Greening Brownfield Properties

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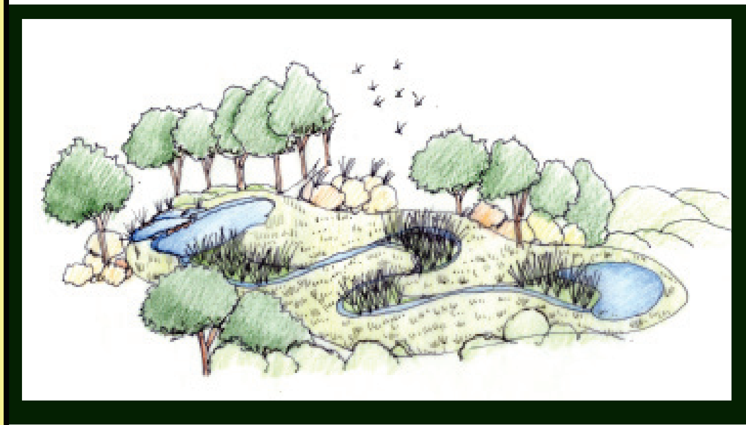

A University of Michigan School of Natural Resources and the Environment Master's Project

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Abstract

In this project we provide a framework for analyzing the benefits of greening brownfield properties. The work completed includes a mail survey on the attitudes of Houston residents toward brownfields and greenspaces, a hedonic pricing analysis examining the extent which the conversion of brownfields into greenspaces impacts nearby property values, a valuation of ecosystem services on a City of Houston brownfield site (Bellfort), and three alternative designs for the brownfield site.

The survey results demonstrate that parks in Houston are farther from the respondents who had relatively lower incomes and that respondents prefer ecosystem services that have direct benefits, such as flood control and air quality improvements. The hedonic pricing analysis shows mixed results: one of the brownfield to park conversions had a positive impact on nearby properties while another brownfield to park conversion had a negative impact on nearby properties. For the conversion that had a positive impact, nearby property values increased between 4.6% and 11.9% depending on the distance from the park. The brownfields/parks studied differed in their size and location in Houston. The ecosystem services analysis for the Bellfort site includes an examination of air quality improvement, carbon sequestration, and stormwater management, which in total currently provide around $64,000 of annual benefits. The alternative designs for the 300-acre Bellfort site, which includes a former landfill and incinerator, propose ideas to increase the benefits the land provides, such as by increasing habitat and recreation areas and constructing stormwater management systems.

All of the project's components aim to provide insight into the benefits of greening brownfield properties. The results of this project should inform the scope and design ultimately approved for the redevelopment on the Bellfort site. More generally, our project has identified some expectations and methodologies for future brownfield redevelopment projects.

Acknowledgements

The "Greening Brownfield Properties" team is grateful for all of the help it received throughout the process of this project, without which the project could not have been completed. First and foremost, the team thanks Dr. Greg Biddinger of ExxonMobil for engaging the team in this project, sharing his time discussing the process for the project, and leading the team around Houston, Texas. The team also thanks Shannon Teasley of the City of Houston for her commitment to the completion of this project. Shannon's efforts in providing information about the site and serving as a liaison between the team and the City of Houston were of utmost value. A third key expression of gratitude is due to Dr. Michael Moore, our faculty advisor who provided us with guidance, feedback, and encouragement.

The team thanks all of the individuals and organizations that provided background information about the site, thoughts about tools for redeveloping brownfields, and expertise in undergoing the process of redeveloping brownfields. These individuals and organizations include (the people we interviewed); Professor Christopher DeSousa (University of Wisconsin-Milwaukee), who provided expert advice on beginning the project; Professor Joan Nassauer, who taught several team members in the "Brownfield Redevelopment" course and met with the team for guidance; Greg Rogers, who came to Ann Arbor from Austin, TX to enjoy dinner with the team and discuss the implications of this project; the Houston Association of Realtors; the Houston-Galveston Area Council, and Conservation Capital.

The team appreciates the support of friends and family members who shared words of encouragement and feedback on the survey content and wording. The team also thanks the over 100 people who expressed their interest in the redevelopment of brownfields to us through completing and returning their surveys.

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Chapter: 1

Introduction

Human activities have resulted in environmental contamination so great that remediation is needed for future safe usage. Today, growing awareness of environmental degradation and increasing pressure to make the most out of limited space is driving interest in redeveloping contaminated sites. These sites, commonly referred to as brownfields, are prevalent throughout the world. Brownfields represent significant costs to society. Remediation entails policy creation, funding allocation, assessment procedures, technological innovation, and expensive procedures which may create their own environmental challenges. However, brownfield redevelopment also represents a means of improving society. For example, instead of using undeveloped land for new projects, returning former brownfields into productive uses is the ultimate form of recycling. Brownfield redevelopment also improves aesthetics through reducing vacant and blighted properties.

Brownfields

In the United States, brownfields are defined as "real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant" (Public Law 107-118). The EPA's 1995 Brownfield Action Agenda describes further that brownfields are "abandoned, idled or under-used," and are typically industrial or commercial sites. Examples of brownfields range from abandoned gasoline stations with underground storage tanks to sites that have experienced disasters, such as the former nuclear facility in Chernobyl, Ukraine.

Assessing the number of brownfields in the United States has proven extremely challenging (De Sousa, 2008, 4-5). In 1995, the EPA estimated that there were at least half a million (Simons, 1999), while a more recent study indicated that there were up to one million sites (Bausmith, 2008). This wide range arises from the fact that brownfields can be defined broadly and that reporting agencies have significant classification and reporting flexibility. For instance, governing authorities may underestimate the number of brownfields because of their perceived stigma, while others may overestimate the number because they seek to harness the redevelopment opportunities (Bausmith, 2008). Recently, interest in redeveloping brownfields has grown because of "regulatory and financial incentives, [a] scarcity of affordable properties, [changes in public perception], and socioeconomic changes," such as the economic downturn (Bausmith 2008).

Brownfield sites have negative implications for environmental health, public safety, and society in general. For the surrounding environment, they degrade groundcover, habitats, microclimates, and entire ecosystems. For human society, they isolate communities and exacerbate social inequities (EPA, Protecting Public Health, 2009). Disputes among political, social, economic, and environmental stakeholders can hinder their future redevelopment.

Brownfields are often kept indefinitely in a vacant state. While they are vacant, they often undergo partial ecological succession without proper measures to ensure that contamination is not cycling through the local ecosystem. In cases where past uses prevent the emergence of a functional ecosystem, potential ecosystem services benefiting either the local flora and fauna or human societies are foregone. Or, if an ecosystem emerges on a contaminated property without the proper preventative measures taken, on-site contaminants may harm organisms passing through the area. These organisms may serve as vectors, spreading the contamination to other areas and, potentially, to humans far from the original site.

Brownfield Redevelopment

Redevelopment takes place within the context of numerous state and federal laws, which have been enacted since the 1970s.[1] These laws intend to "empower states, communities, and other stakeholders to work together in a timely manner to prevent, assess, safely clean up, and sustainably reuse brownfields" (EPA, "Ecological Revitalization").

While brownfield laws have some positive impacts on reducing environmental problems and enabling economic development, they have also created severe unintended side-effects. The most significant unintended consequence is referred to as "brownfield paralysis" (Dowdell et. al., 2007). This paralysis was inadvertently caused by the enactment of the 1980 Superfund Act, which "encouraged owners of former industrial properties to hold potentially contaminated land indefinitely in order to avoid cleanup costs" (Dowdell et. al., 2007). Stringent, inflexible, and thus expensive, cleanup standards for brownfields led to investors preferring virgin lands (Bausmith, 2008). In addition to cleanup costs, developers avoided brownfield properties because of the associated environmental liability risks (Bausmith, 2008), though governments and firms have explored methods to limit liability through various schemes (Rasher, 2009).

The 2002 Brownfields Law provided incentive for investors to purchase brownfields by reducing their risks through "innocent landowner" and "bona fide prospective purchaser" defenses, but the burdens fell upon developers in response (Bausmith, 2008). Developers not only face risks from remediating known contaminants from already conducted Phase I and II assessments, but there is also concern that additional contaminants will be found during remediation (Nassauer, 2009b). Insurance offered to developers is often not enough to offset the risk they face (Nassauer, 2009b).

In Texas, the Texas Commission on Environmental Quality (TCEQ) enforces the laws regulating brownfield cleanup and redevelopment. Programs available in Texas regarding brownfields include the Voluntary Cleanup Program (VCP), Innocent Owner/Operator Program (IOP), Brownfields Site Assessment (BSA), and County Brownfields Law. TCEQ may provide assistance by commenting on county brownfields programs, offering educational, advisory, or technical assistance, or helping obtain federal grants (Frew, 2006).

Successfully redeveloping a brownfield is more complex than developing an undeveloped site. In addition to the typical planning and implementation processes, the site must either be encapsulated or

1 Federal laws include, but are not limited to, the 1976 Toxic Substances Control Act, the 1976 Resource Conservation and Recovery Act, the 1980 Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund"), the 1988 Resource Conservation and Recovery Act Reuse and Brownfields Prevention Initiative, the 1990 Oil Pollution Act, the 1999 and 2001 Cleanup Reforms, and the 2002 Small Business Liability Relief and Brownfields Revitalization Act.

remediated. There are a wide variety of encapsulation and remediation methods. Similar to planning the project design, the remediation strategy should be based on the intended end-use of the site. Further complicating the redevelopment of brownfields is that the amount of time that remediation takes carries significant risk due to the potential for complications. Even for projects not addressing contaminants, factors like the desired final outcome, the ability to finance the project, and the available tools for the process are all subject to change. The technologies that may be used, along with the final outcome, depend on community demand and acceptance. When redeveloping brownfields, new information is likely to arise, such as finding an undocumented underground storage tank, which can cause significant delays. Thus, the costs, benefits, risks, and opportunities of alternatives must be weighed and compared, accounting for both the short- and long-term. Characteristics to consider include flexibility, efficacy, and speed. The challenges posed by brownfields create the demand for public incentives to offset the related risks.

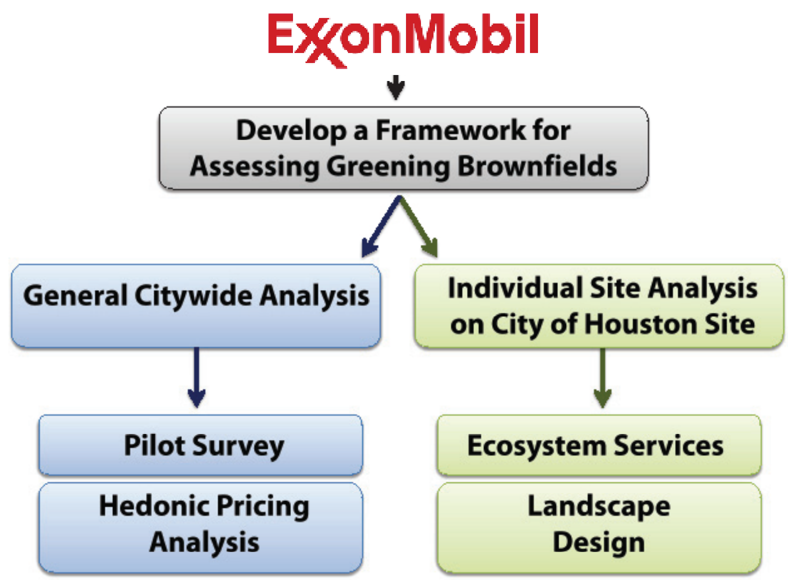
Depending on the context of development, cleaning up brownfields can provide a wide array of benefits. Economic benefits include the creation of employment and housing opportunities, expansion of the local tax base, cost savings through utilization of existing infrastructure and an increase in surrounding property values, all of which ultimately attracts new investment to the area. Social benefits include a reduction in health and safety risks, elimination of negative perceptions, enhanced aesthetics, and potentially more natural spaces and recreational opportunities. Environmental benefits include a reduction in environmental contamination and the prevention of use of previously undeveloped land, (EPA, About Brownfields, 2008). Overall, because of the widespread interest surrounding brownfield remediation today, communities that successfully pursue brownfield remediation enhance their reputation and serve as examples for other communities to follow.

Brownfield redevelopment is a component of popular pursuits like sustainable development and urban revitalization. Many areas with brownfields simultaneously suffer from a dearth of greenspaces (De Sousa, 2006). The redevelopment of brownfields into greenspaces, instead of commercial or industrial developments, is rapidly becoming an attractive option for public officials and local communities due to the increase in quality of life and land values that this redevelopment provides. These efforts have required significant public initiative because, in comparison to creating industrial or commercial developments, the benefits of opting to green a brownfield fall on people who do not bear the costs (Siikamäki and Wernstedt, 2008).

Purpose of Master's Project

The purpose of this report is to develop a framework for assessing the economic, social and ecosystem servicel benefits of redeveloping brownfield properties into greenspaces through application of existing techniques in Houston, Texas. Our approach is outlined in Figure 1.1. We conducted two methods of evaluation, public participation and hedonic pricing analysis, at a city-wide level. Two other methods, ecosystem service analysis and alternative design scenarios were applied to a particular case study site in Houston, 3300 Bellfort St. This site is a former landfill and incinerator currently in the City of Houston's Brownfield Redevelopment Program. Addtionally, we conducted interviews with those who are experienced brownfield redevelopment experts. Key takeaways from these interviews are included in Appendix V. It is hypothesized that the benefits will accrue to both private entities and the public. Through quantifying these benefits, we aim to provide insight into how the conversion of brownfield properties to greenspaces is a viable business and community strategy. It is important to note that we are not examining the value created from commercial or mixed-use redevelopment of brownfields, even though this type of redevelopment can certainly provide value. Research products include:

Figure 1.1 Our Project Approach



- An understanding of Houston residents' preferences for brownfield redevelopment,
- An examination of the impact on nearby appraised property values from converting two brownfield properties into parks in Houston
- An analysis of ecosystem services on a study site, as well as the impact on these services if the site is altered, and
- Design alternatives in terms of restoration, storm water management, recreational development, and community interaction.

Clients

Our client for this project is ExxonMobil Biomedical Sciences, Inc. We are also working with the City of Houston's Brownfield Redevelopment Program. Both entities have been actively involved in providing resources and support.

ExxonMobil Biomedical Sciences, Inc.

ExxonMobil Biomedical Sciences, Inc. is a global consultancy and subsidiary of ExxonMobil (Biddinger Interview, August 25, 2009).[2] ExxonMobil's portfolio has an estimated 10,000 to 15,000 sites that either are or will be available for remediation and redevelopment (Biddenger Interview, August 25, 2009). As a result,

> ExxonMobil environmental scientists pioneered a strategy for natural land management, which brings together technical, legal, and regulatory approaches to conserve or enhance ecological services while delivering lower management costs and higher property returns. [The] strategy includes a site analysis of future ecological and commercial use. Results are used in the development of restoration and redevelopment actions (ExxonMobil, Energy and Environment-Natural Land Management).

Through remediating its surplus properties, ExxonMobil seeks to reduce its liability on previously-used sites while also providing benefits to nearby communities. ExxonMobil's policy prohibits building housing or schools on previously-used sites (Biddinger interview, August 25, 2009). The company hopes to gain from such projects, although it does not require cash flows in order to implement a project. Some potential benefits include reduced contingent liabilities or tax savings and increased regulatory flexibility. This project aims to determine other benefits of a green design on a former industrial property, particularly the value of people using the site, ecosystem services, and impacts on nearby properties.

Around 90% of ExxonMobil's sites are former gasoline stations on one to two acres of land, with the remaining sites being larger in a wide range of sizes. The smaller sites may be turned into pocket parks relatively easily, which could add significant value in some cities and areas (Biddinger interview, August 25, 2009). On the large sites that have open space, in many cases communities have built commercial or residential developments to the edge of these sites, making them "some of the last remaining wildlife habitats in a region" (Biddinger interview, August 25, 2009). ExxonMobil has collaborated with not-for-profits including the Wildlife Habitat Council, the Nature Conservancy, Conservation International, and The Trust for Public Land, in implementing its natural land management strategy (Biddinger Interview, August 25, 2009).

City of Houston

The City of Houston's Brownfield Redevelopment Program assists with the identification, assessment, cleanup, and redevelopment of brownfields. Redevelopment includes anything that benefits the

2 The term "brownfield" is generally applied when there is no clear owner of a property or the owner is not in a financial position to assess site clean-up and redevelopment. Properties with similar characteristics but where the ownership is active and the owner is actively participating in the redevelopment process are more accurately referred to as "surplus" properties. Thus, ExxonMobil's properties are technically surplus properties, not brownfields. Surplus properties do not qualify under the law for any brownfield grant funds or tax relief. However, for the purposes of this study, there is no difference in the value generation potential and the term brownfield can be used (Biddinger, 2009).

community, such as new businesses, housing for the elderly, or parks. The program coordinates with the local government's other neighborhood improvement efforts, other agencies in the government, and entities in the private sector. Through the program, qualified applicants can receive free Phase I and II environmental site assessments, cleanup grants, help with participation in a State Voluntary Cleanup Program, and placement on the City's brownfield website.

The program currently has 41 brownfields in its portfolio as of March 2010, only about a quarter of which are owned by the City of Houston (City of Houston, Brownfield Redevelopment Program). The Brownfield Redevelopment Program operates under the Economic Development Division of the City of Houston.

Strategy for the Master's Project

In order to understand brownfield properties and the benefits from conversion to greenspace, the team gathered and analyzed data on a brownfield site owned by the City of Houston. We conducted a general survey on parks, brownfields and ecosystem services throughout Houston, performed a hedonic pricing analysis for homes surrounding two parks in the city, examined ecosystem services on the 3300 Bellfort site through the application of an ArcGIS software extension, CITYgreen, and proposed alternative designs for it. More information about 3300 Bellfort is provided in Chapter 4. More details for each of the approaches utilized are provided below.

Public Participation

A general survey was conducted throughout the City of Houston with the intent of providing ExxonMobil with an assessment of interest in the Houston area concerning these types of projects. The survey consisted of three sections. Part one assessed park accessibility, usage, and interest in future development. Part two addressed concern, exposure, and opinions about brownfields. Part three measured preferences for the development of a variety of ecosystem services. The results discussed in Chapter 2.

Hedonic Pricing

A hedonic pricing analysis was performed to determine the impact on nearby property values of the conversion of two Houston brownfields into parks. The analysis compared the change in property values at different distances from the two sites, while incorporating the geospatial context of the sites. Based on other studies, the expectation is that redeveloped brownfields increase the value of surrounding homes. The outcome from this analysis is discussed in Chapter 3.

Ecosystem Services

Ecological revitalization of a property requires knowledge of the current ecological benefits that the property provides society in comparison to the available alternatives. These benefits are referred to as ecosystem services, which are the direct and indirect benefits humans derive from nature. To achieve this objective, the team assessed the site's current and potential carbon sequestration, water retention, solar power, landfill gas utilization, and suitability for endangered species using CITYgreen, an ArcGIS software extension. The results of this analysis are discussed in Chapter 5.

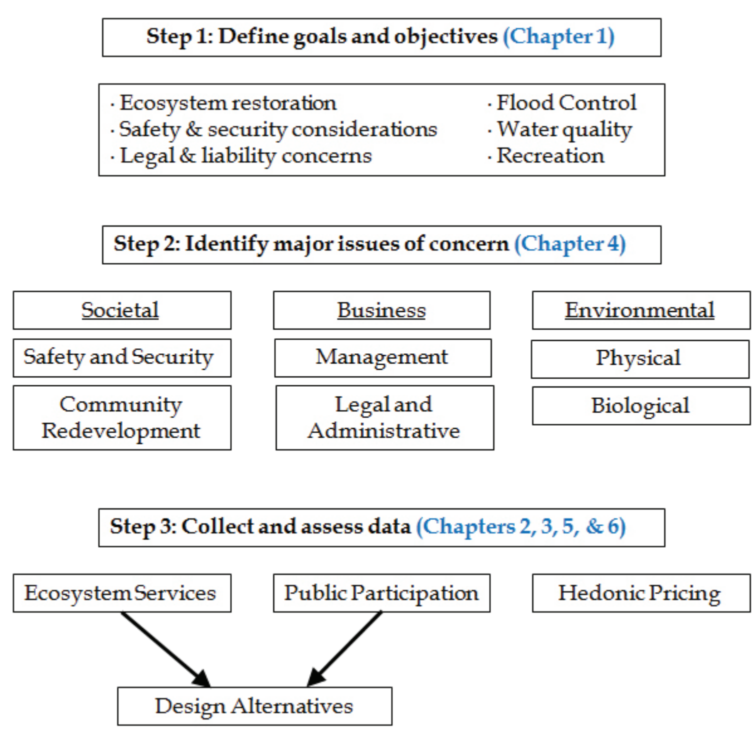
Design

We proposed alternative designs of the Bellfort site based on the results of the ecosystem services assessment, surveys, interviews, and hedonic pricing analysis. The proposed design alternatives are provided and discussed in Chapter 6.

Framework

Through the efforts described above, our team tested elements of our framework for evaluating the transition from brownfield to greenspace. ExxonMobil requested this project for the purpose of advancing the mission of its natural land management strategy through the development and application of a methodological framework. This framework, along with a discussion of challenges that were encountered in this project and those that are likely to arise in similar projects, are presented in Chapter 7. The framework, while informed by a particular site in Houston, is intended to be useful for evaluating future sites across the country and world. With an estimated one million brownfields throughout the United States, our work will be of interest

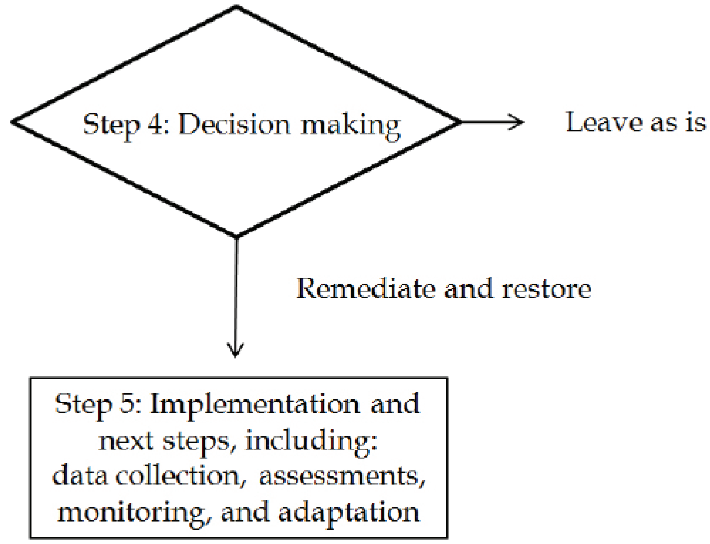
Figure 1.2 Framework for Brownfield Redevelopment Evaluation



not just to ExxonMobil, but also to local and state governments, private-sector firms, and non-governmental organizations (NGOs).

The guiding framework for brownfield evaluation is illustrated below (Figure 1.2). Additional steps that go beyond the scope of this project are outlined in Figure 1.3. This chapter defines the goals and objectives of our studies and analyses. Major site specific considerations are identified and characterized in Chapter 2. Chapters 3 through 6 present the data collected and the related assessments. Chapter 6 also includes the environmental impacts on various site designs. Finally, Chapter 7 concludes with recommendations for next steps.

Figure 1.3 Additional Steps Beyond this Project



Chapter: 2

Public Participation

Public Participation

Public participation is an important part of pursuing ecological revitalization as an alternative future for contaminated and vacant lands, even though the final decision on property reuse may solely rest with the owner of the property. For example, public participation can make the development of urban greenspace projects more likely if it lowers material and labor costs, mobilizes resources, and musters political support.

Involving the public in community projects is common enough that articles have been written explaining the benefits and challenges that arise. After reviewing such literature, we believe that an approach known as "adaptive management" is appropriate for the City of Houston's redevelopment of the 3300 Bellfort site. In this chapter, we introduce "adaptive management" as a tool for public participation, provide examples as illustrated in other projects, report the results of a survey of Houston residents' preferences toward greenspace that was conducted to assess the community's interest in an "adaptive management" process, and provide information gathered about benefits and challenges of brownfield redevelopment from interviews with brownfield experts.

Adaptive Management

Adaptive management is a management approach that involves monitoring the outcomes of a project or issue and, on the basis of that monitoring, improving the way the project is managed. It emphasizes the importance of addressing environmental issues as iterative processes, and stresses the inclusion and involvement of stakeholders (Stringer et al., 2006).

Stakeholders participate in any to all of the stages of redevelopment, including exploration of the problem, goal setting, planning, monitoring, and evaluation. As the project progresses, past stages may need to be readdressed as a result of new findings or external influences, supporting the need for the process to be iterative.

Just as there are many stages in the redevelopment process, there are many types of stakeholders, who have varied backgrounds and interests. Involving parties with an interest in the site to the greatest extent possible is daunting, but offers significant benefits. For example, engaging members from diverse communities can encourage them to effectively cooperate with each other, providing a potential benefit for future community projects. It can also provide them with a passion for ensuring that the project is completed and in the best interest of the community.

Four stakeholders typically involved in land use projects are developers, government agencies, citizens, and nature conservation experts, who often have conflicting interests. For developers, greenspaces may enhance their marketing efforts and increase the acceptance rates of projects. Government agencies seek to work within their established land use plans and zoning laws while responding to their constituents' interests. Citizens benefit from the creation of greenspaces because they allow for leisure activities, social gatherings, and indirect benefits acknowledged in Chapter 3. When working specifically with brownfields, the value of greenspace to nature conservation experts lies in the unique habitat, which is often host to a variety of rare pioneer organisms that result from a history of disturbance. Developers and citizens tend to desire conventional green parks with full access, paths, playgrounds, and picnic areas while the nature conservation experts often propose maintaining areas for pioneer species, preventing succession, or allowing succession to continue until a forested area emerges (Altherr et al., 2007). Ecosystem services are easily overlooked, as mentioned in Chapter 3, but should be seriously considered as an alternative to corrective measures. These varied interests to consider necessitate interdisciplinary dialogues and democratic processes in order to increase the chances for a successful project.

As alluded to above, public participation can range from simple things, such as discussions with citizens, to more difficult arrangements, like giving the public the ability to make important decisions. Konijnendijk (2000) suggests three main components for successful participation: education and information, consultation, and engagement through participation. Education and information activities consist of notification of proposed work, sharing technical information, displaying exhibitions, hosting lectures, and leading guided site visits and educational tours. Using media and partnering with local organizations like schools and community groups can increase the success of these activities. Consultation activities consist of public meetings, community group discussions and workgroups, input via surveys or ballot proposals, and committee involvement and participation. Participation involves direct contact with the land and can include options such as tree planting, allowing citizens to work as tree wardens, and co-management (Konijnendijk, 2000).

The inclusion of stakeholder groups during discussions of environmental problems such as urban greening projects encourages participating stakeholders to learn from each other, develop a sense of ownership of the issue, and support the project (Stringer et al., 2006). This serves to improve understanding between opposition groups and foster appreciation of alternate views. It also promotes collaboration in intergroup politics and enables groups that had initially been in conflict to realize new ways of working together (Stringer et al., 2006). While increasing participation may initially lead to more direct conflict and produce technically inefficient outcomes than less democratic, expert focused management options; it allows for structured debate and social learning among groups, creating new options for cooperation and easing the implementation of solutions. Community dialogue and education leads to more informed and socially beneficial decisions.

However, it is important to facilitate dialogues between ecological experts and communities to minimize any challenges. A facilitator can help clarify technical terminology and help the working group members communicate their feelings and opinions objectively. These dialogues should encompass values, norms, interests, and objectives of creating greenspace (Konijnendijk, 2000). If the communication is effective, citizens may learn the importance of items previously disregarded and increase their willingness to include more ecologically focused aspects in the design of urban greenspace.

