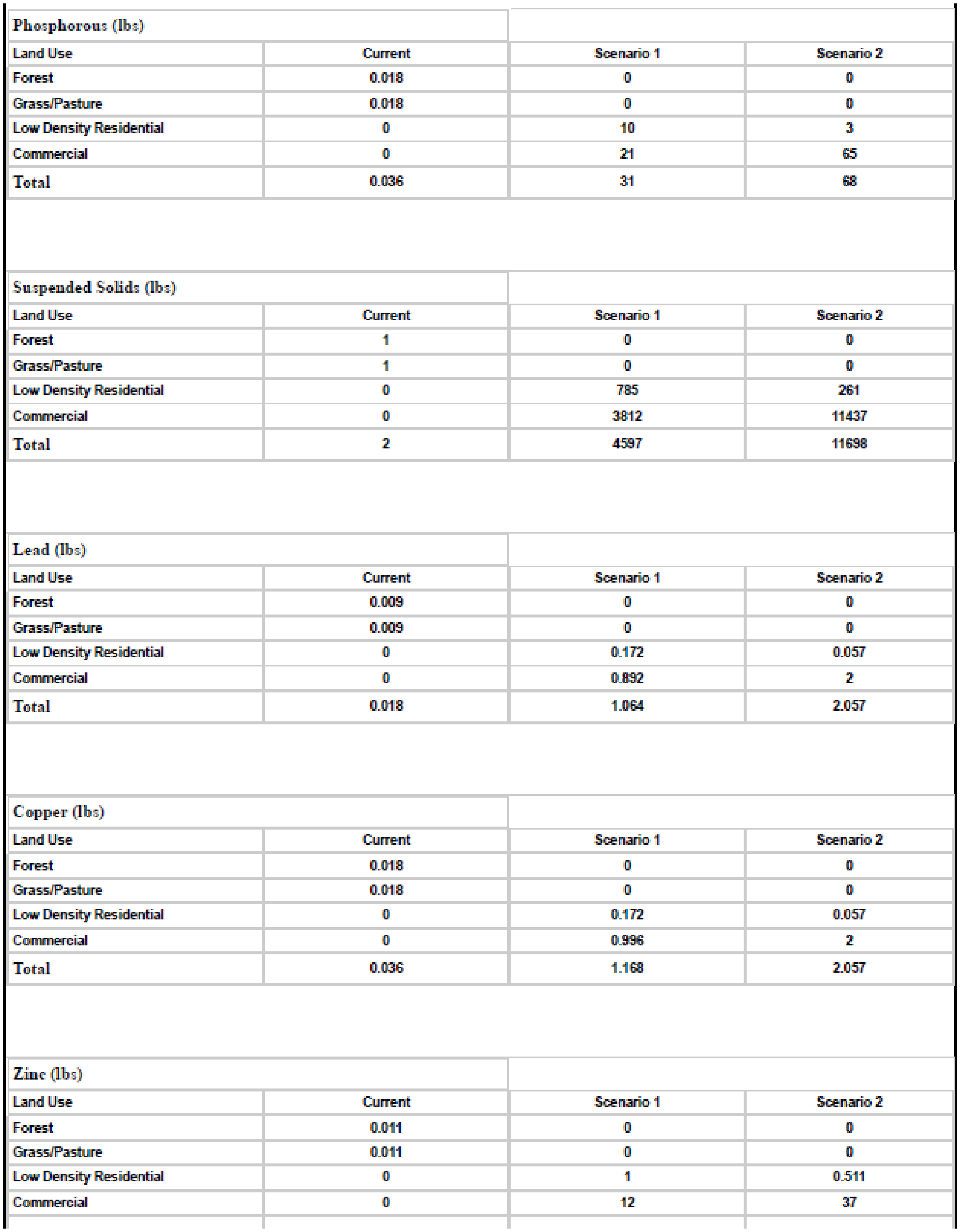
| Land Use | Hydrologic Soil group | Curve Number | Runoff Depth (in) |
|---|---|---|---|
| Forest | A | 30 | 0.11 |
| Grass/Pasture | A | 39 | 0.33 |
| Low Density Residential | A | 54 | 1.13 |
| Commercial | A | 89 | 12.15 |
| Average Annual Rainfall Depth (in) | | | 35.57 |

NONPOINT SOURCE POLLUTANT RESULTS

Nitrogen (lbs)

| Land Use | Current | Scenario 1 | Scenario 2 |
|---|---|---|---|
| Forest | 1 | 0 | 0 |
| Grass/Pasture | 1 | 0 | 0 |
| Low Density Residential | 0 | 34 | 11 |
| Commercial | 0 | 92 | 276 |
| Total | 2 | 126 | 287 |

Figure I-25. Output generated by the Landuse Evolution and Impact Assessment Model analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



| Phosphorous (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0.018 | 0 | 0 |
| Grass/Pasture | 0.018 | 0 | 0 |
| Low Density Residential | 0 | 10 | 3 |
| Commercial | 0 | 21 | 65 |
| Total | 0.036 | 31 | 68 |

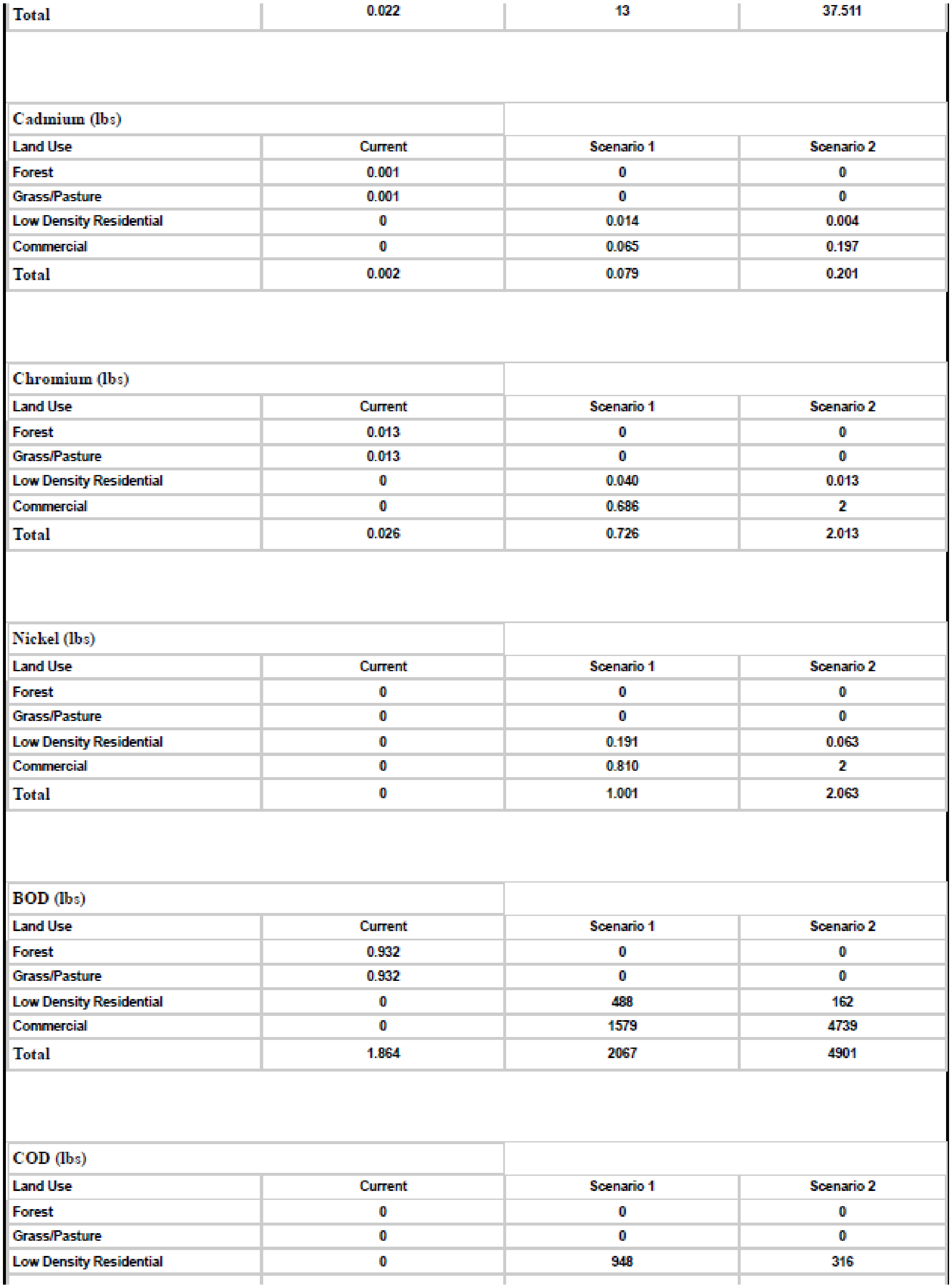
| Suspended Solids (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 1 | 0 | 0 |
| Grass/Pasture | 1 | 0 | 0 |
| Low Density Residential | 0 | 785 | 261 |
| Commercial | 0 | 3812 | 11437 |
| Total | 2 | 4597 | 11698 |

| Lead (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0.009 | 0 | 0 |
| Grass/Pasture | 0.009 | 0 | 0 |
| Low Density Residential | 0 | 0.172 | 0.057 |
| Commercial | 0 | 0.892 | 2 |
| Total | 0.018 | 1.064 | 2.057 |

| Copper (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0.018 | 0 | 0 |
| Grass/Pasture | 0.018 | 0 | 0 |
| Low Density Residential | 0 | 0.172 | 0.057 |
| Commercial | 0 | 0.996 | 2 |
| Total | 0.036 | 1.168 | 2.057 |

| Zinc (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0.011 | 0 | 0 |
| Grass/Pasture | 0.011 | 0 | 0 |
| Low Density Residential | 0 | 1 | 0.511 |
| Commercial | 0 | 12 | 37 |

Figure I-25 Continued.



| | | | |
|---|---|---|---|
| Total | 0.022 | 13 | 37.511 |

| Cadmium (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0.001 | 0 | 0 |
| Grass/Pasture | 0.001 | 0 | 0 |
| Low Density Residential | 0 | 0.014 | 0.004 |
| Commercial | 0 | 0.065 | 0.197 |
| Total | 0.002 | 0.079 | 0.201 |

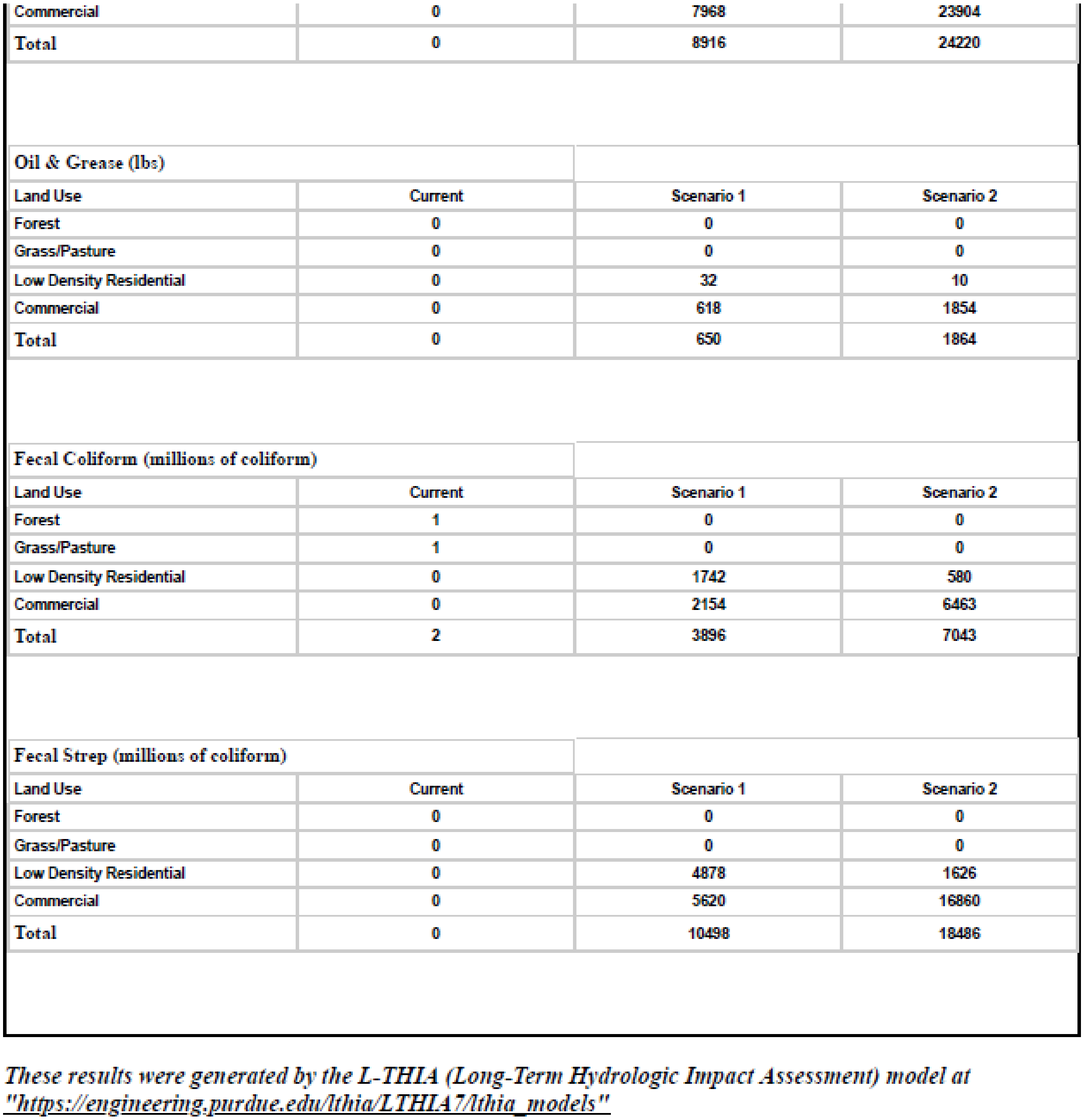
| Chromium (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0.013 | 0 | 0 |
| Grass/Pasture | 0.013 | 0 | 0 |
| Low Density Residential | 0 | 0.040 | 0.013 |
| Commercial | 0 | 0.686 | 2 |
| Total | 0.026 | 0.726 | 2.013 |

| Nickel (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0 | 0 | 0 |
| Grass/Pasture | 0 | 0 | 0 |
| Low Density Residential | 0 | 0.191 | 0.063 |
| Commercial | 0 | 0.810 | 2 |
| Total | 0 | 1.001 | 2.063 |

| BOD (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0.932 | 0 | 0 |
| Grass/Pasture | 0.932 | 0 | 0 |
| Low Density Residential | 0 | 488 | 162 |
| Commercial | 0 | 1579 | 4739 |
| Total | 1.864 | 2067 | 4901 |

| COD (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0 | 0 | 0 |
| Grass/Pasture | 0 | 0 | 0 |
| Low Density Residential | 0 | 948 | 316 |

Figure I-25 Continued.



| | | | |
|---|---|---|---|
| Commercial | 0 | 7968 | 23904 |
| **Total** | 0 | 8916 | 24220 |

| Oil & Grease (lbs) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0 | 0 | 0 |
| Grass/Pasture | 0 | 0 | 0 |
| Low Density Residential | 0 | 32 | 10 |
| Commercial | 0 | 618 | 1854 |
| **Total** | 0 | 650 | 1864 |

| Fecal Coliform (millions of coliform) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 1 | 0 | 0 |
| Grass/Pasture | 1 | 0 | 0 |
| Low Density Residential | 0 | 1742 | 580 |
| Commercial | 0 | 2154 | 6463 |
| **Total** | 2 | 3896 | 7043 |

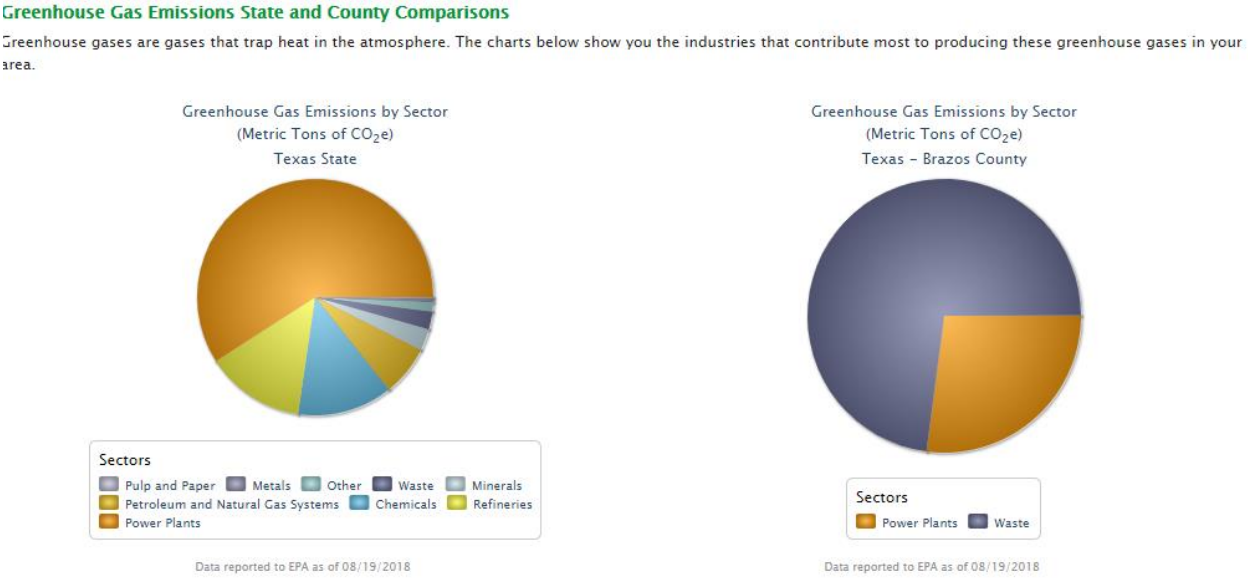
| Fecal Strep (millions of coliform) | | | |
|---|---|---|---|
| Land Use | Current | Scenario 1 | Scenario 2 |
| Forest | 0 | 0 | 0 |
| Grass/Pasture | 0 | 0 | 0 |
| Low Density Residential | 0 | 4878 | 1626 |
| Commercial | 0 | 5620 | 16860 |
| **Total** | 0 | 10498 | 18486 |

*These results were generated by the L-THIA (Long-Term Hydrologic Impact Assessment) model at "https://engineering.purdue.edu/lthia/LTHIA7/lthia_models"*

Figure I-25 Continued.

| # ▲ | Hide | High-light | Policy or Program | Policy or Program Description | Sector(s) | Material or Product Group | Diversion Potential | Upstream Impacts | Local Authority | Receptivity | Staff Knowledge | Community Led Initiatives |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Search... | Search... | Search... | Search... | Med/High ▾ | Med/High ▾ | All ▾ | All ▾ | All ▾ | All ▾ |
| 2 | ☐ | ☑ | **Zero Waste Goal/Plan** | Adopt a goal and plan for reaching 90% or more diversion from landfilling and combustion by a specific year through reduce and reuse as well as recycling and composting. Consider renaming the Solid Waste Department to the Zero Waste Department.<br>Examples and Resources | Community | Various | High | High | Med | Diff | High | Easy |
| 4 | ☐ | ☑ | **Zero Waste Goals for Organics** | Adopt a Zero Food Waste hierarchy; adopt a goal to phase out compostable organics from refuse collection and from entering local transfer stations landfills or incinerators.<br>Examples and Resources | Community | Organics | High | Med | High | Diff | Med | Med |
| 5 | ☐ | ☑ | **Landfill Ban - Organics** | Adopt an ordinance to limit, then ban organics from refuse collection and from entering local transfer stations, landfills and incinerators; support adoption regionally and statewide after expanding composting and digestion programs as needed.<br>Examples and Resources | Community | Organics | High | High | Med | Diff | High | Diff |
| 6 | ☐ | ☑ | **Landfill Ban - Recyclables** | Adopt an ordinance to ban specific recyclable or toxic materials from entering local transfer stations, landfills, and incinerators.<br>Examples and Resources | Community | Paper, Plastics, Metals, Glass, Electronics, HHW, C&D, Various | High | High | Med | Diff | High | Diff |
| 11 | ☐ | ☑ | **Zero Waste Public Venues & Events** | Adopt and implement Zero Waste goals and action plans for all public venues and events. Provide training and technical assistance to venue and event coordinators, displays, and signs.<br>Examples and Resources | Govt | Paper, Plastics, Metals, Glass, Organics | Med | Med | Med | Easy | Med | Med |
| 20 | ☐ | ☑ | **Single Stream Recycling** | Streamline recyclables collection by enabling customers to place recyclables into a single bin or cart for added convenience.<br>Examples and Resources | Residential, ICI | Paper, Plastics, Metals, Glass | Med | Med | Med | Med | Low | Med |
| 24 | ☐ | ☐ | **Product & Packaging Bans** | Adopt ordinances that limit or ban sales of toxic or hard to recover products and product packaging.<br>Examples and Resources | Govt, ICI | HHW, Hard to Recycle, Plastics, Various | Med | High | Med | Diff | Med | Diff |

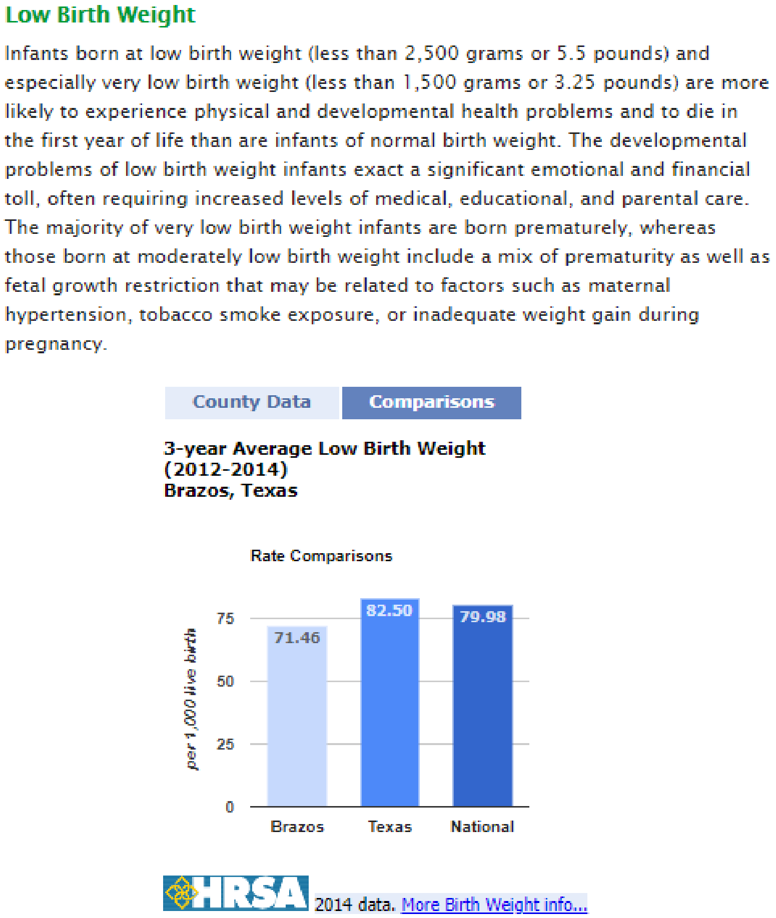
Figure I-26. Zero waste policy options generated by the Managing and Transforming Waste Streams Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Greenhouse Gas Emissions State and County Comparisons

Greenhouse gases are gases that trap heat in the atmosphere. The charts below show you the industries that contribute most to producing these greenhouse gases in your area.

Figure I-27. Greenhouse gas emissions data output generated by the MyEnvironment tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



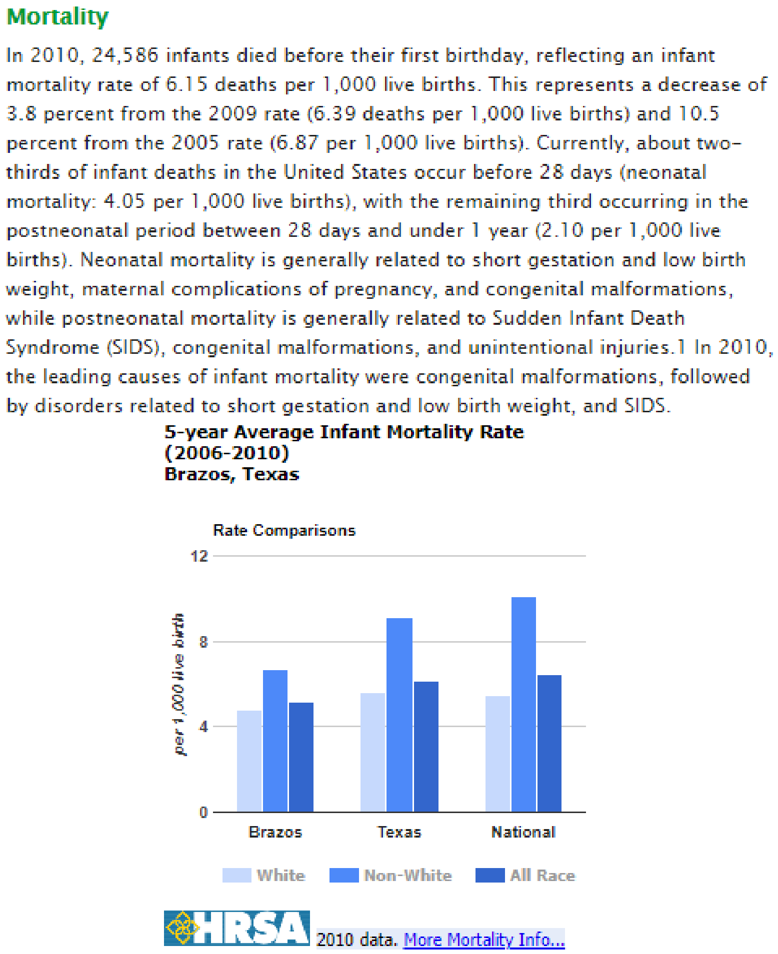
**Low Birth Weight**

Infants born at low birth weight (less than 2,500 grams or 5.5 pounds) and especially very low birth weight (less than 1,500 grams or 3.25 pounds) are more likely to experience physical and developmental health problems and to die in the first year of life than are infants of normal birth weight. The developmental problems of low birth weight infants exact a significant emotional and financial toll, often requiring increased levels of medical, educational, and parental care. The majority of very low birth weight infants are born prematurely, whereas those born at moderately low birth weight include a mix of prematurity as well as fetal growth restriction that may be related to factors such as maternal hypertension, tobacco smoke exposure, or inadequate weight gain during pregnancy.