In addition to improving dialogue within communities, adaptive management can also increase community members' sense of ownership and responsibility toward development projects. This can lead to a community desire to maintain the space through annual beautification projects. This may be critical for projects that lack the funding for annual maintenance, which was the case in one of the examples below. In addition, greater ownership means better long term support for monitoring and maintaining these projects, which has been shown to be far more important to their implementation than even the large upfront capital costs of creating such spaces (Siikamäki and Wernstedt, 2008). Further, with expanded local support, the likelihood for private funding increases, improving the chances that an urban greening project will be viable and successful (Siikamäki and Wernstedt, 2008). It has also been shown that the inclusion of public participation in projects strengthens communities and may have positive effects on social conditions (Konijnendijk, 2000). On the other hand, while it has been shown that greenspaces often create amenities for the surrounding areas, they can attract anti-social behavior if not implemented with high levels of community input (Fraser, 2002).

While participation from the community has benefits, it can result in debate over what type of greenspace to implement, ranging from ecological habitats to recreational uses (De Sousa, 2003). The potential for debate expands as small urban greening projects become more complex or increase in size, increasing the difficulty associated with participation (Stringer et. al., 2006). Inclusion of citizens and community groups in planning of urban spaces leads to creation of more traditional green parks with playground facilities, well manicured lawns, ball fields, and other recreational facilities. It is much more difficult to generate support for the creation of greenspace without such attributes, especially for conservation land that may not allow for public access (Siikamäki and Wernstedt, 2008). In his work on greening brownfields, De Sousa (2003) notes that projects focusing on ecology and nature-oriented design gained support from already-established community-based environmental groups rather than developers or citizens themselves. He also points out that projects focused on creating more traditional green parks were led by smaller groups that were united by a community leader strictly for the purpose of advocating the project. As described in chapter 6, our proposed designs includes both recreation and conservation areas.

Practical Illustrations

The following studies provide a short demonstration of how public participation can influence the development of greenspaces. Although these examples are from other countries, they are just as relevant for a project in Houston.

Greening Bangkok

An example of adaptive management is illustrated in the creation of urban green space in Bangkok, Thailand (Fraser, 2002). The project, which has been ongoing since the late 1990s, began when the Thailand Environment Institute, a Thai non-governmental organization (NGO), approached the International Centre for Sustainable Cities (ICSC), another NGO, to partner on a program to create greenspace in Bangkok, pursuing a goal set by the Bangkok Metropolitan Association, a government agency. Knowing that urban greenspace can enable a range of social, economic, and environmental benefits, the two NGOs designed a program that would take small, unused plots of land in poor neighborhoods that were providing little environmental or amenity value and use them to generate new greenspaces.

For this project, citizens participated in education days, goal setting, planning, and community working groups. The NGOs obtained greater support from local politicians because their perceived legitimacy exceeded that of smaller community organizations. This necessitated building trust between the NGOs and community groups to minimize any threat of animosity. To accomplish this, the NGOs provided experts to work with the citizens in collaboratively designing the greenspace projects. By providing these resources and facilitating citizen participation, the NGOs helped the local populations take ownership of the process.

Regarding the framework for adaptive management, this work successfully integrated different viewpoints, problems, and goals (Stringer et al., 2006). The sites used for creating greenspaces were sufficiently small to allow communities to collaborate when it came to identifying problems, goals, and indicators associated with the projects, moving on to the implementation stage relatively easily (Stringer et al., 2006). In addition, because the land used for these urban greening projects was marginal, these activities faced minimal dissent (Fraser, 2002).

European Urban Forestry

Recently, a new brand of urban forestry in Europe has emerged, which focuses on the social and environmental values of urban woodlands rather than the traditional focus on wood production. Although it primarily deals with areas that are already forested, the setting includes a large number of stakeholders. It emphasizes communication, stakeholder engagement, and participation in a manner similar to other urban greenspace management programs. With woodlands accessible in urban settings, stakeholders have been vociferous in expressing their opinions, leading to a great range of pressures and conflict (Konijnendijk, 2000). A proposal to deal with this conflict is for foresters to more actively engage and educate the public; communicate the values, norms, interests, and objectives of forestry; and create a framework that formally involves citizens and local organizations in decision-making (Konijnendijk, 2000). Konijnendijk argues that urban forest managers have only been truly successful in resolving the conflicts when public involvement was a central goal for urban forestry practices (2000). In fact, managers of urban forestry projects have stressed the need for support from the public, interest groups, and politicians to help educate, conserve, manage, and develop urban forests (Konijnendijk, 2000).

Public Participation in this Project

Whether it is on abandoned agricultural land such as in Bangkok or forests in urban cities such as in Europe, urban greening programs can benefit from an emphasis on participation and communication in a variety of ways. The inclusion of public participation in our work on the 3300 Bellfort site was limited by our distance from the site itself, our outsider status amongst those who live around the site, and time limitations. In order to engage the community in Houston and gather some meaningful information without being physically present for a significant amount of time, the group conducted a general survey of city residents and interviewed stakeholders that would have a significant influence in the design and approval process of the Bellfort site itself.

Though these were our best tools for receiving input, both surveys and interviews are considered a halfway point in the process of involving the public in decision making (Arnstein, 1969). Though the benefits of public participation increase if the process passes this stage and reaches a state of genuine partnership with the public, this advance represents a considerable change as it requires both greater dedication to the process from those in business and government overseeing the decision and the development of citizen organizations and leadership that has the recognized authority to perform negotiations (Arnstein, 1969).

Survey Development and Methodology

The team's advisors encouraged the pursuit of a general pilot survey of City of Houston residents in an attempt to determine resident preferences in regards to park usage, brownfield redevelopment, and ecosystem service provisions. ExxonMobil recognized the value in this analysis as this type of data did not yet exist for the Houston area. A mail-based survey of residents was chosen for several reasons. First, due to the uneven distribution of internet access and home telephone lines, mail surveys remain the most reliable measure of the target population's actual preferences outside of in-person interviews (Dillman, 2000). A second factor was time. Delays associated with our collaboration with the City of Houston removed the potential to attempt other strategies that would have less predictable timetables and response rates.

The survey instrument is included in Appendix IV and is composed of three sections that represent topics influential to the redevelopment of brownfields into greenspaces. Park accessibility, usage, and interest in future development were covered in the first section. Concern, exposure, and opinions about brownfields were addressed in section two. In the third section, a series of questions measured preferences for the development of a variety of ecosystem services. A final section retrieved respondent demographic information. Efforts were made to follow the guidelines outlined by Floyd J. Fowler throughout his book, Improving Survey Questions, to make the survey as clear and concise as possible in an attempt to minimize both survey and question non-response. Survey pretesting was part of this process. In October, 15 individuals took the survey and provided feedback on each question, explaining any confusion that they experienced or could anticipate for others. Though an attempt was made to recruit these respondents from a variety of backgrounds and skill levels, it is not considered important for pretesters to mirror the survey population's characteristics (Babbie, 2004).

The sample for the survey of residents was developed from a list of 1,600,000 residential addresses throughout the City of Houston retrieved from the Houston-Galveston Area Council. Because of limitations in the data available from the Houston Area Realtors, the selection was limited to owner-operated properties. From that data, a random sample of 2,000 addresses was drawn.

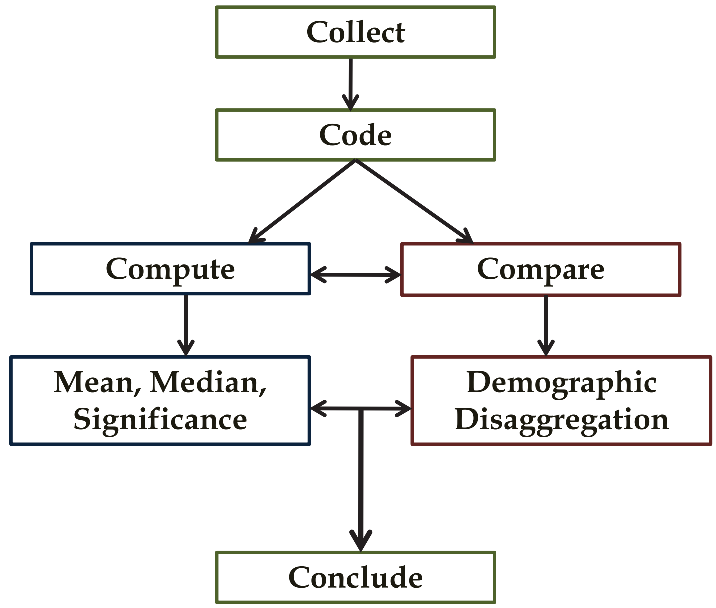
When conducting mail surveys, Don Dillman's Total Design Method is considered the gold standard in terms of survey response. It involves a total of five interactions intended to maximize the potential respondents' sense of responsibility (Dillman, 2000). These five interactions include:

- A cover letter explaining the survey that precedes it by several days;
- The survey which includes a small, token gift;
- A reminder postcard sent to all recipients;
- A replacement questionnaire and letter sent to non-respondents three weeks later; and
- Another replacement questionnaire and letter sent to non-respondents via certified mail seven weeks later.

Uncertainty due to our group's collaboration with the City of Houston surrounding the actual recipients of the survey and the time constraints that this caused, combined with the excessive cost of sending several bulk mailings from Michigan to Houston, forced us to forgo this strategy in favor of only two mailings. The first consisted of English and Spanish versions of the survey accompanied by a cover letter. A follow-up postcard arrived about two weeks later, which included a web address for an online version of the survey that was made through a service at the University of Michigan.

Results

Figure 2.1 – The Survey Result Assessment Process Used



The process for assessing the results of the survey is illustrated in Figure 2.1. The basic outline of this approach was inspired by the method outlined in the chapter, "Postcollection Processing of Survey Data" in the book Survey Methodology (Groves et. alia, 2004). First, responses were coded based on the answer given and placed into an Excel spreadsheet. For example, for yes or no responses, yes answers received a value of 1 and no received a value of 2. Skipping questions or leaving them blank was common. Question non-response was recorded as "no data" for individual cases and was ignored as an answer during analysis. The park usage section was an exception to this rule. When respondents did not indicate the number of times they used parks for a particular purpose it was recorded as 0 and incorporated into the data analysis. Both the mean and median were calculated for each question or prompt. Next, t-test significance analyses was performed in PASW statistics software (formally known as SPSS) to determine the individual questions or prompts within questions where the average respondent's answer was significantly different than neutral (see Appendix II for a more detailed explanation).

Evaluating the usefulness of these results required a comparison of the survey population to the general population being measured. The ultimate aim of a survey is not to simply amass a large quantity of responses, but to gather a mass of responses that is representative of this targeted population (Babbie, 1990; Dillman, 2000). Demographic data was collected to determine how representative those that responded to the survey were of the general population of Houston. Responses were then disaggregated based on demographic information in an attempt to highlight any meaningful patterns in responses based on respondent's education, income, or race. Income was broken down between those whose household income in the past year was less than 20 thousand, 20 to 50 thousand, 50 to 70 thousand, 70 to 90 thousand, 90 to 110 thousand, 110 to 140 thousand, 140 to 175 thousand and those making more than 175 thousand. Racial categories were analyzed based respondent self identification as African American, Asian or Asian American, Hispanic or non-Hispanic White. Other available race responses were marked by only one or no respondents and so no conclusions were drawn from them. Education was broken down into those with and without a college degree. Any interpretations derived from this disaggregation are purely speculative as the sample size becomes very small. For example, only eight respondents identified as African American and eight identified as Asian or Asian American. This is especially true concerning the brownfield related questions, some of which only three African Americans responded to. The patterns outlined are reported for the purpose of encouraging their further consideration during future evaluation processes. Any demographic patterns of responses mentioned in this analysis have associated tables included in Appendix I.

114 surveys were returned with responses. One was returned unanswered with a note inclosed explaining that the respondent refused to answer the survey. This was considered a refusal. 38 surveys were returned to us unopened with their destination address labeled vacant or abandoned. In the literature mail survey response rates can be calculated with or without those returned unopened by the postal service included in the equation (AAPOR, 2000; Babbie,1990). The response rates arrived at through these two equations are as follows:

$$\frac{\textit{Answered Surveys}}{\textit{Answered} + \textit{Returned to Sender} + \textit{No Reponse} + \textit{Refusal}} = \frac{114}{114 + 43 - 1842 + 1} = 5.7\%$$

$$\frac{\textit{Answered Surveys}}{\textit{Answered} + \textit{No Response} + \textit{Refusal}} = \frac{114}{114 + 1842 + 1} = 5.8\%$$

The Survey Sample vs. the Actual Population

This survey failed to represent the actual population in significant ways. As summarized in table 2.1, the differences were pronounced across several categories. In general the respondent population is older, wealthier, and more likely to be both white and female than the general population of Houston.

Table 2.1 - Summary of Demographic Statistics, Houston vs. Survey Population

	Houston	Survey
Median Age	32.9	54
Percent Male	49.9	40.7
Median Household Income ($)	44,315	80,000*
Percent Bachelors or Higher	28.4	64.0
Percent White	49.3	62.8
Percent African American	25.3	7.0
Percent Hispanic	37.4	20.9

Source: For Houston data gender and racial data, retrieved from 2000 US Census SF1 data
Median household income, age and education retrieved from American Community Survey one-year 2008 data
Survey data from Rust into Renewal Survey, Greening Brownfield Properties 2010 SNRE Master's Project
* This is the midpoint of the category on the survey 70 to 80 thousand that was the median

The median age of the survey population is over 20 years older than the Houston median, the annual median income is over $35,000 higher, and respondents are twice as likely to have a college degree as the general population of the city. This is not particularly unexpected considering a low response rate, which favors those with the time and educational resources to participate easily, and the fact that the survey was sent only to owner-occupied housing.

Part I: Park accessibility, usage and interest in future development

Question 1: Park Accessibility

Respondents were first asked how far the nearest park is from their residence. The average distance that individuals gave to their nearest park was 1.8 miles. Next, a series of yes or no questions were asked whose results are summed up in Table 2.2. A majority of respondents answered that their nearest park was accessible without an automobile or public transportation, that they used the nearest park more than other parks, and that they would use it more if it were closer. However, only the results to the first two prompts were statistically significant at a 95% level. It is likely that the higher wealth of the respondent population relative to the general population distorts these results and that parks are less accessible to the Houston residents than these results indicate.

Table 2.2 - Accessibility and Usage of Nearest Park, City of Houston, 2010

Prompt	% yes	Significance
It is accessible to me without the use of an automobile or public transportation.	67*	0.000
I use this park more often than any other.	61*	0.020
If it were closer to me I would use it more.	56	0.263

Source: Rust into Renewal Survey, Greening Brownfield Properties 2010 SNRE Master's Project
* Denotes statistical signficance at the 95% level

This supposition is supported by the finding that a higher household income was associated with having a park closer by. Those whose household made less than 20 thousand were an average of 2.8 miles from their closest park and those making 20 to 50 thousand were 2.9 miles. Meanwhile both those making 140 to 175 thousand and more than 175 thousand reported that they were .8 miles from their nearest park. Non-Hispanic White respondents also reported that they were closer to their nearest park than African American or Hispanic respondents (1.5 miles vs. 2.9 and 2.4 miles respectively).

Question 2: Impressions of Nearest Park

Four questions were then asked about impressions of the nearest park. As shown in Figure 2.3, respondents agreed at a statistically significant level that this park was an important meeting place for people in the area and that it was an important part of their connection to the area. Respondents disagreed at a statistically significant level with the notion that nobody really uses the park (an explanation of significance calculations is included in Appendix II). They were more neutral when asked whether it reduced crime in their neighborhood.

Table 2.3 - Impressions of Nearest Park, Houston, 2010

Based on a 1 - 5 scale where 3 is "neither agree nor disagree", 1 = "strongly disagree", and 5 = "strongly agree"

Prompt	Mean Score	Significance Ɨ
It is an important meeting place for people in the area.	3.66*	0.000
It reduces crime in my neighborhood.	3.06	0.566
Nobody really uses it.	1.72*	0.000
This park is an important part of my feeling of being a resident here.	3.55*	0.000

Source: Rust into Renewal Survey, Greening Brownfield Properties 2010 SNRE Master's Project
* Denotes statistical signficance at the 95% level
Ɨ Significance based off of neutral being 3

Questions 3 and 4: Outdoor Recreational Activity

Potential interest in park usage was measured through outdoor recreational activity. In question 3, respondents provided the number of times that they participated in certain outdoor activities in the City of Houston in the past six months and in question 4 they did the same for locations outside of the city. The results for both questions are summarized in Figure 2.4. The time period of this survey (from September to March) likely had a great influence on these results, given that it covers the school year and colder months, implying that there is less free time and less desire to be outdoors. Many respondents suggested that the survey be done in a different time of the year. On the whole, the average respondent participated in almost three times as many outdoor activities within the city as they did outside of the city from September 2009 to March 2010. Walking, running, bicycling, and in-line skating accounted for more than twice as many activities in the City of Houston as any other activity. In contrast, respondents went outside of Houston to take photographs or observe nature more than they did for any other activity.

Table 2.4 - Outdoor Recreational Activity Within and Outside of Houston, September 2009 to March 2010

	Total Times Participated		Average Times Participated	
Activity	Within	Outside of	Within	Outside of
Walking, running, bicycling, in-line skating	2313	302	21.4	3.0
Taking photographs, observing nature	1046	497	9.6	4.9
Socializing, picnicking	296	194	2.4	1.7
Riding watercraft (boats, kayaks, jet skis)	53	104	0.5	1.0
Swimming, wading	171	145	1.2	1.4
Fishing	57	120	0.6	1.1
Horseback riding	3	16	0.0	0.1
Golf	55	27	0.5	0.3
Other sport	181	55	1.6	0.4
Other activities	628	342	6.7	3.8
Total	**4803**	**1802**	**44.5**	**17.8**

Source: Rust into Renewal Survey, Greening Brownfield Properties 2010 SNRE Master's Project

In general, respondents with higher household incomes used parks within the City of Houston more. Those with a college degree or higher used parks within the City of Houston twice as much in the past six months as those without, 54.4 versus 28.2 times. However, Hispanic respondents used Houston parks more than their fellow respondents identifying with another race despite the fact that they also had the lowest average household income and the lowest average educational attainment. Hispanic respondents used Houston parks an average of 49.7 times in the last six months versus 45.4, 43.6 and 34.0 times for non-Hispanic Whites, African Americans and Asian or Asian Americans respectively.

Question 5: Preferences about Future Park Opportunities

A final prompt in this section allowed respondents to freely comment on what activities they would like to have available if a park were near them. Respondents provided comments, all of which are included in Appendix III. A wide array of desires was expressed for this space, with additional picnic sites being mentioned the most often.

Part II: Concern, exposure, and opinions about brownfields

Question 6: Concern about Brownfields

Question 6 attempted to assess the overall concern over brownfields amongst Houston residents, asking to what degree they agreed or disagreed with the statement: "The number of brownfields in the City of Houston is perceived to be a problem." The average response was 3.56, somewhere between "I Neither Agree Nor Disagree" and "I Somewhat Agree" and were consistent across the demographics evaluated.

These results are undermined by the fact that many respondents may have been confused about the meaning of "brownfield." Many wrote in that they didn't know what it was or that they didn't understand. Defining a brownfield for use amongst the general public is often difficult. This is especially true in the case of a survey, where no direct clarification is possible. Through the pretesting process, the definition of brownfield provided to respondents preceding the question was narrowed to simply "a former industrial property that has been abandoned." When the survey was mailed this was changed to bring the definition in line with the City of Houston's official one: "a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant." It is not possible to know whether the original definition would have led to less confusion, but in the future it will likely be useful to test multiple versions in pretesting.

Question 7: Exposure to Brownfields and Opinions

Twenty-nine out of 114 respondents answered that they knew of a brownfield within a mile of their residence. If respondents answered "yes" to this question, they were asked how many there were in that area, followed by five questions which aimed to gauge how much impact these sites are having. The average number reported was 2.2, and many respondents reported that they had even 4 or 5 brownfields within a mile of their residence. Table 2.5 sums up the findings from the questions gauging impression of the impact of nearby brownfields. Only two of the prompts, "I don't really notice the brownfield much" and "the brownfield land is fine as it is now – there isn't much need for redevelopment", reached statistical significance. Both of these did so because respondents disagreed with the statements.

Table 2.5 - Impression of Nearest Brownfield, Houston, 2010

Based on a 1 - 5 scale where 3 is "neither agree nor disagree", 1 = "strongly disagree", and 5 = "strongly agree"

Prompt	Mean Score	Significance Ɨ
The brownfield makes crime worse in my area.	3.35	0.078
I don't really notice the brownfield much.	2.47*	0.006
Other people in my community complain about the brownfield.	2.98	0.890
It would be better for my area if the brownfield were redeveloped for a new commercial use than if it became a new park.	2.96	0.861
The brownfield land is fine as it is now - there isn't much need for redevelopment.	2.00*	0.000

Source: Rust into Renewal Survey, Greening Brownfield Properties 2010 SNRE Master's Project
* Denotes statistical signficance at the 95% level
Ɨ Significance based off of neutral being 3

Prompting only those who answered that they knew of a brownfield within a mile of their residence with further questions was intended to make the following responses of higher quality, but the results may have suffered from the low level of responses. This is likely further complicated by the confusion over brownfields previously mentioned. Future surveyors may find it useful to rewrite these questions to not filter out potential respondents from sub-questions.

Despite the especially low response rates to this question once demographic identification was factored in, it is worth noting for future inquiry that of the three African Americans respondents who answered the prompt, two said that they "strongly agreed" and one said that they "somewhat agreed" that "It would be better for my area if the brownfield were redeveloped for a new commercial use than if it became a new park" even though the overall response to that question was near neutral. Additionally, both strongly disagreed that "The brownfield land is fine as it is now – there isn't much need for redevelopment", well beyond the other groups whose average was right around "somewhat disagree".

Part III: Preferences of ecosystem service provisions

Finally, question 8 intended to measure preferences for the potential provisions of a variety of ecosystem services and the benefits associated with them. Respondents had the option to choose four responses from “very important” to “not important.” To determine whether the subject of each prompt was considered more or less important than the others, the responses to each prompt were measured against the average response for the entire section. “Don’t know” responses were not factored into the analysis. As shown in Table 2.6, the benefits considered most important by respondents were improving flood protection and air quality. Those considered least important were protecting endangered species in the City of Houston and having more opportunities for education about nature.

Table 2.6 - Environmental Benefits Ordered Most to Least Important, Houston, 2010

Based on a 1 - 4 importance scale where 1 is "very important" and 4 is "not important"

Prompt	Mean Score	Significance Ɨ
Improving flood protection in the City of Houston is:	1.20*	0.000
Improving air quality in the City of Houston is:	1.25*	0.000
Developing vegetation in the City of Houston that will lower greenhouse gas emissions is:	1.55	0.350
Increasing the number of trees in the City of Houston is:	1.62	0.952
Developing solar power in the City of Houston is:	1.63	0.869
Developing new nature trails in the City of Houston is:	1.71	0.230
Protecting endangered species in the City of Houston is:	1.85*	0.011
Having more opportunities for education about nature in the City of Houston is:	1.88*	0.004
Providing more habitat for bird species and other wildlife in the City of Houston is:	1.88*	0.003

Source: Rust into Renewal Survey, Greening Brownfield Properties 2010 SNRE Master's Project

* Denotes statistical signficance at the 95% level

Ɨ Significance based off of neutral being the average answer for all prompts, 1.6518905

These results tend strongly toward "very important" in large part because some respondents simply put "very important" for all of their responses. Additionally, it is difficult to ask questions about environmental issues without eliciting a strong social desirability bias.   Respondents tend to agree with environmentally conscious prompts because they perceive that doing so paints them in a favorable light (Groves et. alia, 2004). This bias is considered to be rooted in human psychology and is true in mail response surveys (Tourangeau et al., 2008). The demographic that strayed from "very important" the most were those whose households made 175 thousand or more a year with an average answer of 1.95. African American respondents exhibited the greatest variation between the prompts, agreeing more strongly than other respondents to the need for more flood protection and improved air quality while recording some of the highest averages recorded amongst any demographic group for the prompts concerning increasing the number of trees, developing solar power and protecting endangered species.

Conclusion

When it is expected that people will interact with a restored brownfield property, public participation is a critical component of insuring that the full extent of the possible social benefits of redevelopment are realized. Public participation not only incorporates the knowledge of local communities about what is actually needed in their area, but it also engenders community support of the final product, making a successful outcome more likely. Utilization of this tool can carry onward beyond the initial revitalization of the property through adaptive management, in which incremental developments are evaluated by public feedback.

In order to provide a product to ExxonMobil that serves as an entry into incorporating the interests of the public into brownfield redevelopment, a general pilot survey was distributed to 2000 randomly selected homeowners throughout the City of Houston.   Topics influential to the transformation of brownfields into greenspaces were covered. These included park accessibility, usage, and interest in the nature of development, concern, exposure, and opinions about brownfields, and preferences for the development of ecosystem services. While the survey's low response rate and skewed demographic representation of the general population of Houston should temper the influence of its results, its findings still provide an initial foray into redevelopment outreach that can inform future efforts. Information about park usage, especially in the free responses provided by respondents, influenced the development of design alternatives on the Bellfort site. It was found that while many residents have trouble understanding the concept of a brownfield, a statistically significant amount of disagreement was registered concerning the idea that nearby brownfields didn't need to be redeveloped and that they weren't noticeable. For ecosystem services, it was found that those that represented immediately practical improvements such as flood control and air quality were considered more important than increasing tree cover, creating habitats or even providing educational services. Future surveys can benefit from avoidance of the pitfalls that this effort encountered and further investigate some of its more intriguing findings.

Chapter: 3

Hedonic Pricing

In this chapter we describe the hedonic pricing method, develop a particular hedonic model to test our hypothesis that the conversion of brownfields to greenspaces causes nearby houses to increase in value, and report the results of running the model on two former brownfield sites which were converted to parks in Houston.

Hedonic Pricing Method

People generally buy a good when they believe the value that they will receive from purchasing it is at least equal to its cost. Therefore, when a transaction takes place in the marketplace, the buyer is implicitly providing information on the good's value. Knowing the value people place on goods is important because if a good can be produced for less than the amount people are willing to pay, the good will be produced. Furthermore, knowing the monetary amount that people ascribe to a particular good makes it possible to know the good's relative value in comparison to other goods. This eases our ability to conduct commerce with one another.

However, there are non-market goods, like greenspaces and brownfields, for which it is more difficult to assess people's perceived value because they are not sold in the market. One effective tool economists use to attempt to determine the value of these non-market goods is hedonic pricing. The hedonic pricing method estimates non-market value by decomposing the item of interest into its constituent characteristics. For example, in order to determine the value of public school quality, data would be gathered on the price of houses, the physical characteristics of houses, and neighborhood characteristics, including the different quality of schools in the study. Once all the data are obtained, a regression is used to isolate the impact of the characteristic in question from the impact of other characteristics. From the regression results, a researcher can determine the marginal willingness to pay for public school quality, controlling for all the characteristics of houses.

Existing Literature

There is substantial and growing literature that explains the impact of environmental amenities and disamenities on real estate values. These studies vary widely in their methodology, ranging from simple surveys to hedonic modeling to matched-pair analysis. The studies have examined the influence of a wide range of land use types, such as playgrounds, community gardens, urban parks, greenbelts, greenways, wetlands, and agricultural spaces, as well as brownfields, landfills, and hazardous waste sites. Much of the research shows that houses located closer to open or greenspaces generally sell at higher prices after controlling for housing characteristics, while properties tend to decrease in value if adjacent to brownfields or other types of depressed lands. Along with access, the positive effects of open and greenspaces are suspected to be due to the scenery, recreational uses, and moderated temperatures that nearby residents can enjoy (Geis, 2009). Despite the fact that the literature on the redevelopment of brownfields in the United States has burgeoned in recent decades, researchers have not devoted much attention to examining the benefits provided from converting brownfield sites to greenspace. (A few exceptions are De Sousa, 2004, and Kirkwood, 2001). Our project attempts to fill this void with a difference-in-differences econometric model.

Project Rationale

In this project, we develop and run a hedonic pricing model for two properties that were formerly in the City of Houston's Brownfield Redevelopment Program. These properties were converted into parks in the first decade of the 21st century. We undertook a difference-in-differences specification of the hedonic pricing model in order to test whether nearby houses increased in value as a result of the brownfield to park conversion. We analyzed how the values of property within a designated distance (e.g. 2,000 feet) of the site changed in comparison to the values of property outside the designated distance. This difference-in-differences approach effectively avoids bias that might be introduced by any systematic differences other than proximity to the park between properties located close to the park and those farther away.

There are only a few studies focused on land use changes using a difference-in-differences method which are relevant to our work. Tranel and Handlin (2006) used a difference-in-differences methodology to assess the neighborhood effects of 54 community gardens in St. Louis, Missouri. They found that median rent, median housing costs for owner-occupied housing, and homeownership rates increased in the immediate vicinity of the gardens relative to the surrounding census tracts after garden opening. Voicu and Been (2008) estimated the impact of community gardens on neighborhood property values in New York City, using a difference-in-differences specification of a hedonic regression model. They found that gardens have significant positive effects, especially in the poorest neighborhoods, and higher-quality gardens have the greatest positive impact. Heintzelman (2008) examined a Massachusetts policy which encouraged communities to raise money through referenda for preservation. He used difference-in-differences to compare home prices before and after such referenda in two towns, finding that preservation has a positive effect on property values.

Our research is a worthwhile analysis because of the limited amount of research associated with transforming brownfield properties into greenspace. In addition, it is interesting to see whether the effect and intensity of nearby greenspaces and brownfields detected in other locations also applies in Houston. Moreover, this study provides the City of Houston with an understanding of the additional tax revenue generated as a result of brownfield redevelopment. This information should be crucial for crafting proper public policies, such as whether public incentives for conversion of brownfield sites into greenspaces are appropriate and the apt amount of resources to invest in brownfield redevelopment.

Sites Chosen

We based our study on Tony Marron Park and Mandell Park, both of which are former properties in the City of Houston's Brownfield Redevelopment Program. Characteristics of both of these sites are summarized in Table 2.1 below. With these two properties we ran separate hedonic pricing studies, one for Tony Marron Park and one for Mandell Park.

Table 3.1 – Site Characteristics of Mandell Park and Tony Marron Park

Property Information	Mandell Park	Tony Marron Park
Address	1531 Richmond Ave, Houston, Texas 77006	808 York St, Houston, Texas 77023
Location relative to downtown Houston	5 miles southwest	3 miles east
Neighborhood	Residential	Industrial, residential
History	Turned into a park during 2004	Turned into a park during 2004-2005
Size	1.22 acres	19.07 acres

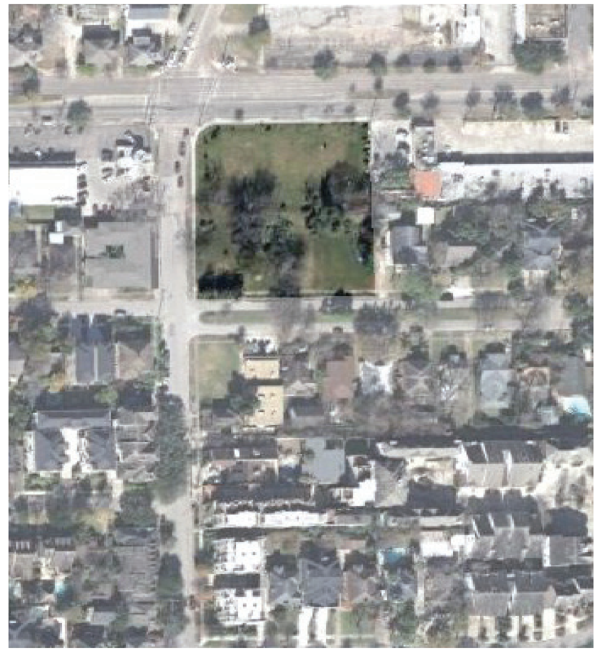
Tony Marron Park

Acquired by Houston's Parks and Recreation Department in 1987, the site that became Tony Marron Park is located three miles east of downtown Houston (Buffalo Bayou Partnership, 2010). The park's immediate surroundings are largely industrial. Buffalo Bayou, a waterway flowing through Houston that links with the Houston Ship Canal, is the northern boundary of the property. Residential neighborhoods lie to the south of the park. Prior to park construction, which began in February 2004 and was completed by November 2005, the property was vacant (City of Houston, 2010a). In creating the park, the City of Houston leveled the land and installed utilities, a pavilion, trails, play equipment, and a water play area (City of Houston, 2010a).

Tony Marron Park

Mandell Park

Mandell Park



The site that would become Mandell Park is located in a residential area five miles southwest of downtown Houston in the Museum District. Rice University is located about one mile to the south. Prior to its purchase by the City of Houston in 1982, the commercial part of the site was a chemical laboratory, gas service station, and dry cleaning facility. After on-site structures were demolished in 1990 in preparation for a library building, environmental assessments conducted showed soil and groundwater contamination, but the contamination levels were not high enough to warrant action (City of Houston, 2010b). The City decided against building the library and people began to use part of the site illegally as a dumping ground (Friends of Mandell Park, 2010). On part of the site, a garden has been maintained by local community groups since the early 1990s. In 2004, when the site was transferred from Houston's Library Department to the Parks and Recreation Department, the City removed 12 underground storage tanks, leveled the land, and planted grass seed on the site (City of Houston, 2010b). The Friends of Mandell Park wants to raise an additional $1.5 million to further increase the attractiveness of the site (Friends of Mandell Park, 2010).

Model Development

Our goal is to estimate the impacts of the two former brownfields' redevelopment on neighboring residential property values. For years both before and after the brownfield to park conversion, we compared the appraised values of properties that are within designated distances of the two sites to appraised values of comparable properties that are outside the designated distance. This type of analysis generates a difference-in-differences estimator, which is our measure of the greening impact on neighborhoods. Using this method, we were able to avoid bias that might be introduced by any systematic differences between properties close to the studied properties and those farther away.

Our model takes the following form where i represents the properties, t represents the years, and j represents the neighborhoods within our sample.

$$\ln P_{it} = \alpha + \beta_1 Near + \beta_2 Treatment\ Years + \beta_3 Impact + \pi_j NID_j + \mu_t Year_t + \varepsilon_{it}$$

Table 3.2 – Hedonic Model Variable Definitions

Variables	Definition
$\ln P_{it}$	The natural logarithm of the deflated (housing-index adjusted) appraised property value in 1995 dollars as determined by the Harris County Appraisal District of property *i* in year *t*.[3,4]
Near	A dummy variable equal to 1 if property *i* is within a specified Euclidian distance of the park; 0 otherwise. We specified various distances for each of the sites.[5]
Treatment Years	A dummy variable equal to 1 if it is in a year after the conversion from brownfield to park is complete; 0 otherwise.
Impact (Near*Treatment Years)	An interaction term of the Near and Treatment Years dummy variables equal to 1 if both Near and Treatment Years equal 1; 0 otherwise. The coefficient on this variable captures the impact of interest since the variable is equal to 1 only for properties "near" the site in the years after conversion.
NID_j	A dummy variable equal to 1 if the property is in neighborhood *j*; 0 otherwise. Neighborhoods were determined using U.S. Census Block Groups. For Tony Marron Park we have 69 neighborhoods and for Mandell Park we have 74 neighborhoods.
$Year_t$	A dummy variable assigned the value of 1 for year *t*; the variable is assigned the value of 0 otherwise.
v_{it}	The error term capturing unobserved heterogeneity of the properties.
ε_{it}	The error term containing other unobserved factors that affect property values.

We did not gather data on the physical characteristics of residential properties because we assumed these characteristics stay constant over the course of the study. In addition, we assumed that the unobserved heterogeneity (differences) in properties is uncorrelated with the variables Near, Treatment Years, Impact, NID, and Year. Using the statistical software STATA, we ran random-effects Generalized Least Squares regressions for our study.

Data

The Houston-Galveston Area Council (H-GAC) provided the appraised (tax-assessed) property values.

3 The natural logarithm of the deflated value was used because this made the distribution of appraised values normal-looking. Without taking the natural logarithm, the distribution is skewed to the right.
4 The housing price index was determined using all the properties in our study except those within one mile of the site. For the properties remaining, we summed the values of all the properties for each year. Then, we compared this summed value to the summed value for 1995 to develop the appropriate deflator for each year.
5 We used ArcGIS to calculate the distance between the center of the residential property and the center of the site.

H-GAC received these appraised property values from the Harris County Appraisal District. We only included residential properties within two miles of the sites that had values for every year over the period 1995-2008. We had data from earlier years but it was in a different format and we believed beginning in 1995 was sufficient. Also, we did not include any properties that had a value of 0 as the value of the physical structure on the site for any year. Lastly, we ran the model with different designations for the variable "Near" to see how the impact varies with distance.

Results

Tony Marron Park Results

For the Tony Marron Park site, Table 3.5 shows that in years before the brownfield has been converted into a park, residential properties within 2,000 feet of the brownfield have a deflated price 15.5% less,

Table 3.3 – Tony Marron Park Descriptive Statistics[6]

	Mean	Median	Standard Deviation	Minimum	Maximum
$\ln P_{it}$	9.996	10.053	0.551	7.160	14.371
Distance (in feet)	7,882	8,367	2,400	784	11,257
$Near^T_{2000}$	0.0146	–	–	–	–
$Near^T_{5000}$	0.1607	–	–	–	–
$Near^T_{8000}$	0.4481	–	–	–	–

on average, than properties located more than 2,000 feet from the brownfield, holding all other factors constant. In years after the brownfield has been converted into a park, residential properties within 2,000 feet of the park experience a deflated price increase of 11.9%, on average, relative to properties located

6 There are 11,108 unique houses with data over 14 years (1995-2008), providing a total of 155,512 observations.
NearT2000 is defined as properties within 2,000 feet of the site. Under this definition, 1.46% of properties in our study are near the site.
NearT5000 is defined as properties within 5,000 feet of the site. Under this definition, 16.07% of properties in our study are near the site.
NearT8000 is defined as properties within 8,000 feet of the site. Under this definition, 44.81% of properties in our study are near the site.

7 There are 13,308 unique houses with data over 14 years (1995-2008), providing a total of 186,312 total observations.
NearM2000 is defined as properties within 2,000 feet of the site. Under this definition, 5.67% of properties in our study are near the site.
NearM5500 is defined as properties within 5,500 feet of the site. Under this definition, 37.37% of properties in our study are near the site.

Table 3.4 – Mandell Park Descriptive Statistics[7]

	Mean	Median	Standard Deviation	Minimum	Maximum
$\ln P_t$	11.8557	11.8038	0.7386	8.1696	16.4591
Distance (in feet)	6,408	6,608	2,672	0	10,673
$Near^M_{2000}$	0.0567	–	–	–	–
$Near^M_{5000}$	0.3737	–	–	–	–

Table 3.5 – Tony Marron Selected Results 2,000 ft.

Variables	Coefficient (Standard Error)
Near	-0.1550 (0.0327)
Treatment Years	-0.0874 (0.0025)
Impact	0.1191 (0.0099)

Note: All coefficients are significant at the 1% level.

Table 3.6 – Tony Marron Selected Results 5,000 ft.

Variables	Coefficient (Standard Error)
Near	-0.1825 (0.0279)
Treatment Years	-0.0959 (0.0026)
Impact	0.0635 (0.0032)

Note: All coefficients are significant at the 1% level.

Table 3.7 – Tony Marron Selected Results 8,000 ft.

Variables	Coefficient (Standard Error)
Near	-0.0215*** (0.0164)
Treatment Years	-0.1062* (0.0027)
Impact	0.0459* (0.0024)

Note: * denotes 1% significant level, *** 10% significant level.

more than 2,000 feet from the park, holding all other factors constant. Thus, after the brownfield to park conversion, properties located within 2,000 feet of the park are only worth 3.6% less, on average, than properties located more than 2,000 feet from the park.

For the Tony Marron Park site, Table 3.5 shows that in years before the brownfield has been converted into a park, residential properties within 2,000 feet of the brownfield have a deflated price 15.5% less, on average, than properties located more than 2,000 feet from the brownfield, holding all other factors constant. In years after the brownfield has been converted into a park, residential properties within 2,000 feet of the park experience a deflated price increase of 11.9%, on average, relative to properties located more than 2,000 feet from the park, holding all other factors constant. Thus, after the brownfield to park conversion, properties located within 2,000 feet of the park are only worth 3.6% less, on average, than properties located more than 2,000 feet from the park.

Table 3.6 shows that in years before the brownfield has been converted into a park, residential properties within 5,000 feet of the brownfield have a deflated price 18.2% less, on average, than properties located more than 5,000 feet from the brownfield, holding all other factors constant. In years after the brownfield has been converted into a park, residential properties within 5,000 feet of the park experience a deflated price increase of 6.4%, on average, relative to properties located more than 5,000 feet from the park, holding all other factors constant. Thus, after the brownfield to park conversion, properties located within 5,000 feet of the park are only worth 11.8% less, on average, than properties located more than 5,000 feet from the park.

Table 3.8 – Mandell Selected Results 2,000 ft.

Variables	Coefficient (Standard Error)
Near	-0.1406 (0.0215)
Treatment Years	0.0267 (0.0023)
Impact	-0.0510 (0.0046)

Note: All coefficients are significant at the 1% level.

Table 3.9 – Mandell Selected Results 5,500 ft.

Variables	Coefficient (Standard Error)
Near	-0.0340* (0.0200)
Treatment Years	0.0267*** (0.0023)
Impact	-0.0523*** (0.0045)

Note: * denotes 1% significant level, *** denotes 10% significant level.

Table 3.7 shows that in years before the brownfield has been converted into a park, residential properties within 8,000 feet of the brownfield have a deflated price 2.2% less, on average, than properties located more than 8,000 feet from the brownfield, holding all other factors constant. In years after the brownfield has been converted into a park, residential properties within 8,000 feet of the park experience a deflated price increase of 4.6%, on average, compared to properties located more than 8,000 feet from the park, holding all other factors constant. Thus, after the brownfield to park conversion, properties located within 8,000 feet of the park are worth 2.4% more, on average, than properties located more than 8,000 feet from the park. For more detailed regression results see Appendix VI.

Mandell Park Results

For the Mandell Park site, Table 3.8 shows that in years before the brownfield has been converted into a park, residential properties within 2,000 feet of the brownfield have a deflated price 14.06% less, on average, than properties located more than 2,000 feet from the brownfield, holding all other factors constant. In years after the brownfield has been converted into a park, residential properties within 2,000 feet of the park experience a deflated price decrease of 5.1%, on average, compared to properties located more than 2,000 feet from the park, holding all other factors constant.

Table 3.9 shows that in years before the brownfield has been converted into a park, residential properties within 5,500 feet of the brownfield have a deflated price 3.4% less, on average, than properties located more than 5,500 feet from the brownfield, holding all other factors constant.

In years after the brownfield has been converted into a park, residential properties within 5,500 feet of the park experience a deflated price decrease of 5.23%, on average, compared to properties located more than 5,500 feet from the park, holding all other factors constant.

Discussion

The results obtained from the model indicate mixed impacts of greening brownfields on property values. For Tony Marron Park, the results in all three distance scenarios match our expectations: first, properties located near a brownfield have a lower value than those farther from the brownfield at a statistically significant level; second, in years after the brownfield has been transformed into a park, properties near the site increase in value relative to those farther from the site at a statistically significant level. Moreover, as the distance which is considered "near" increases, the impact of the park decreases. In moving from where near is considered to be 2,000 feet or less to 5,000 feet or less to 8,000 feet or less, the impact of the park on "near" property values decreases from 11.9% to 6.4% to 4.6%. This is exactly what we would expect; as properties farther from the park become considered "near," the park's impact is reduced.

On the contrary, the results for Mandell Park show that the redevelopment efforts of the site have had a negative impact on nearby residential property values. There are a few possible explanations for the lack of a positive property value effect. First, although local community members have been working to improve the site since the early 1990s, the park is still in the redevelopment phase; further work is planned for the site. Being in such a transition stage, the site could be less appreciated by the local community because of the uncertainties associated with the park's future. Second, considering the dense and relatively wealthy residential community surrounding Mandell Park, the site could provide a haven for loitering or other undesirable social behavior. This could result in nearby properties actually decreasing in value, as our results indicated. Finally, as the area of Mandell Park is relatively small, the positive impact we think it should provide might be too small to be capitalized in property values. Further study — beginning with communication with real estate agents in the area — could attempt to determine why the results for Mandell Park do not match common expectations.

Conclusions

Brownfield redevelopment is a central imperative of government efforts to revitalize urban cores and promote smart growth. As discussed in Chapter 4, the City of Houston's Brownfield Redevelopment Program promotes beneficial redevelopment of brownfield sites. If cities are going to invest public money on these projects, there needs to be evidence that this is a worthwhile investment.

This study examines one important aspect of brownfield redevelopment that local public officials should consider in their efforts. The results suggest that brownfield redevelopment has significant, while mixed, effects on surrounding appraised property values. Obviously, changes in appraised property values have an impact on city tax revenues. Our findings should help local governments make sounder decisions about whether and how much to invest in brownfield revitalization. In addition, our results could indicate that redevelopment of larger brownfields, in locations that have mixed residential and industrial properties, may provide larger increases in appraised property values. The 300-acre Bellfort property, located in a depressed area, seems to be a good candidate for brownfield redevelopment efforts in the City of Houston.

Chapter: 4

3300 East Bellfort Street

In this chapter, we discuss the basis for selecting the Bellfort site, background information on the site and nearby community, and current activity at the site.

The Bellfort Site

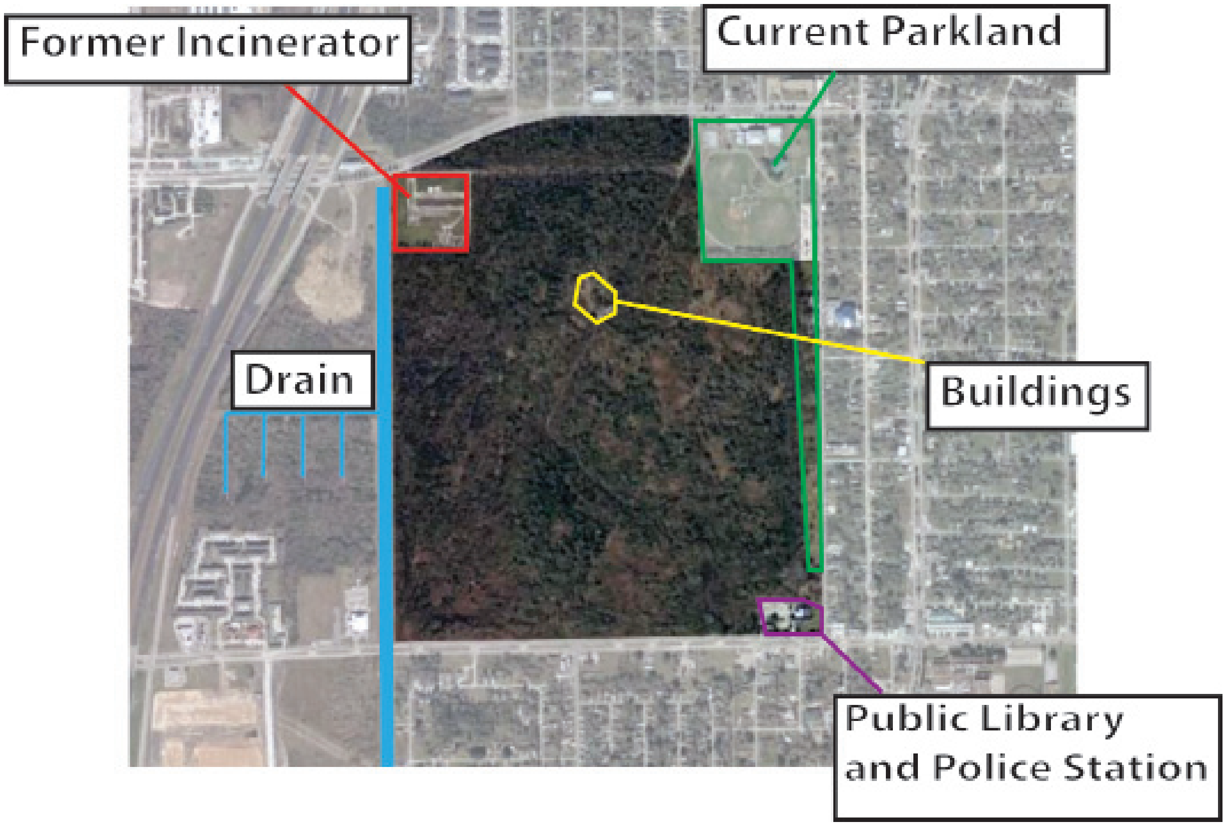
The initial intent of the project was to develop plans for a site with perceived contamination owned by ExxonMobil. Potential legal concerns arising from our use of ExxonMobil's sites for this project led the team to focus instead on sites managed by the City of Houston. The team considered the sites in Houston's brownfield program. Several were visited, including 3300 Bellfort Street, 0 Airport Road at Highway 288, 100 Japhet Street, 1801 Allen Parkway, 1400 Fulton Street, 4600 Clinton Drive, 117 Eastwood Street, 222 Milby Street, 2002 Blodgett, and 11017 Cullen Boulevard. The majority of the sites were eliminated from consideration because of the difficulty posed in accessing them, their isolation from other developed areas, or existing decisions about their development. Ultimately, because 3300 Bellfort Street avoided all of these constraints and provided unique opportunities, our focus was narrowed to that site. The site, owned by the City of Houston, was formerly a landfill and the location of an incinerator.

The Bellfort site is located about ten miles south of downtown Houston in the Sunnyside neighborhood (see Figure 2.1). The most obvious physical barrier to its redevelopment is the extensive trees and brush throughout the site (Chen et al., 2009). Pervasive wild grasses, trees, shrubs, and invasive species reduce visibility, thereby causing danger and risk.

A police station and library occupy the southeast corner of the site, while Sunnyside Park and Community Center occupy the northeast corner (see Figure 2.2). The park and the community center include a playground, an outdoor basketball court, a half-mile hiking and biking trail, lighted tennis courts, an indoor gymnasium, weight rooms, meeting rooms, a lighted athletics field, and a swimming pool. A dilapidated path runs north and south for about 500 feet along the eastern border of the site. A ditch runs along the eastern edge of the property.

Figure 2.1 3300 Bellfort and the Sunnyside Neigborhood
The Sunnyside Neighborhood surrounds the former Holmes Road Landfill

Figure 2.2 Existing Features on 3300 Bellfort



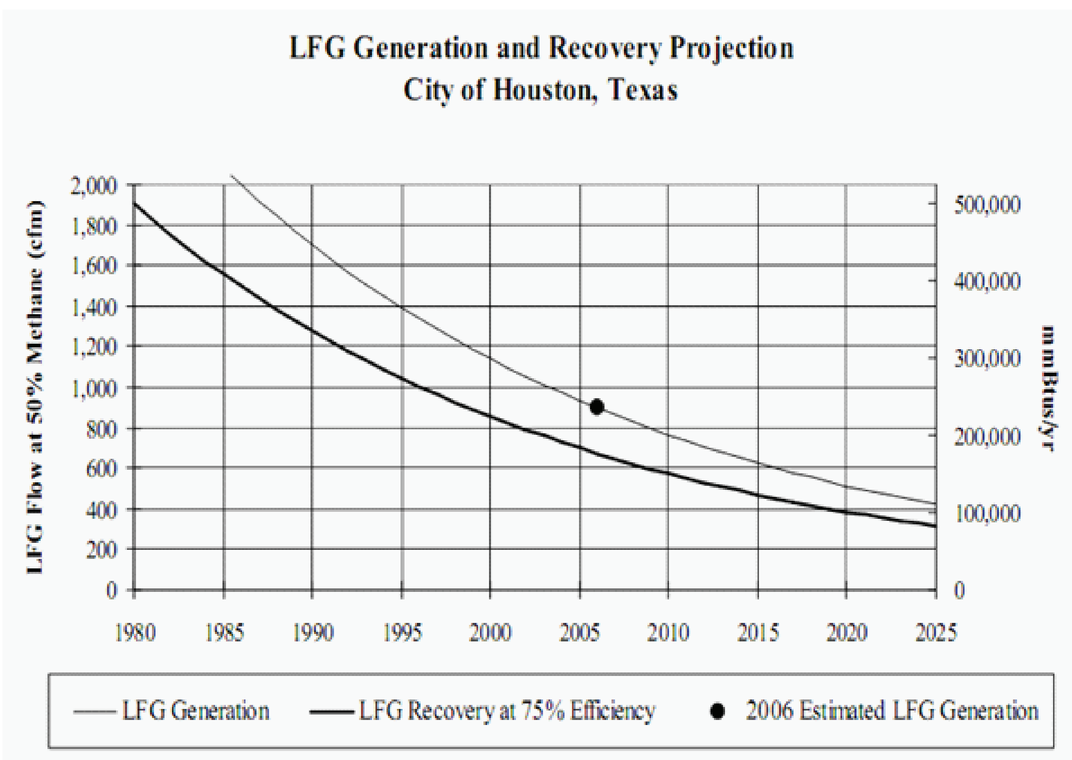
Not coincidentally, the area where this site is located in Houston is not well-off economically. In the decades after World War II, people making decisions about the placement of landfills and incinerators tended to place these sites in poorer communities (Bullard, 2007). The former Holmes Road Landfill is located in a predominantly poor African-American neighborhood. This pattern is seen throughout the city of Houston: "Although blacks composed just over one-fourth of the city's population from the 1920s through the 1970s, all five of the city-owned landfills and six of the eight city-owned incinerators were built in Houston's black neighborhoods" (Bullard, 2007, 212). The placement of locally unwanted land uses in less influential neighborhoods has resulted in "lowered property values, accelerated physical deterioration, and increased disinvestment in Houston's black neighborhoods" (Bullard, 2007, 209).

The landfill, in operation from 1937 to 1970 (City of Houston, Brownfield Redevelopment Program), occupies 264 acres of the site's 300 acres. Its depth, ranging from 30 to 60 feet, contains more than 9.7 million tons of waste (Landfill Methane Outreach Program, 2006). The landfill "was reportedly used for disposal of brush, construction and demolition debris, household waste, industrial waste, tires, and scrap" (SRA International).

Upon closure of the landfill, it was capped in order to seal contaminants within. Impermeable capping is a common method to deal with contaminants because it is relatively cheap and can take place relatively quickly. Fundamentally, the cap aims to prevent surface exposure of the contaminants, such as through penetration by flora, fauna, or rainwater. Yet, as a form of in-situ treatment, the contaminants remain on-site and untreated. Groundwater and sub-surface fauna can interact with the contaminants and carry them offsite. Furthermore, the cap deteriorates over time, creating "exposure pathways," or avenues for contaminants to be released. Another threat to the stability of landfill caps is direct damage, such as through puncturing by plant roots. In the case of the Holmes Road Landfill, a forest grew on top of the site over the past forty years with no control or maintenance.