**3-year Average Low Birth Weight (2012-2014)**
**Brazos, Texas**

2014 data. More Birth Weight info...

Figure I-28. Low birth weight data output generated by the MyEnvironment tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



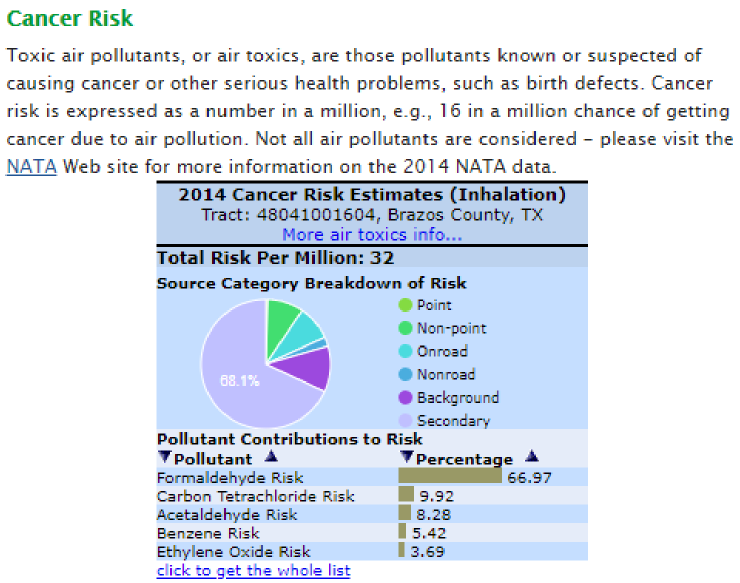
**Mortality**

In 2010, 24,586 infants died before their first birthday, reflecting an infant mortality rate of 6.15 deaths per 1,000 live births. This represents a decrease of 3.8 percent from the 2009 rate (6.39 deaths per 1,000 live births) and 10.5 percent from the 2005 rate (6.87 per 1,000 live births). Currently, about two-thirds of infant deaths in the United States occur before 28 days (neonatal mortality: 4.05 per 1,000 live births), with the remaining third occurring in the postneonatal period between 28 days and under 1 year (2.10 per 1,000 live births). Neonatal mortality is generally related to short gestation and low birth weight, maternal complications of pregnancy, and congenital malformations, while postneonatal mortality is generally related to Sudden Infant Death Syndrome (SIDS), congenital malformations, and unintentional injuries.1 In 2010, the leading causes of infant mortality were congenital malformations, followed by disorders related to short gestation and low birth weight, and SIDS.

**5-year Average Infant Mortality Rate**
**(2006-2010)**
**Brazos, Texas**

2010 data. More Mortality Info...

Figure I-29. Mortality data output generated by the MyEnvironment tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



**Cancer Risk**

Toxic air pollutants, or air toxics, are those pollutants known or suspected of causing cancer or other serious health problems, such as birth defects. Cancer risk is expressed as a number in a million, e.g., 16 in a million chance of getting cancer due to air pollution. Not all air pollutants are considered – please visit the NATA Web site for more information on the 2014 NATA data.

**2014 Cancer Risk Estimates (Inhalation)**
Tract: 48041001604, Brazos County, TX
More air toxics info...

**Total Risk Per Million: 32**

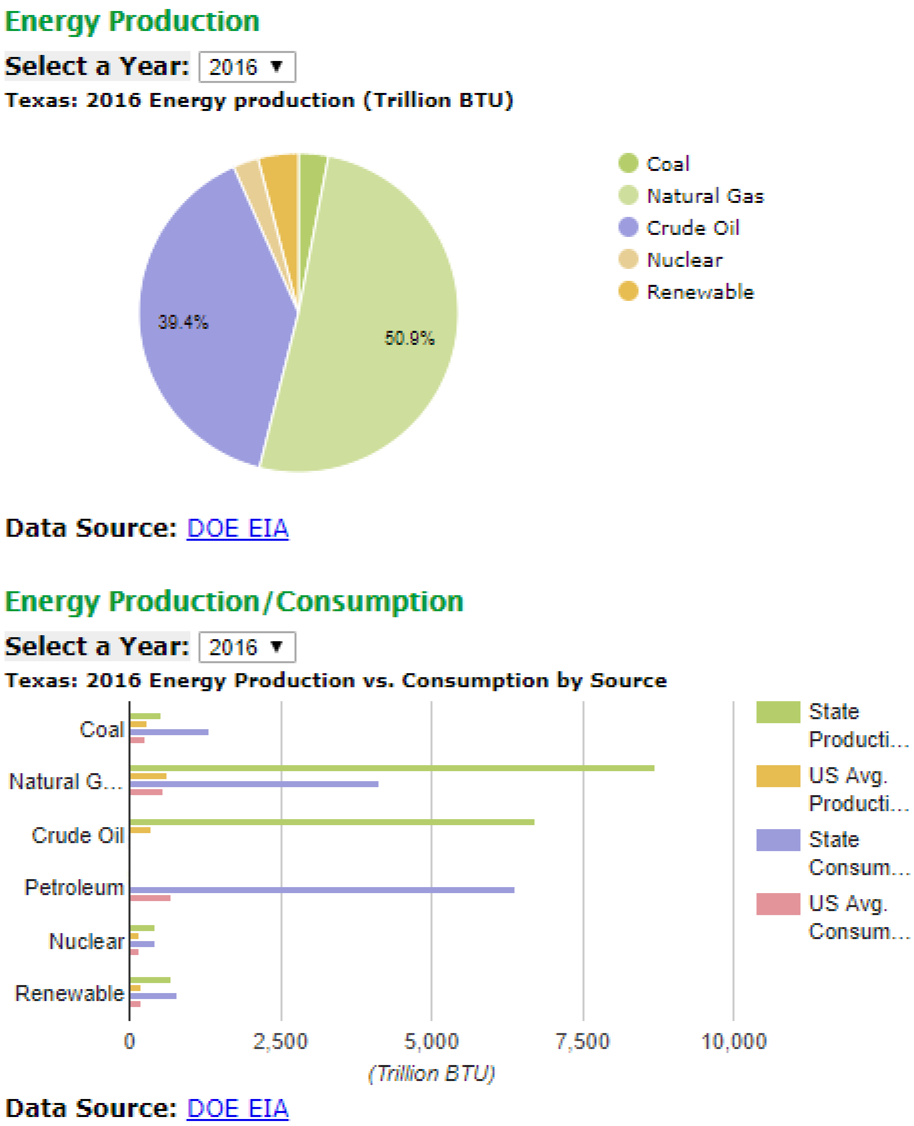
**Source Category Breakdown of Risk**

**Pollutant Contributions to Risk**

| ▼Pollutant ▲ | ▼Percentage ▲ |
|---|---|
| Formaldehyde Risk | 66.97 |
| Carbon Tetrachloride Risk | 9.92 |
| Acetaldehyde Risk | 8.28 |
| Benzene Risk | 5.42 |
| Ethylene Oxide Risk | 3.69 |

click to get the whole list

Figure I-30. Cancer risk data output generated by the MyEnvironment tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Energy Production

Select a Year: 2016 ▼

Texas: 2016 Energy production (Trillion BTU)

Data Source: DOE EIA

Energy Production/Consumption

Select a Year: 2016 ▼

Texas: 2016 Energy Production vs. Consumption by Source

Data Source: DOE EIA

Figure I-31. Energy production and consumption data output generated by the MyEnvironment tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

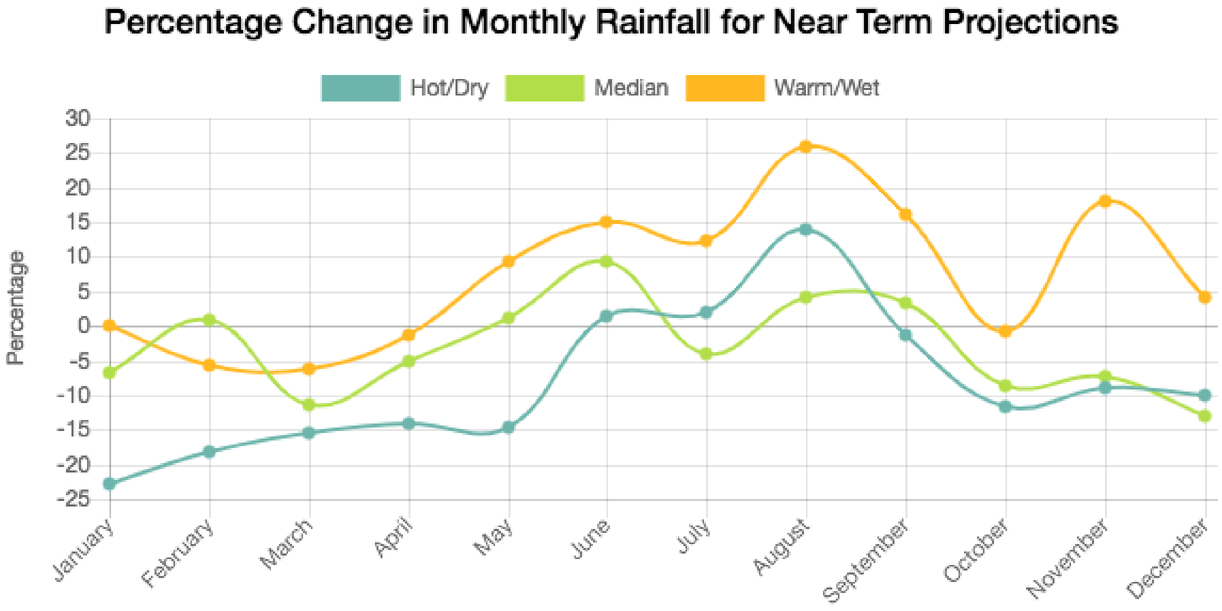


Figure I-32. Monthly rainfall projections generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

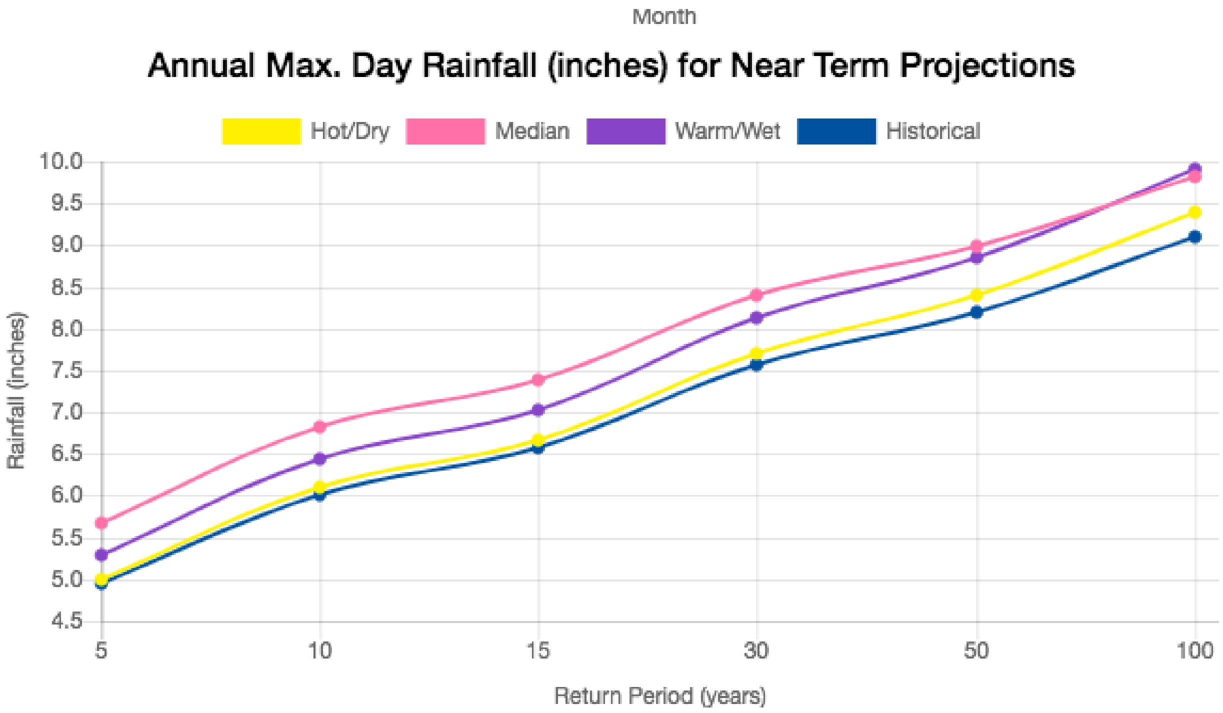
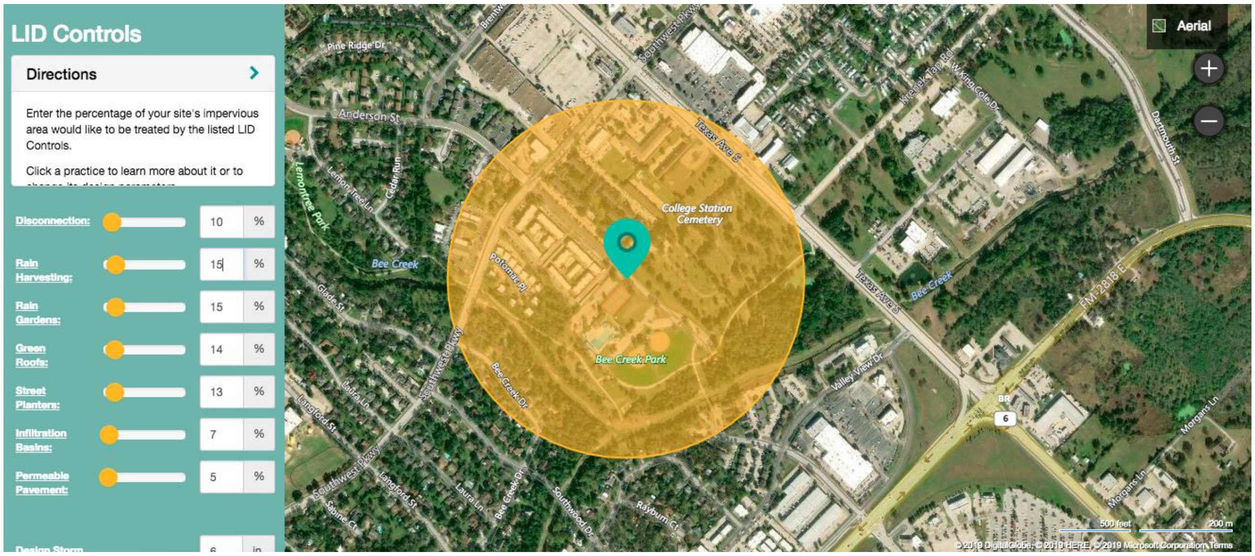


Figure I-33. Maximum daily rainfall projections over one hundred years generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



## LID Controls

**Directions**

Enter the percentage of your site's impervious area would like to be treated by the listed LID Controls.

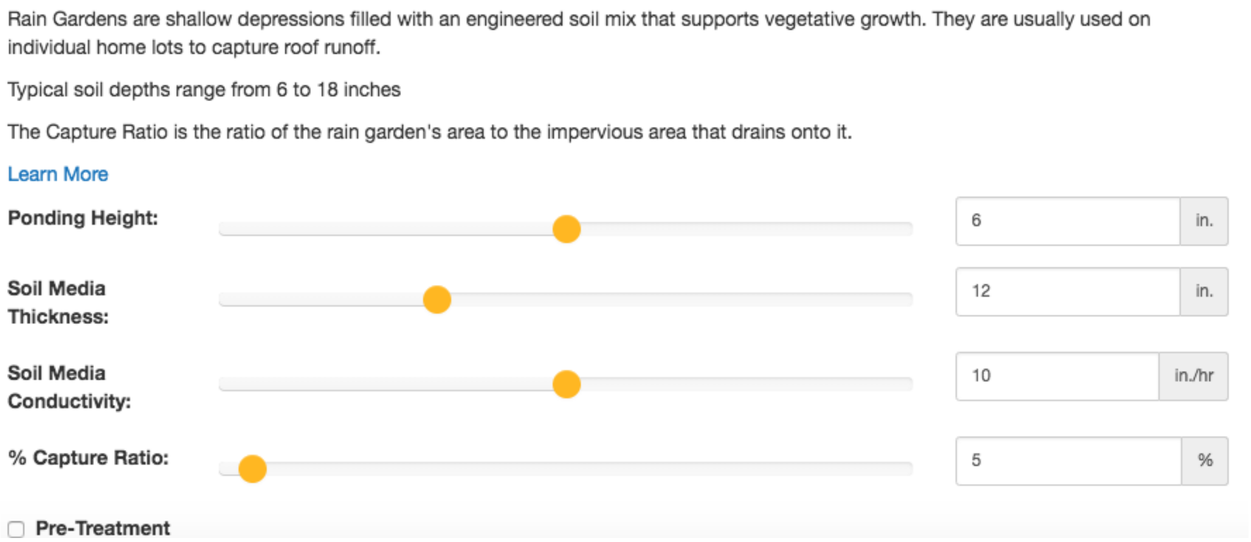
Click a practice to learn more about it or to

Disconnection: 10 %
Rain Harvesting: 15 %
Rain Gardens: 15 %
Green Roofs: 14 %
Street Planters: 13 %
Infiltration Basins: 7 %
Permeable Pavement: 5 %

Figure I-34. Sample map and selection tool for choosing various low impact development programs in the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

Cistern Size: 100 Gal.
Emptying Rate: 50 Gal./Day
Number per 1,000 sq. ft.: 4 /1,000 sq. ft.

Figure I-35. Sample data output for water harvesting generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Rain Gardens are shallow depressions filled with an engineered soil mix that supports vegetative growth. They are usually used on individual home lots to capture roof runoff.

Typical soil depths range from 6 to 18 inches

The Capture Ratio is the ratio of the rain garden's area to the impervious area that drains onto it.

Learn More

**Ponding Height:** 6 in.

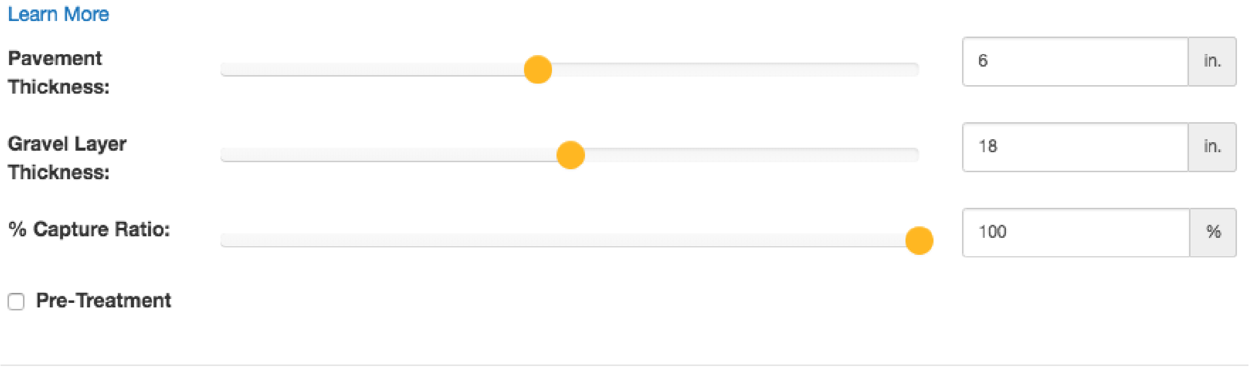
**Soil Media Thickness:** 12 in.

**Soil Media Conductivity:** 10 in./hr

**% Capture Ratio:** 5 %

☐ **Pre-Treatment**

Figure I-36. Sample data output for rain gardens generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Learn More

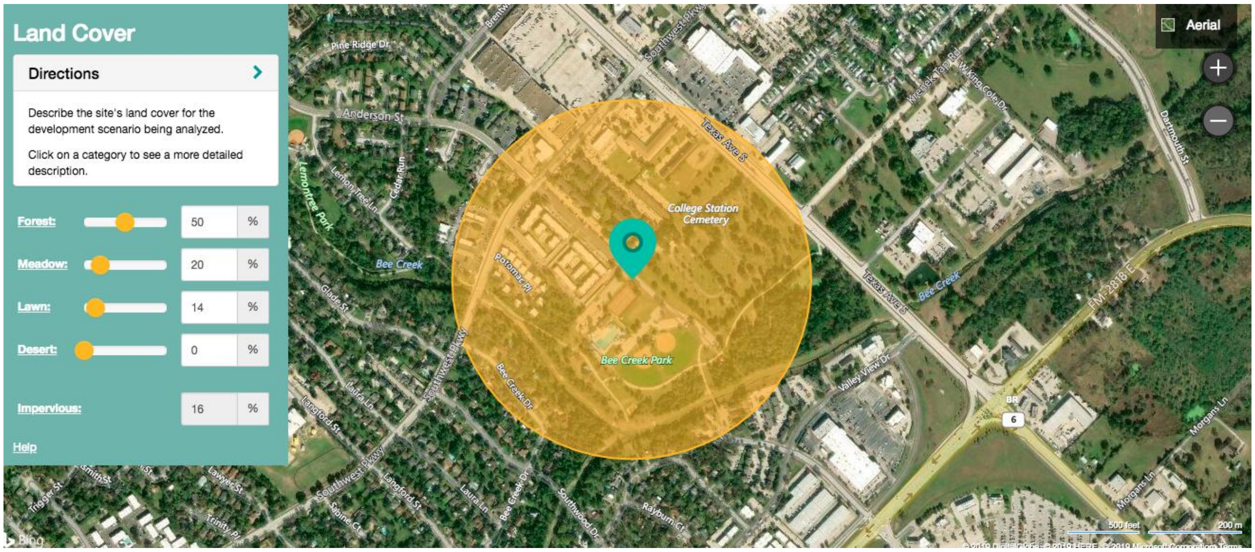
**Pavement Thickness:** 6 in.

**Gravel Layer Thickness:** 18 in.

**% Capture Ratio:** 100 %

☐ **Pre-Treatment**

Figure I-37. Sample data output for infiltration basins generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Land Cover

Directions

Describe the site's land cover for the development scenario being analyzed.

Click on a category to see a more detailed description.

Forest: 50 %

Meadow: 20 %

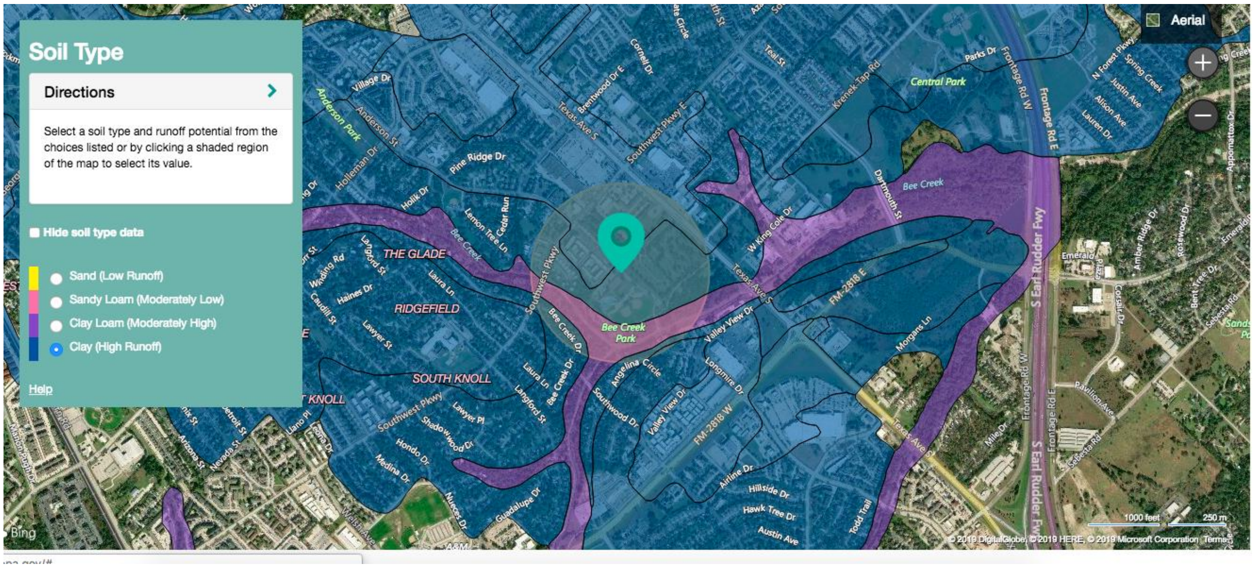
Lawn: 14 %

Desert: 0 %

Impervious: 16 %

Help

Figure I-38. Sample map and selection tool for choosing various land management scenarios in the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Soil Type

Directions

Select a soil type and runoff potential from the choices listed or by clicking a shaded region of the map to select its value.