Landfills naturally emit gases as their waste decomposes. With advanced technologies, these gases can be captured and used to generate energy. Yet, the gases can also pose significant threats to humans and the environment. The generation and potential recovery of gases from the 3300 Bellfort site was estimated by the Landfill Gas Emissions Model (LandGEM), developed by the EPA and partner organizations.[1] Figure 2.3 below shows that generation and potential recovery decline over time. At the time of this writing the site is estimated to be emitting less than 800 cubic feet per minute of methane. That amount is decreasing over time, which places time pressures on the feasibility of recovering any emissions for other uses .

Figure 2.3 Gas Generation and Potential Recovery Decline Over Time on 3300 Bellfort



1 LandGEM assumes that the gases emitted are "roughly half methane and half carbon dioxide with additional, relatively low, concentrations of other air pollutants" (EPA, "LandGEM Version 3.02 User's Guide).

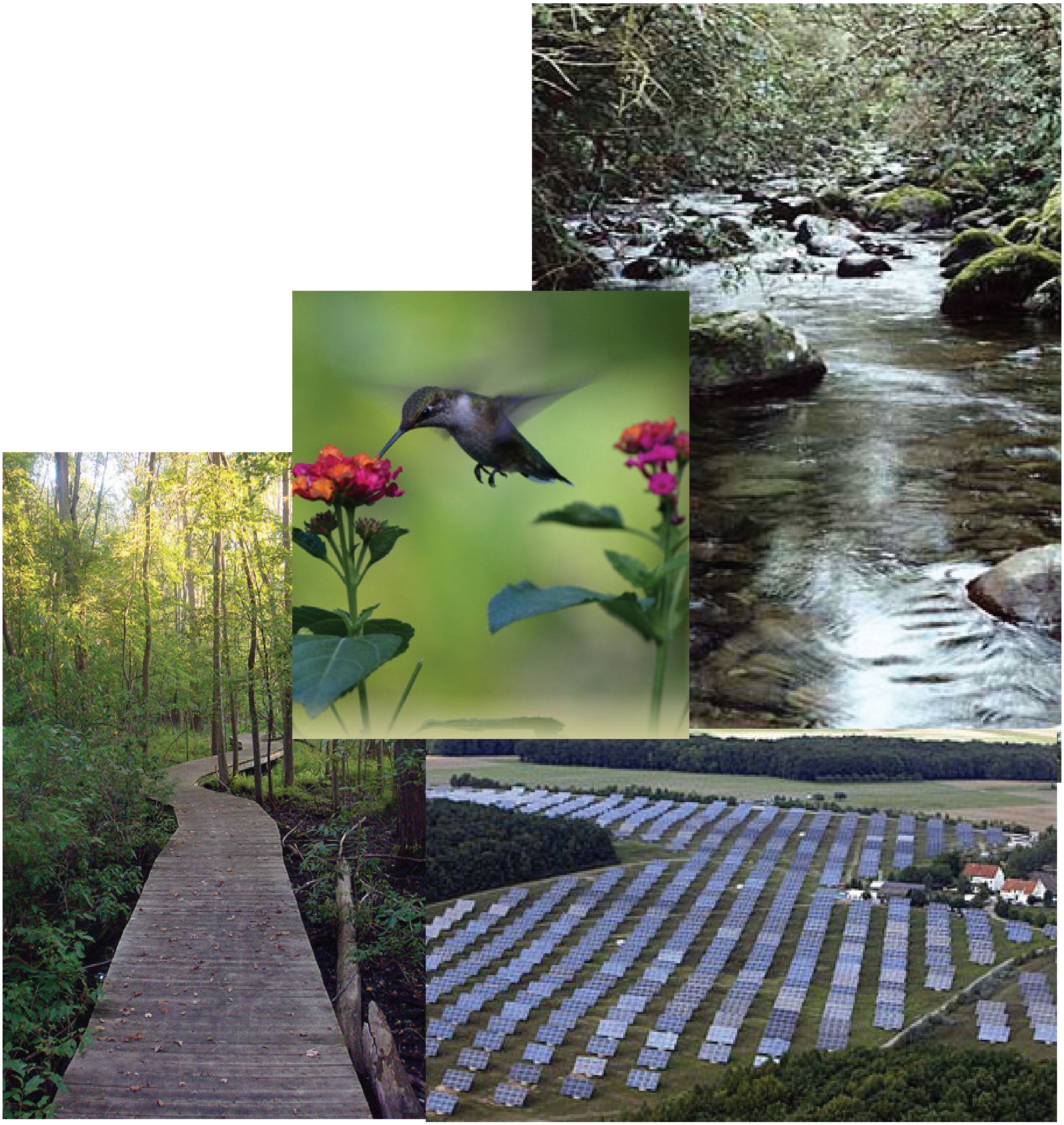
Several environmental assessments have been conducted on the ten acres in the northwest corner of the site, where an incinerator operated from 1965 to 1971 (City of Houston, Brownfield Redevelopment Program). The assessments have shown the presence of contamination on the site.[2] Specifically, levels of lead and polychlorinated bisphenyls have been detected above permissible levels (City of Houston-Brownfield Redevelopment Program). In this report we are not focusing on the contamination clean-up. However, this obviously needs to be considered when redeveloping the site.

The level of interest on the entire Bellfort site from other parties led to the City of Houston placing its redevelopment at a higher priority than other sites it owns. The United States Business Council for Sustainable Development (USBCSD) ranked the 3300 Bellfort Street site as its most preferred site out of sixty in the Houston area to "green," based on a study that looked at environmental, social, and economic considerations (USBCSD, 2009). In regards to the environment, the site is large enough that it can be habitat for wildlife, provide stormwater management, and perform other actions, such as composting, mulching, carbon sequestration, and environmental education. Socially, improving the site will attract more people to participate in recreational opportunities available at Sunnyside Park. Furthermore, in its current condition, parts of the site may be a health hazard for the surrounding community, so its redevelopment will provide immediate benefits to the surrounding community; because of this, any redevelopment is likely to receive community support. Finally, the site is large enough for economically viable mixed-used opportunities, which may provide spill-over benefits to the nearby neighborhoods.

2 In 1994, a health and safety assessment report was prepared by Fugro Environmental, Inc. An Environmental Baseline Investigation was conducted by Environmental Resources Management Southwest on the ten acre incinerator facility in March 1999. A site investigation was conducted at the former incinerator facility by Corrigan Consulting, Inc. in 2001. An application was submitted to the Texas Commission on Environmental Quality for the site to be enrolled in a Voluntary Cleanup Program; and the site was designated as VCP site no 1452.

Chapter: 5

Ecosystem Services



In this chapter, we define ecosystem services, determine the ecosystem services currently on the Bellfort site as well as the services if solar panels were placed on half the site, and calculate the value of the ecosystem services.

Introduction

Ecosystem services are technically defined as the direct and indirect benefits humans derive from nature (Millennium Ecosystem Assessment, 2005). To date, our society has had an incomplete understanding of the quality and total value of the goods and services derived from ecological systems and natural resources, but it is clear these services are critical to the functioning of human and other biological life systems on Earth. The White House's Office of Science and Technology has recently recognized the importance of these services (White House Office of Science and Technology, 2010).

In order for human decisions to incorporate the value of these services, there is increasing acceptance in placing monetary values on them. As expected, the monetary values are complicated to determine and subject to debate as these services have not been assigned economic values until recently.

The Millennium Ecosystem Assessment is the authoritative study on ecosystem health and the related implications for human well-being. In an attempt to demonstrate the benefits of ecosystem services, the Assessment classified ecosystem services into four categories: provisioning, regulating, supporting, and cultural services.

Provisioning services are ecosystem goods used by humans including food and medicine, fresh water, energy production from hydropower and bio-fuels, and genetic resources. If solar panels were placed on the Bellfort site, the energy production would be considered a provisioning service.

Regulating services are ecosystem processes that stabilize the environment for humans including flood control, climate regulation, carbon storage and sequestration, water purification and waste decomposition, disease and pest regulation, nutrient dispersal, and natural hazard regulation. For example, studies done in certain United States cities have shown that trees helped regulate climate change by moderating temperatures. Such studies in urban settings in United States cities have demonstrated that 100,000 properly planted mature trees may save up to $2 billion in heating and cooling costs (Krieger, 2001). The trees on the Bellfort site provide regulating services, including climate regulation and carbon storage.

Cultural services include recreation and social activities, spiritual inspiration, scientific discovery, and aesthetics. Various studies have established people's willingness-to-pay to keep certain ecosystems preserved for wildlife habitat as well as for aesthetic and recreational reasons. For example, Barnhill (1999) found that people in North Carolina and Virginia counties who visit the Blue Ridge Parkway spend $1.3 billion every year, generating $98 million in tax revenue and creating 26,500 jobs annually. Cultural services provided by the Bellfort site include the recreational and social opportunities that the site makes available.

Supporting services include soil formation, photosynthesis, nutrient cycling, and water cycling. Nutrients and matter naturally cycle within our planet through biological processes. For example, trees trap and remove pollutants such as carbon dioxide, sulfur dioxide, ozone, nitrogen oxides and particulate matter, leading to improved air quality and human health. Examining particulate matter in Tucson, Arizona, it was estimated that half a million mesquite trees would remove 6,500 tons of particulate matter annually, resulting in cost savings of $1.5 million every year (Krieger, 2001). The supporting services provided by the Bellfort site include removal of local air pollutants by trees.

Calculating Ecosystem Services

The ecosystem services portion of the project assesses current ecosystem service benefits generated by the Bellfort site and compares them to the benefits the site could produce under alternative configurations proposed in this project. The primary resource used to calculate the environmental benefits is CITYgreen, an ArcGIS extension developed by American Forests, a non-profit organization (American Forests, 2004). The software has been used by cities in the United States and abroad, including Cambridge, Massachusetts; Ottawa, Canada; and Nanjing, China. In this chapter, we provide the CITYgreen analysis as the site currently exists ("Baseline") and if half the site were to be covered by solar panels ("Solar"), which has been proposed by the City of Houston. In Chapter 6, which concerns the landscape designs we have proposed for the site, we perform additional CITYgreen analyses based on these alternative designs.

CITYgreen determines air pollution removal, carbon storage and sequestration, stormwater control, and water quality services provided on a specific site. The software calculates these services based on the amount of land area on the site in different land cover categories. The land cover categories include impervious surfaces, trees, shrubs, and open space. CITYgreen translates some of these services into monetary values.

Air Pollution Removal

The air pollution model, developed by the United States Forest Service, calculates the air pollution removal capacity of urban forests. Specifically, CITYgreen determines the pounds of nitrogen oxides, sulfur dioxide, ozone, carbon monoxide, and particulate matter less than ten microns that the tree canopy removes from the atmosphere each year.

CITYgreen has a two-step process to determine the pounds of a pollutant removed. First, the pollution removal rate (in units of grams per centimeter squared per second) is found by multiplying the deposition velocity (in units of centimeter per second) by the concentration of the pollutant (in units of grams per centimeter cubed). The deposition velocity is assumed constant over all cities, but pollutant concentration varies across cities. Houston, one of 55 United States cities that has pollution concentration data already incorporated into the CITYgreen software program, is automatically selected because of the geo-referenced aerial image. The second step is multiplying the pollution removal rate by the tree canopy area of a site for periods in which the pollutant is known to exist over the surface. The greater the tree canopy, the more air pollution is removed. The pounds of pollution removed by the tree canopy are also converted to dollar values. The conversions are listed in Table 5.1. The monetary benefit from removing a pound of pollutant from the atmosphere comes from reduced health care costs and higher tourism.

Table 5.1 Monetary Benefits of Pollutant Removal per Pound

Pollutant	$ per pound
Nitrogen oxides	3.53
Sulfur dioxide	0.86
Ozone	3.53
Carbon monoxide	0.49
Particulate matter less than 10 microns	2.36

Carbon Storage and Sequestration

Forests act as a sink of atmospheric carbon dioxide, a greenhouse gas. CITYgreen calculates both carbon storage, the total amount of carbon stored in the trees on a site, and carbon sequestration, the additional amount of carbon stored on a site over the course of a year. CITYgreen performs these calculations simply by multiplying the tree cover area of a site by average values for carbon stored (9,646 grams per meter squared) and sequestered per unit area (75 grams per meter squared). This is a crude calculation since the actual carbon stored and sequestered depends on such factors as the tree species, tree diameter at breast height, canopy height, canopy width, and canopy condition (Nowak and Crane, 2002).

In order to determine the value for carbon storage and sequestration on the site, a monetary value must be assigned per unit of emissions. Presently, there are no regulations on the emission of carbon dioxide in the state of Texas. However, ten northeastern states and two Canadian provinces have enacted a cap-and-trade system for greenhouse gas emissions, called the Regional Greenhouse Gas Initiative (RGGI). Since September 2008, the RGGI has conducted auctions to buy the right to pollute in quantities of one metric ton of carbon dioxide equivalent. The average price in these auctions, weighted by the number of permits sold, has been $2.75 per ton of carbon dioxide emitted (Regional Greenhouse Gas Initiative, 2010). We use this price to determine the value of trees on the Bellfort site in terms of their carbon storage and sequestration.

Stormwater Runoff

The Natural Resource Conservation Service, a division of the United States Department of Agriculture, developed the stormwater model used by CITYgreen. This model uses the amount of tree cover, soil type, and precipitation level (automatically inputted for the Houston area by CITYgreen due to the geo-referenced aerial image) to determine the additional volume of stormwater that would run off a land area if the trees on the site were replaced by a more impervious land cover during a 2-year 24-hour storm. A 2-year 24-hour storm is defined as the largest amount of rainfall expected over a 24-hour period during a 2-year interval (LEEDuser, 2010). For Houston, CITYgreen reports the 2-year 24-hour storm as 4.75 inches of precipitation. For the analyses in this report, we assumed the tree cover was replaced by the CITYgreen category "open space: grass/scattered trees <50%" as the more impervious surface.

The additional runoff caused by the land cover conversion could be handled with construction of retention or detention ponds, the costs of which CITYgreen conservatively estimates at $2.00 per cubic foot. Cambridge, Massachusetts used a figure of $22.00 per cubic foot in its own CITYgreen analysis (City of Cambridge, 2005). CITYgreen spreads the costs of retention or detention pond construction over 20 years, assuming an interest rate of 6% on bonds, and reports a yearly cost.

Water Quality

Purdue University and the EPA developed the water quality model used in CITYgreen. The replacement of trees by open grassland decreases the rate of filtration of surface water, thereby increasing the pollutant loadings in surface runoff water. Using land cover data, the model reports the percent increase in contaminant loadings for biological oxygen demand, cadmium, chromium, chemical oxygen demand, lead, nitrogen, phosphorus, suspended solids, and zinc if the tree cover on the site were replaced by a more impervious surface. Again, we assumed the tree cover would be replaced by the CITYgreen category "open space: grass/scattered trees<50%." For the water quality ecosystem services, CITYgreen does not calculate a monetary value; we do not either.

Configuring CITYgreen

Before we could use CITYgreen, we acquired a high quality geo-referenced aerial image of our study site from the Houston-Galveston Area Council (HGAC). We used this image as a base map for identifying and digitizing all the land cover features present on the study site. The major land cover features on the site are the small to medium growth trees scattered all across the area (CITYgreen category "trees: forest litter understory: no grazing, forest litter and brush adequate cover soil"), open grassland (CITYgreen category "open space: grass/scattered trees"), and impervious surfaces such as pavements and buildings (CITYgreen category “impervious surfaces: buildings/structures: all other buildings”). We digitized these different land covers and stored them as vector data. Then these vector data were converted to a raster file so that the CITYgreen program could process and analyze the data.

CITYgreen Results

Baseline Scenario

CITYgreen determined that there are 129.2 acres of tree canopy cover on the study site. The amount and value of the ecosystem services currently provided by these trees on the site are shown in Table 5.2 and Table 5.3. Complete CITYgreen results are available in Appendix VII. The total yearly monetary benefit from air pollution removal, carbon sequestration, and reductions in storm water runoff is $64,203.67 for the approximately 300 acre site. To provide context for the value of these ecosystem benefits, the current asking price of undeveloped land near the Bellfort site ranges from $60,000 to $170,000 per acre (Chron.com, 2010).

Table 5.2 Baseline Scenario Ecosystem Service Values

Ecosystem Service	Amount	Annual $ Value
Annual air pollution removal	15,436 pounds	41,241
Total carbon storage	5,561 tons	--
Annual carbon sequestration	43 tons	118
Annual storm water runoff increase	129,144 cubic feet	22,519

Table 5.3 Baseline Scenario Water Quality Impact from Tree removal

Contaminant	% Increase
BOD	5
Cadmium	6
Chromium	7.2
COD	7.5
Lead	2.3
Nitrogen	3
Phosphurous	5.7
Suspended Solids	5
Zinc	1.7

Solar Scenario

As part of the EPA Brownfields Sustainability Pilot Community, the Bellfort site is under consideration to have ten megawatts of solar power generated on the site. Generating ten megawatts of solar power in Houston requires about 150 acres, which is half the area of the Bellfort site (SRA International, 2009). A consulting report recommends that the solar panels be placed on the southern part of the former landfill, as the utility lines there have a greater capacity than those located elsewhere on the site (SRA International, 2009). The report estimates that the solar panels will generate more than 12 million kilowatt-hours of electricity in an average weather year, meeting one percent of the City government's needs, and more than 300 million kilowatt-hours over its expected 30 year life, given that photovoltaic module output degrades over time. The purpose of the solar project is for demonstration, education, and energy generation for use by the City government.

Since installing solar panels on the site will require trees on this section of the site to be removed, the ecosystem services that these trees provide will be lost. Table 5.4 below shows the CITYgreen numbers of the ecosystem services in a scenario where trees on the southern half of the site are removed.

Table 5.4 Solar Scenario Ecosystem Service Values

Ecosystem Service	Amount	Annual $ Value
Annual air pollution removal	8,401 pounds	22,444
Total carbon storage	3,026 tons	--
Annual carbon sequestration	24 tons	66
Annual storm water runoff increase	72,468 cubic feet	22,519

Table 5.5 Water Quality Impact from Tree removal

Contaminant	% Increase
BOD	2.5
Cadmium	2.9
Chromium	3.4
COD	3.6
Lead	1.2
Nitrogen	1.5
Phosphorous	2.8
Suspended Solids	2.5
Zinc	0.9

The total yearly monetary benefit from air pollution removal, carbon sequestration, and reductions in storm water runoff is $35,322, as compared to the baseline value of $64,193.

Table 5.4 summarizes air pollution removal comparison between the two scenarios. In comparison to the baseline, air pollution removal decreases from 15,436 pounds per year to 8,401 pounds per year. CITYgreen calculates that the dollar value of the benefit of air pollution removal changes from $41,241 per year to $22,444 per year. The chart below shows the specific air pollution removal amounts for the Baseline and Solar scenario, along with the difference between the two scenarios. Notice that under the Solar Scenario, there is less removal of each air pollutant since there are fewer trees on the site.

Table 5.6 Air Pollution Removal Per Year Comparison (in pounds)

Pollutant	Baseline	Solar	Difference
Carbon Monoxide	461	251	210
Ozone	5,184	2,821	2,363
Nitrogen Oxides	2,304	1,254	1,050
Particulates	5,414	2,946	2,468
Sulfur Dioxide	2,073	1,128	945
Total	15,436	8,401	7,036

The total amount of carbon storage changes from 5,561 tons to 3,026 tons (a change of 9,295 tons of carbon dioxide) and annual carbon sequestration changes from 43 tons to 24 tons (a change of 70 tons of carbon dioxide). Using $2.75 as the price per ton of carbon dioxide, the one-time loss in carbon storage is valued at $25,561.25. The reduction in carbon sequestration is valued at $192.5 per year.

The removal of trees results in a loss of ecosystem services, but producing electricity with solar panels will reduce the amount of electricity needed to be generated from Houston's existing electricity grid. Currently, Houston generates roughly 60% of its energy from natural gas, 27% from coal, and 13% from nuclear power (NRG Energy, 2010). These sources of electricity cause the following amounts The pollution per kilowatt-hour produced by these sources of electricity is outlined in Table 5.7.

Table 5.7 Pollution from Power Sources (in pounds per kilowatt-hour produced)

Pollutant	Natural Gas	Coal	Nuclear
Carbon Dioxide	1.135	2.249	0
Sulfur Dioxide	0.0001	0.015	0
Nitrogen Oxides	0.0017	0.006	0

Thus, the generation of 12,000 kilowatt-hours of electricity using 60% natural gas, 27% coal, and 13% nuclear power over the course of a year would result in the emission of 15,459 pounds of carbon dioxide, 43 pounds of sulfur dioxide, and 32 pounds of nitrogen oxides. Using solar panels to produce the 12,000 kilowatt-hours of electricity would effectively avoid production of this pollution. Over the thirty year life of the solar project, removing trees to make way for solar panels results in carbon dioxide increasing by 22,790,000 pounds (9,295 tons in carbon storage and 70 tons per year in sequestration). On the other hand, 463,770 pounds of carbon dioxide is not produced from Houston's grid because the solar panels are operating (15,459 pounds per year). Therefore, on net, there is an increase of 22,326,230 pounds of carbon dioxide emitted over the thirty years of solar panel operation.

The removal of trees in order to install solar panels also has an impact on sulfur dioxide and nitrogen oxides pollution generated. Removing trees from the site increases the pounds of sulfur dioxide in the atmosphere by 945 pounds per year. On the other hand, 43 pounds of sulfur dioxide per year is not produced from Houston's grid because the solar panels are operating. Therefore, on net, there is an increase of 27,060 pounds of sulfur dioxide in the atmosphere over the thirty years of solar panel operation. For nitrogen oxides, removal of trees from the site increases nitrogen oxides in the atmosphere by 1,050 pounds per year. On the other hand, 32 pounds of nitrogen oxides per year is not produced from Houston's grid because the solar panels are operating. Therefore, on net, there is an increase of 30,540 pounds of nitrogen oxides in the atmosphere over the thirty years of solar panel operation.

Other Potential Revenue Generating Activities

In addition to the naturally occurring ecosystem services, the Bellfort site allows has the potential of generating revenue from gas generation, conservation banking, and conservation easements.

Gas Generation

Besides the ecosystem services on the site, another attribute of the site is landfill gas generation. This gas could be used to generate electricity in lieu of other sources of electricity. Karl Pepple, Director of Environmental Programming at the City of Houston, in conjunction with the EPA, identified six potential end users within five miles that could use the landfill gas for electricity (Landfill Methane Outreach Program, 2006). However, the project was deemed infeasible because of the costs required to capture and transport the energy (Pepple, 2009).

In deciding managing the site's landfill gases, the City of Houston should consider environmental, social, and economic risks and benefits. Landfill gas is dirtier than natural gas (Ewall, 2008). If it is used, toxic contaminants should first be filtered out and treated with non-burn technologies (Ewall, 2008).

Conservation banking

The legal basis for conservation banking in the United States comes from the Endangered Species Act (ESA). In May 2003, the U.S. Fish and Wildlife Services released official federal guidance for the establishment, use, and operation of conservation banks. Though the "Conservation Banking Agreement" is the most standardized mechanism for creating bankable endangered species credits, other legal agreements have been used in the past, such as wetland banking agreements, safe harbor agreements, habitat conservation plans, and memoranda of agreement. Under conservation banking the unit traded depends on the ecology of the species aimed to be conserved. It may be an acre of habitat, a breeding pair, or a combination of a unit of habitat and an actual number of species. Conservation bank credit buyers may be private firms such as real estate developers or government agencies such as transportation departments needing to mitigate their actions.

Conservation Easements

Also influencing the design of brownfield redevelopment is the potential for conservation easements, which incorporate plans to prevent future intensive uses of sites. Conservation easements are "legally binding agreements that limit certain types of uses from taking place on a property now and in the future, while protecting the property's ecological or open-space values" (The Nature Conservancy, 2010). A conservation easement is made between a landowner, who retains the land as private property, and a government agency or land protection organization. Conservation easements are individually written for the specific needs of the landowner and remain on the property, held in trust perpetually. By 2003, 5.1 million acres had been protected in the United States through conservation easements (The Nature Conservancy, 2010).

Because conservation easements are voluntary, they tend to benefit both parties in the agreement. The landowner, even if she is not acting out of environmental stewardship, may receive tax and other financial benefits, such as income from the sale of the easement to the governing body. For tax purposes, the landowner will be subjected to lower property taxes because the market value of the property decreases after the conservation easement is in place. In return, the government agency or land protection organization receives a guarantee that the ecological or open-space value of the site will remain on the site perpetually, accruing to the general public (Blaine and Lichtkoppler, 2004).

Conclusion

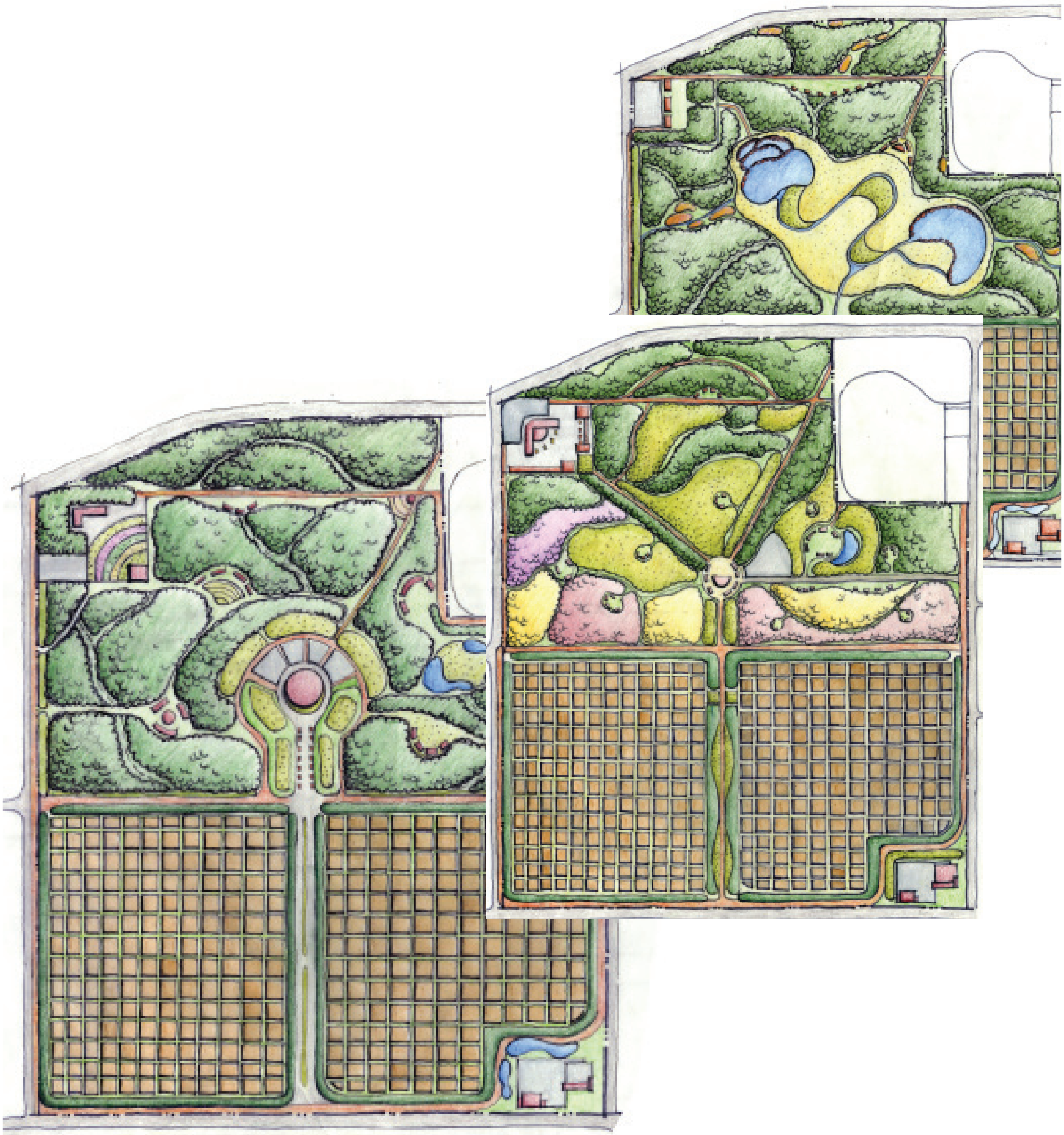
Natural sites provide a wide range of ecosystem services. In order for the importance of these services to be recognized it is important to place monetary value on them, even if it is difficult and contentious. In this chapter, we have used CITYgreen software to measure the ecosystem services of air pollution removal, carbon storage and sequestration, stormwater runoff, and water quality on the Bellfort site. CITYgreen provides monetary values for some of these ecosystem services. CITYgreen can be an important decision-making tool for communities because it can be used to calculate the effects of future land cover change before making development choices.

Currently, the trees on the Bellfort site remove more than 15,000 pounds of local air pollutants per year, sequester 43 tons of carbon annually, and prevent the runoff of almost 130,000 cubic feet of water. The value of these services is about $64,000 for the 300 acre Bellfort site. The current asking price for undeveloped land near the site is several hundred times more than this dollar value.

If half of the site were to be covered with solar panels, the remaining trees on the Bellfort site would remove about 8,400 pounds of local air pollutants per year, sequester 24 tons of carbon annually, and prevent the runoff of about 72,500 cubic feet of water. The value of these services would be about $35,000. Clearly, removing trees from the site in order to generate clean electricity with solar panels does not come without environmental losses. The total amount of carbon dioxide, sulfur dioxide, and nitrogen oxides in the atmosphere actually increases when trees are removed to put in solar panels.

Chapter: 6

Design



Introduction

With the understandings developed in the preceding chapters, we propose alternative landscape designs for the 3300 Bellfort property in this chapter. Most influential to the design, the results of the survey indicate that ecological revitalization is important to the respondents. None of the items listed were "not important" on average. Thus, the design alternatives include each of the items listed in the survey: flood protection, air quality, vegetation, solar power, nature trails, wildlife habitats, and educational opportunities. While these results express preferences of homeowners in the City of Houston, it will be important for the Sunnyside neighborhood to obtain a better understanding of its residents' preferences before finalizing the design for the Bellfort site, as indicated by the results of the hedonic pricing analysis. Certainly, the City will want to ensure that whatever investment it makes in the community will increase the surrounding property values. Finally, with our basic understanding of community preferences and a proposed design to meet those preferences, we calculated the value of ecosystem services that each of the alternative designs will provide, given the differing levels of ecosystem services involved. These results will differ from the ultimate design that is preferred by the Sunnyside neighborhood and the City of Houston. The final design chosen should maximize the potential increase in surrounding property values by addressing the desires of the local community, including: biodiversity, aesthetic attraction, community cohesion, and economic improvement to the adjacent properties and community, while minimizing the environmental and social hazards present. We attempted to address the desires in the proposed designs below. First, we share insight into the assumptions that also influenced the design proposals.

Assumptions

A project of this scale and scope, such as the number of acres on the site and the complications from contaminants on the site, initiates many questions. Time constraints limited our ability to address many of those questions, requiring us to make several assumptions. First and foremost, when creating designs for the site we assumed that the site was adequately cleaned, meaning that the soil and air contamination has been remediated to a level such that the past industrial activities do not preclude human activity on the site and that there are no significant risks associated with recreational activities. Any encapsulation on the site is impervious, preventing the movement of contamination between the landfill and the surface. This also includes an assumption that our designs correspond with the clean-up remedies put into place on the site. Second, the design alternatives focus solely on open space, omitting any contemplation of residential or commercial activities on the site. The omission of residential activities is based on the assumption that it is too risky to develop homes on a contaminated property, regardless of the strength of the site encapsulation. The potential threat of liability to the potential residents precludes the risk. Yet, there are case studies of industrial sites of a similar size being redeveloped into commercial space, such as the 243-acre former landfill that is now the Fairlane Green Shopping Center in Allen Park, Michigan and the 126-acre former steel finishing mill site that is now the Steelyard Commons Shopping Center in Cleveland, Ohio (Steelyard

Commons, 2010; "Steelyard Commons"). These sites also include sustainable site designs in relation to the buildings and grounds as well as the latest approaches for financing such projects, making them good case studies for the City of Houston to consider. With a focus on open space emphasized by the project sponsors, we created the design alternatives to fulfill their desires.

Project Sponsor Desires

Both Dr. Biddinger of ExxonMobil and the City of Houston recognize the need for greenspace in urban areas. Based on Dr. Biddinger's experience, brownfields resulting from oil wells, landfills, or other uses can have great potential as open greenspaces. While these sites were separated from the community when they were operating, residences and businesses were often built right up to their property lines. This often made them into "the last remaining wildlife habitats in a region" (Biddinger, 2009a) and now demonstrates a need for ensuring that these sites function as a wildlife habitat. Yet, because land prices within cities tend to be high, urban greenspaces are often foregone in favor of options that more directly affect local economies. As societies have become increasingly metropolitan, the need for urban greenspaces and their economic, social, and environmental benefits has become more acute (Stringer et al., 2006; Siikamäki and Wernstedt, 2008).

In addition to the interest in open space and wildlife habitat, the City has three main goals for the available space on the Bellfort site: a recreation path along the eastern side of the property to connect a library on the southeast corner to Sunnyside Park on the northeast corner, a botanical garden or other public attraction, and stormwater management structures such as retention ponds, detention ponds, and rain gardens (Sandberg, 2009). The City of Houston would like the attractions to bring people to the site as well as to educate the public about sustainability and brownfield reuse. We considered all of these features when creating potential designs for the site.

Finally, as discussed previously, a solar power farm has been proposed for the southern half of the Bellfort site. Each of the design alternatives includes this solar panel farm.

After these guidelines were established for developing future alternatives for the site, an understanding of the site context was developed in order to better address the desires of the surrounding community. A site context map showing the location of the site in relation to the county is included as Appendix XX - Harris County Context Map. Appendix XX shows a context map for the Bellfort site itself. Although the City of Houston and any public participation efforts can inform a deeper understanding of the desires and opportunities for this site, the team developed an initial understanding based on its interviews and a site visit.

Initial Understanding of Opportunities

The opportunities identified for the site include ways to leverage the resources both on and off of the site. The site itself already has a park that provides for recreational, social, and cultural activities. Further, variations in the site's topography and the large acreage of the Bellfort site provide opportunities for on-site stormwater treatment and management. For example, constructed wetlands or other water infiltration infrastructures such as bio-swales, rain gardens, and permeable pavement can be installed. Finally, well-vegetated areas on the Bellfort site provide opportunities for creating wildlife habitat and constructing pathways for hiking through the urban forest. Beyond the boundaries of the site are physical features to draw people to the site. For example, community centers, vegetable gardens, and public parking are nearby. The Bellfort site can be designed in a way that connects these features and strengthens social cohesion through involving the local residents in site redevelopment, increasing feelings of ownership and ensuring the long-term maintenance of the site. Residents of neighborhoods surrounding the site may provide a source of community support for redeveloping the area. Finally, the vegetation within and along the edges of the site can be maintained as a buffer to provide separation from the noise and other negativities of the transportation on the freeway and local roads and the unpleasant sight of the solar panel arrays.

Design Alternatives for the 3300 Bellfort Site

With the above themes in mind, we developed three alternative designs for the site. The alternatives emphasize the three common aspects of sustainability: society, the environment, and the economy. The proposal most focused on society is the recreational alternative, titled "A Place for People to Play." Second is an alternative focused on wildlife, tilted "A Place for Nature to Live." Finally is an alternative focused on stormwater management, titled "A Place for Water to Flow."

Scenario 1: "A Place for People to Play"

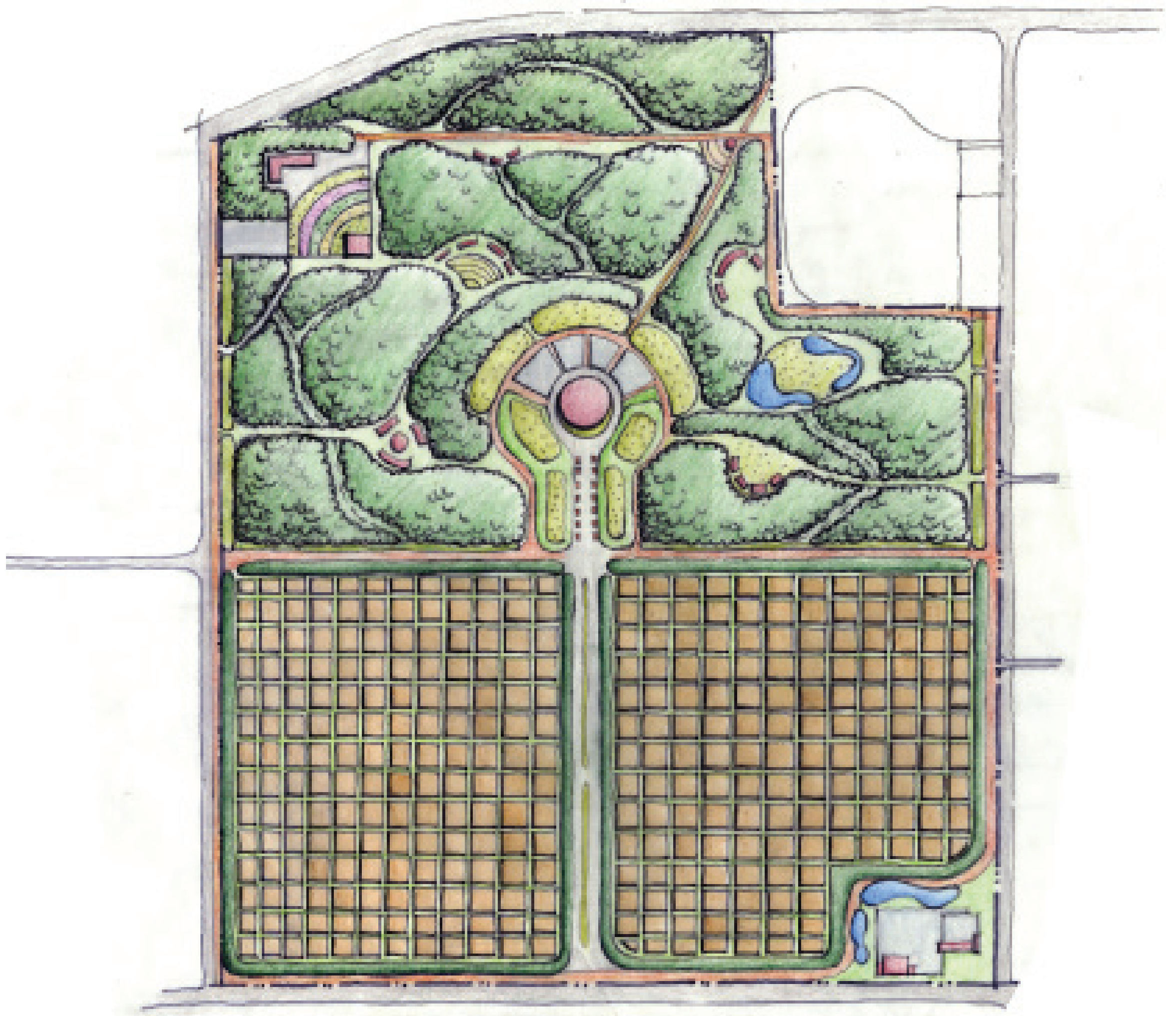


Figure 6.2 – Scenario 1

Scenario drivers

The results of the survey indicate that a majority of respondents visit parks for walking, running, bicycling, and in-line skating. Further, more than half of the respondents indicated that they would visit parks more often if they were closer to their homes. While, on average, respondents did not rank increasing educational opportunities as the highest in importance of environmental benefits, they did rank it as relatively important.

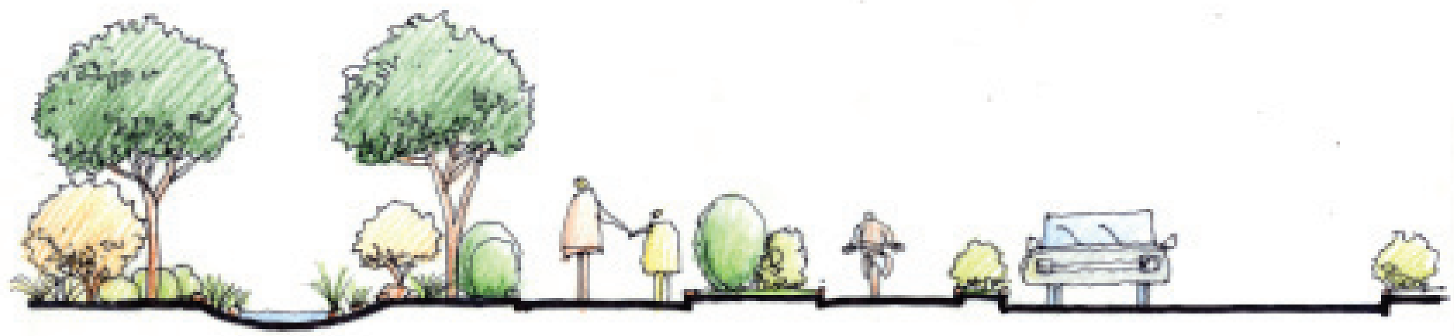


Figure 6.3: Bioswale, pedestrain street, and bicycle trail along eastern side (Not to Scale)

Detailed design solutions

Based on these scenario drivers, the site proposal includes recreational trails and stationary attractions to draw locals to the site. First, the recreational trails will surround the entire Bellfort site. They will connect different functional zones of the site to each other as well as connect portions of the site to the surrounding contextual area. They will also assist in the creation of more aesthetically-pleasing features along the eastern side of the property and attract local residents as well as help them collectively recognize and use the site as a community asset. Along the trails, there will be planting strips and bio-swales which can act as buffer areas while also collecting rainwater. Second, there will be openings in the tree canopy creating spaces for people to rest, play, and picnic while appreciating the surrounding landscape. For those nodes in the landscape, various amenities could enhance recreational use, such as benches, sculptures, platforms and performance stages, vegetation mazes, and fish ponds. Finally, some of the larger natural land covers such as the forested areas and grasslands can be designed as waterscapes, nightscapes, or an urban forest adventure park to provide various spaces to interact with nature and enhance the site's aesthetics.

In addition to the natural features of the site, the local residents may appreciate the remnants of the site's industrial facility and history being incorporated into the design. For example, the existing tires, transporting structures, shelters, and poles can be preserved and included in the site design as indicators of the industrial heritage of the site, providing character and uniqueness. Some of the tires, walls, and poles can be used to construct or inspire the design of recreational facilities, such as climbing walls for children. Allowing people to have close contact with those historical structures can create a better sense of their neighborhood's history and culture. Moreover, the former industrial site can serve as an educational center in which people can be taught about sustainable industrial production and contrast it with past practices. Educational kiosks can be incorporated to preserve and showcase the industrial heritage of the site.

Finally, local residents suggest the installation of more lighting facilities along the path and around the industrial remnants to help people recognize the site and feel more comfortable with it. These would also be included in the design.

All these activities will benefit the existing neighborhood and communities. The site will function as a cultural and communication center for people to come together, develop relationships, have fun, educate children, and create social cohesion. Moreover, from the perspective of public safety, more people using the site will create informal social surveillance which could potentially reduce socially undesirable activities on the site.

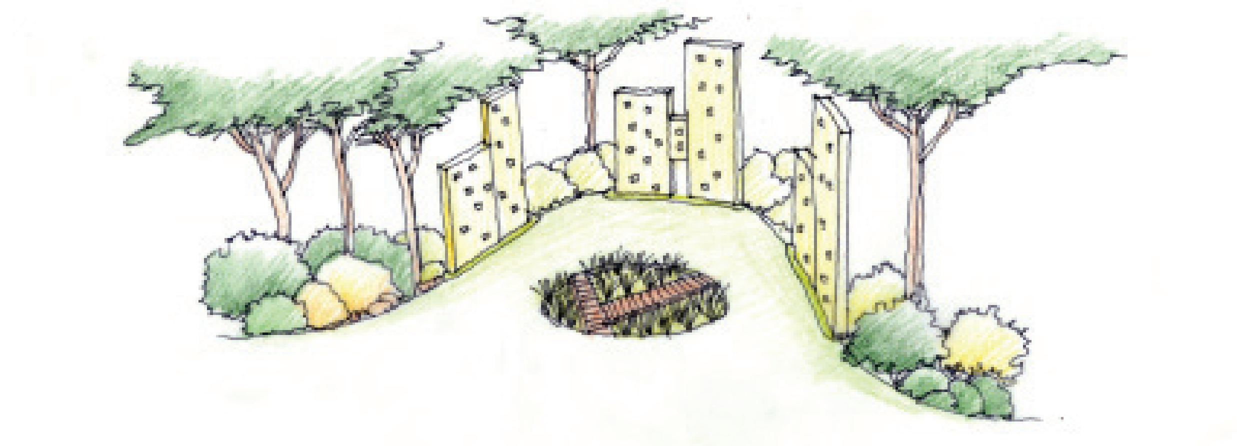


Figure 6.4: Perspective on some typical open spaces in Scenario One: recreational use of thespace such as wall climbing for children

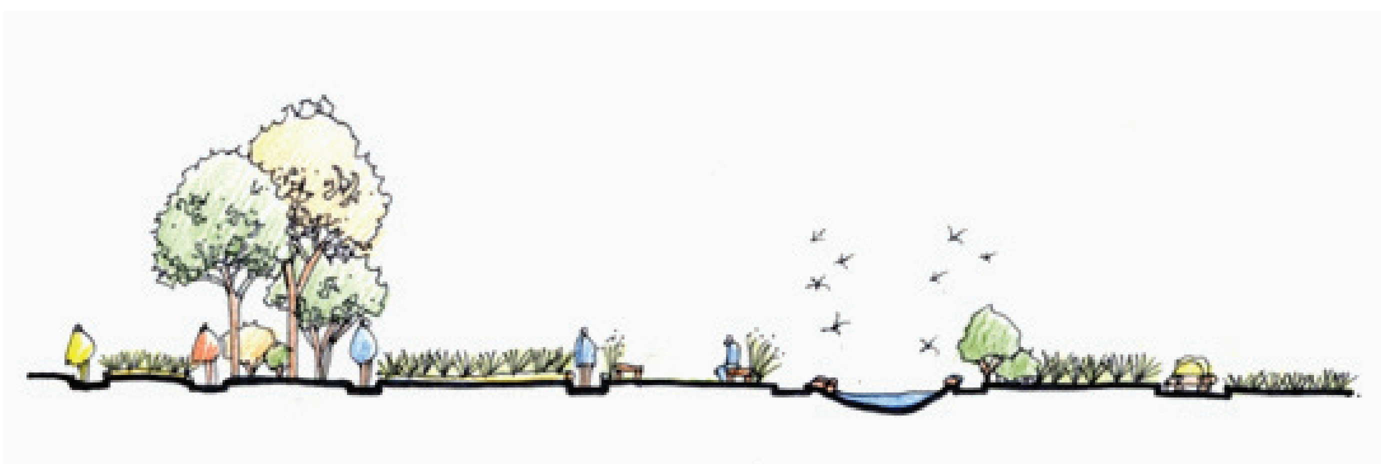


Figure 6.5: Section looking along the north-south axis in the site (Not To Scale)

Scenario 2: "A Place for Nature to Live"

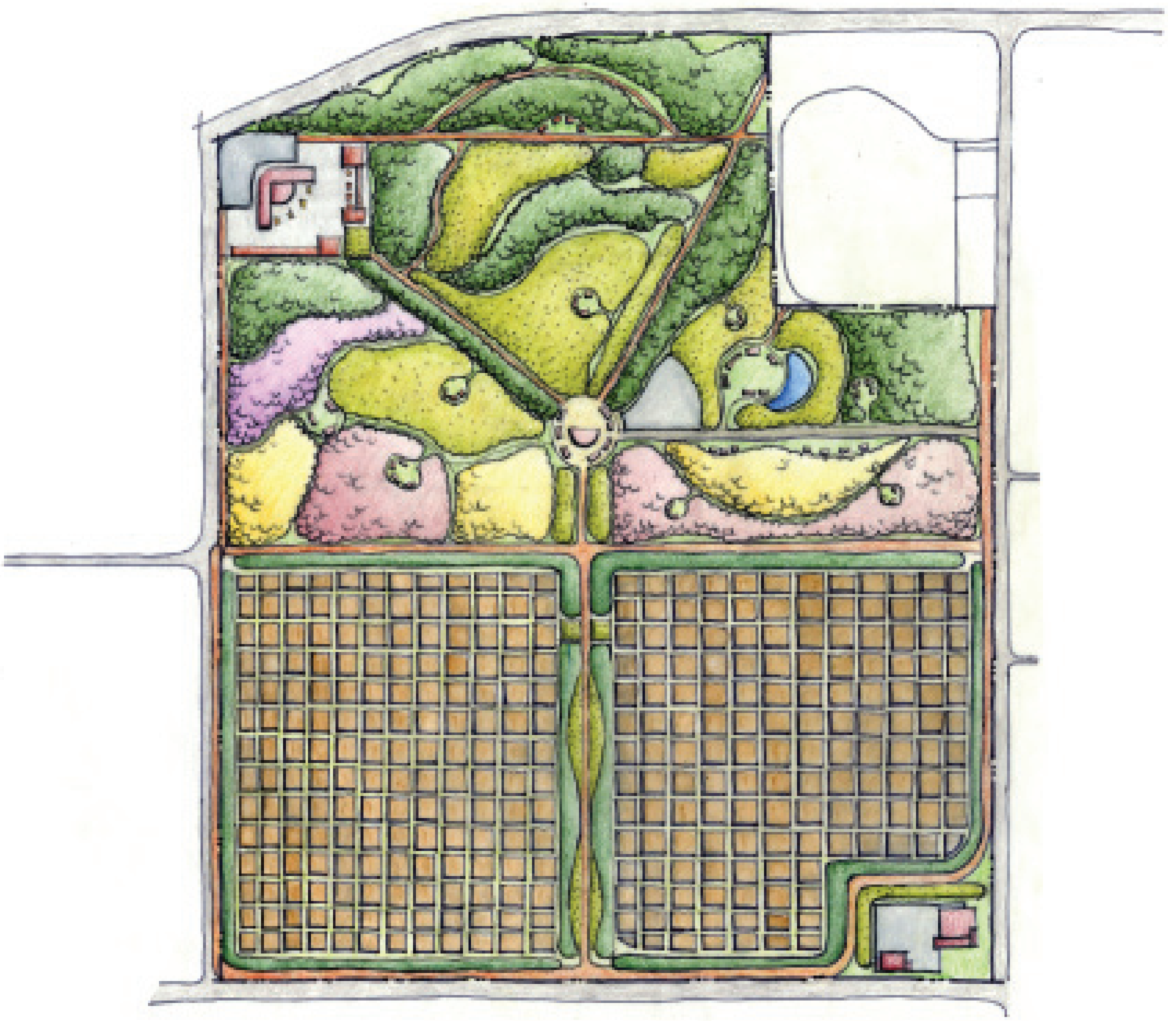


Figure 6.6 – Scenario 2

Scenario drivers

This scenario assumes that environmental quality will be restored largely through ecological revitalization. Ecological revitalization strives to maximize a site's ecosystem services through providing "functional and sustainable" habitats. The most significant characteristic of ecological revitalization is that it uses a long-term approach to restoring depleted landscapes, especially through the use of vegetation. Depleted landscapes, whether or not contaminated, can increase in value through improvements to soil health, diversity of vegetation, reduced threats of soil erosion, and reduced perceptions associated with the sites (Environmental Protection Agency, 2009).

The ecological revitalization of the site will provide benefits to plants, animals, and local residents, sustaining diverse wildlife habitats and increasing the value of the biodiversity contained within the site. In the larger ecological context of the City of Houston, the improvement of ecological patches on the Bellfort site will provide opportunities for the wildlife in the City to better flourish through improved habitats and greater connectivity between habitats throughout the city. The various landforms already present on the Bellfort site provide significant opportunities to create various ecological habitats such as wetland, grassland, and urban forestry habitats.

Detailed design solutions

The first component of this design scenario is to re-create various wildlife habitats on the Bellfort site. As can be seen in the photographs of the site, the property is already well covered by trees and shrubs. However, based on our observation, this thick vegetation cover is highly haphazard and lacks diversity of plant species, limiting the ability of wildlife to meet their vital needs on the site. Therefore, we suggest that new tree and shrub species be introduced as a sustainable vegetation community which can provide wildlife a habitat in which to flourish. Different types of habitats will be considered based on the existing condition on the site. For example, large native trees such as oaks or maples with extensive branching would be introduced onto the site. They provide plenty of room within their branches and understory for birds to build their nests. In addition, their shade will be beneficial for local residents during sunny days in the summer.

The second component of this scenario is to create visual interest on the site, which can be achieved by the colors of tree foliage, shrubs, and flowers. It is typical for the diversity of colors to be perceived as an indicator of natural health, providing visitors with a feeling of the breadth of nature on the site. In order to have a diversity of leaf color on the site, certain tree species will be added to the existing urban forest. These added trees and flowering shrubs with different textures and colors will change the existing "inanimate" look of the site. In addition, the seasonal changes these species undergo will bring local people to the site while also attracting butterflies and birds. Some examples of trees that could be added include the Drummond red maple (Acer rubrum drummondii), Possumhaw holly (Ilex decidua), and Parsley hawthorn (Crataegus marshallii). Some perennials and annuals can also provide seasonal interest, such as the Blue Daze (Evolvulus glomeratus) and Gerbera Daisy (Gerbera Jamesonii).

Third, since the connectivity among urban ecological patches and habitats is of vital importance for wildlife, it will be strengthened. The habitats provided on the site for wildlife are simply not enough; they should be connected and well-oriented for the potential movement of animals through these habitats. Thus in our design solution, various ecological corridors will be considered and provided to function as a linkage for wildlife activities and human movements.

Finally, the intent of ecological revitalization is to minimize the recreational activity on a site in favor of habitat provision. Open spaces for recreational activities, such as golfing and playgrounds, are not considered aspects of ecological revitalization. Yet, with all the natural features of the site, low-impact recreational activities such as hiking and bird watching can take place. Shelters and nests can be built to invite birds to the site and nodes in the landscape can be established for people to observe the birds. Bird watching can also be linked to educational activities with schools, providing specific workshops focusing on recognizing bird species and learning how to protect them. Migrating birds that pass through the Houston area, which are valuable for the environment and local residents, include the Blue-winged Warbler, Tennessee Warbler, Northern Parula, Yellow-billed Cuckoo, Common Nighthawk, and Chimney Swift (Bird Notes, 2010).

This design alternative would improve the aesthetics and perceptions of the site while offering educational opportunities. It may be a preferred option if the City would like to revitalize the site but not invest in such items as playground equipment or stormwater technologies.