☐ Hide soil type data

○ Sand (Low Runoff)

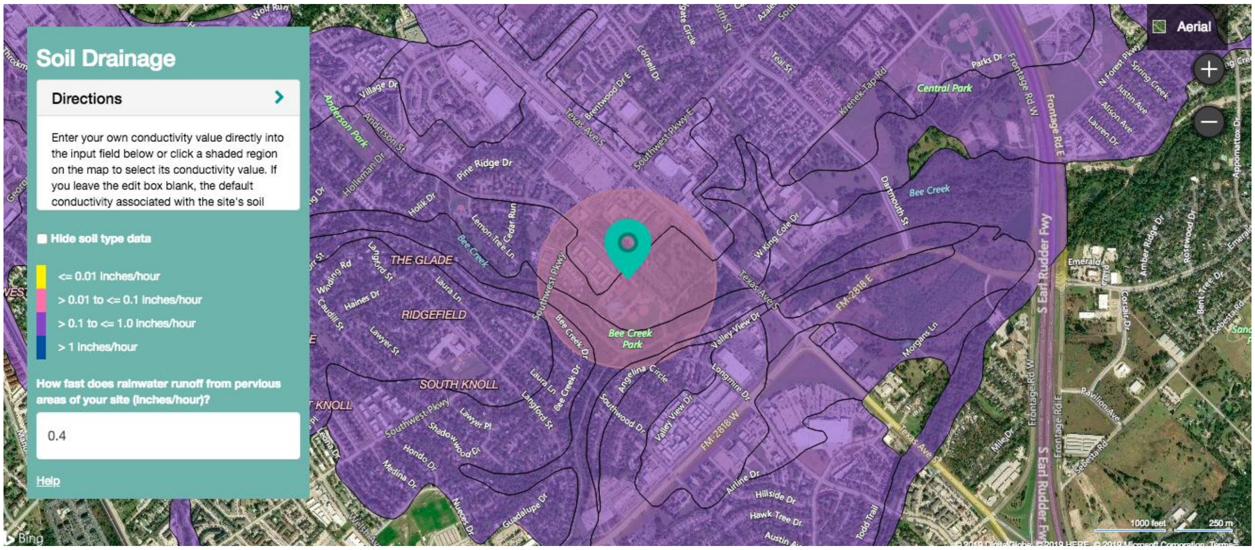
○ Sandy Loam (Moderately Low)

○ Clay Loam (Moderately High)

● Clay (High Runoff)

Help

Figure I-39. Output for soil type existing in Bee Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Soil Drainage

Directions

Enter your own conductivity value directly into the input field below or click a shaded region on the map to select its conductivity value. If you leave the edit box blank, the default conductivity associated with the site's soil

☐ Hide soil type data

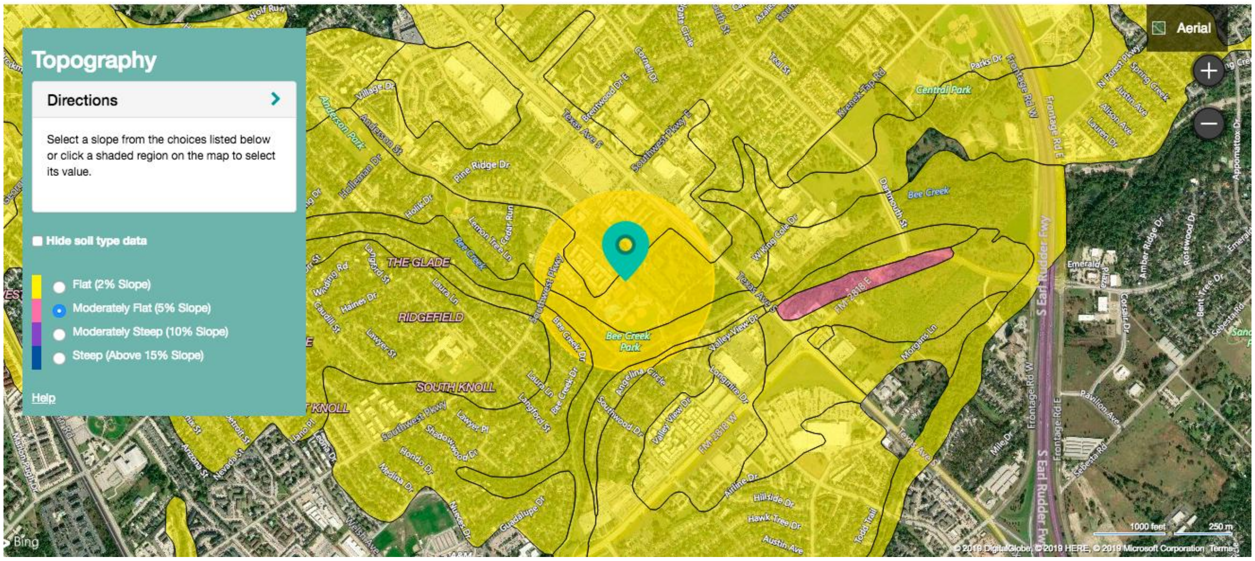
- 🟨 <= 0.01 inches/hour
- 🟥 > 0.01 to <= 0.1 inches/hour
- 🟪 > 0.1 to <= 1.0 inches/hour
- 🟦 > 1 inches/hour

How fast does rainwater runoff from pervious areas of your site (inches/hour)?

0.4

Help

Figure I-40. Output for type of soil drainage in Bee Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Topography

Directions

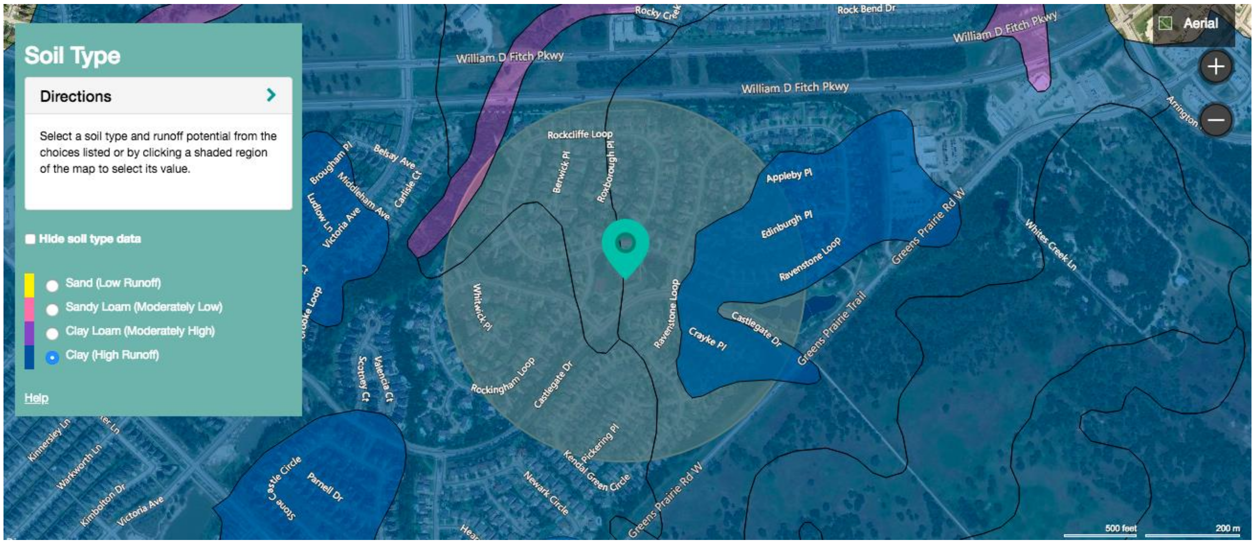
Select a slope from the choices listed below or click a shaded region on the map to select its value.

☐ Hide soil type data

- 🟨 ○ Flat (2% Slope)
- 🟥 ● Moderately Flat (5% Slope)
- 🟪 ○ Moderately Steep (10% Slope)
- 🟦 ○ Steep (Above 15% Slope)

Help

Figure I-41. Topography output for Bee Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Soil Type

Directions ›

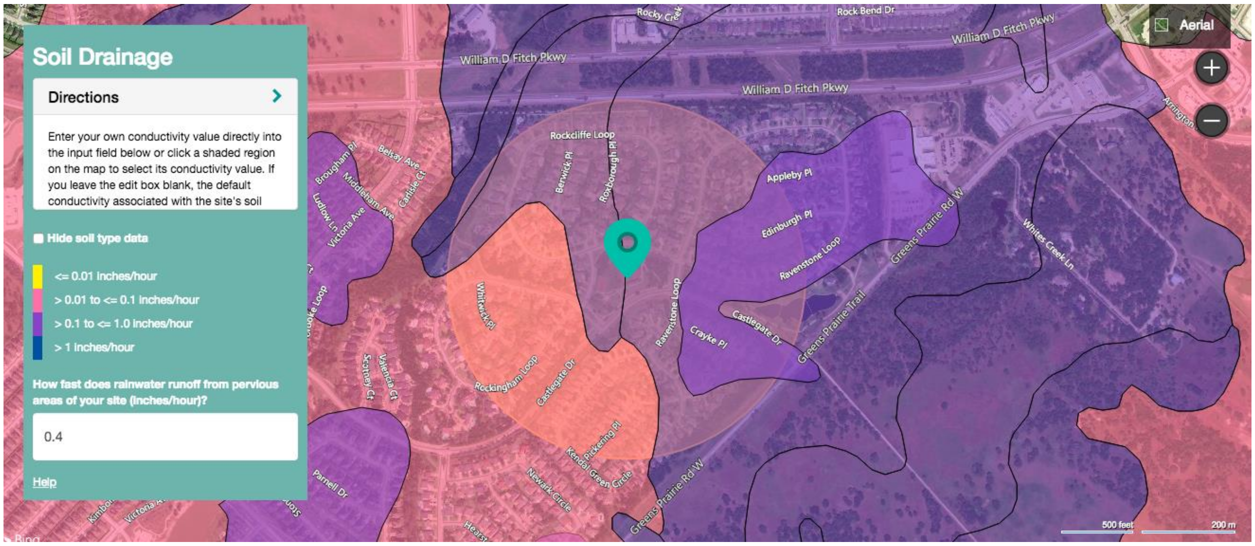
Select a soil type and runoff potential from the choices listed or by clicking a shaded region of the map to select its value.

☐ Hide soil type data

🟨 ○ Sand (Low Runoff)
🟪 ○ Sandy Loam (Moderately Low)
🟪 ○ Clay Loam (Moderately High)
🟦 ● Clay (High Runoff)

Help

Figure I-42. Output for soil type existing in Castlegate Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Soil Drainage

Directions ›

Enter your own conductivity value directly into the input field below or click a shaded region on the map to select its conductivity value. If you leave the edit box blank, the default conductivity associated with the site's soil

☐ Hide soil type data

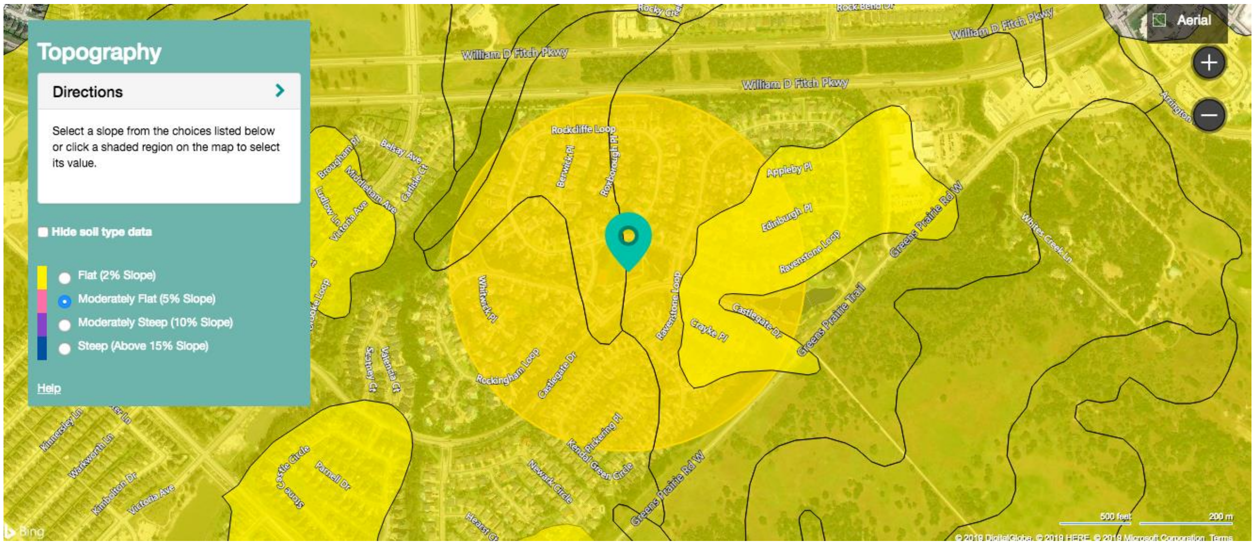
🟨 <= 0.01 inches/hour
🟪 > 0.01 to <= 0.1 inches/hour
🟪 > 0.1 to <= 1.0 inches/hour
🟦 > 1 inches/hour

How fast does rainwater runoff from pervious areas of your site (inches/hour)?

0.4

Help

Figure I-43. Output for type of soil drainage in Castlegate Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Topography

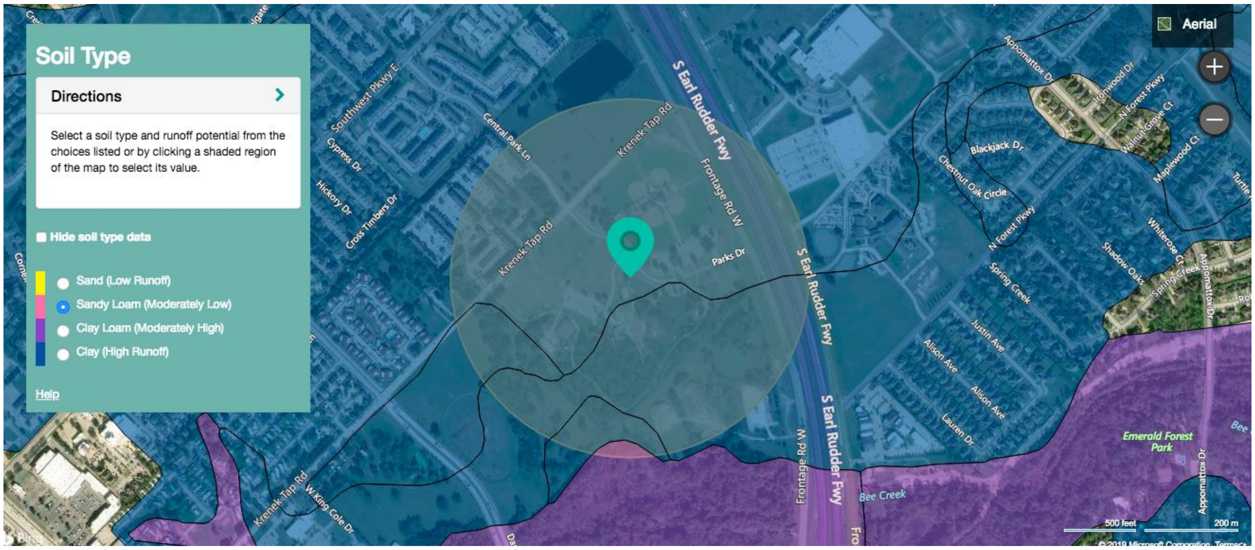
Directions

Select a slope from the choices listed below or click a shaded region on the map to select its value.

☐ Hide soil type data

○ Flat (2% Slope)
● Moderately Flat (5% Slope)
○ Moderately Steep (10% Slope)
○ Steep (Above 15% Slope)

Figure I-44. Topography output for Castlegate Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Soil Type

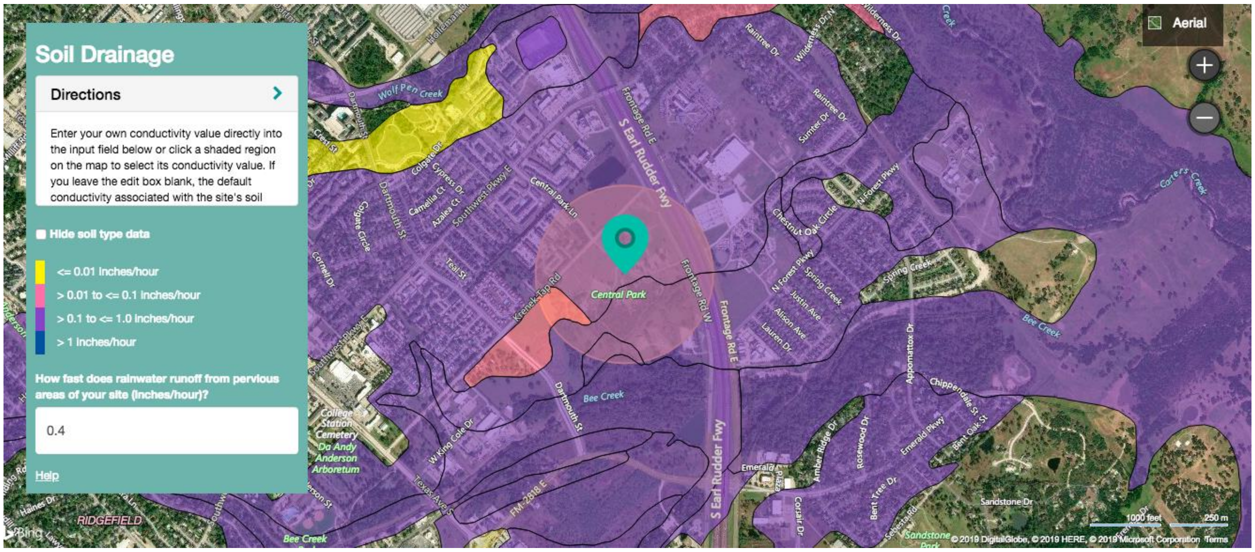
Directions

Select a soil type and runoff potential from the choices listed or by clicking a shaded region of the map to select its value.

☐ Hide soil type data

○ Sand (Low Runoff)
● Sandy Loam (Moderately Low)
○ Clay Loam (Moderately High)
○ Clay (High Runoff)

Figure I-45. Output for soil type existing in Central Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



**Soil Drainage**

Directions

Enter your own conductivity value directly into the input field below or click a shaded region on the map to select its conductivity value. If you leave the edit box blank, the default conductivity associated with the site's soil

☐ Hide soil type data

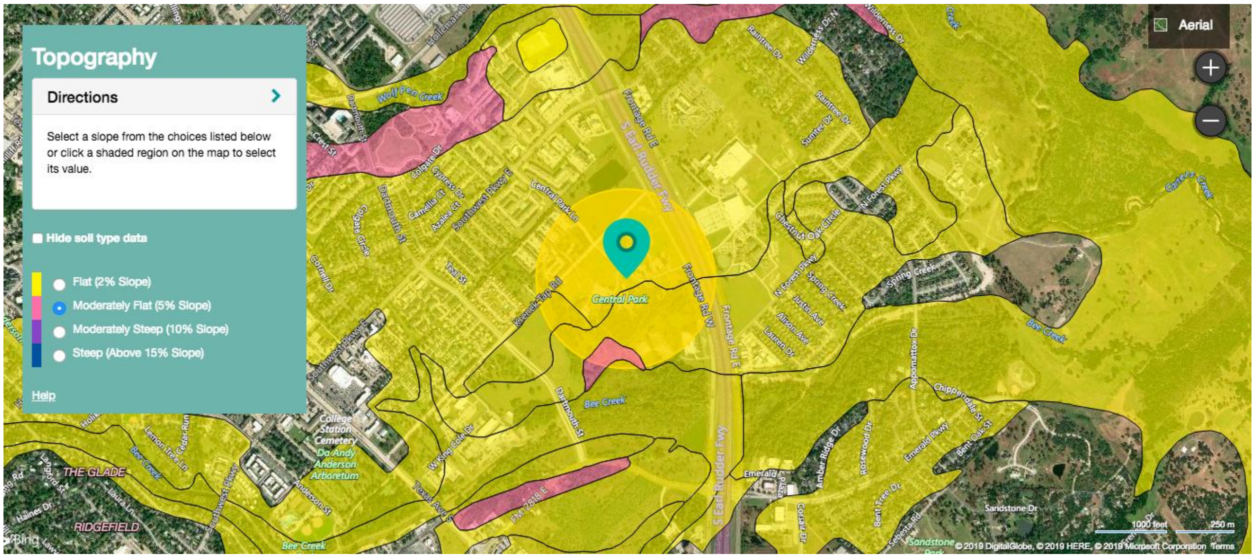
🟨 <= 0.01 inches/hour
🟥 > 0.01 to <= 0.1 inches/hour
🟪 > 0.1 to <= 1.0 inches/hour
🟦 > 1 inches/hour

How fast does rainwater runoff from pervious areas of your site (inches/hour)?

0.4

Help

Figure I-46. Output for type of soil drainage in Central Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



**Topography**

Directions

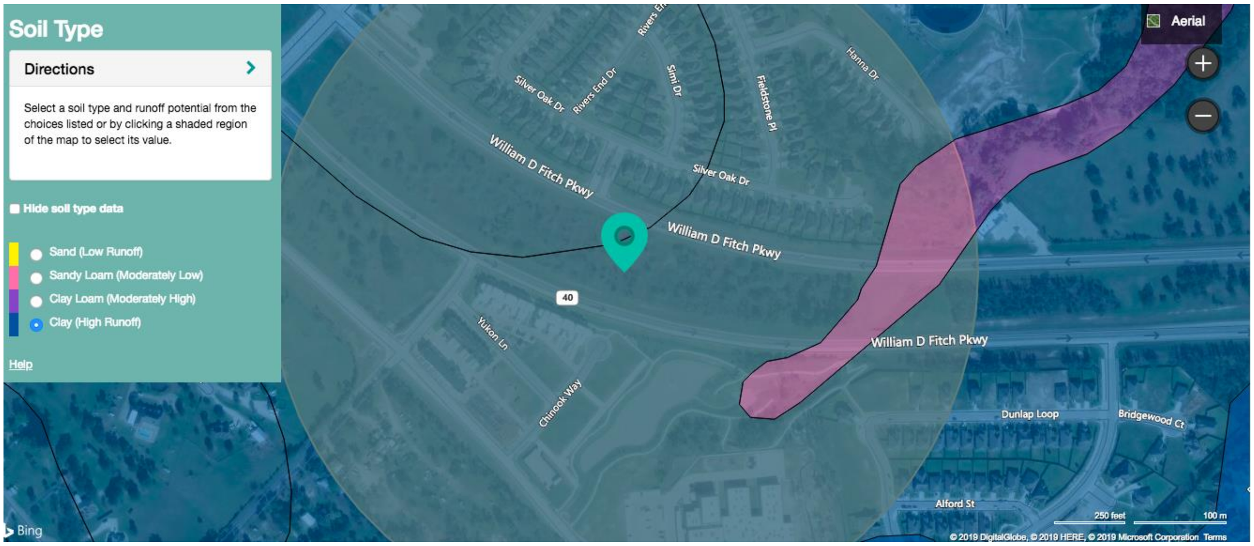
Select a slope from the choices listed below or click a shaded region on the map to select its value.

☐ Hide soil type data

🟨 ○ Flat (2% Slope)
🟥 ● Moderately Flat (5% Slope)
🟪 ○ Moderately Steep (10% Slope)
🟦 ○ Steep (Above 15% Slope)

Help

Figure I-47. Topography output for Central Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Soil Type

Directions

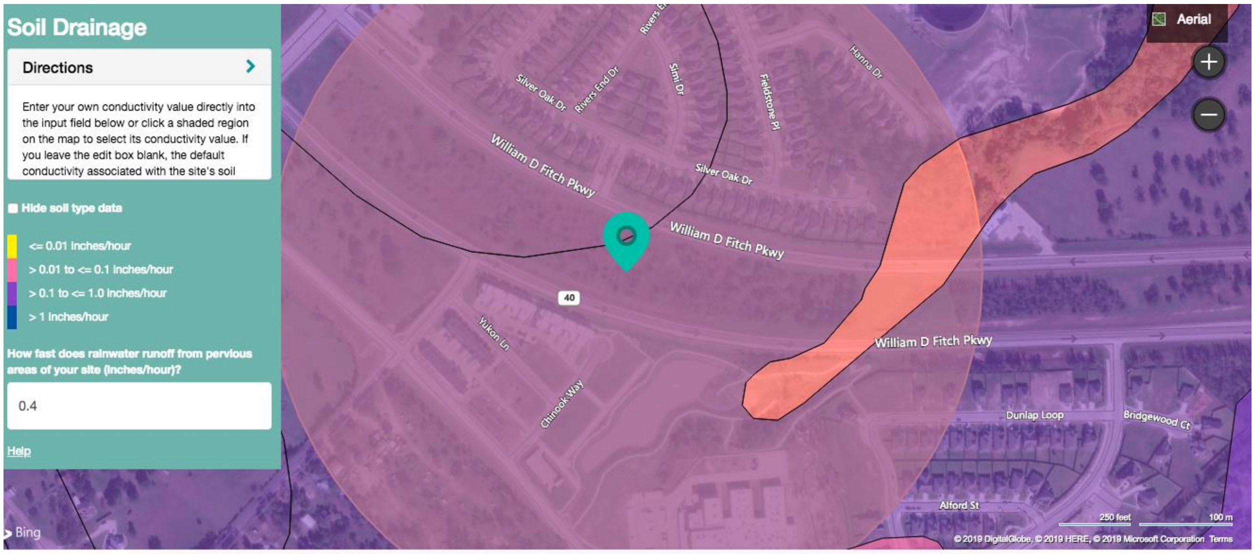
Select a soil type and runoff potential from the choices listed or by clicking a shaded region of the map to select its value.

☐ Hide soil type data

- 🟨 ○ Sand (Low Runoff)
- 🟪 ○ Sandy Loam (Moderately Low)
- 🟪 ○ Clay Loam (Moderately High)
- 🟦 ● Clay (High Runoff)

Help

Figure I-48. Output for soil type existing in Lick Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Soil Drainage

Directions

Enter your own conductivity value directly into the input field below or click a shaded region on the map to select its conductivity value. If you leave the edit box blank, the default conductivity associated with the site's soil

☐ Hide soil type data

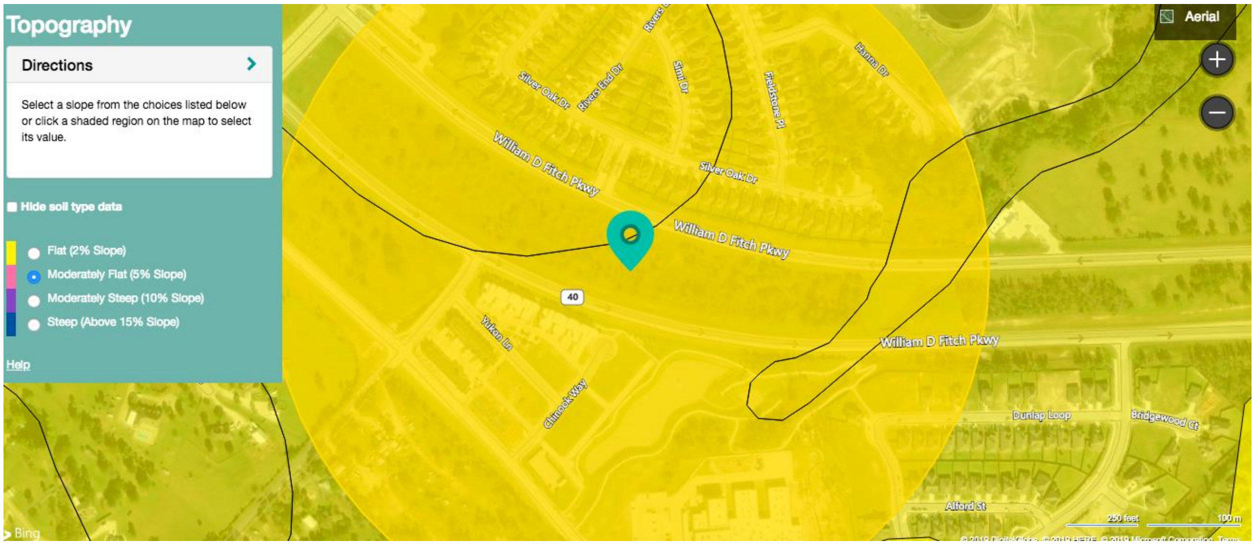
- 🟨 <= 0.01 inches/hour
- 🟪 > 0.01 to <= 0.1 inches/hour
- 🟪 > 0.1 to <= 1.0 inches/hour
- 🟦 > 1 inches/hour

How fast does rainwater runoff from pervious areas of your site (inches/hour)?

0.4

Help

Figure I-49. Output for type of soil drainage in Lick Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Topography

Directions

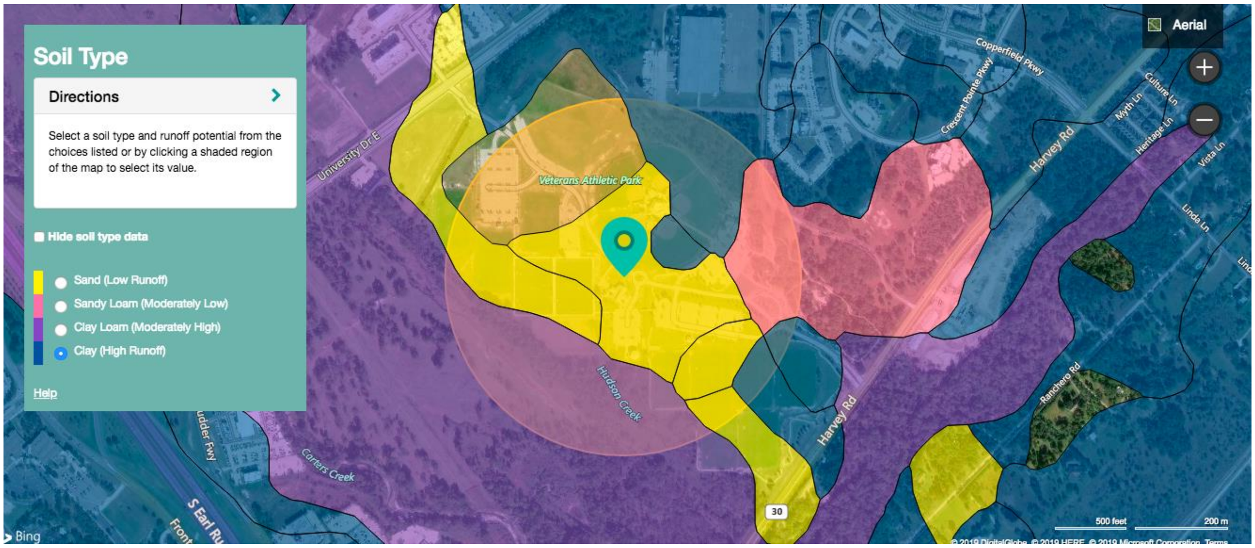
Select a slope from the choices listed below or click a shaded region on the map to select its value.

☐ Hide soil type data

- 🟨 ○ Flat (2% Slope)
- 🟥 ● Moderately Flat (5% Slope)
- 🟪 ○ Moderately Steep (10% Slope)
- 🟦 ○ Steep (Above 15% Slope)

Help

Figure I-50. Topography output for Lick Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Soil Type

Directions

Select a soil type and runoff potential from the choices listed or by clicking a shaded region of the map to select its value.

☐ Hide soil type data

- 🟨 ○ Sand (Low Runoff)
- 🟥 ○ Sandy Loam (Moderately Low)
- 🟪 ○ Clay Loam (Moderately High)
- 🟦 ● Clay (High Runoff)

Help

Figure I-51. Output for soil type existing in Veterans Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

**Soil Drainage**

**Directions** ›

Enter your own conductivity value directly into the input field below or click a shaded region on the map to select its conductivity value. If you leave the edit box blank, the default conductivity associated with the site's soil

☐ Hide soil type data

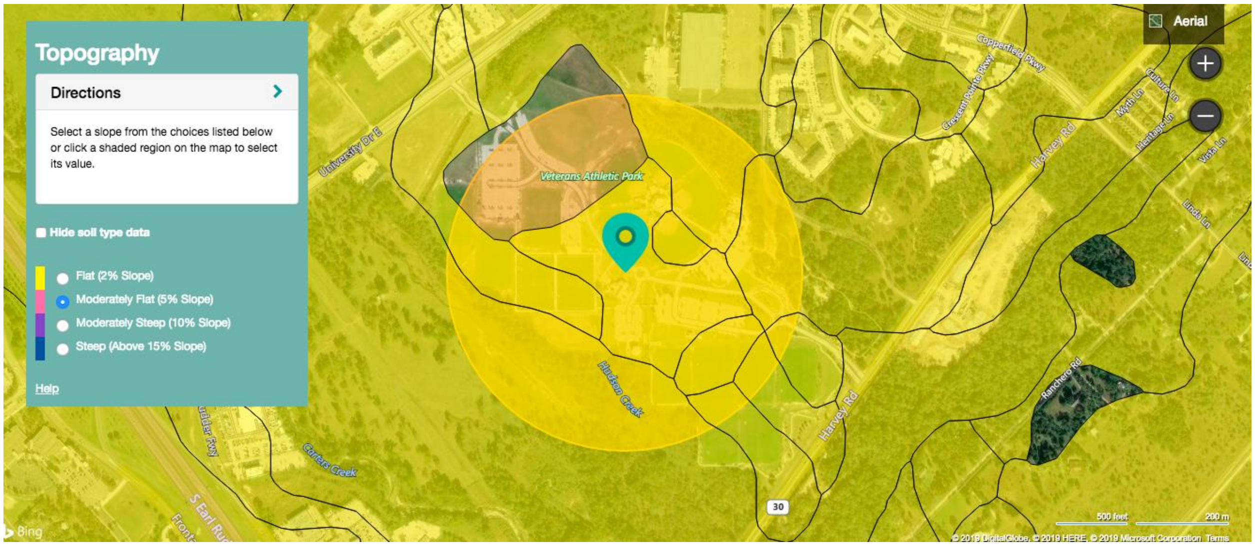
🟨 <= 0.01 inches/hour
🟥 > 0.01 to <= 0.1 inches/hour
🟪 > 0.1 to <= 1.0 inches/hour
🟦 > 1 inches/hour

How fast does rainwater runoff from pervious areas of your site (inches/hour)?

0.4

Help

Figure I-52. Output for type of soil drainage in Veterans Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



**Topography**

**Directions** ›

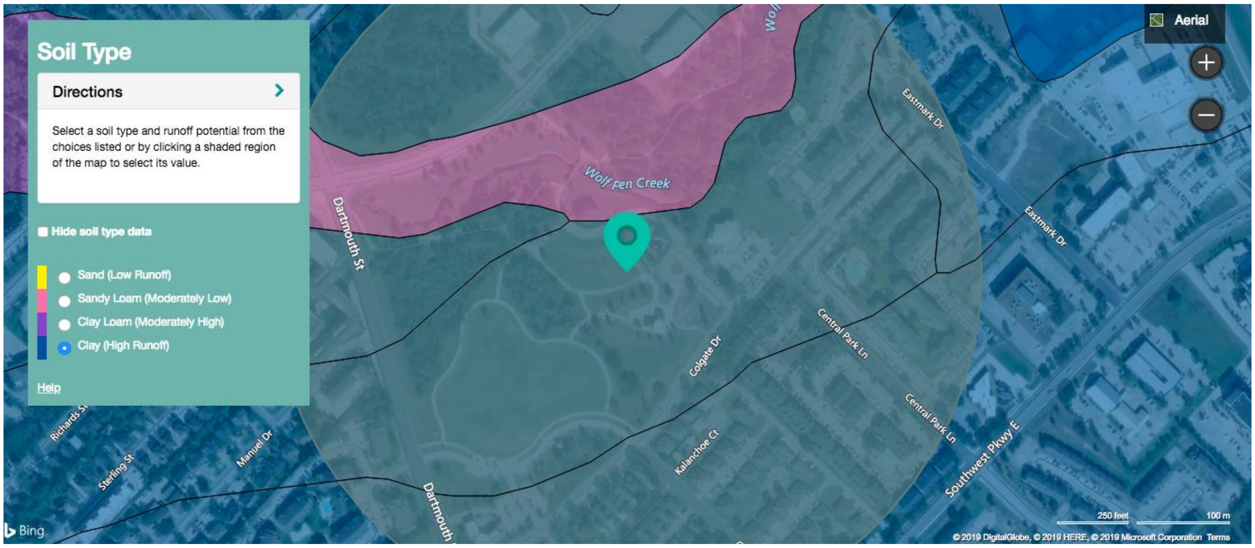
Select a slope from the choices listed below or click a shaded region on the map to select its value.

☐ Hide soil type data

🟨 ○ Flat (2% Slope)
🟥 ● Moderately Flat (5% Slope)
🟪 ○ Moderately Steep (10% Slope)
🟦 ○ Steep (Above 15% Slope)

Help

Figure I-53. Topography output for Veterans Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Soil Type

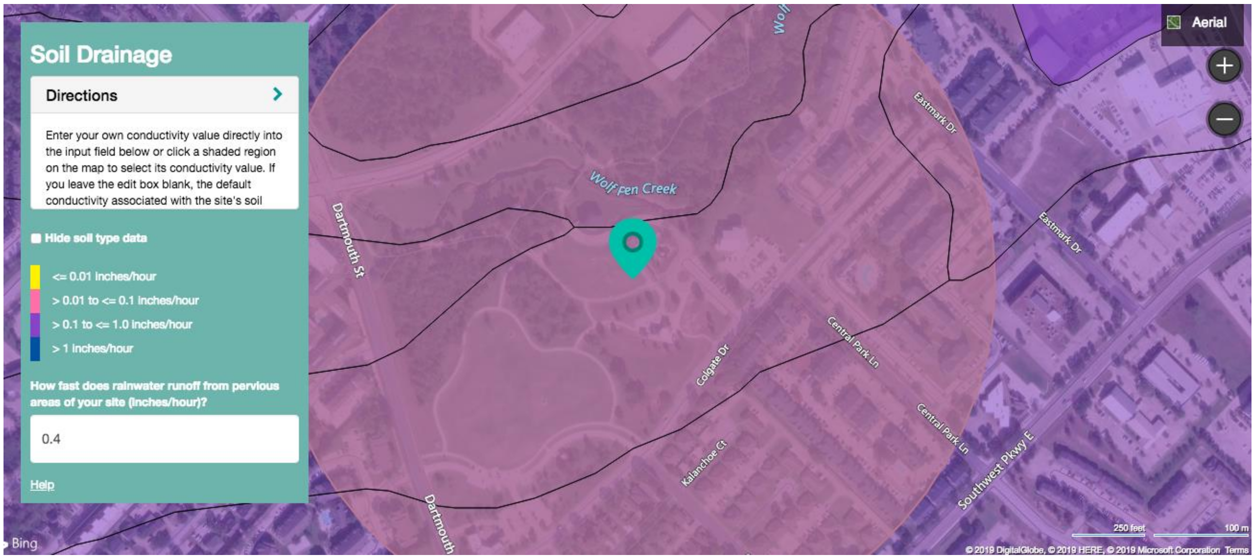
Directions

Select a soil type and runoff potential from the choices listed or by clicking a shaded region of the map to select its value.

☐ Hide soil type data

🟨 ○ Sand (Low Runoff)
🟪 ○ Sandy Loam (Moderately Low)
🟪 ○ Clay Loam (Moderately High)
🟦 ● Clay (High Runoff)

Figure I-54. Output for soil type existing in Wolf Pen Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Soil Drainage

Directions

Enter your own conductivity value directly into the input field below or click a shaded region on the map to select its conductivity value. If you leave the edit box blank, the default conductivity associated with the site's soil

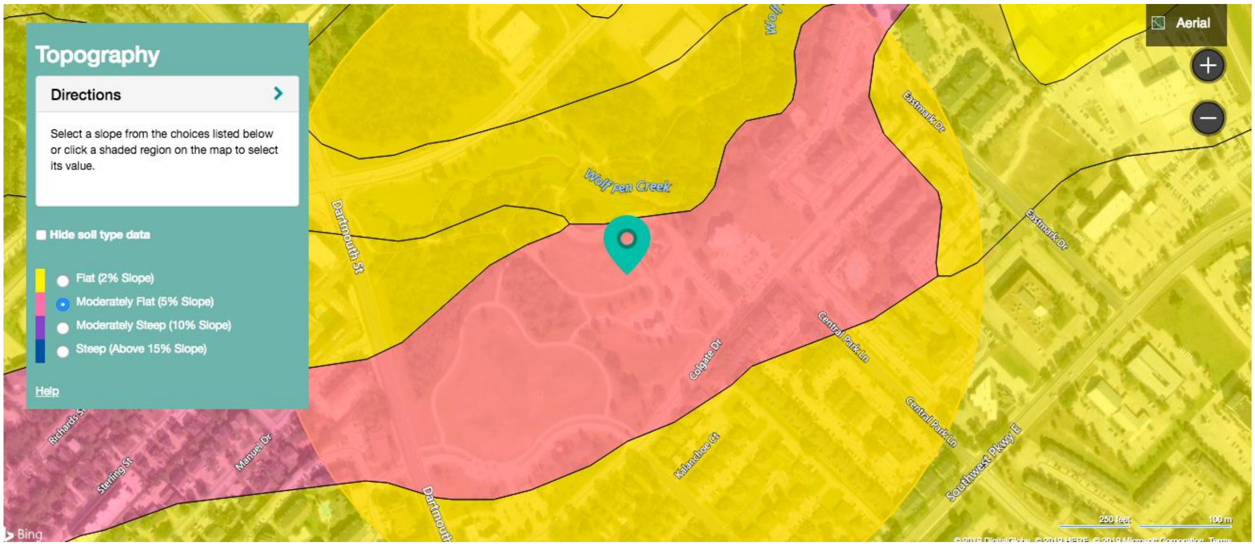
☐ Hide soil type data

🟨 <= 0.01 inches/hour
🟪 > 0.01 to <= 0.1 inches/hour
🟪 > 0.1 to <= 1.0 inches/hour
🟦 > 1 inches/hour

How fast does rainwater runoff from pervious areas of your site (inches/hour)?

0.4

Figure I-55. Output for type of soil drainage in Wolf Pen Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



Select a slope from the choices listed below or click a shaded region on the map to select its value.

☐ Hide soil type data

🟨 ○ Flat (2% Slope)
🟥 ● Moderately Flat (5% Slope)
🟪 ○ Moderately Steep (10% Slope)
🟦 ○ Steep (Above 15% Slope)

Help

Figure I-56. Topography output for Wolf Pen Creek Park generated by the National Stormwater Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

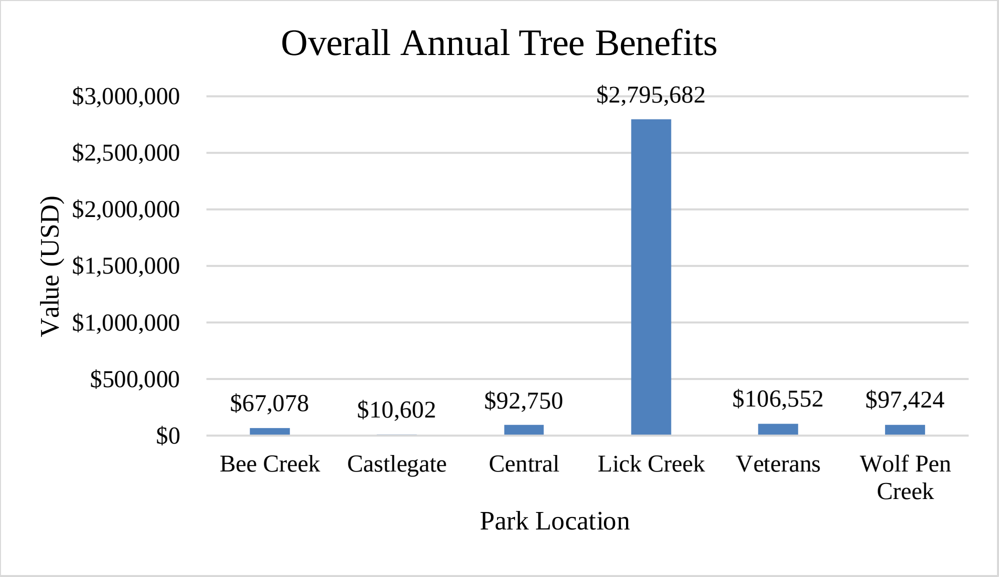


Figure I-57. Output for the overall annual benefits of trees generated by the National Tree Benefit Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

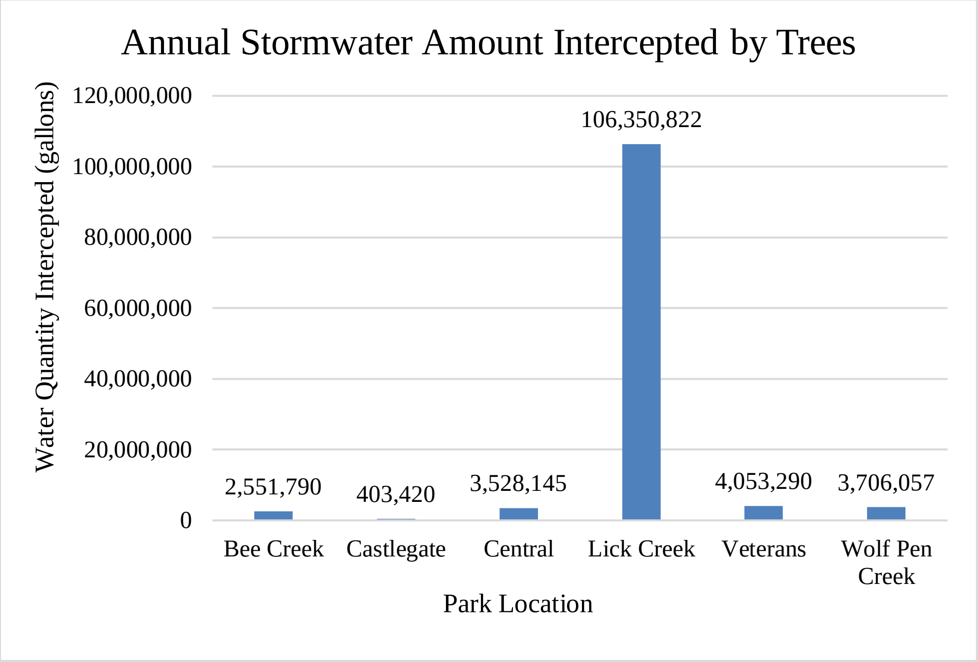


Figure I-58. Output for the annual amount of stormwater intercepted by trees generated by the National Tree Benefit Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

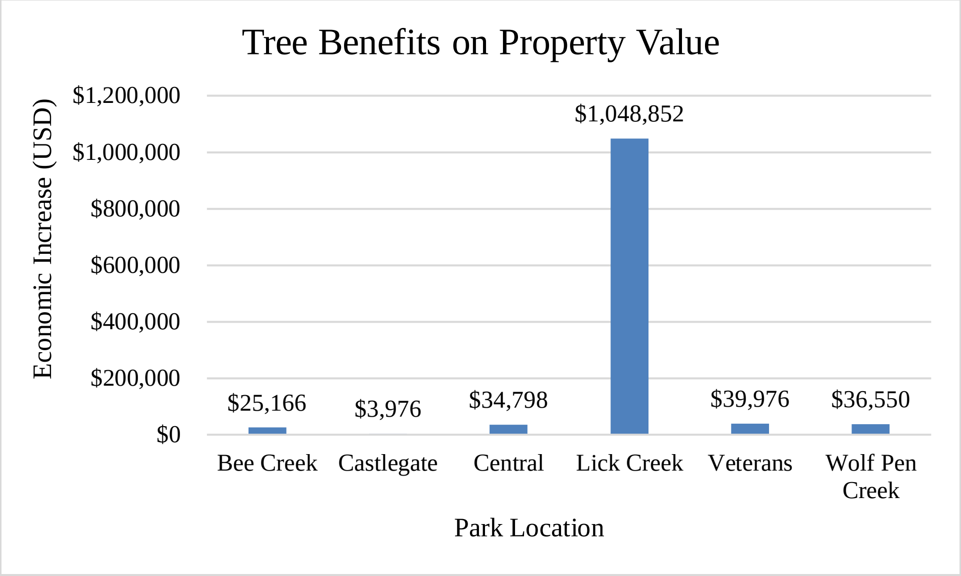


Figure I-59. Output for the proximate property value of trees generated by the National Tree Benefit Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

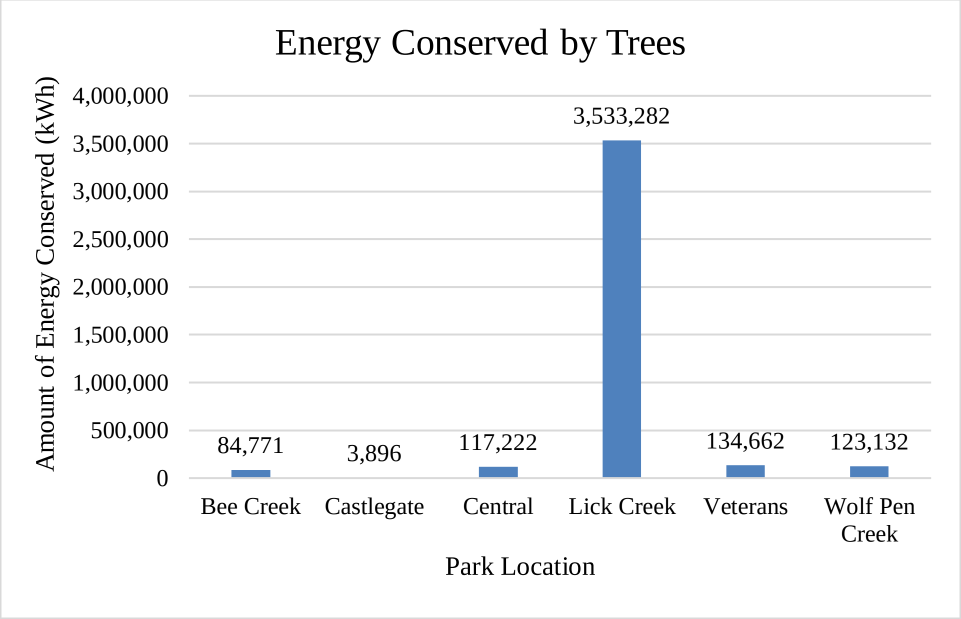


Figure I-60. Output for the amount of energy conserved by trees generated by the National Tree Benefit Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

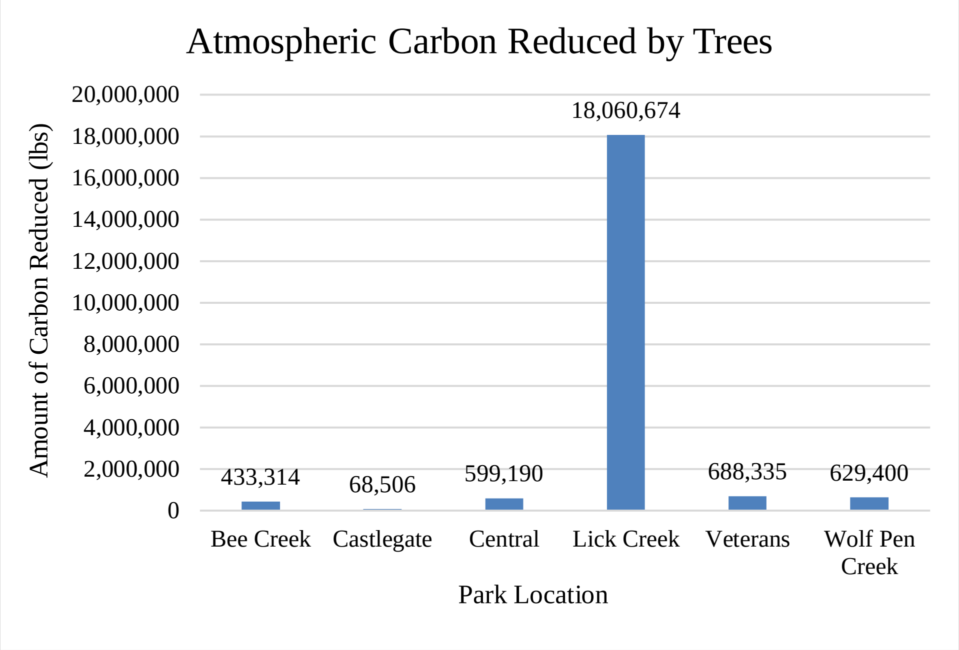


Figure I-61. Output for the amount of carbon reduced by trees generated by the National Tree Benefit Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