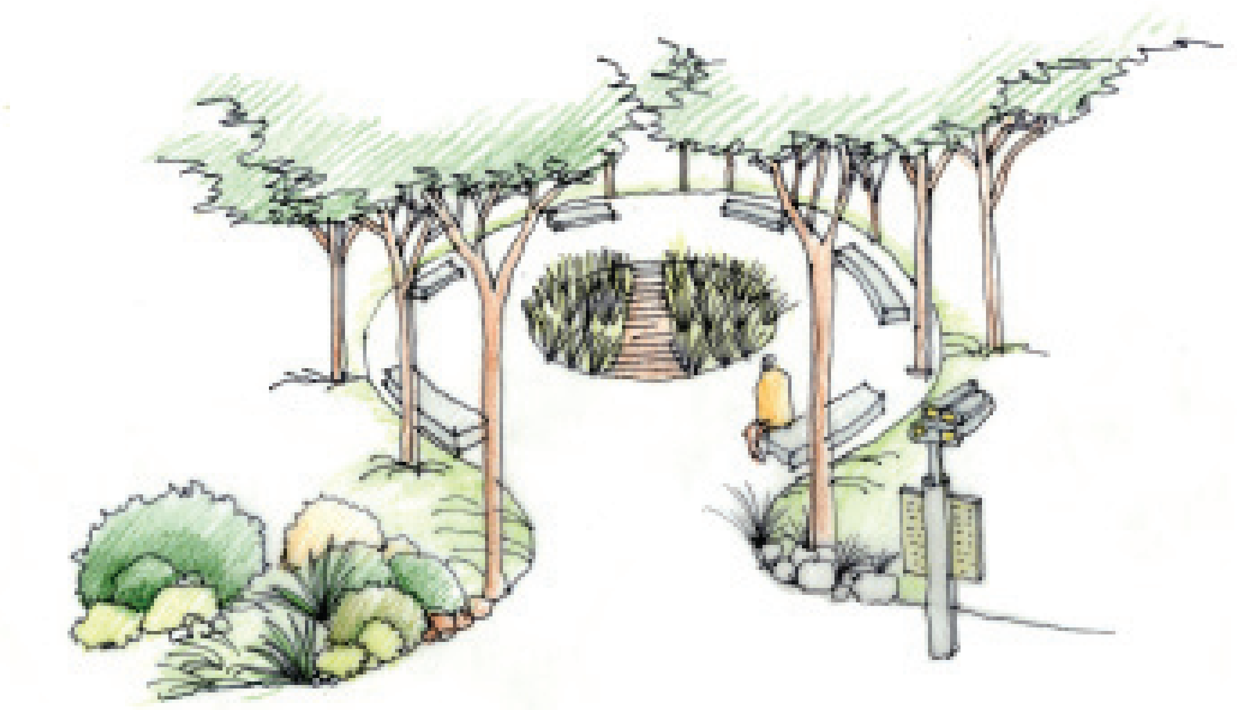


Figure 6.7: Perspective on the typical tree openings under Scenario Two. In these resting areas a telescope is provided for people to watch birds and other wildlife, and informational kiosks are provided to educate people about nature.

Scenario 3: "A Place for Water to Flow"

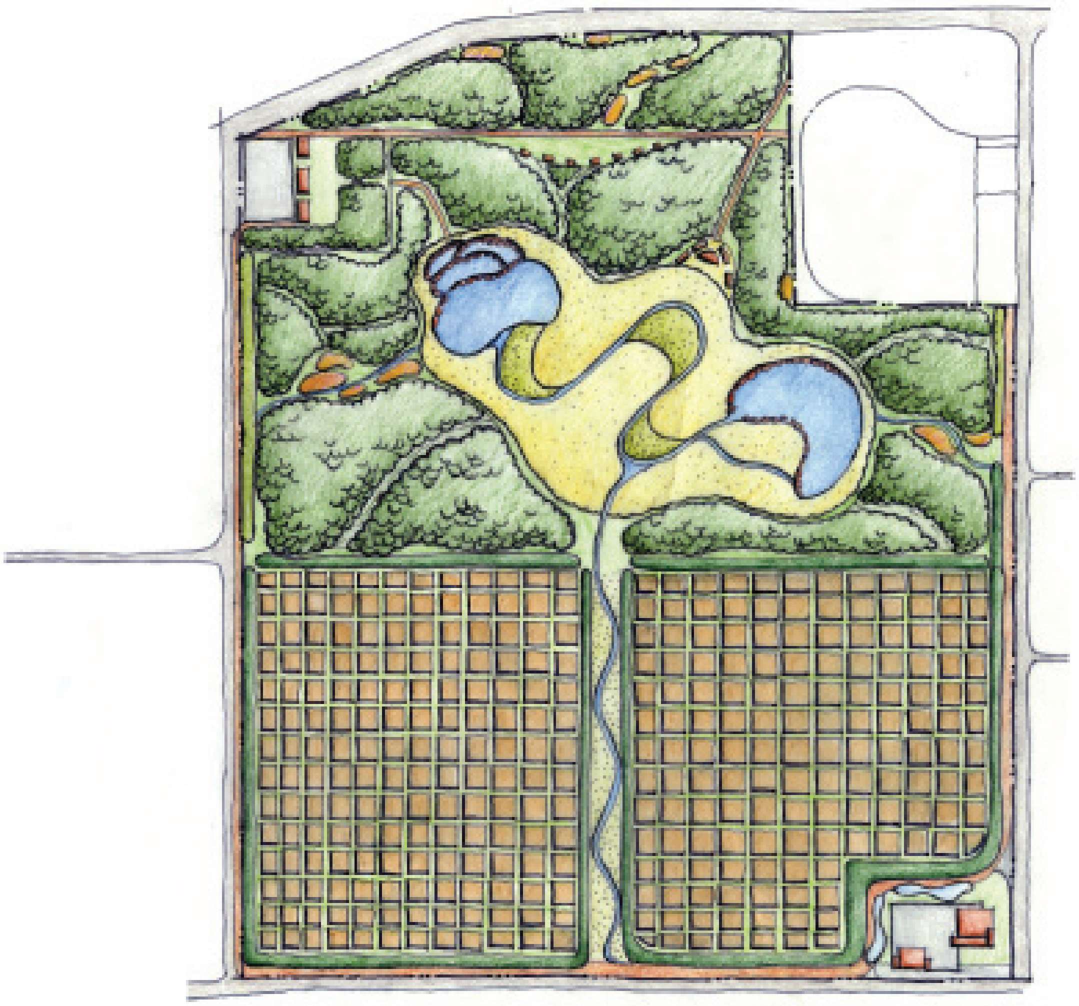


Figure 6.8 – Scenario 3

Scenario drivers

Significant rainfall in the Houston area makes stormwater treatment a very important issue. The proposed solar farm, which will cover approximately half of the area of the site, will require the removal of a significant number of trees, resulting in further stormwater runoff from the site. Therefore, adequate stormwater features need to be considered on the site. Evidence of the need for flood control is the results of the survey, for which "improving flood protection" was the most important, on average.

Detailed design solutions

In response to the above scenario drivers, this design proposal focuses on stormwater management and passive water recreation on the 3300 Bellfort site. Based on the existing topography of the site, the overall water flow trend is towards the western, southern, and eastern boundaries of the site. The northern portion of the site has low points in the landscape. Much of the stormwater run-off will be accumulated on the site during the flooding season. In order to reduce any negative impacts caused by stormwater runoff, such as erosion and the transport of pollutants, the stormwater needs to be correctly oriented, slowed down, and treated.

A common practice for treating stormwater is a method known as "Low Impact Design (LID)," which uses primarily soil and plants to retain and treat water resources. LID solutions include grading plans, constructed wetlands, rain gardens, bioswales, and permeable pavement, as just a few examples. Keeping the stormwater on site for as long as possible will allow time for the water to infiltrate the ground, which is a natural form of removing pollutants. Variations in the Bellfort site's topography and the large acreage of the site provide opportunities for on-site stormwater management and treatment. The proposed design includes common LID practices.

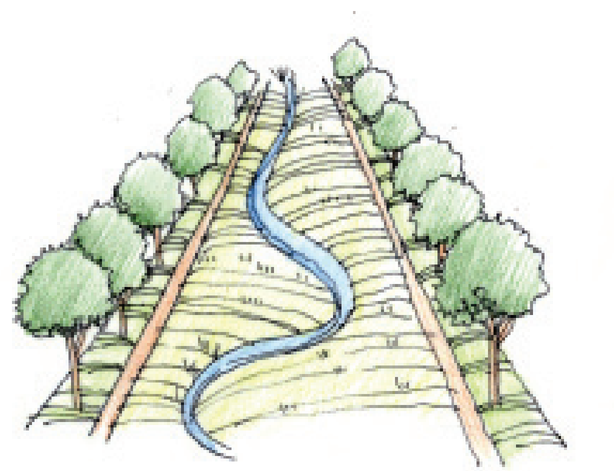


Figure 6.9: Perspective on the bioswale along the south main entrance of the site

Those LID practices on the site include bio-swales, retention and detention ponds, constructed wetlands, and forebays. Gathering stormwater with these framing structures can reduce the flow of water and induce the water to infiltrate the ground. The proposed design features a bio-swale around the boundary of the site, a series of detention or retention ponds on the low-lying parts of the site, and constructed wetlands on the flat areas of the site. Ponds may extend to the larger areas via water flow branches from a larger forebay and the surrounding wetlands. In addition to treating and restoring groundwater, these LID practices provide several other benefits.

First, landscape designs focused on LID provide habitat for biodiversity. Second, they offer recreational activities. For example, rain gardens, mini-water fountains, water-related sculptures and other water-related features could be used to attract local residents who are interested in appreciating the site's restorative value. Wooden bridges, trails around the ponds, and strategically placed benches can be installed for residents interested in hiking, bird-watching, or fishing. Water features can also provide recreation and educational opportunities for children. For example, a mini rain water purification system using specific aquatic species can illustrate the process of phytoremediation to the local community. When accompanied by educational kiosks, these systems can make this newly developed technology widely known and accepted. Third, retained rain water can also function as an irrigation source for the site's landscaping. Finally, aesthetically pleasing plantings incorporated with the stormwater plans can improve visual aesthetics and change public perceptions toward the site.

The benefits beyond reducing stormwater runoff may increase property values for the surrounding sites, but do not impact the value of the ecosystem services offered by the site. The following section discusses the value of the ecosystem services offered by each of the three design proposals.

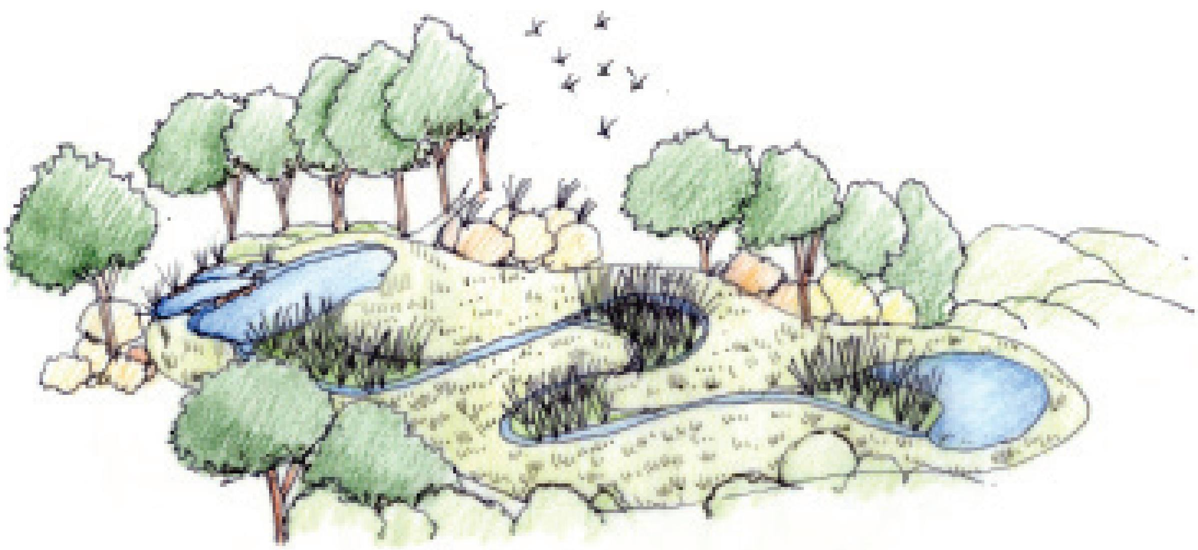


Figure 6.10: Perspective on the constructed wetland. The wetland ecosystem will be an ideal combination of wetland habitats, rainwater treatment, and other recreational activities.

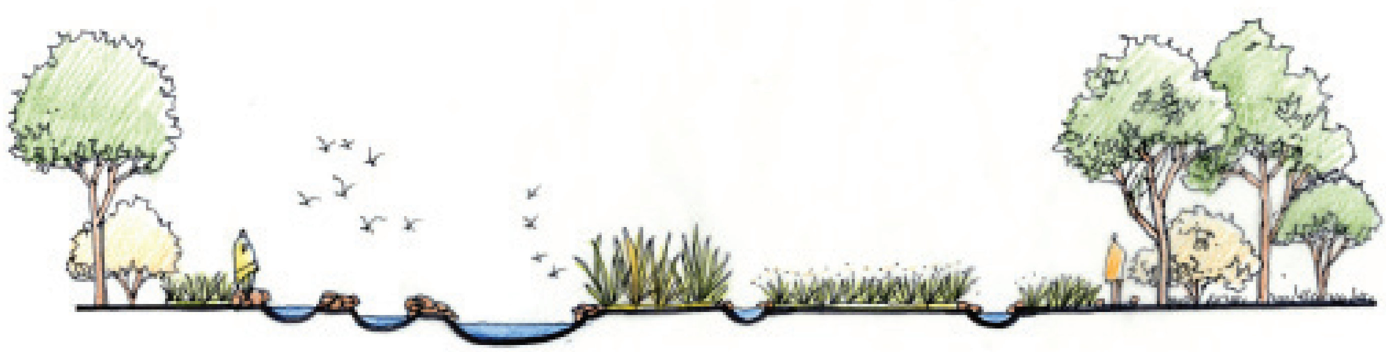
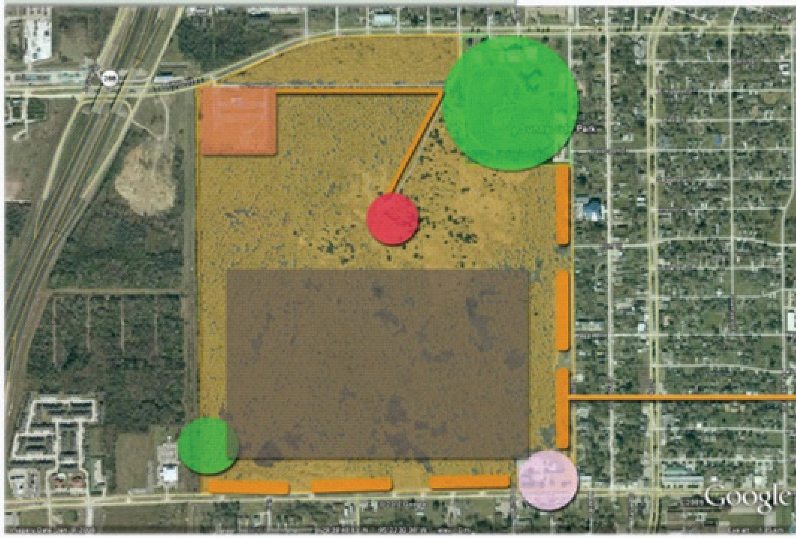


Figure 6.11: Section along the constructed wetland on the site which goes across the forebay, high marsh area, the low marsh area and the surrounding forests

Site Analysis

Potential development pattern



Potential public park

Historical site

Police station

Potential education

Potential trail (bicycle/pedestrian)

Proposed solar installation

Remaining natural landcover (forest/open grassland/wetland)

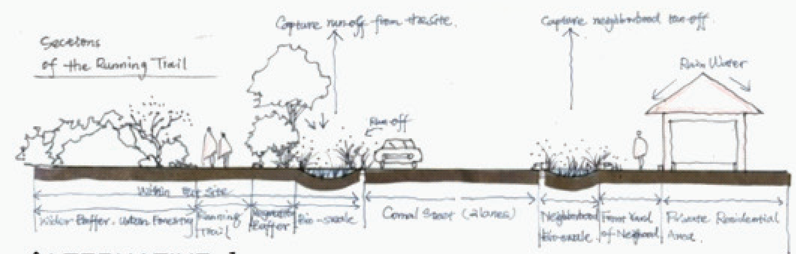
Site hydrology analysis

Bio-swale

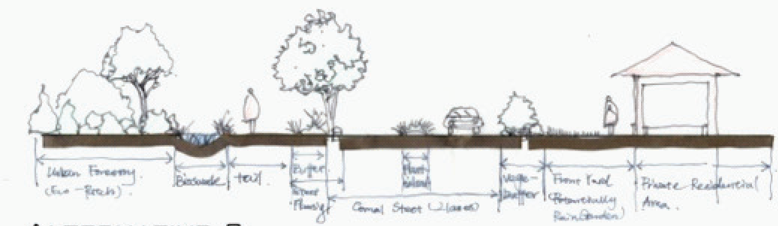
Water flow

Water collection point

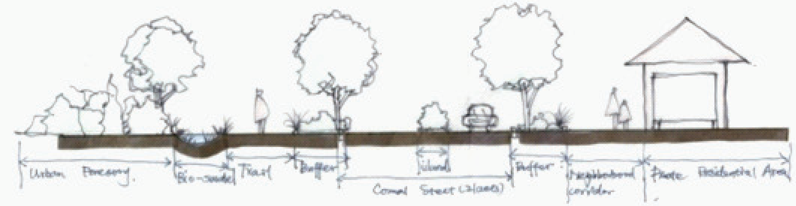
Alternative sections of the running trail



Alternative 1



Alternative 2



Alternative 3

Comparing the Three Scenarios with CITYgreen

Each of the designs alternatives were valued and compared to determine the optimal choice of design. Using the CITYgreen software, we calculated the air pollution removal and carbon storage and sequestration under the three scenarios proposed in this chapter. The dollar values are based on the current market price of carbon dioxide credits in the RGGI, which is approximately $2.75 per ton. The results are summarized in Table 6.1 below.

Table 6.1 Ecosystem Services Scenario Comparisons

	Air Pollution Removal		Carbon Sequestration		
Scenario	lbs/year	$/year	tons/year	$/year	Carbon Storage
1	11,028	29,463	31	312	3,973
2	14,655	39,154	41	413	5,279
3	14,655	39,154	41	413	5,279

The total amount of annual air pollution removal and carbon sequestration are 11,028 tons and 31 tons, respectively, in Scenario 1. The corresponding monetary values are $29,463 per year and $312 per year, respectively. The annual dollar value of carbon sequestration for Scenario 1 is $312.58 per year. The total carbon storage in Scenario 1 is 3,973 tons.

Scenarios 2 and 3 produce identical amounts and monetary values for the ecosystem services considered in this analysis. In these scenarios, the air pollution removal amount is 14,655 pounds per year, which is 33% higher than the 11,028 pounds per year removed in Scenario 1. This is because there is less tree cover in Scenario 1 due to the construction of impervious structures such as footpaths and buildings. The carbon storage and sequestration amounts are 5,279 and 41 tons per year, respectively for Scenarios 2 and 3. The corresponding monetary values for the annual air pollution removal and carbon sequestration are $39,154 and $413 per year, respectively.

Ideally, the ecological design should maximize the value of ecosystem services; however, in order to have a balance of ecosystem benefits and other human uses of the site, brownfield redevelopment projects should also consider such items as educational values, aesthetic values, recreational values, and economic values. Hedonic pricing analyses similar to the one in Chapter 3 can satisfy this need.

Conclusion

It is hoped that the revitalization of the Bellfort site will create a healthier ecosystem, increase safety for surrounding residents, and help stimulate economic development. The proposed designs above were created with those intentions. Yet, before moving forward the City of Houston will need to further research the alternatives, including investigating issues that the above proposals omit. Specific next steps include determining additional details of the site context, the desires of the Sunnyside community, the appropriate method for remediating the contaminants on-site, and investigating potential sources of funding.

Site Context

The information presented above includes a basic understanding of the Bellfort site's context in itself and within the surrounding community. Yet, the ultimate design proposal could be more informed by an understanding of the land uses surrounding the site, such as the success of local businesses and residences. This could also include other historical and cultural characteristics of the community. Within the site, it would help to have a better understanding of the physical features, such as the topography, hydrology, drainage areas, vegetation, physical properties of the soil, and climatic features such as sun angles, aspect, and wind. For example, invasive vegetative species on the site should be removed. A site analysis will diagram these factors on a base map of the site and will provide the foundation and rationale for the design program.

Public Participation

The proposals above are based on the results of a survey sent throughout the entire City of Houston. Ultimately, the design will need to be based on this site's actual stakeholders, which may exclude many of the survey respondents. The Sunnyside neighborhood will need to be involved in determining a design that fits its desires.

Site Remediation

Brownfield remediation experts recommend developing remediation actions based on the planned use for a site (Cichon, 2002). This can mitigate the risks involved with redeveloping a brownfield site, especially because of the complications caused by the contaminants and the variety of remediation options. For example, it is not necessary to remove all the contaminated soils from a site that will be encapsulated and used for big-box retail. Likewise, it is not appropriate to encapsulate a site when there is a likelihood of implementing phytoremediation techniques in the near future. Overall, the risks are based on the toxicity of the contaminants and the potential of those contaminants affecting nearby land, wildlife, and humans (Long et al., 2002). Those factors, along with the desires of the local community, will influence the ultimate design and required remediation techniques.

The remediation techniques can involve physical, biological, and chemical processes. In particular regards to the Bellfort site, the vegetation that has haphazardly grown on the site may have penetrated the cap. As a result, contaminants may have been treated naturally over the last four decades through bioaccumulating in the site's vegetation, essentially already using phytoremediation techniques. The

City could choose to leave the site as is, saving money from investing in the cleanup, but incurring the opportunity cost from developments that could increase the City's revenues. If the City chooses to redevelop the site, in order to remediate the remaining contaminants the City will need to choose from the latest technologies available, including deciding whether to treat the contaminants on or off the site. Available technologies include phyto- and bio-remediation (Carman, 2001; Pivitz, 2001), encapsulation, and excavation. If an ecological revitalization or other phytoremediation approach is taken, human access to areas posing health risks will need to be limited. In addition to remediated contaminated soils, the compacted roads will need to be tilled and aerated.

A third issue to consider in the site's remediation is the bridge the site creates between its contaminants and the surrounding ecosystem. If stormwater interacting with the site would cause contaminants to leach into groundwater or nearby sites, the use of phytoremediation and any LID techniques should be minimized. It may be best to develop methods for moving the stormwater off site with as little interaction with the site as possible.

Financing

Finally, the City will need to investigate methods for financing any redevelopment in relation to the respective potential benefits. Examples of current financing terms include state brownfield grants or tax credits, Tax Increment Financing from local taxing authorities, and federal tax incentives such as the New Markets Tax Credits. These funds can finance site cleanup. In addition, any future sale of the site may be inhibited by the significant risks contained in the site. In some similar situations, responsible parties have maintained ownership of the contaminated lands, selling the right to develop on the site but protecting developers from the liabilities caused by the contaminants (Pinkham, 2000).

Chapter: 7

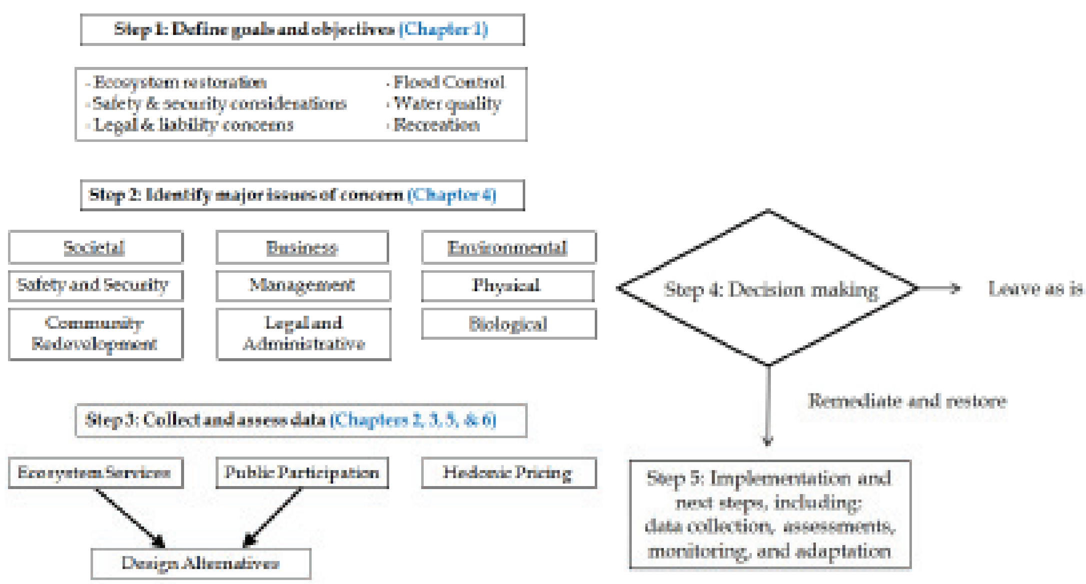
Conclusion

In this chapter we present a synopsis of the results of this project. This chapter also presents the challenges faced in conducting this project, and a framework that we developed for greening brownfield properties, which incorporates preparation for obstacles and challenges that were faced in conducting this project. These obstacles and challenges are based on those that are likely in similar projects. The intent of this chapter is to prepare anyone interested in conducting similar projects with a summary of the efforts undertaken for this project and expectations of challenges that may arise.

Project Summary and Final Framework

Figure 7.1 outlines our recommendations for a structure to direct the decision making process for the greening of brownfield properties. For this project we performed steps 1-3 of this framework: defining goals and objectives, identifying major issues of concern, and collecting and assessing data.

Figure 7.1: Proposed Framework for Brownfield Redevelopment Evaluation



When defining goals and objectives, a site should first be characterized by the conditions on the site and any goals and objectives appropriate to its redevelopment should be considered. These goals could be barriers to greening or they could provide potential opportunities for adding green infrastructure to or changing the function of a property. Once the goals and objectives are determined, major issues of concern toward achieving those goals should be addressed. The major issues of concern can be viewed as falling into three categories: social, economic, and environmental. The next step in the process chain is to collect data that can be used to assess the potential value from greening or otherwise redeveloping the property. The assessments attempt to place a dollar value on services where possible, and otherwise quantify benefits where dollar values are not readily calculable. For example, legal thresholds may be appropriate benchmarks when ecosystem valuation is not feasible. Once these assessments are conducted they may be used together to make recommendations as to which combination of options are most feasible on a particular site. If the timing and economics are appropriate for greening or other redevelopment and there are no conditions otherwise precluding redevelopment, the project enters the implementation phase. In the implementation phase, the initial site work to prepare the property is done and plans for management, maintenance, monitoring, and assessment are made to measure the levels of service the property will provide. Throughout the operation of the site, decisions are continuously made in response to feedback from the site and nearby community. The use of early planning and adaptive management frameworks can be used to help seek out feedback about the operation of a site and improve the effectiveness of responses to feedback.

Define Goals and Objectives

The initial goal for this project was to develop alternatives for a brownfield that would optimize the economic, social, and environmental values to the surrounding community. The four assessments that were used in this work included a hedonic pricing analysis, public participation involvement, an ecosystem services valuation, and landscape design alternatives. This section will present the initial goals and key findings from the analyses, in relation to steps 1 and 3 of the framework. The challenges that arose during the project will be presented below, as they can now be incorporated into step 2 for future iterations of this project.