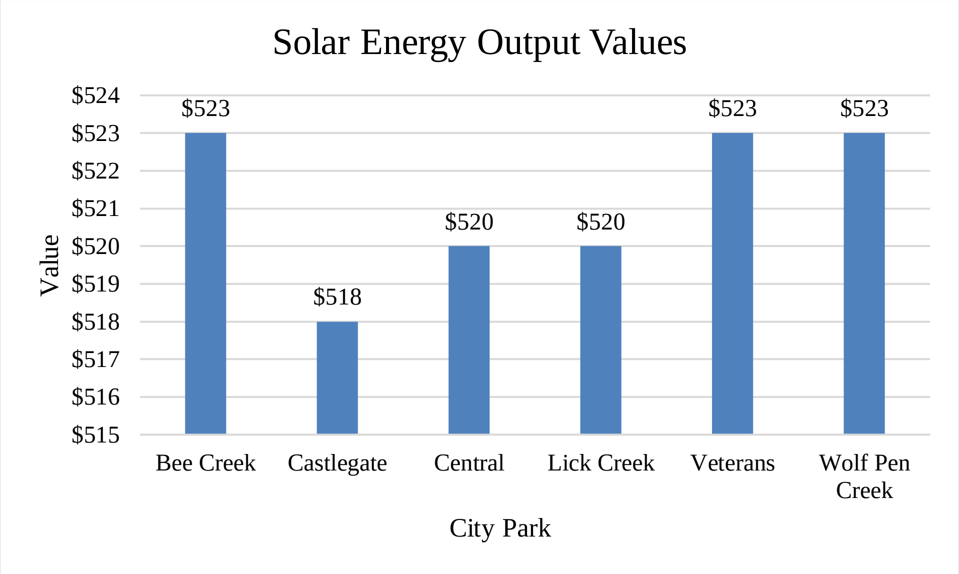


Figure I-62. Solar energy output generated by the PV Watts Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

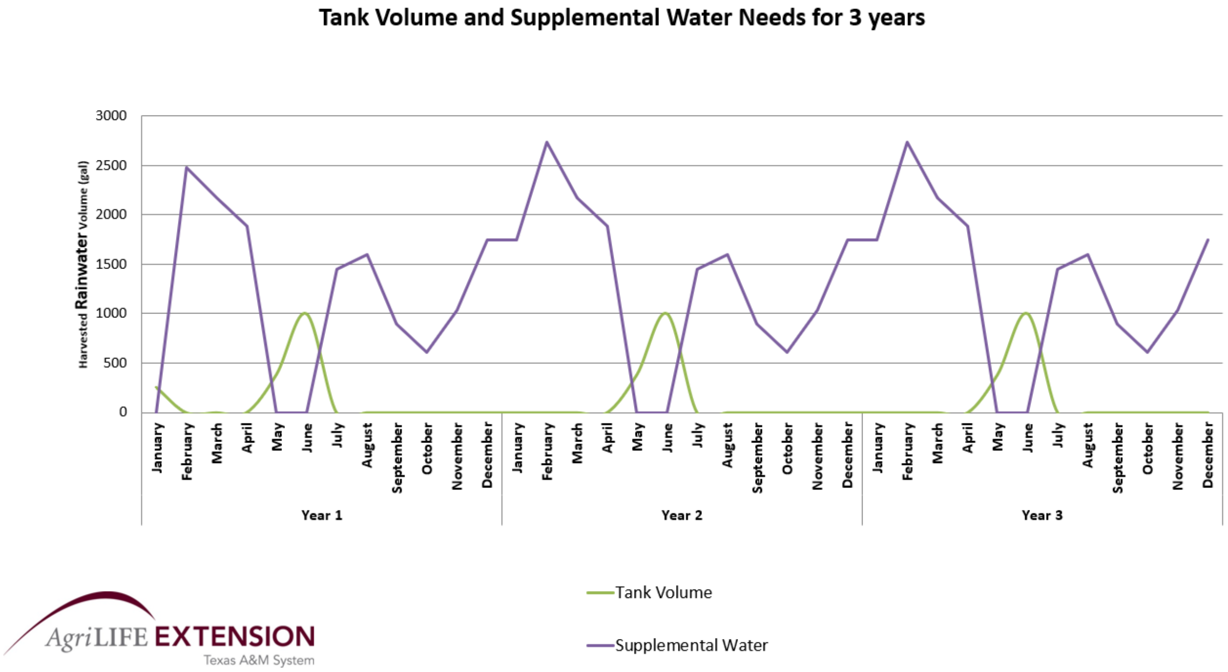


Figure I-63. Output for the tank volume and amount of supplemental water needs over three years for a scenario with a 1,000-gallon tank, a 7,000-gallon water demand, and 3,000 square feet catchment area generated by the Rainwater Harvesting Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

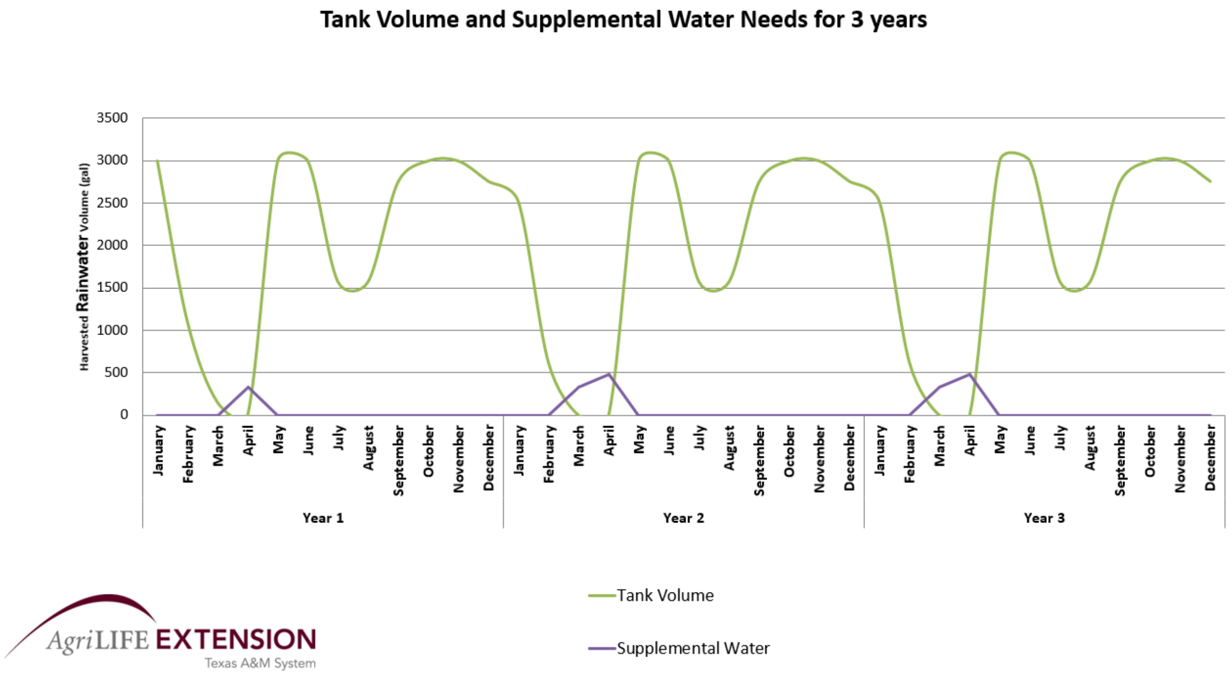


Figure I-64. Output for the tank volume and amount of supplemental water needs over three years for a scenario with a 3,000-gallon tank, a 9,000-gallon water demand, and 5,000 square feet catchment area generated by the Rainwater Harvesting Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

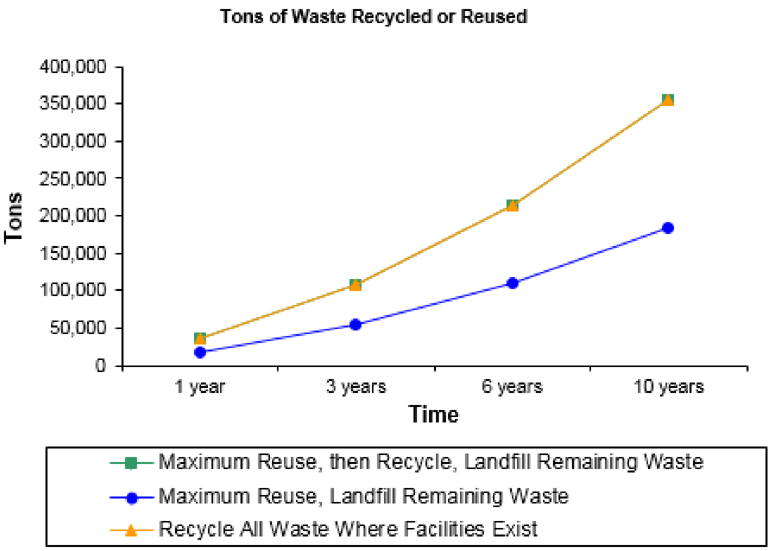


Figure I-65. Comparison of waste recycling and reuse practices over ten years generated by the Recycling and Reusing Landscape Waste Cost Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

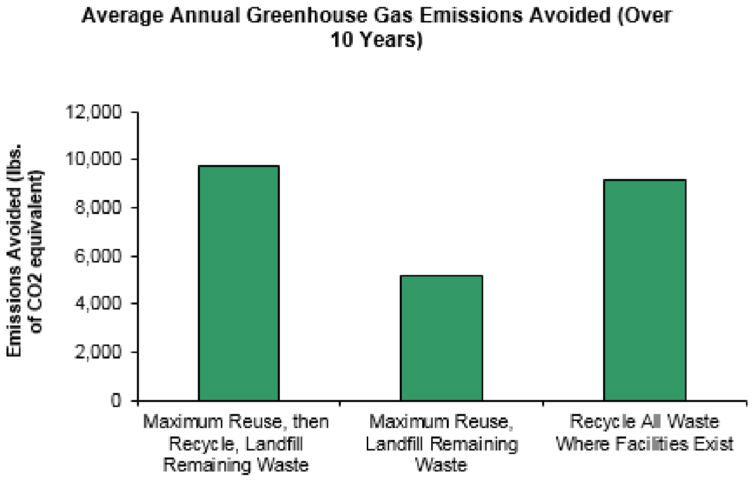


Figure I-66. Comparison of average annual greenhouse gas emissions avoided over ten years with different waste recycling and reuse practices generated by the Recycling and Reusing Landscape Waste Cost Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

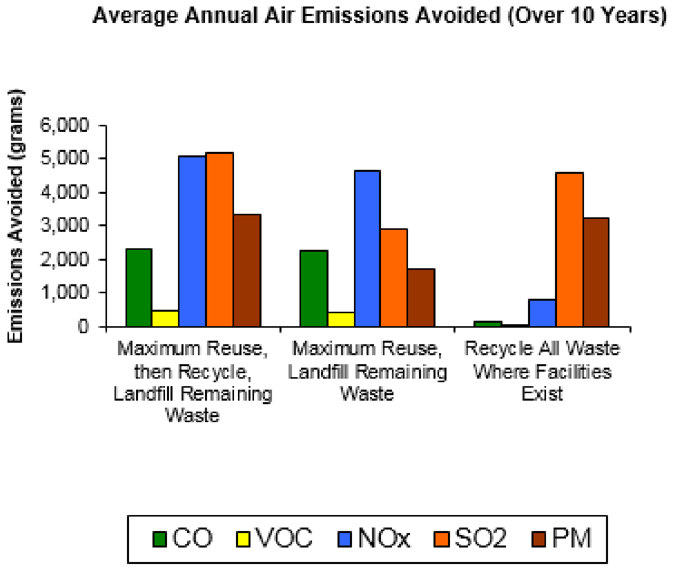


Figure I-67. Output for average annual air emissions avoided with different waste recycling and reuse practices generated by the Recycling and Reusing Landscape Waste Cost Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

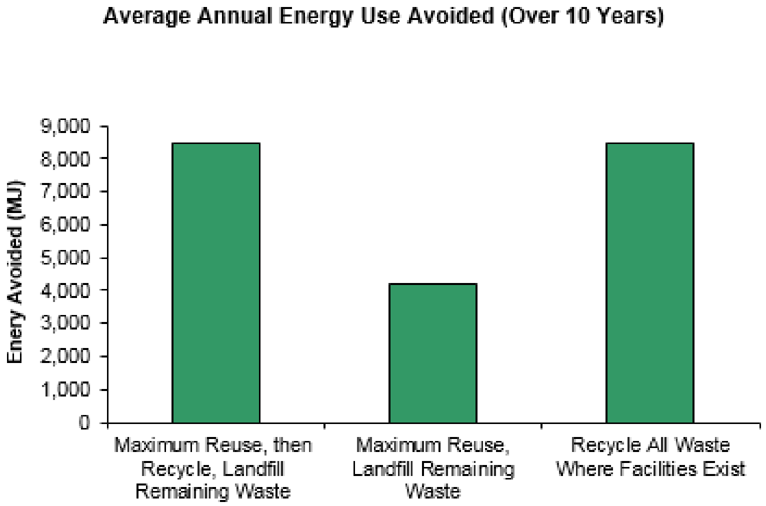


Figure I-68. Output for average annual energy use avoided with different waste recycling and reuse practices generated by the Recycling and Reusing Landscape Waste Cost Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

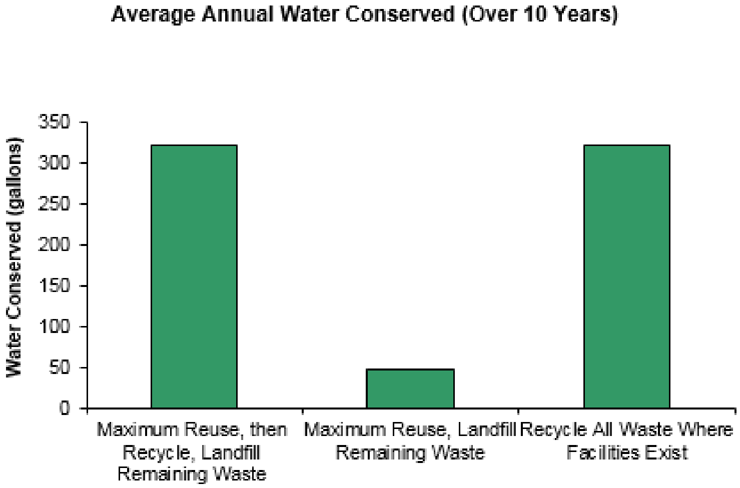


Figure I-69. Output for average annual amount of water conserved with different waste recycling and reuse practices generated by the Recycling and Reusing Landscape Waste Cost Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

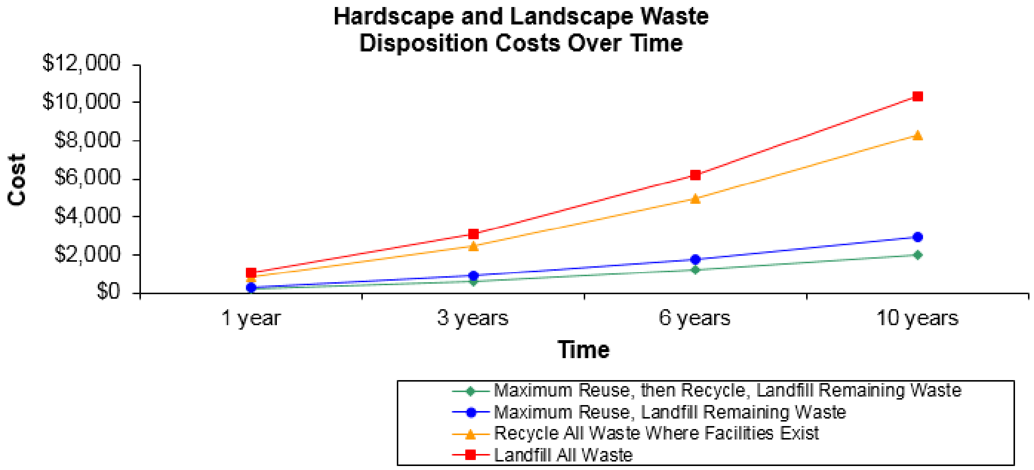


Figure I-70. Output for disposition costs over ten years with different waste recycling and reuse practices generated by the Recycling and Reusing Landscape Waste Cost Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

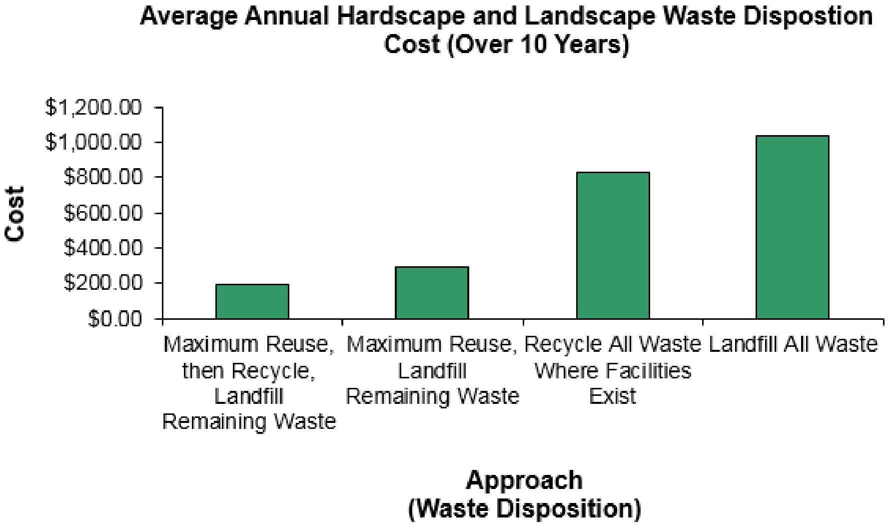


Figure I-71. Output for average annual hardscape and landscape waste disposition with different waste recycling and reuse practices generated by the Recycling and Reusing Landscape Waste Cost Calculator analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

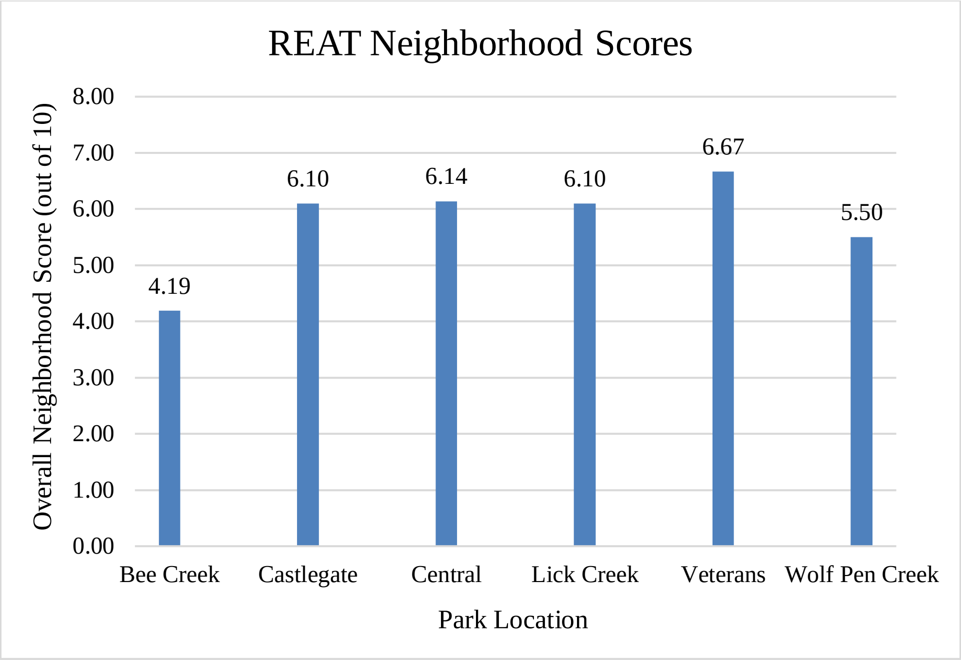


Figure I-72. Output for park neighborhood scores generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

## Street level observations

### Natural surveillance

| | |
|---|---|
| Can you get a clear view of the whole street and houses? | No |

### Greenery

| | |
|---|---|
| Street level greenery | The road is tree lined, there are other purposively planted trees in public spaces, there is purposively planted vegetation in public spaces |

### Neighbourhood condition

| | |
|---|---|
| How littered are the streets? | Predominantly free of litter and refuse except for some small items |
| What is the general condition of public spaces? | Good |
| How much vandalism/graffiti is present on both public spaces and private properties? | Some |

### Miscellaneous

| | |
|---|---|
| How are cars mainly parked? | Predominantly off street private parking |
| Any recreational space (inc. non-green) that children could play on? | Yes |
| Any Neighbourhood Watch signs? | Yes |

Figure I-73. Street observations for Bee Creek Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

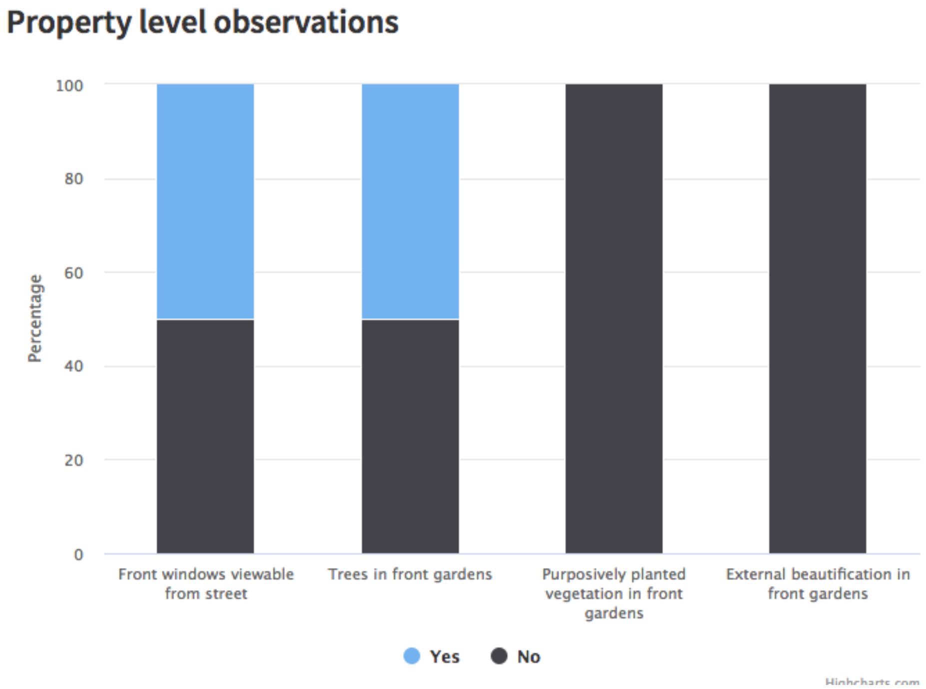


Figure I-74. Property observations for Bee Creek Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

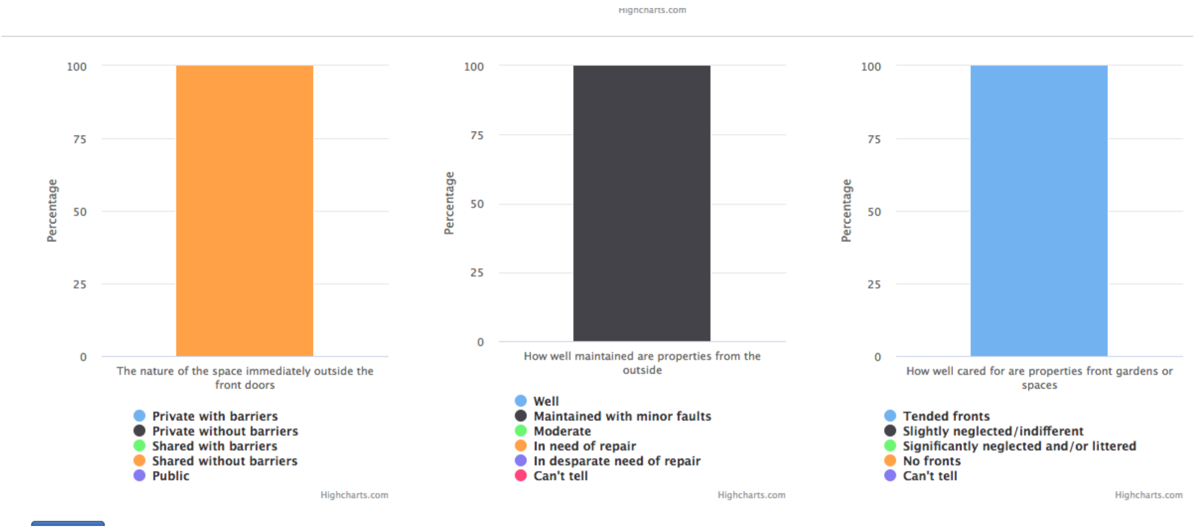
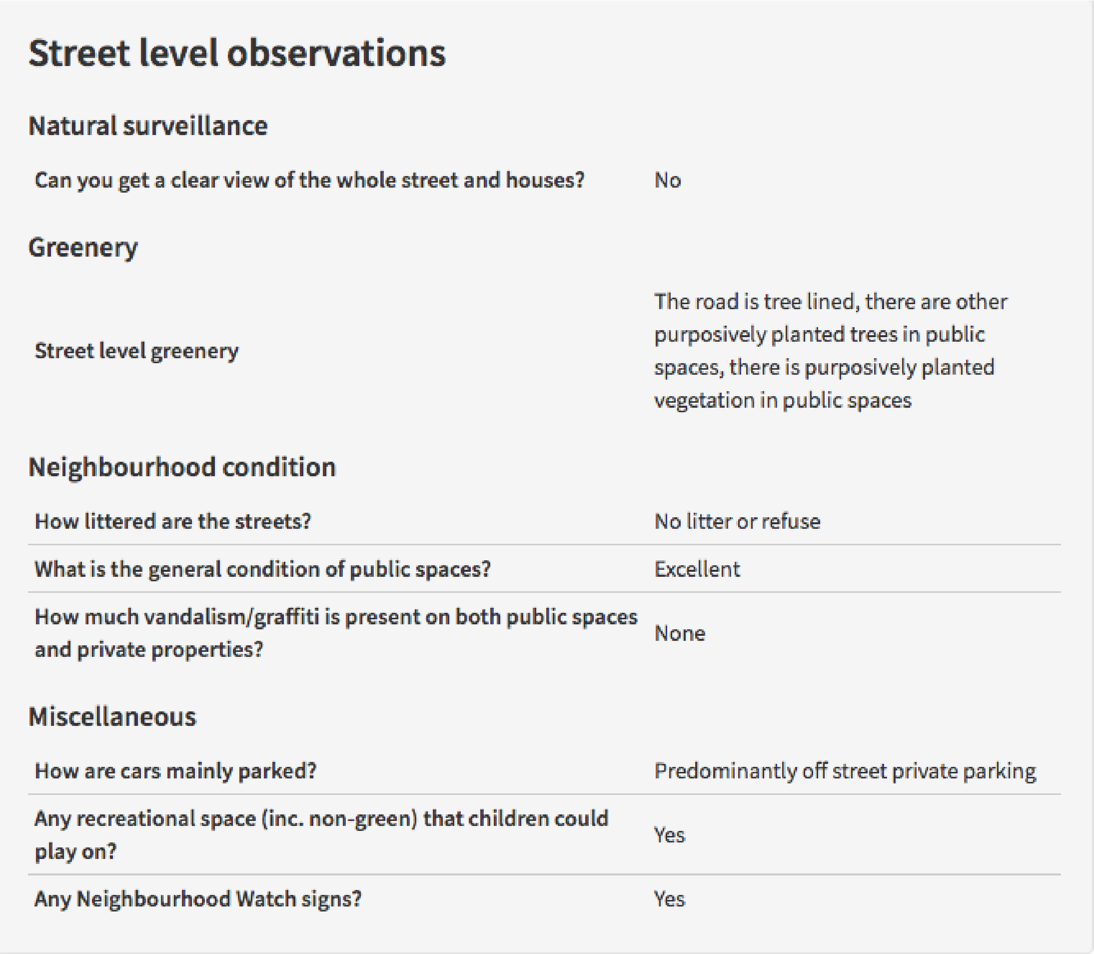