Ecosystem Services

Ecosystem services for the site were measured using CITYgreen, an ArcGIS extension developed by American Forests. The valuations were prepared for two alternatives, the site in its current condition ("baseline") and the site with solar panels installed on the southern half. The monetary values used in the CITYgreen model suggest that leaving the site as is would provide more ecosystem service value than modifying the site layout with solar panels would.

Yet, significant factors need to be considered before a coming to a definite conclusion. First, further analyses need to be done to truly compare the baseline with the solar panel option. This could include considering whether trees growing on this site negatively impact community or ecosystem health, the potential value of educational opportunities through local solar energy generation, and the relative upstream environmental impacts of producing solar versus carbon-based energy. Second, this study compared only two of the five alternatives. If the site were developed in accordance to the other proposed alternatives, the likelihood of human or environmental exposure to on-site contaminants can be reduced while increasing values for the community through additional educational opportunities, greater recreational options, and a strengthened community. Other alternatives certainly need to be explored in order to choose a design that will provide the most benefit for the surrounding community.

Public Participation

An attempt was made to involve the community in developing design proposals for the Bellfort site. The initial goal was to include local residents through personal interaction, a form of public participation. Public participation can benefit governmental agencies and other community developers or planners, whether it's used to seek input in the redevelopment of a site in a way that benefits a community or to build interest and acceptance for a proposal among community members. Because the remediation of the Bellfort site is not guaranteed and because of time and geographic constraints, the City and team agreed not to solicit individual feedback from local residents. Rather, the team conducted a survey of property owners throughout Houston.

While the number of survey responses was not high enough to adequately measure public demands, it did show that there is confusion as to the concept of brownfields and disagreement as to how significant a problem brownfields are and how they ought to be dealt with. Only a small subset of responding individuals recognizes the issues brought about by brownfields, while the rest of the respondents think that brownfields are not a problem. Further, community members tended to desire ecosystem services from which they could directly benefit, such as the improvement of flood control and air quality, rather than additional tree cover, habitats, or environmental education.

Hedonic Pricing Analysis

It was hypothesized that residential properties nearer to a brownfield would have lower initial values than properties further from a site and that greening brownfields would cause greater increases to nearby property values than properties further away. Ultimately, the hedonic pricing analysis yielded mixed results with respect to the hypothesis. The results agreed with the hypothesis for one of the two sites, but property values actually decreased for the second site.

This discrepancy can be explained by at least two overarching themes. First, the property values surrounding the parks may have been affected by other significant changes in the communities. Second, residents near the parks may have different preferences toward parks or the amenities included in parks. This demonstrates the importance of understanding the unique context and characteristics for each potential site. If municipalities are going to be convinced to support initiatives that focus on greening brownfields, it will be vitally important to prove that the investment is worthwhile. Demonstrating increased property values or other economic benefits is an integral part of the analysis. Crafting proposals that consider community desires is essential. In addition, in order to increase the validity of the findings from this project, it is necessary for future researchers to analyze other sites and further examine the reasons why results may differ from the hypotheses.

Landscape Design

Depending on various site specific constraints, opportunities, and goals, a number of potential designs may be viable for any given site. By incorporating local desires, broad goals, and the impacts on a wide range of ecosystem services into the design, a particular design that matches the capabilities of the site with the needs of the stakeholders may be found. We developed three design alternatives, beyond the baseline and solar power installation analyses, all of which consider stakeholder desires and the capabilities of the site. The three alternatives individually emphasize recreation, wildlife, and stormwater management. In future phases of developing design alternatives, pieces of each alternative presented here can be combined. The City of Houston can use these designs as guiding examples to initiate dialogues with the local community on how to proceed.

Identify Major Issues of Concern

The analyses that were conducted as part of this project attained varying levels of success, but nonetheless may be used as illustrative examples of the types of analyses to do in order to inform a decision on whether to move forward with greening a brownfield site. As part of an iterative process, the data that were collected and gathered in this project, falling under step 3, can now be used by the City of Houston to reevaluate the goals and objectives, step 2, for the site, providing the City with a more informed understanding of the major issues of concern. Identifying and understanding the challenges encountered on this project is important for those who may perform similar projects in the future, especially for setting expectations and minimizing potential set-backs.

Along these lines, the lead client for the project, Dr. Biddinger, requested that every challenge from the process be documented, ultimately building a checklist of expectations for future projects along with the respective knowledge that was gained (Biddinger, 2009a). In addition, he stated that the checklist should be exhaustive, including items that may seem obvious to some but would be unexpected by others. Ideally, this checklist would be used throughout future processes for redeveloping sites, and would be updated each time with new items to expect and additional knowledge gained. The challenges related to this particular project are discussed in detail below as distinguished by the three categories in step 2: social, economic, and environmental.

Societal Concern - Community Redevelopment

Most of the time it is reasonable to assume that information gathered from surveys and interviews is biased. Interviews conducted by the team were certainly limited to information that interviewees were willing to share. For example, Conservation Capital was willing to provide some insight for the overall project, but also wanted to ensure that they would not jeopardize losing work for themselves on the redevelopment of the 3300 Bellfort site.

Drafting a survey is certainly not the only challenge in understanding community concerns. Because the future of a community depends on what transpires on these sites, political concerns can unexpectedly affect the development of these project. In this instance of collaborating with a government agency, several issues needed to be negotiated before the survey could be conducted. First, the City had to approve of the language that would be included in the survey. This took several months due to the timing of city council meetings and relaying information between the team and the City of Houston. Second, the process for providing the surveys to the community and then returning the surveys to the team had to be negotiated. This included whether the survey would be available on City-owned kiosks and in hard-copy. The City of Houston owns a tool, called Survey Tracker, which the team could have used. Yet, due to changes within the City of Houston's office, access to Survey Tracker would not have necessarily been available for the entire duration of this project. Negotiations with the City of Houston also included whether the City would initially collect and review the surveys before forwarding them to the team. The complexity of working within a political environment became daunting as additional layers of governance were involved.

Finally, obtaining results for the survey was challenging. The team intended to follow the standard protocol for surveying that includes five points of contact, as proscribed by Dillman, but did not have sufficient time to fully apply it. The relatively weak response rate of the survey undermines the credibility of its conclusions, as the smaller the percentage of respondents is, the less likely the responses are to accurately represent the general population. Additionally, the results were less than optimal because of the manual process of completing the survey and the potential for the surveyed individuals to be uninterested in the issue itself. Finally, it is challenging to teach individuals about a topic such as brownfields through a short, written prompt while simultaneously asking for their opinions. Other barriers to receiving a significant level of input from individuals includes the staff time involved with performing the necessary communications and the expectations that can be formed about site development once discussions begin.

In regards to the hedonic pricing analysis, actual housing sale transactions would ideally be used for a hedonic pricing study. Actual housing sale transactions are a true representation of market value. Until September 2009, we thought the Houston Association of Realtors (HAR) would provide us with this data for a modest fee. However, HAR became fearful of what our study might show and decided not to provide us with this data. When HAR concluded to not provide information, we decided to use appraised house values that we already had from H-GAC. Appraised values, which in Texas are supposed to reflect a property's true market value, are nevertheless not necessarily accurate because properties are not actually being bought and sold on the market. Appraised values may differ systematically from actual housing prices. For example, there may be a cap on how much appraised values may change over the course of a year. In fact, certain properties in Harris County, where Houston is located, are only allowed to increase by 10% each year.

Finally, site designs are heavily influenced by stakeholder demands, which are difficult to accurately gauge and can fluctuate with other changes in the community and economic cycles. The site design is also influenced by the characteristics of the site itself, such as the topography and condition of the site and the structures currently in place. The site design prepared is based on assumptions of stakeholder desires. Beyond an understanding of stakeholder desires obtained through surveys, it may be better to obtain an understanding through more engagement methods, such as a workshop that incorporates education and facilitated feedback.

Business Concerns - Administrative

Over the year-long process of working on the project, the team's main contact at the City of Houston, Shannon Teasley, switched offices and also had to spend time on the mayoral election. Further, the team, as graduate students in various programs, had to coordinate their own schedules and deadlines. It is clear to us now how it can easily take a full year to gather and report on information for even just this initial stage of a much larger project.

Business Concerns - Legal

At the outset of the project, we had planned to have one or more ExxonMobil properties for our study site. However, these sites were ultimately excluded because of the company's concern about potentially exposing confidential information with the public. This includes liabilities for site restoration that had not been previously identified and other potential legal concerns. Further, ExxonMobil properties did not meet the team's interests in that threats of delays or discontinuance because of a controversial site were not an option for the team, whose planned graduation date was contingent on completing this project.

Business Concerns - Management

Another reason the initial site selection was challenging was because of the availability of information. The team struggled to find a site with enough information. It took time to obtain information about the sites and understand how to compare the sites. Further, because the public databases had not been updated, we did not know that some sites were already under development or inaccessible until we visited them. There may also have been sites that were not considered because they were not in the database. After selecting several sites, finding information about the historical ownership and use of the site provided further obstacles.

Finally, the team encountered challenges coordinating the contract between a large educational institution and a large publicly-traded company. Contract language and internal processes delayed funding, emphasizing the importance of having lines of credit or other sources of funding in order to take on a development project.

Other management challenges included dealing with the amount of information available. After searching for information to help clarify developments in some of the project's topics that are just becoming of interest to the common public, mainly ecosystem valuation, the team had to reduce the information shared in this report in order to maintain consistency with the scope of the project and to prepare a report that was targeted toward the interests of the City of Houston. While there may not be an exhaustive amount of information available on the topics included in this report, this report certainly does not include a comprehensive summary of the current initiatives in progress.

Business Concerns - Financial

The results of this project may not be entirely financially feasible. First, financing redevelopment projects can be challenging when considering gaps between the costs of remediation and redevelopment, financing, and expected future cash flows. Second, projects may not be approved because of financial decision-making processes. In this case, an entirely practical project may not be approved because the rate of return does not meet the hurdle rate set by the project stakeholders. For example, at ExxonMobil the only projects that do not have to meet a minimum return rate are safety projects and those required by regulation (Biddinger, 2009a). Since greening a brownfield is not required, it must provide some measurable value to the company and shareholders. That value does not necessarily need to be income but could take other forms including avoided liability, regulatory flexibility, or some other form of value to the company or the community. As Dr. Biddinger explained to us, at ExxonMobil, the hurdle rate is set based on the Return on Investment or Return on Capital Employed target for the specific division which could range depending on the division (Biddinger, 2009a). This means that the more values that can be quantified, the company can make better decisions. In addition, relationships with other stakeholders could be pursued in order to find the proper project-breakout in order to make the project financially feasible, including donations of time, labor, and expertise from community organizations (Biddinger, 2009b).

Environmental Concerns

Evaluating the values from ecosystem services is especially challenging because they are not traded regularly on the market. While the prices for many products are stable, the little amount of available information for the price of ecosystem services makes it challenging to set an accurate value. Thankfully, research on this realm is growing and data will become easier to obtain and more reliable in the future. Until this area of interest becomes more mature, those pursuing this venue are challenged with knowing which ecosystem services are more valued; finding means to value those services, and ensuring the accuracy and validity of current estimated values.

Further, the accuracy of the estimated values for sites will depend on the depth of information obtained for the particular sites. Large sites may require additional time for understanding the various ecosystem services provided by the range of plants, soil types, and other forms of infrastructure. For this Bellfort site, the team intended to use the Quadrat method for understanding the mix of vegetation on the site. Yet, as may be common for future projects, the size of the site, barriers for navigating through the site, and time constraints inhibited the team from using this method. In addition, the range of information about the local watershed, ecosystems, human infrastructure, and other influential characteristics may appear endless. Simply narrowing down the most critical factors to assess is a challenging and time-consuming process.

Conclusions

This project is the beginning of a much larger process. At this point, the group has identified the general interests and concerns of stakeholders throughout the City of Houston, the future limitations and possibilities for the site, and developed potential designs to encourage dialogue for the final outcome. Ideally, now the City of Houston would issue a Request for Proposals to find parties who are interested in purchasing the site and redeveloping it for the community. The City should stay abreast of the redevelopment plans and ensure the public interest is considered, especially for a site this large and contentious. Now, as part of an iterative process, the data that were collected and gathered in step 3 can be used by the City of Houston to reevaluate the goals and objectives for the site and develop a more informed understanding of the major issues of concern. When the City is ready to move forward it can begin more in-depth methods of public participation and other forms of collecting and assessing data, then decide whether to remediate and restore the site and the next steps for doing so. Once the various aspects of creating value through redeveloping a brownfield have been examined and assessed, negotiations with stakeholders can commence and the financing process for implementation of a project can begin. In regards to the timing of involvement, participation need not be limited to the initial revitalization of the property, but can be maintained by allowing community members to actively care for the site and keeping open communication channels to continuously receive feedback from the community. We look forward to seeing how this project progresses in the coming years.

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Appendix I: Selected Survey Results by Demographic Affiliations

Table I.1 - Self Reported Distance to Nearest Park (in miles) by Income

Annual Household Income (in thousands), 2009	Distance to nearest park
less than 20	2.8
20 to 50	2.9
50 to 70	2.4
70 to 90	0.9
90 to 110	1.3
110 to 140	2.4
140 to 175	0.8
175 or greater	0.8

Source: Rust into Renewal Survey, Greening Brownfield Properties 2010 SNRE Master's Project

Table I.2 - Self Reported Distance to Nearest Park (in miles) by Identified Race

Identified Race	Distance to nearest park
African American	2.9
Asian	2.0
Hispanic	2.4
White	1.5

Source: Rust into Renewal Survey, Greening Brownfield Properties 2010 SNRE Master's Project

Table I.3 - Self Reported Park Usage, Past 6 Months by Identified Race

Identified Race	Distance to nearest park
African American	43.6
Asian	34.0
Hispanic	49.7
White	45.4

Source: Rust into Renewal Survey, Greening Brownfield Properties 2010 SNRE Master's Project

Table I.4 - Impressions of Environmental Benefits and Identified Race of Respondent

Based on a 1 - 4 importance scale where 1 is "very important" and 4 is "not important"

Prompt	African American	Asian	Hispanic	White
Increasing the number of trees in the City of Houston is:	2.3	1.3	1.5	1.7
Developing solar power in the City of Houston is:	2.1	1.4	1.5	1.7
Protecting endangered species in the City of Houston is:	2.8	1.8	1.7	1.8
Improving flood protection in the City of Houston is:	1.1	1.0	1.2	1.2
Providing more habitat for bird species and other wildlife in the City of Houston is:	2.0	2.1	1.7	1.9
Developing vegetation in the City of Houston that will lower greenhouse gas emissions is:	1.6	1.1	1.4	1.6
Developing new nature trails in the City of Houston is:	1.8	1.1	1.7	1.8
Improving air quality in the City of Houston is:	1.1	1.1	1.3	1.3
Having more opportunities for education about nature in the City of Houston is:	1.9	1.3	1.7	2.0

Source: Rust into Renewal Survey, Greening Brownfield Properties 2010 SNRE Master's Project

Appendix II: Survey Significance Calculations Explanation

T-test significance analyses were performed in PASW statistics software (formerly known as SPSS) to gauge whether respondents' answers were significantly different than a neutral value for individual questions or prompts within questions. A walkthrough of basic survey analysis techniques like those utilized in this research can be found in Arlene Fink's How to Manage, Analyze and Interpret Survey Data (Fink, 2003). Testing for significance first requires establishing a null hypothesis, which describes a scenario in which nothing is occurring. In this case, the null hypothesis was that the average of the responses would equal a neutral value and show no consistent deviation from it. The columns labeled "significance" in the tables featured in the survey response section contain the p-value found for each test. The p-value is the probability that the mean that was found for the data present would have occurred if the null hypothesis were true. Therefore, a p-value of .04 means that there is only a 4% chance that the null hypothesis is true given the data present. In the context of the survey it means that there is a 96% chance that the average response to that question is something other than neutral, and respondents had a discernable opinion. In our analysis, in order for a result to be considered significant, a 95% threshold had to be reached (a p-value of .05 or less). This is a typical standard for social research. These tests were made possible by coding answers. For example, for yes or no responses, yes answers received a value of 1 and no received a value of 2. When this was the case, the neutral value for analysis was 1.5. For scales of agreement or disagreement, "strongly disagree" received a value of 1, "strongly agree" received a value of 5 and the neutral value "neither agree nor disagree" had a value of 3.

The null hypothesis of question 8 was developed slightly differently. The purpose of question 8 was not to test whether respondents found the pursuit of these environmental benefits important, but to see which ones they preferred in comparison to the others presented. To test whether respondents preferred individual prompts relative to the others, the value of the average response for all of the prompts, 1.652, was used as the neutral value against which to test significance.

Appendix III: Survey Write-In Responses

Question 5 Responses

Finally, if a new park were to be placed near where you live, what activities would you most want it to provide?

- Jogging on trail or track
- Line dancing, knitting, computer classes, adult travel club, canteen dance for teenagers, tap dance for children, photography classes, social etiquette classes
- Swimming, craft activities
- Safe, clean equipment for children to play on
- Swimming, walking, and bicycling and picnicking
- Bike riding trails, running trails, playground for children
- Luz las 24 Horas – Seguridad – Las Canchas mas Cuidadas: 24 hour security lights, better care for tennis courts
- Dog park
- Boardwalks for observing nature
- Walking trail, bicycling trail, socializing, picnicking, fishing
- I am 87 years old and have to use a walker to walk. I am physically unable to use a park.
- Un area para caminar. Juegos para los ninos. Areas the picnic.: Areas for walking. Games for children. Picnic areas.
- Basketball, football, softball or baseball field, swings, slides, etc.
- More activities for children.
- Running, biking, picnicking, swimming
- I would like to see a nice training facility to encourage youth participation, senior programs and a miniature golf course to teach our youth to play golf.
- Walking

- Walking trail
- Walking path
- Place for people to play chess. Area geared to attract retired citizens to get them out and moving, socializing, volunteering.
- Clean picnic areas with grills, playground for younger and older children
- Fishing, miniature golf, activity center. Indoor swimming, weight room, yoga. Like Mary Jo Peckham – I take my students there for field trips.
- Water play, pool
- Stop crime
- Walking, running, bicycling, in-line skating, taking photographs, observing, socializing, picnicking
- Walking, socializing, picnicking, basketball
- Tennis, horseback riding
- Walking, golf
- Children's equipment
- Shaded seating, playground equipment. Hiking, walking trail
- Walking on bicycle paths, sporting fields
- RV hookups
- Picnic, bicycling, kayak
- Roller skate park
- Walking, running, bicycling, observing nature, socializing, picnicking, wading
- Activities for young people
- I had been ill and forced into a sedentary lifestyle sitting and observing nature
- Table tennis, shuffle-board, checkers, chess
- Swimming, walking
- Walking trail

- Walking and bicycle trails, trees, bird-watching, picnic area
- Shooting areas, dog park
- Juegos de aepia para los ninos, area para caminar. Juegos para ninos alberca: games for children, areas for walking, pool games for children
- Fishing, bicycling, picnicking, watercraft
- Area for dog walking, bike path
- Walking trail or nature observation
- Adult classes
- Se gurida da d para los visitants y los ninos
- Not needed in my house's area
- Nice area to enjoy flowers and trees
- Disc golf, kayaking, Frisbee, picnic, biking, running
- Walking path, bike path, areas to entice birding population, birding areas – trees, water, areas for kayaking if possible
- Walking trails, playground for children
- Walking trail, playground for kids
- Swings, slides, water activities
- Playground for children, walking path, nice grass for picnic and dogs to run around, old trees, benches
- Walking, biking, jogging, picnicking
- Fishing – picnicking
- Children's playground, basketball court, tennis court
- Karate, tai kwon do, mas parkes cow cauchos artales y lugares como salones para practicor muchos. Casas que nos proparceonen menlaledad. Camo hoar egercise en
- Baseball field, basketball
- Basketball, baseball, biking

- Greenspace for relaxing, track for walking, BIKE PATHS – Houston needs badly, NOT in parks – rather as a means of commuting
- Playground, sport fields, walking trails, dog park, picnic shelter
- Biking
- Sand volleyball
- Golf, swimming, night star gazing
- Playground activities for the whole family, picnic area, walking trail, nature walks
- Karate, tai chi
- Picnic facilities
- Dog area, walking/hiking trail or path, woods
- Que estuviera seguro y que no fuera ton grande para no sentir miedo
- Walking paths, children's playground, free parking, restrooms, water fountains, some covered areas, picnic areas with BBQ pits and tables
- Sand volleyball
- Walking, observing nature, socializing, fishing pond
- Una alberca publica: A public pool
- Walking trails, biking, swimming, miniature golf
- Family gathering places
- Ball parks for baseball to have games with family and friends. Walking nature trail and bike trail. Playground area and picnic area. Covered pavilion
- Walking/jogging trail, tennis courts, volleyball courts
- Picnic and skate park
- Lugas – de juego, para los Jouenes – Como: jugar basketball, caminas, picinas lugas. Para undar en bicicleta
- Mas vancas, mas juegos

- Safe, will lit running trail. The park near my house does not feel safe enough for a woman to run by herself. I drive to another park about 2 miles away to run/walk about 4x a week. Playgrounds are nice. They attract families that too feel safe.
- Trees for shade
- Swimming pool, scenic (for photographs), bike trail, aerobic classes
- Tennis, running trail, bike trail (dirt), dog park with lake
- A wonderful community center which would provide lots of learning activities that would help the community get better quality people that would grow to be better people. Children to adulthood and of course the elderly. This area of this part of town has a lot of hardworking and poverty people that really would benefit by all the wonderful services and classes that could be provided and a lot them could be offered by a lot of good people that could committee to volunteering. It would surely keep people healthier and out of trouble.
- Exercise machines, tennis court, more picnic tables
- Walking running, jogging tracks
- Walking/jogging trail, nature/wildlife areas for habitat preservation and observation
- Picnic areas, recreation areas (tennis courts, softball, running/biking trails), community garden, community center for various community activities
- I watch my grandchildren play. Lots of space for throwing and kicking balls around. Not so much plastic put together slides etc. Can't see through that new mountain of junk to watch kids. Clean like old fashioned swings and bars with space between so kids don't get hurt.

Final Question Responses

Is there anything else that you would care to let us know about brownfieds and/or parks in the City of Houston?

- Since trees which were planted on esplanades and feeders of freeways are not being groomed and maintained I advise that the program be discontinued (they obstruct vision and add little beautification. I would recommend that the City continue to spend revenue on abandoned buildings (Old Comet Rice Mill on Emile St.) and abandoned houses. Replace buildings with shopping center, bowling alley, theatre, fine dining restaurant, overpass over railwood trail (husch/ Waco/
- I like the way Houston has utilized the bayous and flood retention pond for parks and walk/bike ways. I also love the trees in Houston.
- Hay muchos Jovenes que Usan El parquet para drogarse en Las Noches o Fines de Semanas y no Hay Suficiente Luz en las Noche's. Nesesita-mas Anuncios de Proibir El Alhco L o drogas. Gracias Por Esta Encuesta.
- I am not familiar with them.
- Brownfields and or commercial property that is vacant in Houston are a blight on the city. Land owners should be fined and required to maintain the properties or should forfeit the property and the buildings be demolished at the owner's expense. Ordinances for neglected yards/ property also need to be enforced. There are far too many "ugly" parts of the city and these are not just low income areas.
- I have been working toward developing Townwood Park since 1980. Last year after much persistence we were able to get a recreation center. We have struggled for years to obtain one decent park in this area and we are still a long way from accomplishing our goal. We do not have on fully planned park in an area of more than 50,000 or more residents. The City of Houston buys many park spaces but are always complaining about funding once they receive the land. Why do you continue buying park space that you cannot maintain? This is very frustrating for me as my goal is to have facilities for families and especially programs that are fully funded to get our youth off the street including security for safety reasons. Our park does not even have proper lighting after dark – you are afraid to go there.
- Where I live there are two small parks within walking distance and one large park we drive to (about a mile away)
- I strongly agree the number of brownfields being perceived to be a problem if this includes druggies

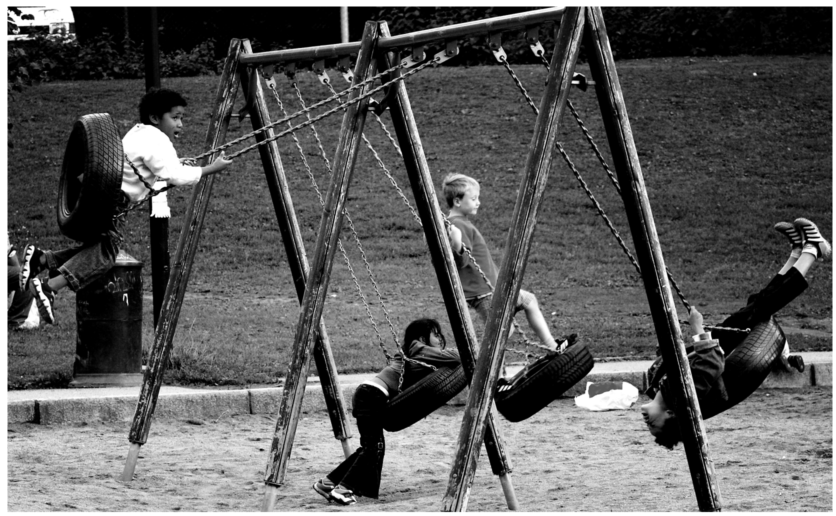
hanging around old properties as contaminants.

- Parks with lots of trees, well kept up, running or standing water, colorful plants – all very soothing in the Medical Center area where families can go to escape – for a short time – from the realities of the dread diseases being fought. Especially helpful would be to have “volunteer” dogs and cats available for patients to tend to or help care for – even temporarily – something that needs you even in whatever mental or medical state you are in. You can help walk a dog or pet and love a dog.
- More walking trails
- Better public transportation to and from the center city to developments be established. Taxi and other are too expensive. If you do not drive you are immobilized.
- While I highly value parks and nature spaces also highly value the city having a balanced budget and lower taxes. I would strongly discourage over investment in parks in the current fiscal environment or the raising of taxes in order to do so.
- The greenways created in the City of Houston generated a place that my friends and family enjoy frequently ci.e. Buffalo Bayou, Steve Raddick). I would very much enjoy and use additional parks throughout Houston
- Parks established by Steve Raddick are absolutely wonderful. Terry Hersley and bike path along Buffalo Bayou are fantastic – Bush Park, great!! Any park, any reclaimed land – a definite plus.
- We have always needed more nice parks in Houston. It has been getting better but there should be more. Houston offers nice weather most of time and parks would be a great way to enjoy outdoors, get exercise. It would be nice to have a nice park with a playground closer to home. Lots of families are moving back into the city and need playgrounds since homes here either have no backyard or small backyards.
- Que manlingas areas ilenas de arbalest y parques para la oxy ginacion y que los manlingan limpeas. Con mucho luez
- Thank you for engaging the public in future development, however March 8th isn’t a good time to be engaging the public
- Preserve and save more trees due to global warming and have cleaner air also cleaner environment
- En mi zona hay un lote bacio pero esta ileno de Arboles y he oido que estan recavdando firmas para que se haga un parquet y si no la ciudad lo un a vender y estarian hacienda en ese lugar una Cantina y una gasolinera y you creo que estaria major que se decidan por hacer el parquet va que estamos en una zona Recidencial esto esta en frente de un buiding de la ciudad la zona postal es 77023 entre

wayside y wheler

- Gracias por hau esto com la ciudad de Houston, il interis, espero que muy pronto se poseden un los cambios que se nesciuto si hoy alguna entidoret que pone arboles gratis,pueolen Ilamone ol 731-270-0125. Muchos gracias.
- I would like a park near my home but I do not want to sell my property in order to get that park. If any of this means that people will have to move and lose their homes, then count me OUT! I'd rather give a home to humans than to some birds. God will take care of the birds.
- Yes we diffently need one wonderful community center across from where I live at 3600 Jeanetta. We now have a very ½ ass park which I appreciate we have but we need a complete park with center, this would enhance community in many ways.
- I like the idea of "pocket parks", meaning single or double lot parks within neighborhoods to break up the density and balance the streetscapes. Perhaps the city can purchase lots, either through delinquent taxes or otherwise, to create such parks. Density breeds crime and blight. Our neighborhood, Pecan Park, has several lots with houses scheduled for demolition as unsafe. Pocket parks would be good substitutes in these spots.
- Parks are a fabulous asset to any community. We paid a higher price for our home to be within walking distance of 2 parks.