Figure I-75. Maintenance observations for Bee Creek Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



## Street level observations

### Natural surveillance

| | |
|---|---|
| Can you get a clear view of the whole street and houses? | No |

### Greenery

| | |
|---|---|
| Street level greenery | The road is tree lined, there are other purposively planted trees in public spaces, there is purposively planted vegetation in public spaces |

### Neighbourhood condition

| | |
|---|---|
| How littered are the streets? | No litter or refuse |
| What is the general condition of public spaces? | Excellent |
| How much vandalism/graffiti is present on both public spaces and private properties? | None |

### Miscellaneous

| | |
|---|---|
| How are cars mainly parked? | Predominantly off street private parking |
| Any recreational space (inc. non-green) that children could play on? | Yes |
| Any Neighbourhood Watch signs? | Yes |

Figure I-76. Street observations for Castlegate Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

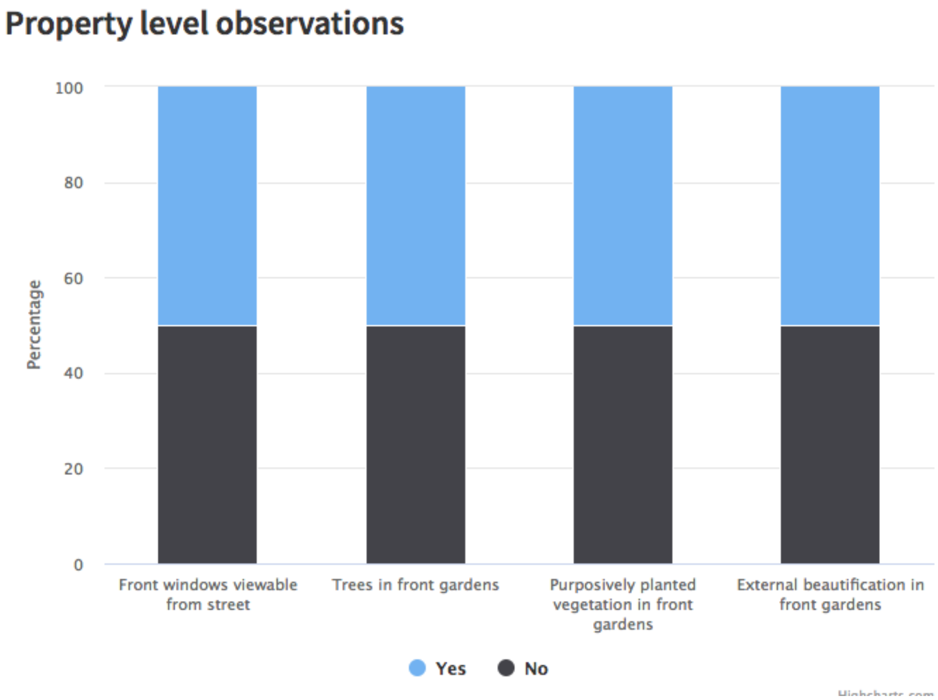


Figure I-77. Property observations for Castlegate Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

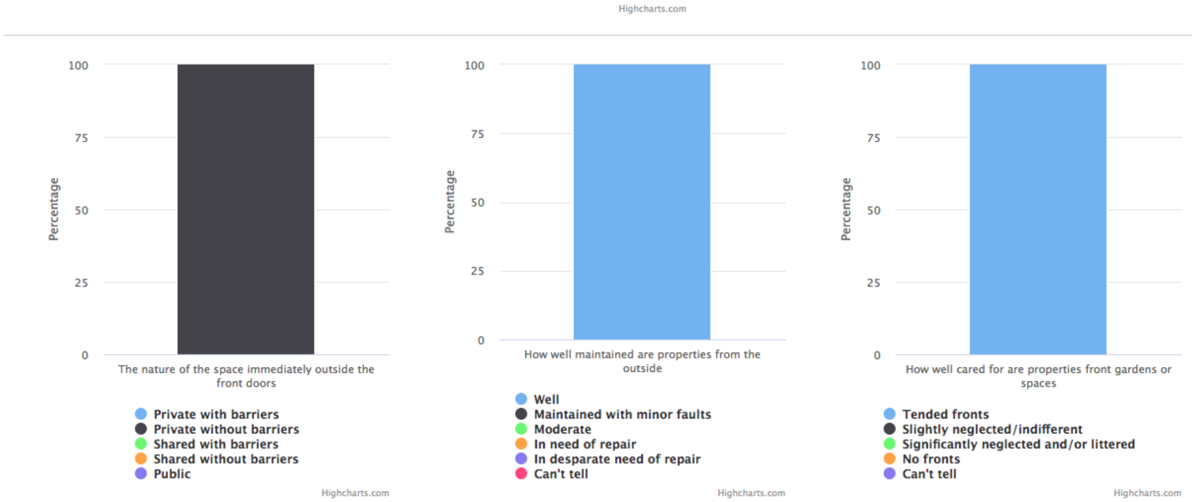


Figure I-78. Maintenance observations for Castlegate Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

## Street level observations

### Natural surveillance

| | |
|---|---|
| Can you get a clear view of the whole street and houses? | Yes |

### Greenery

| | |
|---|---|
| Street level greenery | The road is tree lined, there are other purposively planted trees in public spaces, there is purposively planted vegetation in public spaces |

### Neighbourhood condition

| | |
|---|---|
| How littered are the streets? | Predominantly free of litter and refuse except for some small items |
| What is the general condition of public spaces? | Good |
| How much vandalism/graffiti is present on both public spaces and private properties? | None |

### Miscellaneous

| | |
|---|---|
| How are cars mainly parked? | Predominantly off street private parking |
| Any recreational space (inc. non-green) that children could play on? | Yes |
| Any Neighbourhood Watch signs? | Yes |

Figure I-79. Street observations for Central Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

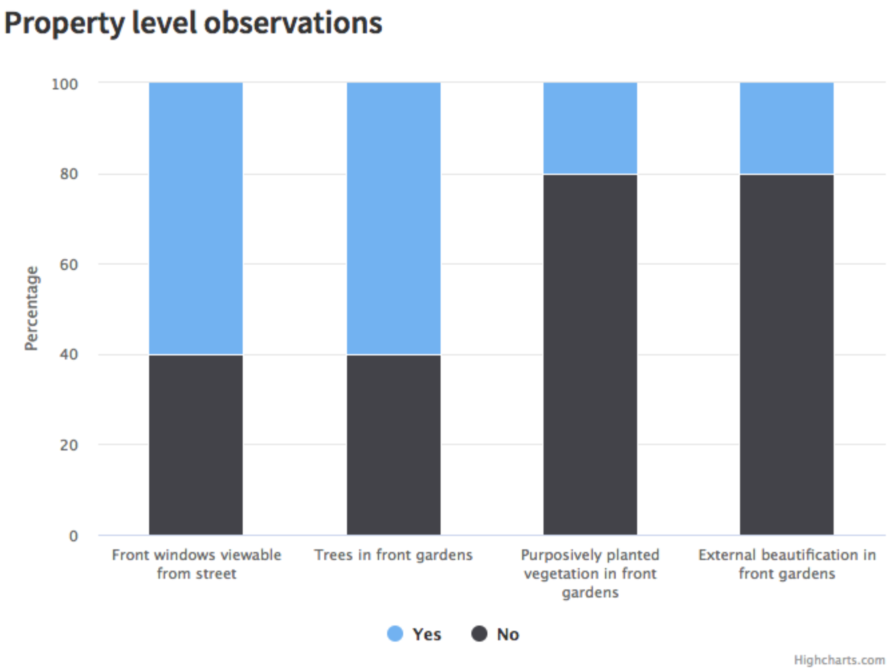


Figure I-80. Property observations for Central Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

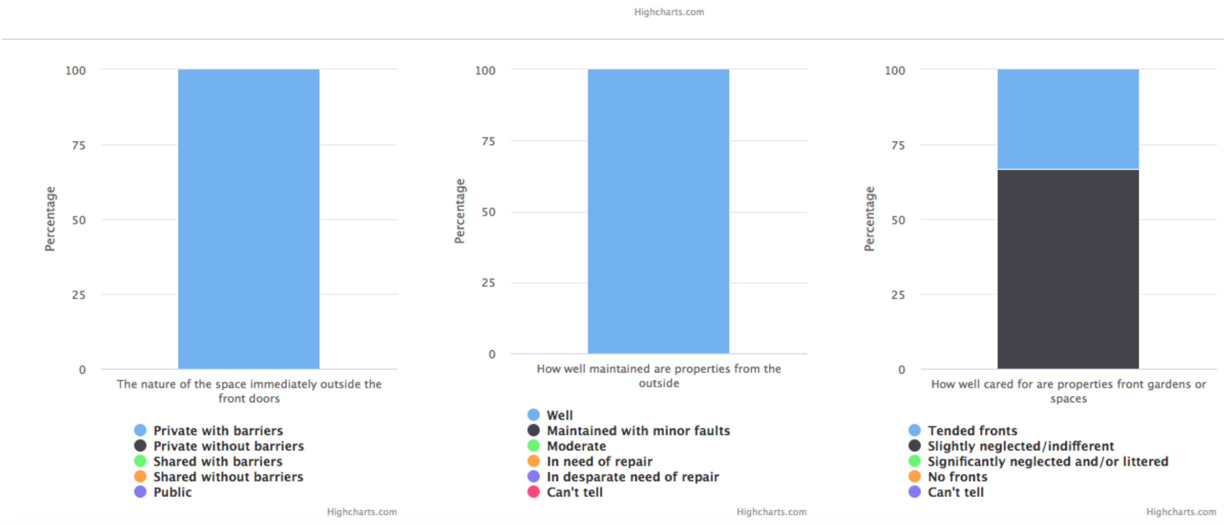


Figure I-81. Maintenance observations for Central Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

## Street level observations

### Natural surveillance

| | |
|---|---|
| Can you get a clear view of the whole street and houses? | No |

### Greenery

| | |
|---|---|
| Street level greenery | The road is tree lined, there are other purposively planted trees in public spaces, there is purposively planted vegetation in public spaces |

### Neighbourhood condition

| | |
|---|---|
| How littered are the streets? | No litter or refuse |
| What is the general condition of public spaces? | Excellent |
| How much vandalism/graffiti is present on both public spaces and private properties? | None |

### Miscellaneous

| | |
|---|---|
| How are cars mainly parked? | Predominantly off street private parking |
| Any recreational space (inc. non-green) that children could play on? | Yes |
| Any Neighbourhood Watch signs? | Yes |

Figure I-82. Street observations for Lick Creek Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

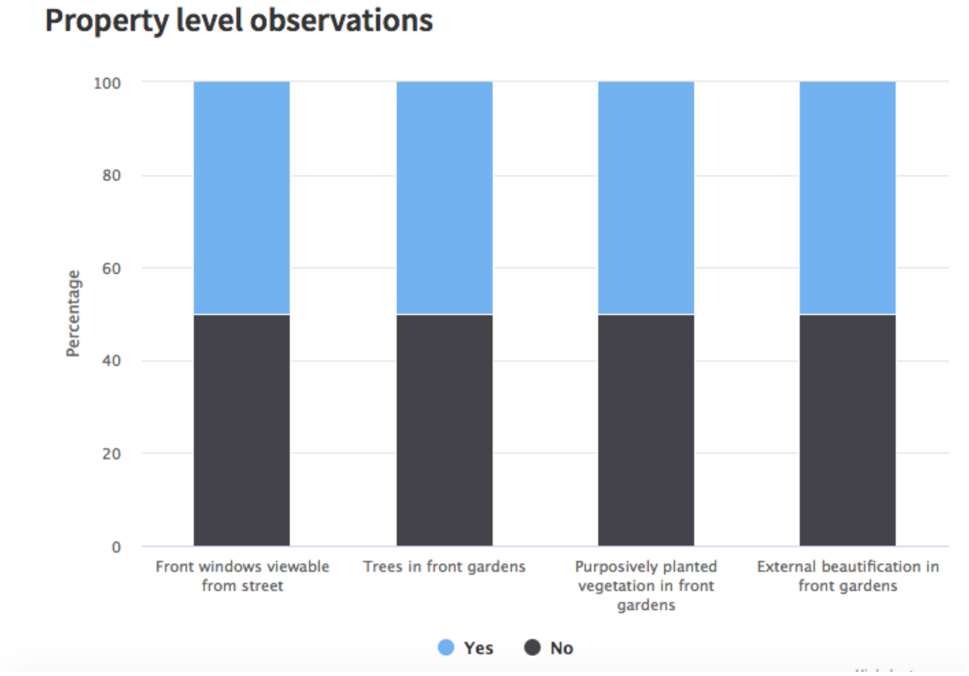


Figure I-83. Property observations for Lick Creek Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

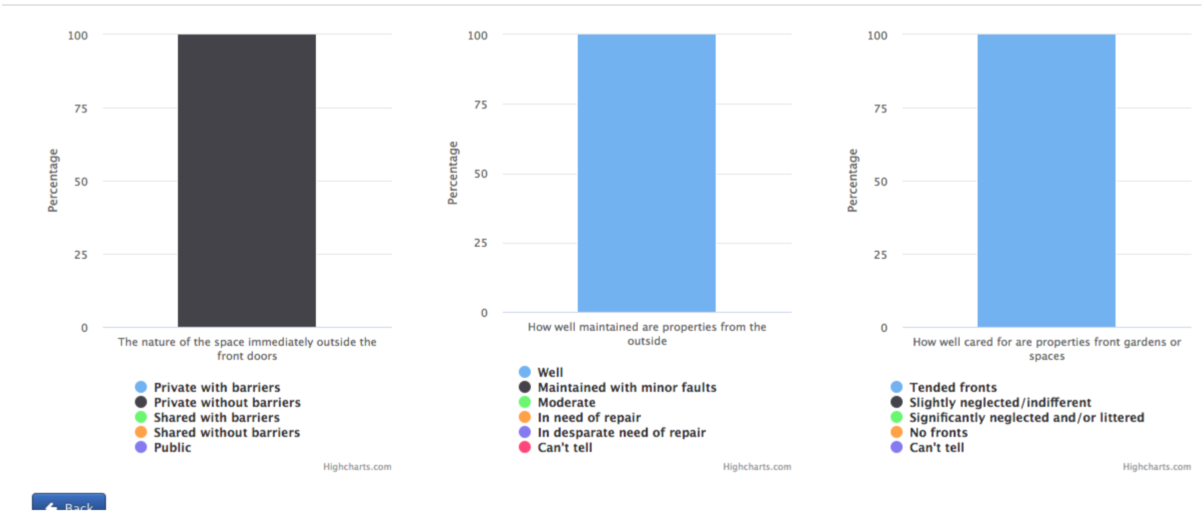
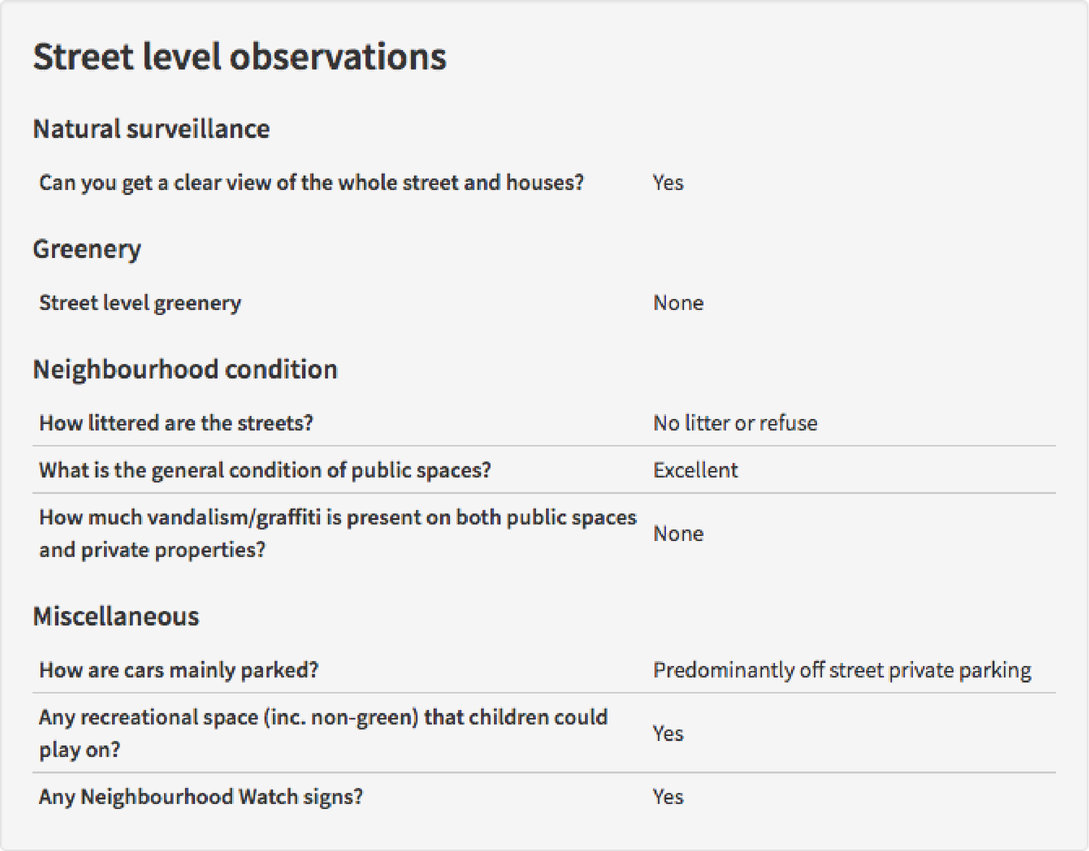


Figure I-84. Maintenance observations for Lick Creek Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



## Street level observations

### Natural surveillance

| | |
|---|---|
| Can you get a clear view of the whole street and houses? | Yes |

### Greenery

| | |
|---|---|
| Street level greenery | None |

### Neighbourhood condition

| | |
|---|---|
| How littered are the streets? | No litter or refuse |
| What is the general condition of public spaces? | Excellent |
| How much vandalism/graffiti is present on both public spaces and private properties? | None |

### Miscellaneous

| | |
|---|---|
| How are cars mainly parked? | Predominantly off street private parking |
| Any recreational space (inc. non-green) that children could play on? | Yes |
| Any Neighbourhood Watch signs? | Yes |

Figure I-85. Street observations for Veterans Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

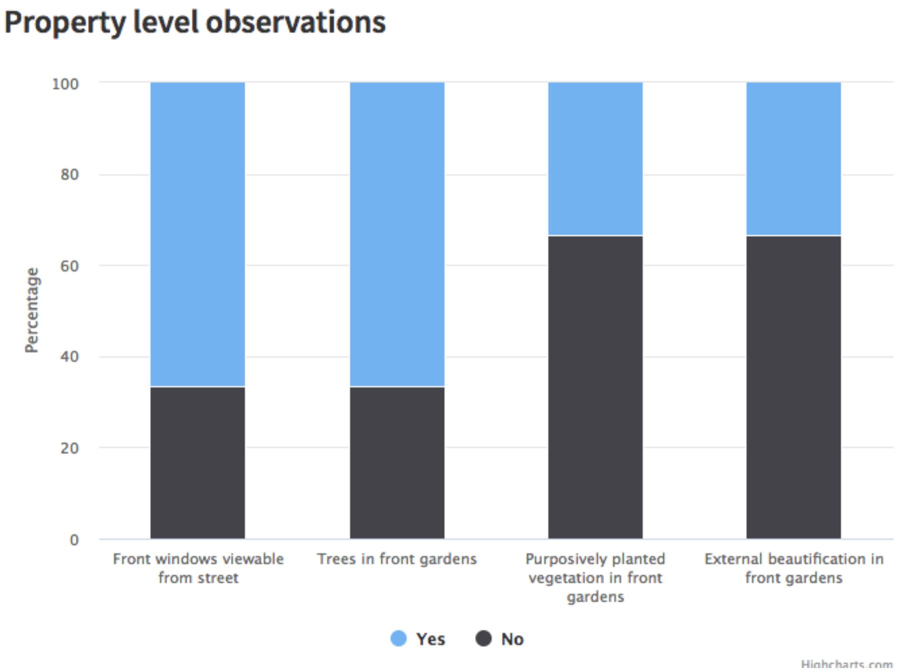


Figure I-86. Property observations for Veterans Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

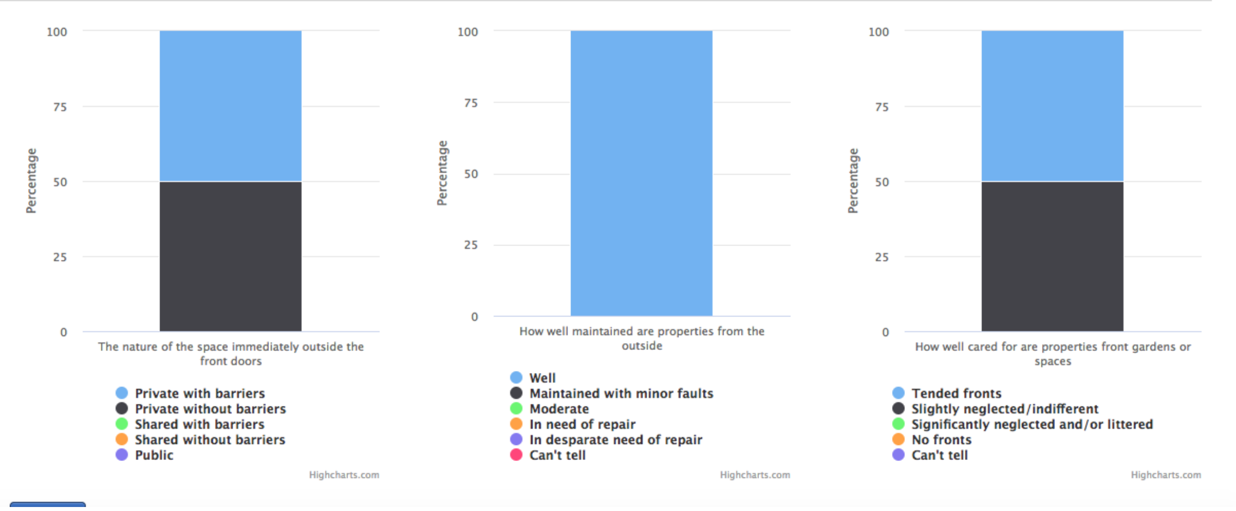


Figure I-87. Maintenance observations for Veterans Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

## Street level observations

### Natural surveillance

| | |
|---|---|
| Can you get a clear view of the whole street and houses? | No |

### Greenery

| | |
|---|---|
| Street level greenery | None |

### Neighbourhood condition

| | |
|---|---|
| How littered are the streets? | No litter or refuse |
| What is the general condition of public spaces? | Excellent |
| How much vandalism/graffiti is present on both public spaces and private properties? | None |

### Miscellaneous

| | |
|---|---|
| How are cars mainly parked? | Predominantly off street private parking |
| Any recreational space (inc. non-green) that children could play on? | No |
| Any Neighbourhood Watch signs? | No |

Figure I-88. Street observations for Wolf Pen Creek Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

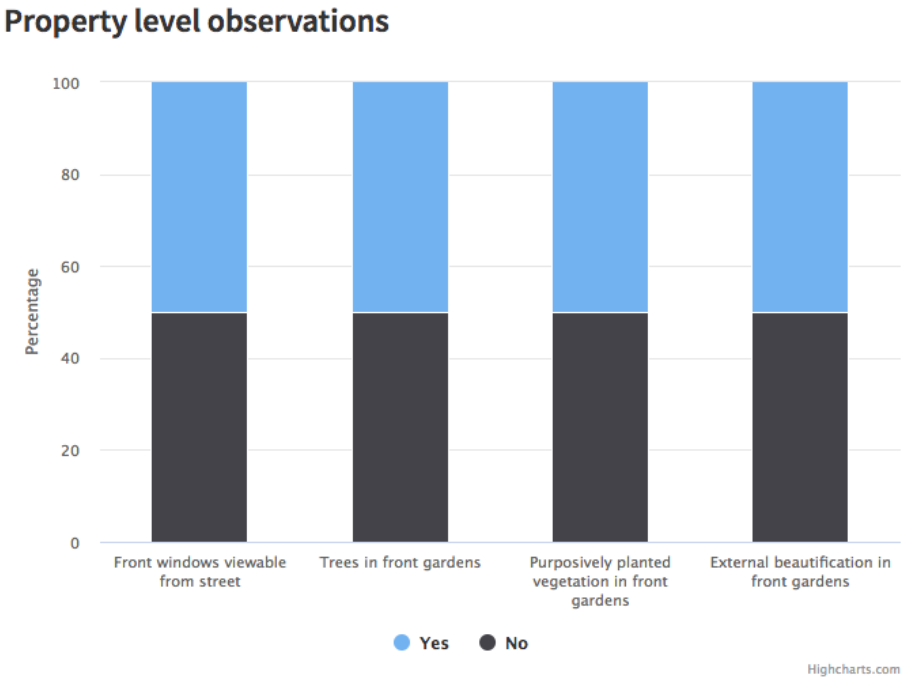


Figure I-89. Property observations for Wolf Pen Creek Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

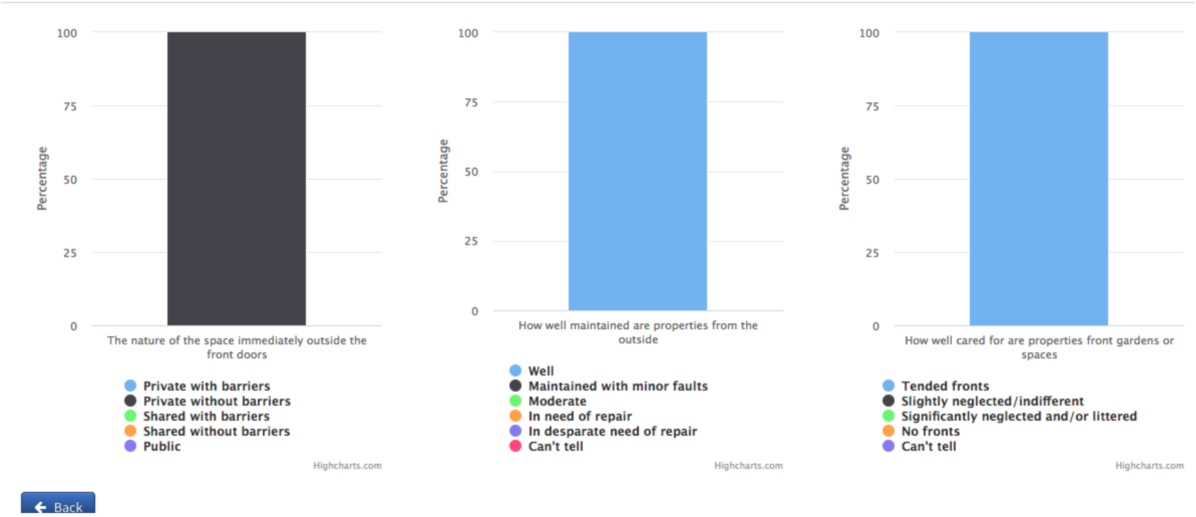


Figure I-90. Maintenance observations for Wolf Pen Creek Park generated by the Residential Environment Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

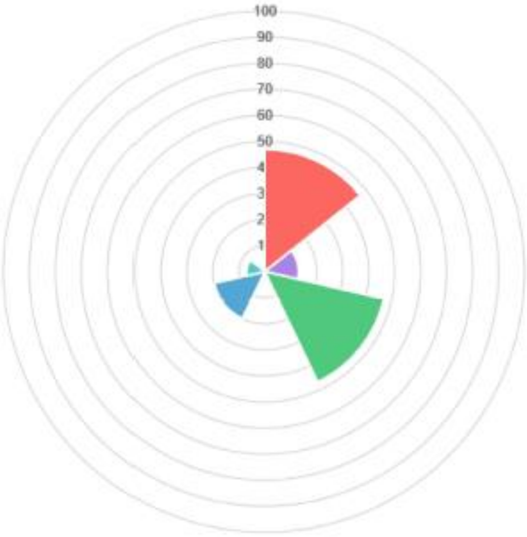


Figure I-91. Scoring output for responses by the City of College Station generated by the Social Value Self-Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

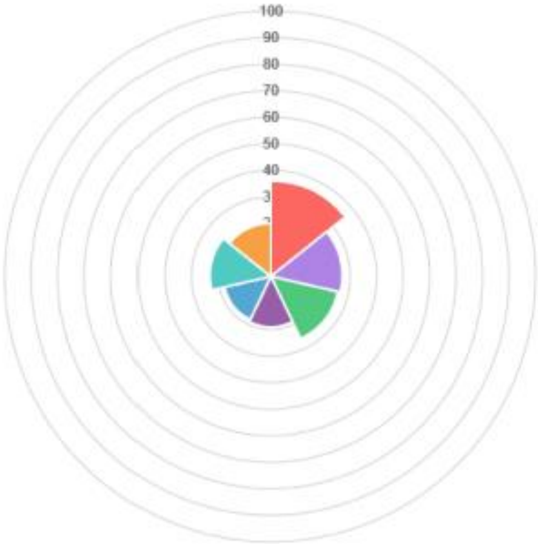


Figure I-92. Average scoring for responses by cultural and recreational organizations generated by the Social Value Self-Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

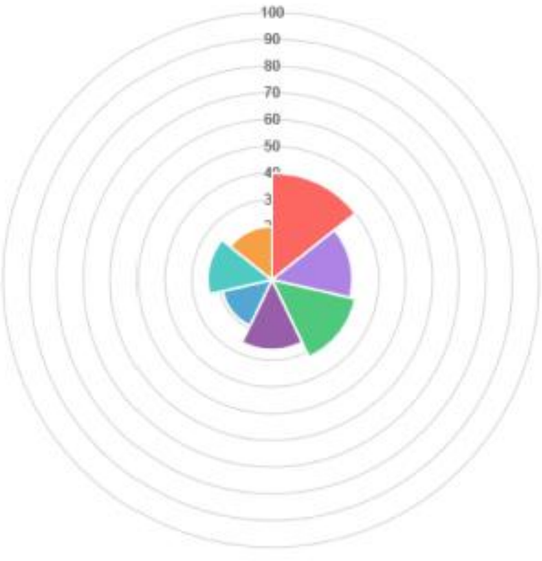
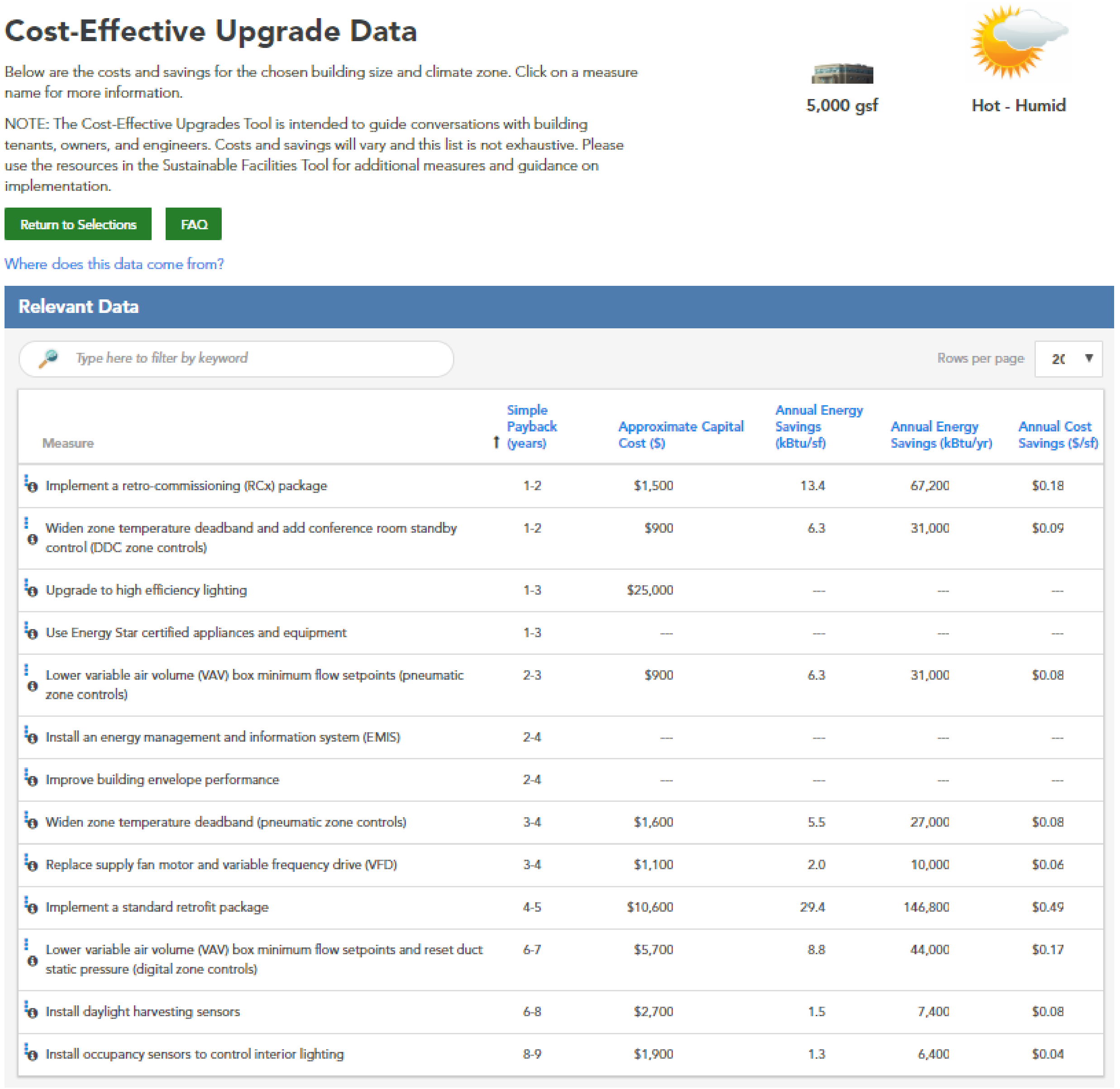


Figure I-93. Average scoring for responses by cultural and recreational organizations generated by the Social Value Self-Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



## Cost-Effective Upgrade Data

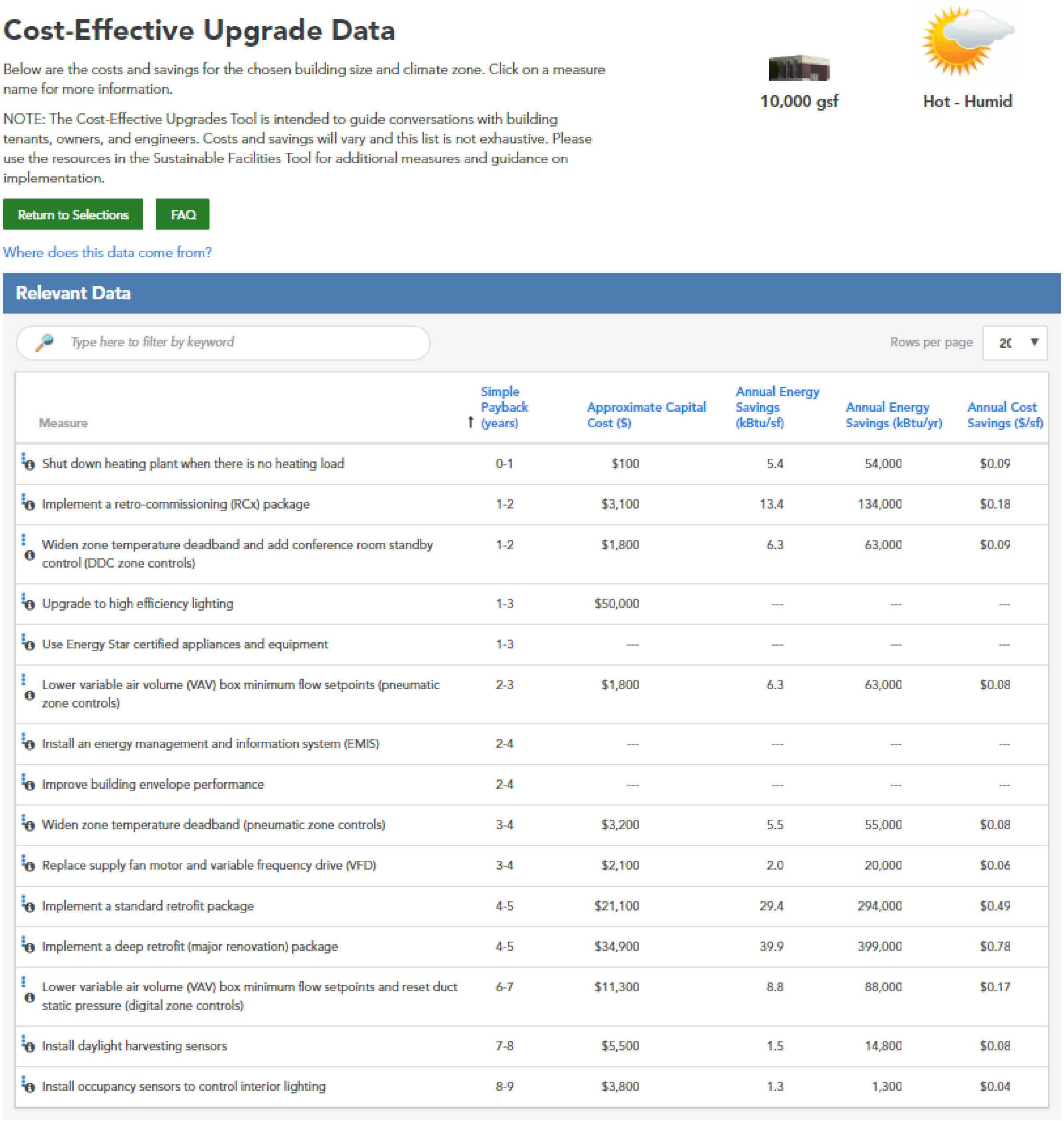
Below are the costs and savings for the chosen building size and climate zone. Click on a measure name for more information.

NOTE: The Cost-Effective Upgrades Tool is intended to guide conversations with building tenants, owners, and engineers. Costs and savings will vary and this list is not exhaustive. Please use the resources in the Sustainable Facilities Tool for additional measures and guidance on implementation.

### Relevant Data

| Measure | Simple Payback (years) | Approximate Capital Cost ($) | Annual Energy Savings (kBtu/sf) | Annual Energy Savings (kBtu/yr) | Annual Cost Savings ($/sf) |
|---|---|---|---|---|---|
| Implement a retro-commissioning (RCx) package | 1-2 | $1,500 | 13.4 | 67,200 | $0.18 |
| Widen zone temperature deadband and add conference room standby control (DDC zone controls) | 1-2 | $900 | 6.3 | 31,000 | $0.09 |
| Upgrade to high efficiency lighting | 1-3 | $25,000 | --- | --- | --- |
| Use Energy Star certified appliances and equipment | 1-3 | --- | --- | --- | --- |
| Lower variable air volume (VAV) box minimum flow setpoints (pneumatic zone controls) | 2-3 | $900 | 6.3 | 31,000 | $0.08 |
| Install an energy management and information system (EMIS) | 2-4 | --- | --- | --- | --- |
| Improve building envelope performance | 2-4 | --- | --- | --- | --- |
| Widen zone temperature deadband (pneumatic zone controls) | 3-4 | $1,600 | 5.5 | 27,000 | $0.08 |
| Replace supply fan motor and variable frequency drive (VFD) | 3-4 | $1,100 | 2.0 | 10,000 | $0.06 |
| Implement a standard retrofit package | 4-5 | $10,600 | 29.4 | 146,800 | $0.49 |
| Lower variable air volume (VAV) box minimum flow setpoints and reset duct static pressure (digital zone controls) | 6-7 | $5,700 | 8.8 | 44,000 | $0.17 |
| Install daylight harvesting sensors | 6-8 | $2,700 | 1.5 | 7,400 | $0.08 |
| Install occupancy sensors to control interior lighting | 8-9 | $1,900 | 1.3 | 6,400 | $0.04 |

Figure I-94. Output of cost upgrades for a 5,000-square foot building generated by the Sustainable Facilities Cost-Effective Upgrades Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



**Cost-Effective Upgrade Data**

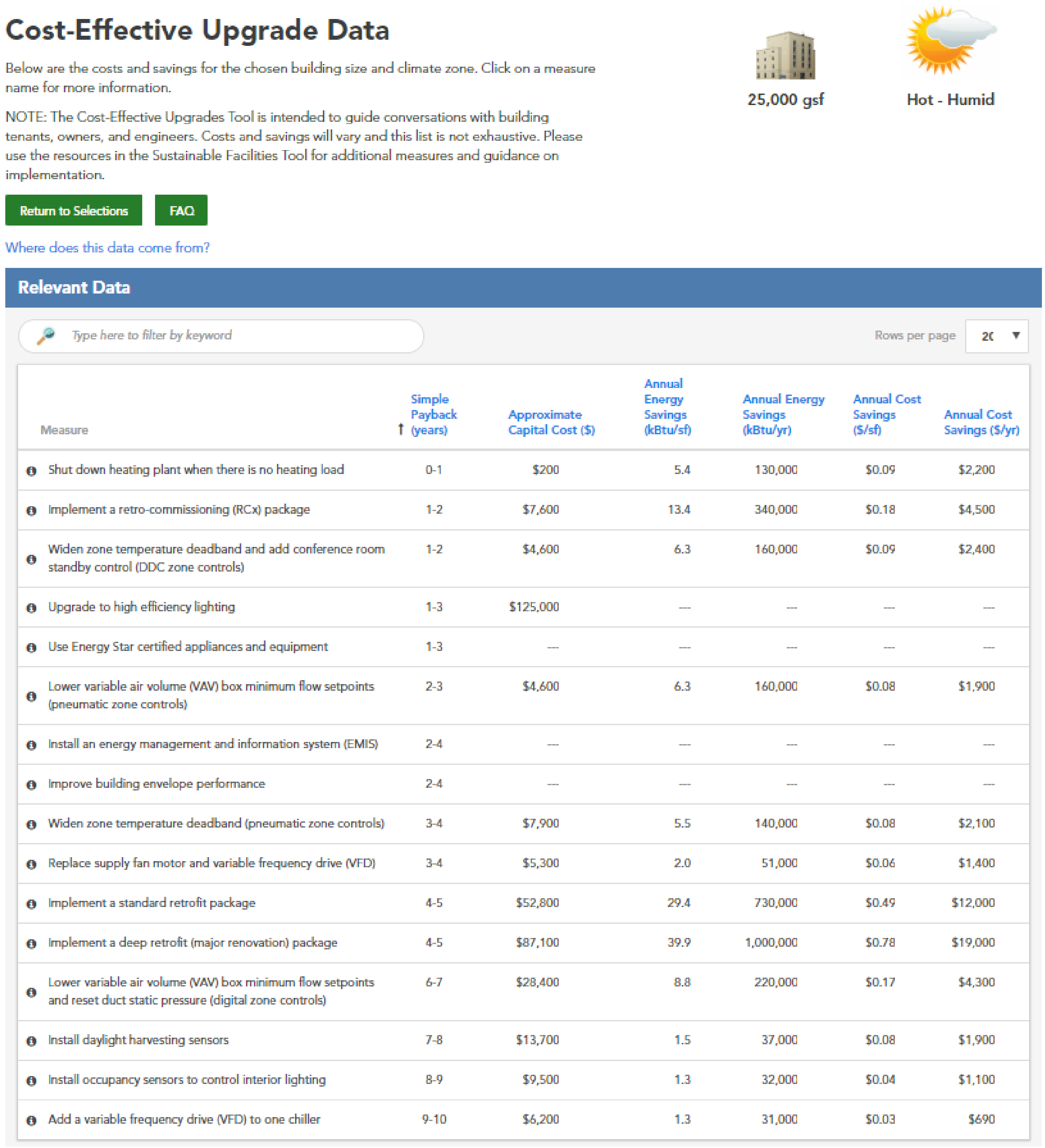
Below are the costs and savings for the chosen building size and climate zone. Click on a measure name for more information.

NOTE: The Cost-Effective Upgrades Tool is intended to guide conversations with building tenants, owners, and engineers. Costs and savings will vary and this list is not exhaustive. Please use the resources in the Sustainable Facilities Tool for additional measures and guidance on implementation.

**Relevant Data**

| Measure | Simple Payback (years) | Approximate Capital Cost ($) | Annual Energy Savings (kBtu/sf) | Annual Energy Savings (kBtu/yr) | Annual Cost Savings ($/sf) |
|---|---|---|---|---|---|
| Shut down heating plant when there is no heating load | 0-1 | $100 | 5.4 | 54,000 | $0.09 |
| Implement a retro-commissioning (RCx) package | 1-2 | $3,100 | 13.4 | 134,000 | $0.18 |
| Widen zone temperature deadband and add conference room standby control (DDC zone controls) | 1-2 | $1,800 | 6.3 | 63,000 | $0.09 |
| Upgrade to high efficiency lighting | 1-3 | $50,000 | — | — | — |
| Use Energy Star certified appliances and equipment | 1-3 | — | — | — | — |
| Lower variable air volume (VAV) box minimum flow setpoints (pneumatic zone controls) | 2-3 | $1,800 | 6.3 | 63,000 | $0.08 |
| Install an energy management and information system (EMIS) | 2-4 | — | — | — | — |
| Improve building envelope performance | 2-4 | — | — | — | — |
| Widen zone temperature deadband (pneumatic zone controls) | 3-4 | $3,200 | 5.5 | 55,000 | $0.08 |
| Replace supply fan motor and variable frequency drive (VFD) | 3-4 | $2,100 | 2.0 | 20,000 | $0.06 |
| Implement a standard retrofit package | 4-5 | $21,100 | 29.4 | 294,000 | $0.49 |
| Implement a deep retrofit (major renovation) package | 4-5 | $34,900 | 39.9 | 399,000 | $0.78 |
| Lower variable air volume (VAV) box minimum flow setpoints and reset duct static pressure (digital zone controls) | 6-7 | $11,300 | 8.8 | 88,000 | $0.17 |
| Install daylight harvesting sensors | 7-8 | $5,500 | 1.5 | 14,800 | $0.08 |
| Install occupancy sensors to control interior lighting | 8-9 | $3,800 | 1.3 | 1,300 | $0.04 |

Figure I-95. Output of cost upgrades for a 10,000-square foot building generated by the Sustainable Facilities Cost-Effective Upgrades Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



## Cost-Effective Upgrade Data

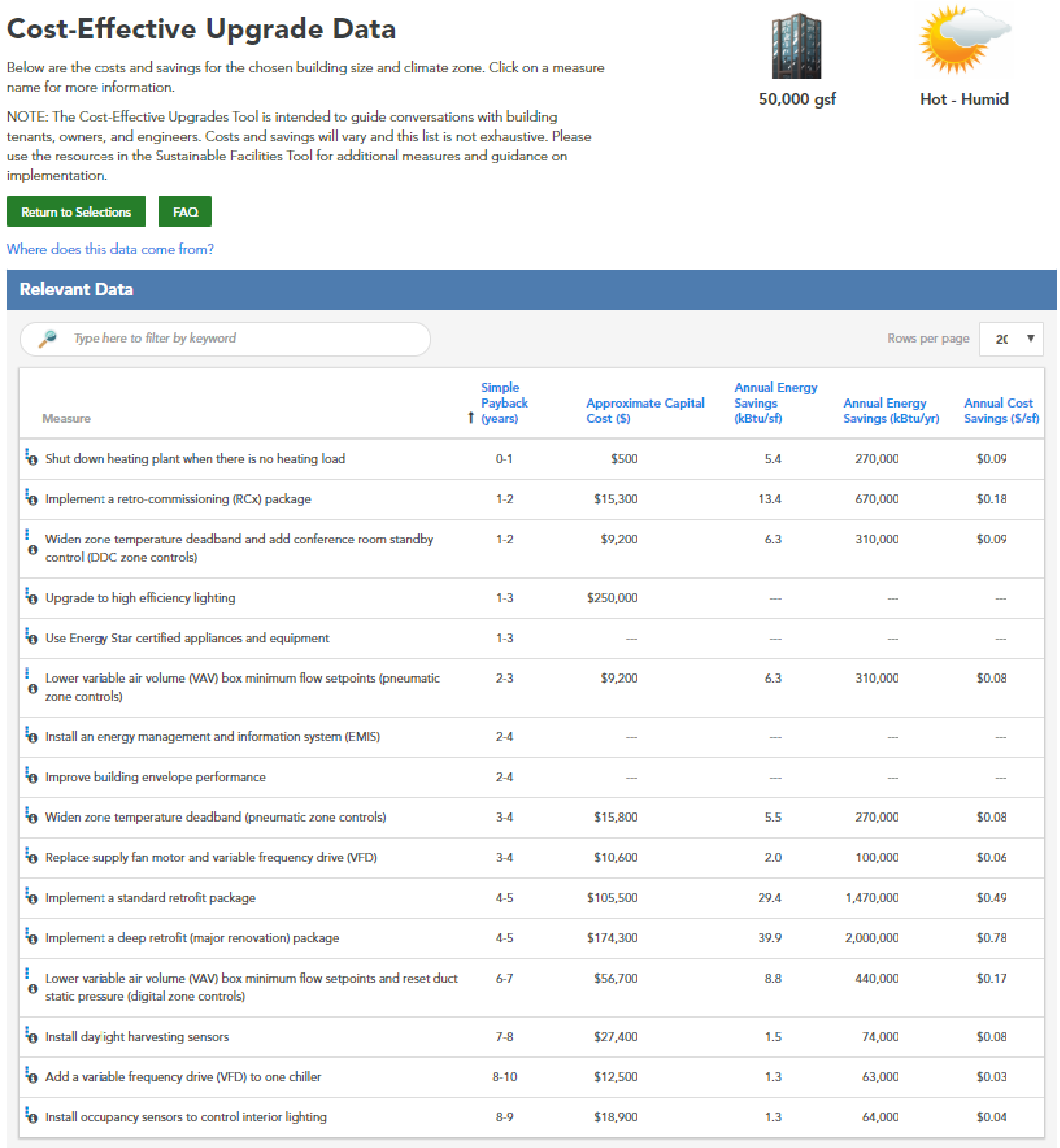
Below are the costs and savings for the chosen building size and climate zone. Click on a measure name for more information.

NOTE: The Cost-Effective Upgrades Tool is intended to guide conversations with building tenants, owners, and engineers. Costs and savings will vary and this list is not exhaustive. Please use the resources in the Sustainable Facilities Tool for additional measures and guidance on implementation.

**Relevant Data**

| Measure | Simple Payback ↑ (years) | Approximate Capital Cost ($) | Annual Energy Savings (kBtu/sf) | Annual Energy Savings (kBtu/yr) | Annual Cost Savings ($/sf) | Annual Cost Savings ($/yr) |
|---|---|---|---|---|---|---|
| Shut down heating plant when there is no heating load | 0-1 | $200 | 5.4 | 130,000 | $0.09 | $2,200 |
| Implement a retro-commissioning (RCx) package | 1-2 | $7,600 | 13.4 | 340,000 | $0.18 | $4,500 |
| Widen zone temperature deadband and add conference room standby control (DDC zone controls) | 1-2 | $4,600 | 6.3 | 160,000 | $0.09 | $2,400 |
| Upgrade to high efficiency lighting | 1-3 | $125,000 | — | — | — | — |
| Use Energy Star certified appliances and equipment | 1-3 | — | — | — | — | — |
| Lower variable air volume (VAV) box minimum flow setpoints (pneumatic zone controls) | 2-3 | $4,600 | 6.3 | 160,000 | $0.08 | $1,900 |
| Install an energy management and information system (EMIS) | 2-4 | — | — | — | — | — |
| Improve building envelope performance | 2-4 | — | — | — | — | — |
| Widen zone temperature deadband (pneumatic zone controls) | 3-4 | $7,900 | 5.5 | 140,000 | $0.08 | $2,100 |
| Replace supply fan motor and variable frequency drive (VFD) | 3-4 | $5,300 | 2.0 | 51,000 | $0.06 | $1,400 |
| Implement a standard retrofit package | 4-5 | $52,800 | 29.4 | 730,000 | $0.49 | $12,000 |
| Implement a deep retrofit (major renovation) package | 4-5 | $87,100 | 39.9 | 1,000,000 | $0.78 | $19,000 |
| Lower variable air volume (VAV) box minimum flow setpoints and reset duct static pressure (digital zone controls) | 6-7 | $28,400 | 8.8 | 220,000 | $0.17 | $4,300 |
| Install daylight harvesting sensors | 7-8 | $13,700 | 1.5 | 37,000 | $0.08 | $1,900 |
| Install occupancy sensors to control interior lighting | 8-9 | $9,500 | 1.3 | 32,000 | $0.04 | $1,100 |
| Add a variable frequency drive (VFD) to one chiller | 9-10 | $6,200 | 1.3 | 31,000 | $0.03 | $690 |

Figure I-96. Output of cost upgrades for a 25,000-square foot building generated by the Sustainable Facilities Cost-Effective Upgrades Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



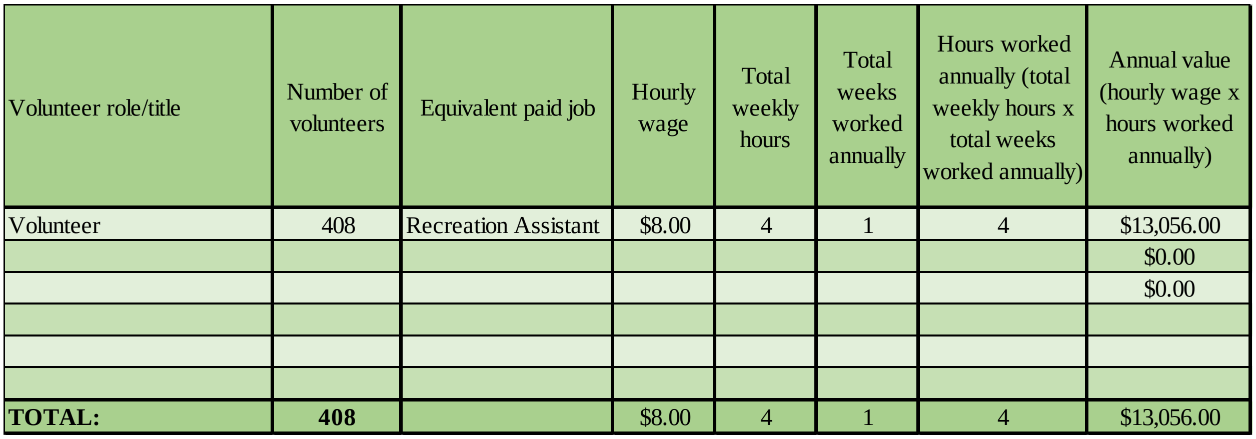
## Cost-Effective Upgrade Data

Below are the costs and savings for the chosen building size and climate zone. Click on a measure name for more information.

NOTE: The Cost-Effective Upgrades Tool is intended to guide conversations with building tenants, owners, and engineers. Costs and savings will vary and this list is not exhaustive. Please use the resources in the Sustainable Facilities Tool for additional measures and guidance on implementation.

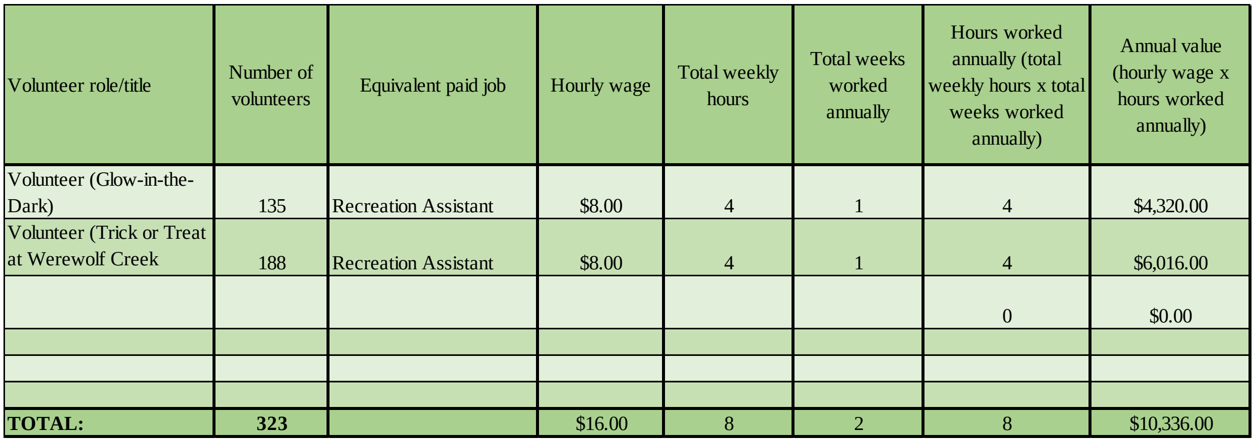
| Measure | Simple Payback (years) | Approximate Capital Cost ($) | Annual Energy Savings (kBtu/sf) | Annual Energy Savings (kBtu/yr) | Annual Cost Savings ($/sf) |
|---|---|---|---|---|---|
| Shut down heating plant when there is no heating load | 0-1 | $500 | 5.4 | 270,000 | $0.09 |
| Implement a retro-commissioning (RCx) package | 1-2 | $15,300 | 13.4 | 670,000 | $0.18 |
| Widen zone temperature deadband and add conference room standby control (DDC zone controls) | 1-2 | $9,200 | 6.3 | 310,000 | $0.09 |
| Upgrade to high efficiency lighting | 1-3 | $250,000 | — | — | — |
| Use Energy Star certified appliances and equipment | 1-3 | — | — | — | — |
| Lower variable air volume (VAV) box minimum flow setpoints (pneumatic zone controls) | 2-3 | $9,200 | 6.3 | 310,000 | $0.08 |
| Install an energy management and information system (EMIS) | 2-4 | — | — | — | — |
| Improve building envelope performance | 2-4 | — | — | — | — |
| Widen zone temperature deadband (pneumatic zone controls) | 3-4 | $15,800 | 5.5 | 270,000 | $0.08 |
| Replace supply fan motor and variable frequency drive (VFD) | 3-4 | $10,600 | 2.0 | 100,000 | $0.06 |
| Implement a standard retrofit package | 4-5 | $105,500 | 29.4 | 1,470,000 | $0.49 |
| Implement a deep retrofit (major renovation) package | 4-5 | $174,300 | 39.9 | 2,000,000 | $0.78 |
| Lower variable air volume (VAV) box minimum flow setpoints and reset duct static pressure (digital zone controls) | 6-7 | $56,700 | 8.8 | 440,000 | $0.17 |
| Install daylight harvesting sensors | 7-8 | $27,400 | 1.5 | 74,000 | $0.08 |
| Add a variable frequency drive (VFD) to one chiller | 8-10 | $12,500 | 1.3 | 63,000 | $0.03 |
| Install occupancy sensors to control interior lighting | 8-9 | $18,900 | 1.3 | 64,000 | $0.04 |

Figure I-97. Output of cost upgrades for a 50,000-square foot building generated by the Sustainable Facilities Cost-Effective Upgrades Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



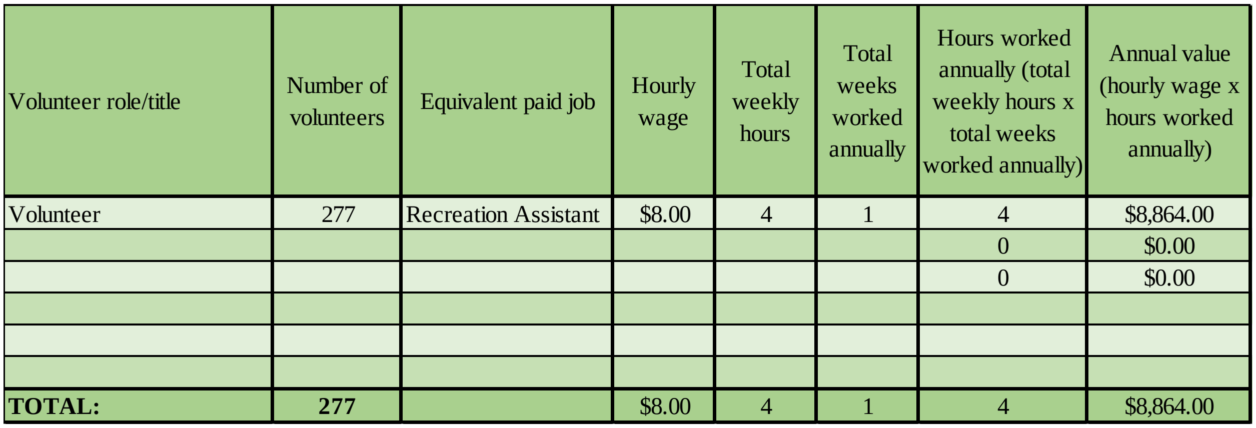
| Volunteer role/title | Number of volunteers | Equivalent paid job | Hourly wage | Total weekly hours | Total weeks worked annually | Hours worked annually (total weekly hours x total weeks worked annually) | Annual value (hourly wage x hours worked annually) |
|---|---|---|---|---|---|---|---|
| Volunteer | 408 | Recreation Assistant | $8.00 | 4 | 1 | 4 | $13,056.00 |
| | | | | | | | $0.00 |
| | | | | | | | $0.00 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| **TOTAL:** | **408** | | $8.00 | 4 | 1 | 4 | $13,056.00 |

Figure I-98. Impact value of volunteers at Central Park generated by the Volunteering Impact Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



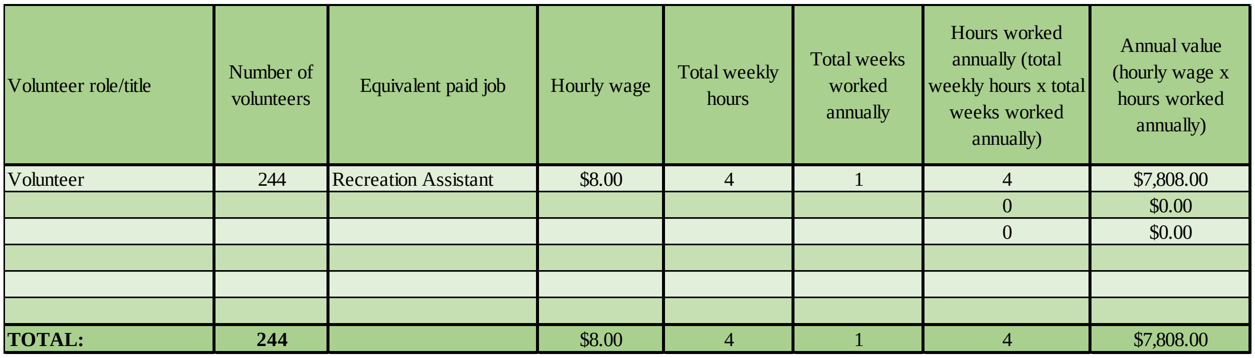
| Volunteer role/title | Number of volunteers | Equivalent paid job | Hourly wage | Total weekly hours | Total weeks worked annually | Hours worked annually (total weekly hours x total weeks worked annually) | Annual value (hourly wage x hours worked annually) |
|---|---|---|---|---|---|---|---|
| Volunteer (Glow-in-the-Dark) | 135 | Recreation Assistant | $8.00 | 4 | 1 | 4 | $4,320.00 |
| Volunteer (Trick or Treat at Werewolf Creek | 188 | Recreation Assistant | $8.00 | 4 | 1 | 4 | $6,016.00 |
| | | | | | | 0 | $0.00 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| **TOTAL:** | **323** | | $16.00 | 8 | 2 | 8 | $10,336.00 |

Figure I-99. Impact value of volunteers at Wolf Pen Creek Park generated by the Volunteering Impact Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



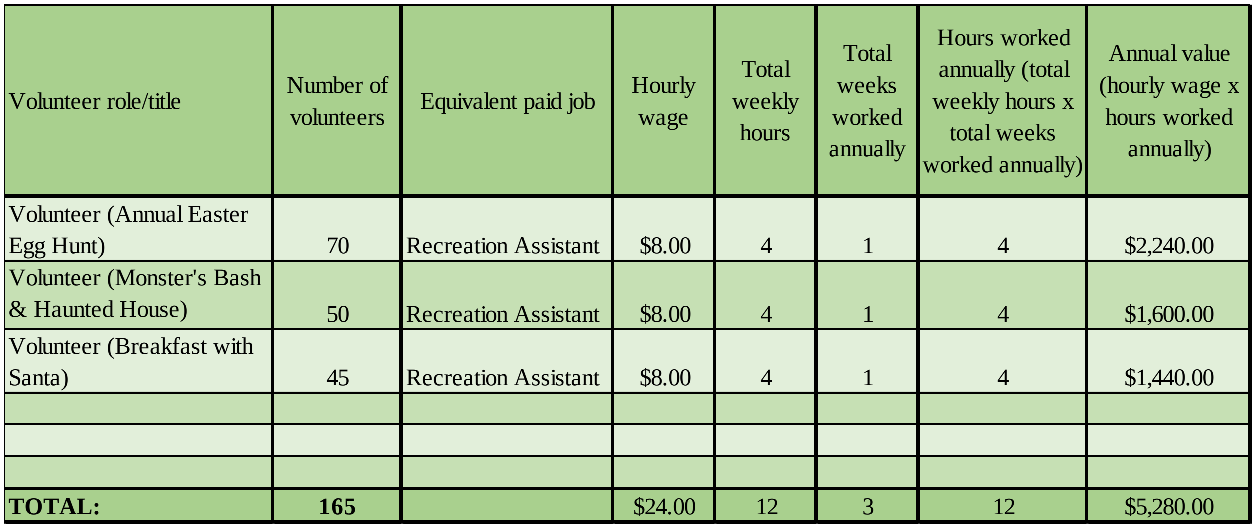
| Volunteer role/title | Number of volunteers | Equivalent paid job | Hourly wage | Total weekly hours | Total weeks worked annually | Hours worked annually (total weekly hours x total weeks worked annually) | Annual value (hourly wage x hours worked annually) |
|---|---|---|---|---|---|---|---|
| Volunteer | 277 | Recreation Assistant | $8.00 | 4 | 1 | 4 | $8,864.00 |
| | | | | | | 0 | $0.00 |
| | | | | | | 0 | $0.00 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| **TOTAL:** | **277** | | $8.00 | 4 | 1 | 4 | $8,864.00 |

Figure I-100. Impact value of volunteers for the City of College Station Senior Games generated by the Volunteering Impact Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



| Volunteer role/title | Number of volunteers | Equivalent paid job | Hourly wage | Total weekly hours | Total weeks worked annually | Hours worked annually (total weekly hours x total weeks worked annually) | Annual value (hourly wage x hours worked annually) |
|---|---|---|---|---|---|---|---|
| Volunteer | 244 | Recreation Assistant | $8.00 | 4 | 1 | 4 | $7,808.00 |
| | | | | | | 0 | $0.00 |
| | | | | | | 0 | $0.00 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| **TOTAL:** | **244** | | $8.00 | 4 | 1 | 4 | $7,808.00 |

Figure I-101. Impact value of volunteers for the City of College Station Games of Texas event generated by the Volunteering Impact Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.



| Volunteer role/title | Number of volunteers | Equivalent paid job | Hourly wage | Total weekly hours | Total weeks worked annually | Hours worked annually (total weekly hours x total weeks worked annually) | Annual value (hourly wage x hours worked annually) |
|---|---|---|---|---|---|---|---|
| Volunteer (Annual Easter Egg Hunt) | 70 | Recreation Assistant | $8.00 | 4 | 1 | 4 | $2,240.00 |
| Volunteer (Monster's Bash & Haunted House) | 50 | Recreation Assistant | $8.00 | 4 | 1 | 4 | $1,600.00 |
| Volunteer (Breakfast with Santa) | 45 | Recreation Assistant | $8.00 | 4 | 1 | 4 | $1,440.00 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| **TOTAL:** | **165** | | $24.00 | 12 | 3 | 12 | $5,280.00 |

Figure I-102. Impact value of volunteers for the City of College Station events generated by the Volunteering Impact Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

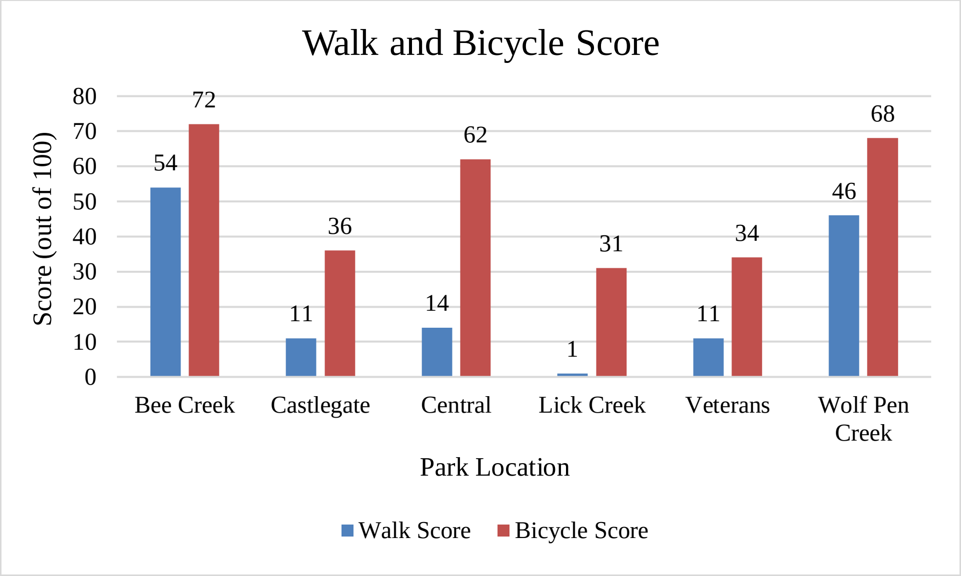


Figure I-103. Output generated by the Walk Score tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

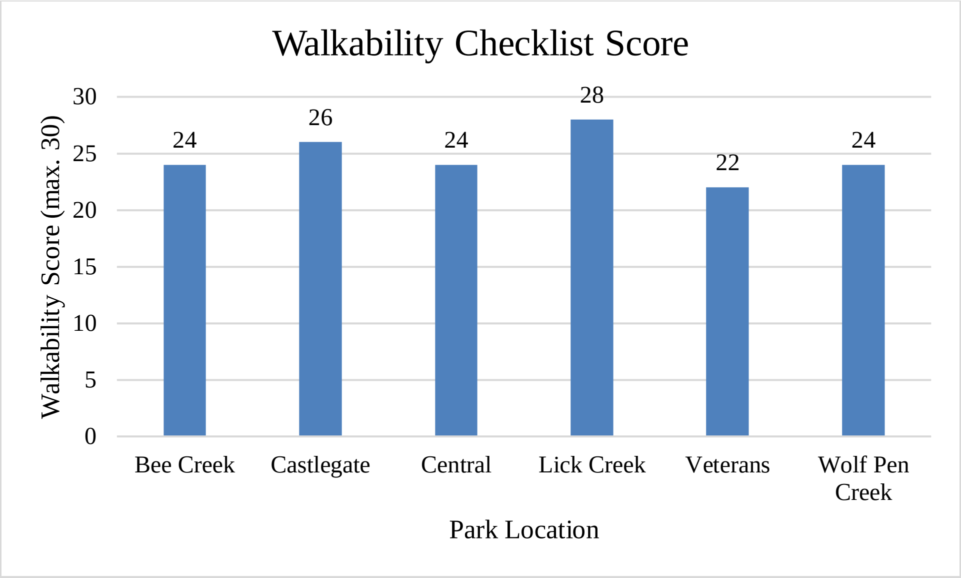


Figure I-104. Output generated by the Walkability Checklist survey analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

Table I-1. Field observations using the Parks and Recreation Areas Self-Report Survey analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

| **Question prompt** | **Bee Creek** | **Castlegate** | **Central** | **Lick Creek** | **Veterans** | **Wolf Pen Creek** |
|---|---|---|---|---|---|---|
| **How often do you visit?** | Less than once a month | Less than once a month | Once a month | Less than once a month | Few times per month | Less than once a month |
| **How long do you usually stay?** | Less than one hour | Less than one hour | Between 1-2 hours | Less than one hour | Between 1-2 hours | Less than one hour |
| **Why do you visit?** | | | | | | |
| To go to a camp/afterschool program | | | | | | |
| To attend a class (like dance, karate, boxing, swimming lessons, etc). | | | | | | |
| To go swimming | X | | | | | |
| To play sports (soccer, volleyball, basketball, baseball, etc). | | | X | | X | |
| To hang out and talk with friends or family | | X | | | X | |
| To walk a dog | | | X | X | X | |
| To exercise | X | X | X | X | X | X |
| To walk through on the way to somewhere else | | | | | | |
| To play on the playground equipment | | | | | | |
| To have a picnic | | X | | X | | |
| To play | | | | | | X |
| To relax or read | | | | X | | |
| To go to a market, festival, party, etc | | | | | | |
| Other | | | | | | |

Table I-1. Continued.

| Question prompt | Bee Creek | Castlegate | Central | Lick Creek | Veterans | Wolf Pen Creek |
|---|---|---|---|---|---|---|
| **What does this place have to do for fun?** | | | | | | |
| Playground equipment | Good condition | Good condition | Good condition | None | Good condition | Good condition |
| Baseball diamond | Good condition | None | Good condition | None | Good condition | None |
| Open grassy areas | Good condition | Good condition | Good condition | Good condition | Good condition | Good condition |
| Tennis courts | Good condition | Good condition | Good condition | None | None | None |
| Volleyball courts | None | None | Good condition | None | None | None |
| Basketball courts | None | Good condition | Poor/bad condition | None | None | None |
| Soccer fields | None | None | None | None | Good condition | None |
| Paths/trails | Good condition | Good condition | Good condition | Good condition | Good condition | Good condition |
| Skate park | None | None | None | None | None | None |
| Football fields | None | None | None | None | Good condition | None |
| Water playground | Good condition | None | None | None | None | None |
| Indoor gymnasium | None | None | None | None | None | None |
| Outdoor or indoor swimming pool | Good condition | None | None | None | None | None |
| Lake or pond where swimming is allowed | Good condition | None | Don't know | None | None | None |
| **What other things are at this place?** | | | | | | |
| Restrooms | Poor/bad condition | None | Good condition | Good condition | Good condition | Good condition |
| Drinking fountains | Poor/bad condition | Good condition | Good condition | Good condition | Good condition | Good condition |
| Shelter/shade | Poor/bad condition | Good condition | Good condition | Good condition | Good condition | Good condition |
| Picnic facilities | Poor/bad condition | Good condition | Good condition | Good condition | Good condition | Good condition |
| Parking lot | Poor/bad condition | None | Good condition | Good condition | Good condition | Good condition |
| Bike racks | Don't know | Good condition | None | None | None | None |
| **What kinds of programs?** | | | | | | |
| Classes | None | None | Don't know | Don't know | None | Don't know |
| Day camp or after school programs | Don't know | Don't know | Don't know | Don't know | None | Don't know |
| Cost too much | Don't know | Don't know | Don't know | Don't know | Don't know | Don't know |

Table I-1. Continued.

| Question prompt | Bee Creek | Castlegate | Central | Lick Creek | Veterans | Wolf Pen Creek |
|---|---|---|---|---|---|---|
| **How does the place look?** | | | | | | |
| Enough lighting | Yes | No | Yes | Yes | Yes | Yes |
| Broken glass | No | No | No | No | No | No |
| Spray paint, graffiti, or tagging | No | No | No | No | No | No |
| Litter | No | No | No | No | No | No |
| **How safe is this place?** | | | | | | |
| I feel safe | Disagree | Agree | Agree | Agree | Agree | Agree |
| On my way to and from this place, I feel safe walking, riding my bike, or skating | Disagree | Agree | Agree | Agree | Agree | Agree |
| There are mean or threatening people in or at this place | Agree | Disagree | Disagree | Disagree | Disagree | Disagree |
| There are often gang members at this place | Agree | Disagree | Disagree | Disagree | Disagree | Disagree |
| There are often gang members in the area | Agree | Disagree | Disagree | Disagree | Disagree | Disagree |
| This place needs more parents or other adults to make me feel safe | Agree | Disagree | Disagree | Disagree | Disagree | Disagree |
| I get bullied, teased, harassed here | Disagree | Disagree | Disagree | Disagree | Disagree | Disagree |
| **What improvements would you like to see?** | Security, soccer field, map | Restrooms | Football field | Sports complex, more fun | Bike racks, security | Sports complex |

Table I-2. Scoring output for responses by the City of College Station generated by the Social Value Self-Assessment Tool analyzed in a multiple-case studies approach on six parks located in the City of College Station, TX, and managed by the Department of Parks and Recreation for the evaluation of decision-support tools that measure environmental and socioeconomic benefits.

| **Principle** | **Score** |
|---|---|
| Principle One: Involve stakeholders | 47% |
| Principle Two: Understand what changes | 13% |
| Principle Three: Value things that matter | 47% |
| Principle Four: Only include what is material | 0% |
| Principle 5: Avoid overclaiming | 20% |
| Principle Six: Be transparent | 7% |
| Principle Seven: Verify the result | 0% |
| **Total Score:** | **19%** |