Rust into Renewal:



Turning abandoned lots into green spots in the City of Houston

A community survey from:

The City of Houston

In Partnership with:

NATURAL RESOURCES AND ENVIRONMENT
UNIVERSITY OF MICHIGAN

Rust into Renewal:
Turning abandoned lots into green spots in the City of Houston

On behalf of our project group and the City of Houston, we thank you for taking the time to fill out this questionnaire. We need your input to get a sense of citizen interest in the conversion of abandoned former commercial and industrial properties to park areas in the City of Houston and what types of activities and environmental benefits that you are most interested in having these spaces provide.

Park and Outdoor Recreational Activity

In this section we are hoping to gain an understanding of the opportunities for outdoor recreational activity and park usage that are available to you, and how much you use them.

About how far away from your residence is the nearest park? ______ miles

Concerning this particular park that is closest to you, please circle either Yes or No in response to the following questions:

It is accessible to me without the use of an automobile or public transportation.	Yes	No
I use this park more often than any other.	Yes	No
If it were closer to me I would use it more.	Yes	No

Still thinking about this same park closest to you, please mark the extent to which you agree or disagree with the following statements:

Statement:	Strongly Disagree ▼	Somewhat Disagree ▼	Neither Agree nor Disagree	Somewhat Agree ▼	Strongly Agree ▼
It is an important meeting place for people in the area.	☐	☐	☐	☐	☐
It reduces crime in my neighborhood.	☐	☐	☐	☐	☐
Nobody really uses it.	☐	☐	☐	☐	☐
This park is an important part of my feeling of being a resident here.	☐	☐	☐	☐	☐

Please estimate the number of times in the last 6 months that you participated in each of the following recreational activities outdoors anywhere within the city of Houston:

Walking, running, bicycling,
In-line skating ________ times
Taking photographs,
Observing nature ________ times
Socializing, picnicking ________ times
Riding watercraft
(boats, kayaks, jet skis, etc.) ________ times

Swimming, wading ________ times
Fishing ________ times
Horseback riding ________ times
Golf ________ times
Other sport ________ times
Other activities:
________________ ________ times

Again thinking about the last 6 months, how many times have you traveled outside of the City of Houston for the purpose of engaging in one of these activities:

Walking, running, bicycling,
In-line skating ________ times
Taking photographs,
Observing nature ________ times
Socializing, picnicking ________ times
Riding watercraft
(boats, kayaks, jet skis, etc.) ________ times

Swimming, wading ________ times
Fishing ________ times
Horseback riding ________ times
Golf ________ times
Other sport ________ times
Other activities:
____________________ ________ times

Finally, if a new park were to be placed near where you live, what activities would you most want it to provide?

Brownfields in your Area

A brownfield is a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.

Please circle the extent to which you agree or disagree with the following statement:

The number of brownfields in the City of Houston is perceived to be a problem.

I Strongly Disagree	I Somewhat Disagree	I Neither Agree nor Disagree	I Somewhat Agree	I Strongly Agree

Mark yes or no for this question and then follow the directions to proceed.

Are you aware of any brownfields within a mile of your residence?

yes ____ (please continue to the next question)

no _____ (please skip to the next page)

How many brownfields are you aware of within a mile of your residence? __________

Concerning the brownfield that is closest to your residence, how much do you agree or disagree with the following statements:

Statement:	Strongly Disagree ▼	Somewhat Disagree ▼	Neither Agree nor Disagree	Somewhat Agree ▼	Strongly Agree ▼
The brownfield makes crime worse in my area.	☐	☐	☐	☐	☐
I don't really notice the brownfield much.	☐	☐	☐	☐	☐
Other people in my community complain a lot about the brownfield.	☐	☐	☐	☐	☐
It would be better for my area if the brownfield were redeveloped for a new commercial use than if it became a new park.	☐	☐	☐	☐	☐
The brownfield land is fine as it is now – there isn't much need for redevelopment.	☐	☐	☐	☐	☐

Environmental Benefits

There are many benefits that our local natural environment can provide us like a nice view, a shady spot on a hot day, or even cleaner energy. However, we are also limited in the time, money and land we can devote to developing these opportunities. In this section we would like to find out which of these opportunities you're more interested in than others.

Please mark the box that best describes your interest in the city pursuing the following goals:

Goal:	Very Important ▼	Important ▼	Somewhat Important ▼	Not Important ▼	Don't Know ▼
Increasing the number of trees in the City of Houston is:	☐	☐	☐	☐	☐
Developing solar power in the City of Houston is:	☐	☐	☐	☐	☐
Protecting endangered species in the City of Houston is:	☐	☐	☐	☐	☐
Improving flood protection in the City of Houston is:	☐	☐	☐	☐	☐
Providing more habitat for bird species and other wildlife in the City of Houston is:	☐	☐	☐	☐	☐

Goal:	Very Important ▼	Important ▼	Somewhat Important ▼	Not Important ▼	Don't Know ▼
Developing vegetation in the City of Houston that will lower greenhouse gas emissions is:	☐	☐	☐	☐	☐
Developing new nature trails in the City of Houston is:	☐	☐	☐	☐	☐
Improving air quality in the City of Houston is:	☐	☐	☐	☐	☐
Having more opportunities for education about nature in the City of Houston is:	☐	☐	☐	☐	☐

Other Helpful Information

What year were you born?
19_____

Do you own or rent your place of residence?
I own ___
I rent ___
Other____

What is your gender? Female ___ Male ___

How do you describe yourself? (please check the one option that best describes you)

__ American Indian or Alaska Native
__ Hawaiian or Other Pacific Islander
__ Asian or Asian American
__ Black or African American
__ Hispanic or Latino
__ Non-Hispanic White
__ Biracial or multi-racial
__ Other

What is the highest level of education you've completed?

___ Less than 9th grade
___ 9th to 12th grade, no diploma
___ High school graduate or GED
___ Some college, no degree
___ Associate's degree
___ Bachelor's degree
___ Graduate or professional degree

What was your household income in 2008 before taxes?

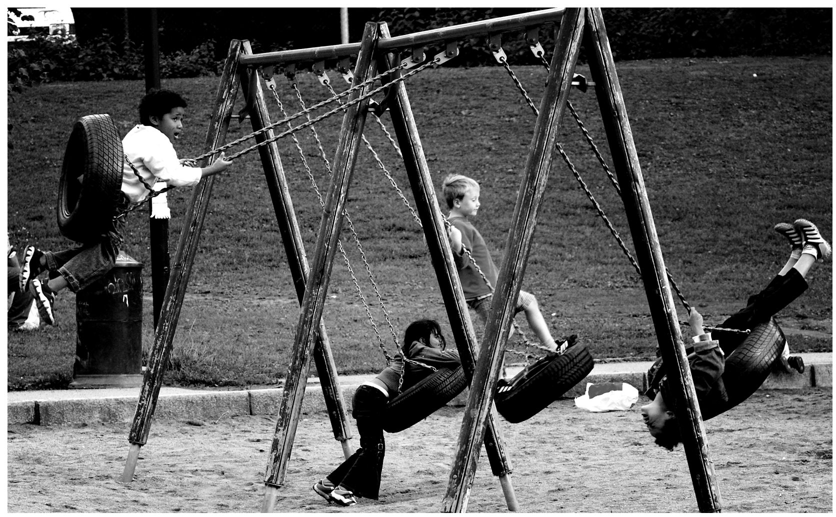
___ Less than $10,000
___ $10,000 - $19,999
___ $20,000 - $34,999
___ $35,000 - $49,999
___ $50,000 - $69,999
___ $70,000 - $89,999
___ $90,000 - $109,999
___ $110,000 – $139,999
___$140,000 - $ 175,000
___ More than $175,000
___ I prefer not to indicate

Thank you very much for your support. This completes our survey.

Is there anything else that you would care to let us know about brownfields and/or parks in the City of Houston? Use the space below.

Del Aherrumbrado a la Renovación:

Convirtiendo lotes abandonados en zonas verdes en la ciudad de Houston



Una encuesta comunitaria:

La Ciudad de Houston

En sociedad con:

NATURAL RESOURCES AND ENVIRONMENT
UNIVERSITY OF MICHIGAN

Del Aherrumbrado a la Renovación:

Convirtiendo lotes abandonados en zonas verdes en la ciudad de Houston

En nombre de nuestro grupo de proyecto y de la Ciudad de Houston, gracias por tomarse el tiempo para llenar este cuestionario. Necesitamos su colaboración para tener una idea del interés de los ciudadanos en la conversión de las antiguas propiedades abandonadas comerciales e industriales a las zonas del parque en la ciudad de Houston y qué tipo de actividades y los beneficios ambientales que son los más interesados en que estos espacios ofrecen.

Parques y Actividades Recreacionales al Aire Libre

En esta sección esperamos comprender el uso cotidiano de los parques y las actividades recreacionales que están a su disponibilidad, y que tan a menudo las utiliza.

¿A que distancia, en millas, esta el parque más cercano a su residencia? ______ millas

Con respeto al parque que le quede más cercano, por favor circule Sí o No como respuesta a las siguientes preguntas::

El parque es accesible a mí sin el uso de un automóvil o de un transporte público. Sí No

Utilizo este parque más a menudo que cualquier otro. Sí No

Si estuviera más cercano a mí, lo utilizaría más. Sí No

Considere el parque o espacio abierto que le sea más cercano e indique usando la escala presentada, el grado con el que esta de acuerdo con las siguientes declaraciones:

Declaración:	Discrepo Fuertmente ▼	Discrepo Moderad-amente	Neutral	Convengo Monderad-amente	Conveno Fuertmente ▼
El parque es un lugar de reunión importante para la gente en el área.	☐	☐	☐	☐	☐
Tener el parque reduce el crimen en mi barrio.	☐	☐	☐	☐	☐
En verdad, nadie usa el parque.	☐	☐	☐	☐	☐
El parque es una parte importante de sentirme como residente del área.	☐	☐	☐	☐	☐

Estime por favor el número de veces en los últimos 6 meses en el que usted participó en las siguientes actividades recreacionales dentro de la ciudad de Houston:

Caminar, correr, andar en bicicleta, patinar	________ veces	Nadar	________ veces
Tomar fotografías, observar la naturaleza	________ veces	Pescar	________ veces
Socializar, merendar en el campo	______ veces	Montar a caballo	________ veces
Utilizar kayak, botes, esquís de jet	_____ veces	Golf	________ veces
		Otros deportes	________ veces
		Otras actividades: ____________________	________ veces

En los últimos 6 meses, cuántas veces viajó fuera de la ciudad de Houston para participar en unas de estas actividades:

Caminar, correr, andar en bicicleta, patinar	________ veces	Nadar	________ veces
Tomar fotografías, observar la naturaleza	________ veces	Pescar	________ veces
Socializar, merendar en el campo	______ veces	Montar a caballo	________ veces
Utilizar kayak, botes, esquís de jet	_____ veces	Golf	________ veces
Cazar	______ veces	Otros deportes	________ veces
		Otras actividades: ____________________	________ veces

¿Si un parque nuevo fuera a ser colocado cerca de donde vive usted, qué actividades quisiera usted que el parque le proporcionara?

Brownfields en su área

Para los propósitos de esta encuesta, los "brownfields" son sitios comerciales o industriales que han sido abandonados

Por favor circule el punto con que está de acuerdo o no está de acuerdo en la siguiente afirmación:

El número de brownfields en la ciudad de Houston es un problema grande

Discrepo-Fuert-mente	Discrep Modera-damente	Neutral	Convengo Modera-damente	Convengo Fuert-mente

Marque Sí o No para esta pregunta y siga las direcciones para continuar.

¿Conoce usted de algun brownfields a una milla de su residencia?

Sí ____ (continúe)

no _____ (salte a la página siguiente)

¿Cuántos brownfields quedan dentro de una milla de su residencia? __________

Con respecto al brownfield más cercano a su residencia, indique por favor el grado con el que esta de acuerdo con las siguientes declaraciones:

Declaración: :	Discrepo Fuertmente ▼	Discrepo Moderad-amente	Neutral	Convengo Monderad-amente	Conveno Fuert-mente
El brownfield incrementa el crimen en mi área..	☐	☐	☐	☐	☐
En verdad no noto el brownfield.	☐	☐	☐	☐	☐
La otra gente en mi comunidad se queja mucho por el brownfield.	☐	☐	☐	☐	☐
Sería mejor para mi área si el brownfield fuese reconstruido para nuevos usos comerciales en vez de un parque nuevo.	☐	☐	☐	☐	☐
El brownfield esta bien ahora—no hay necesidad de reconstrucción	☐	☐	☐	☐	☐

Ventajas Ambientales

Hay muchas ventajas que nuestro ambiente natural nos proporcionar como un ambiente agradable, un punto sombrío en un día caliente, o aún energía más limpia. Sin embargo, también tenemos límites en el tiempo, el dinero y la tierra que podemos dedicar a desarrollar estas oportunidades.

Por favor marque la caja que mejor describe su interés en que la ciudad busque las siguientes metas:

Objetivo:	Muy Importante ▼	Importante ▼	Algo Importante ▼	Nada Importante ▼	No Opinio ▼
Incrementar el numero de árboles en la ciudad de Houston es:	☐	☐	☐	☐	☐
Desarrollar energía solar en la ciudad de Houston es:	☐	☐	☐	☐	☐
Proteger especies en peligro de extinción en la ciudad de Houston es:	☐	☐	☐	☐	☐
Mejorar la protección de inundación en la ciudad de Houston es::	☐	☐	☐	☐	☐
El abastecimiento de mas hábitat para pájaros y otra fauna en la ciudad de Houston es:	☐	☐	☐	☐	☐

Objetivo:	Muy Importante ▼	Importante ▼	Algo Importante ▼	Nada Importante ▼	No Opinio ▼
Desarrollar vegetación que absorba emisiones de dióxido de carbono en la cuidad de Houston es:	☐	☐	☐	☐	☐
Desarrollar nuevos rastros y caminos de naturaleza en la cuidad de Houston es:	☐	☐	☐	☐	☐
Mejorar la calidad de aire en la cuidad de Houston es::	☐	☐	☐	☐	☐
Tener mas oportunidades par ala educación sobre la naturaleza en la cuidad de Houston es:	☐	☐	☐	☐	☐

Otra informacion provechosa

¿En que año nació usted?
19_____

¿Cuál es su género?
mujer ___ hombre ___

¿Es usted dueño o inquilino de su domicilio?
Dueño ___
Inquilino ___
Otro ____

¿Cómo se describe a si mismo? (escoja por favor la opción que le describe mejor)

__ Indígena o Americano Nativo
__ De Hawai u otra isla pacífica
__ Americano-asiático o asiático
__ Negro o afro americano
__ Hispano o Latino
__ Blanco no-Hispano
__ Biracial o multirracial
__ Otro

¿En qué cantón (ward) de la ciudad de Houston vive usted?

__ 1st
__ 2nd
__ 3rd
__ 4th
__ 5th
__ 6th
__ No se

¿Cuál es el nivel más alto de educación que usted ha completado?

___ Menos del 9no grado
___ Secundaria (9no a 12vo grado), sin diploma
___ Diploma de secundaria (High School) o GED
___ Universidad, sin diploma
___ Associate's
___ Licenciatura (bachelor's)
___ Professional o pos-grado

¿Cuál fueron sus ingresos domésticos en 2008 antes de impuestos?

___ menos de $10.000
___ $10,000 - $19,999
___ $20,000 - $34,999
___ $35,000 - $49,999
___ $50,000 - $69,999
___ $70,000 - $89,999
___ $90,000 - $109,999
___ $110,000 – $139,999
___$140,000 - $ 175,000
___ más de $175.000
___ prefiero no indicar

Muchas gracias por su apoyo. Esto concluye la encuesta.

¿Hay algo más que usted le gustaría dejarnos saber sobre los brown-fields y/o los parques de la ciudad de Houston? Utilice el espacio abajo.

Appendix V - Key Takeaways from Interviews

Interview 1: Pamela Tames

Pamela is a professional engineer and project manager in charge of remediation at the Marathon Battery site, a site that formerly produced batteries for the military.

VOC Plume management

The Marathon Battery site has a plume of volatile organic compounds (VOCs) that extends off-site. Initially the remedy of choice was monitored natural attenuation. It was thought that once buildings were demolished and the construction on the site was finished, that the plume would wash its way out via the nearby river and the levels would decrease over time.

For any Superfund site that contains VOC contaminants in the groundwater, the EPA is required to do a vapor intrusion study if there are residences within 100 ft of the plume. Pamela has a number of sites where they sample residences near VOC plumes. The EPA does not force people to have their residences sampled, but they send out letters to potentially affected properties, explain the situation, and have public meetings. For the Marathon Battery site, they sampled nearby buildings to determine if they had high levels of VOC intrusion in their sub slabs and assisted residents with systems to deal with any problems that were discovered. In some cases where potential intrusion of VOCs was found, the EPA asked residents to install mitigation systems.

Cap in the Marsh

Also on the Marathon Battery site, there is a 12 acre area that has been capped that is located in the marsh. For that cap, the contaminated sediments were excavated and removed, but the EPA chose to cap the site anyways because the cadmium levels were still above background levels. It is being developed to be a marsh again and is designed to provide ecological value by creating habitat for flora and fauna.

Development Opportunities on a Cap

Several landfill sites have been capped and later had structures such as Home Depots built on top of them. If you want to put a building on top of a landfill, you can design your cap accordingly so that it will support a building on top. One of the issues with any sort of cap is settlement. Once you put a cap on, you are going to have settlement especially if you do not know what is underneath - if you have a landfill, you are going to have voids or other areas that are not as densely compacted as other areas.

It is important to ensure that plants that grow on top of a cap are appropriate and do not have roots that too deeply penetrate the cap and serve as vectors to bring up capped material. On the other hand, however, by adding vegetation on top of the cap, one can increase the stability of the soils on top of the cap. The cap that was used in this case was called bentiment, which is a 1 inch layer of bentimite clay which is sandwiched in between two layers of geotextile (a nylon fabric), which is rolled out like carpeting. On top of this is a foot of clean fill. In the case of the Marathon Battery marsh, tree growth is unlikely and would not reasonably cause an issue.

Specific Features and Lessons Learned at Marathon Battery

- Educational features included on a 95 acre Scenic Hudson site include a Civil War era foundry site that is a registered historic site. Michigan Tech has been conducting industrial archeological work on site.
- There were constructed walking paths that some included bricks that were already on site to pave walking paths, but archeologists said that they should not have moved any of these bricks. Most of the paths that have been constructed more recently are simple dirt paths.
- There were issues between town and developer that included unpaid taxes, poor zoning, and lack of infrastructure for industrial use.
- People tend to have short memories, so development does not tend to be a hard sell, even when it involves sites with histories of contamination, provided that clean-ups and site reuses are economically viable.
- There were issues with geese were eating new plantings, so the EPA revitalization workers used nets and strings with bright colored streamers attached to keep birds away. These nets were also used to keep birds away from self seeding plants too.
- When bare areas are allowed to regrow, there are often issues with invasive species taking hold. In the case of this site, there was an issue with Purple Loosestrife. Beetles that were bred to prefer eating the plant were used to keep out Purple Loosestrife. The beetles came from Cornell Cooperative Extension and cost around $1 to $2 a piece. The beetles lasted through the winter, and continue to eat Purple Loosestrife. There is a fair amount of certainty that beetles will not become a nuisance as they will move on to new patches of Purple Loosestrife rather than eating native plants.

Interview 2: Hilary Thornton

Hilary is a Remedial Project Manager with the EPA, which means that he is responsible for overseeing on-site remedial action for various contaminated sites. He has had experience with a number of different sites, including some experience with landfill remediation and wetland restoration.

Landfill Capping

Landfill capping technologies have changed since the 1970s, but even for landfill sites that have been capped recently, there a variety of different technologies that are used. The Wildcat Landfill site was capped around 1991 with soil and rather than multilayer geotextile, geomembrane "RCRA" caps that are often used on Superfund landfills. The nature and distribution of the waste in the Wildcat Landfill enabled the designers to select a soil cap rather than a more expensive alternative. The landfill contained a large amount of municipal trash in addition to hazardous waste as it was a mixed waste landfill (it was not built to contain hazardous waste, but sloppy disposal practices resulted in the presence of hazardous waste mixed in with municipal solid waste). Because the issue of the presence of hazardous waste was not that bad and existing soil cover on top of the waste was intact and sound, the EPA decided that it was not necessary to recap all of the landfill. Material was added to areas where soil cover that existed was insufficient, thus bringing the entire area of the cap up to standards that were protective of human health and the environment. Lives of 30 years are often used in estimations for projects, but this figure is more often a financial or cost estimating timeframe rather than a good estimate of how long the remedy will retain its efficacy. When the EPA estimates that the cap will last for 30 years, they plan for 30 years of funding; they put all of the remedies on the same timescale so they can be appropriately compared. Each remedy needs to be evaluated individually – a cap might have a much longer or shorter lifespan if it is evaluated under various conditions; for instance, if it going through many freeze-thaw cycles, lots of rainfall, or other environmental factors, the lifespan of certain caps could easily be shortened.

Vegetative Cover

Root depth is a significant consideration when selecting vegetation cover for capped areas. Generally trees are undesirable on caps, because the relatively shallow nature of the soil cover on top of the waste does not allow the trees to be able to root properly to resist wind. Then the trees will grow for 15-20 years and then be vulnerable to blowing over during wind storm events. If trees on caps are uprooted, there is potential for the exposure of waste materials. A team of biologists at EPA advises remedial project managers as to which plants and seed mixtures would be appropriate to maximize the ecological benefit gained from vegetation growing on the cap. Adding vegetation is an important consideration for the cap as its roots can stabilize the soil to ensure that it does not erode away.

If there are already grown trees on a capped site, it would be reasonable to get advice from knowledgeable professionals as to whether or not it would be worthwhile to do a tree-cutting. The professionals are well positioned to make assessments as to whether the trees are a threat to blowing down and exposing waste or rooting down deeply to draw up contamination and serve as vectors to wildlife who may consume parts of the tree. At Wildcat Landfill, several areas where trees naturally seeded were cut down to decrease the likelihood of exposure.

Wetlands

Wetlands can provide a buffer between highly contaminated areas and areas where contaminants could potentially be further transported. Wetlands typically have both aerobic and anaerobic components, which can be an important combination if you are looking to degrade or remediate various compounds, making them a good place for natural remediation to occur. They also provide habitat for various wildlife, and the EPA's mission is to protect both human health and the environment, so they are looking to restore and repair the environment for wildlife as well and wetlands are an important element of that. The EPA often looks to construct wetlands where they can on sites or restore the function of wetlands that have been harmed by contamination or industrial practices.

Interview 3: Michelle Mahoney, Mark Sprenger, and Harry Compton

Michelle, Mark, and Harry are all employees at the EPA. Michelle researches, compiles, and communicates information on rehabilitation and remediation of contaminated sites. Her job is to make resources and tools for implementing ecological restoration easily accessible to site managers. Mark works in the Office of Superfund Remediation and Technology Innovation, and Harry Compton is the Deputy Branch Chief of the Analytical Services Branch of the EPA's Technology Innovation Program.

Ecological Revitalization

People are often skeptical about the efficacy of remediation, especially remediation that involves ecological revitalization. Often contaminants are left in place, but altered to reduce their bioavailability. This can create concern among stakeholders who may have concerns about solutions. The EPA has to go through much iteration of arguments and demonstrate scientific credibility to assure stakeholders as to the stability of a particular site. Testing is vital and often integrates not just explorations that make scientific sense to the EPA, but also tests that local stakeholders have identified as important to their understanding and assurance that the site contamination has been properly remediated.

Public Participation

Public meetings, newspaper and radio announcements, and other methods for notifying the public are widely used to attempt to identify all relevant stakeholders early on and give voice to their opinions with respect to work on a particular site. Often these meetings are regular and involve not just addressing concerns of stakeholders, but also developing a relationship between EPA employees and stakeholders. A significant objective of these meetings is to describe exactly what the EPA is doing on a site in order to promote trust through transparency. Information can also come from the community, and these communications with stakeholders also serve to ensure that issues are identified that could affect a property's viability for future reuse.

Education

Often in sites where ecological revitalization has taken place, nearby K-12 education is engaged through fieldtrips or performing basic maintenance on site. This type of engagement improves public awareness and buy-in in addition to serving as an educational tool. The participants in this conversation, however, could not think of an example where students had been engaged at the remediation phase.

Interview 4: Christopher Timmins

Christopher Timmins does work on measuring hedonic price effects of Superfund sites. His work tries to examine the change in value to residential building properties from the deletion of a Superfund site from the NPL.

Recommendations for and Insights of Relevance for Our Study

Christopher recommended visually looking at how changes in housing value vary as distance increases; this is something that could be done in ArcMap. Dr. Timmins also recommended that we examine pretrends for a few years before the park conversion was announced. This could reveal how the price change rates of houses close to a specific site were higher or lower as compared to houses further away from the site. This method could allow us to make stronger claims about how the green redevelopment of sites affects local values.

In a similar vein, Dr. Timmins suggested that we try to determine when the public would have first known about the plans to convert these sites as that knowledge could cause changes in housing values even before construction began on the site. This exact information was not easily available for our sites, but after discussions with local personnel who work in the park system, we have a fairly good idea when this information was made public and have attempted to integrate that consideration into our model by creating a cushion of a few years before the conversions took place where possible.

For the purposes of our model, using the log of housing value is the most appropriate way to integrate that data into our model. In general, these types of regression models fit much better in log prices. Hedonic models tend to explain things better in percentage increase, which is achieved using logarithms in the model. For example, a $10,000 increase in housing value can mean something very different if the starting price is $40,000 as compared to $180,000.

Christopher also mentioned that an alternative way to organize our model would be to find similar neighborhoods to those in which our sites are located and use data from those neighborhoods to compare against our "treatment neighborhoods" that underwent greening of brownfield sites. The reason that we had decided against this methodology was that we were concerned that we would not be able to gather enough data about the changes going on in and around these other neighborhoods that our model could potentially become weaker due to adding in more communities that would potentially be differentially affected by changes over time that we could not account for in our model.

In his own work, Christopher has found significant effects from approximately half of a kilometer from Superfund sites to approximately two or three kilometers from them. Most effects tend to disappear after three or four kilometers. Most of the work that has been done at this point examines distances that are no further out than three to five miles. The effects of these sites are largely localized. He expects that for sites that are not as high profile and pose less of a threat than Superfund sites, the distance where significant effects can be measured could very well be less. For a park, he suggests that the significant changes would be only seen in areas where residents might access the park, perhaps within half of a mile.

Christopher has experience comparing data from different sources, specifically comparing Census data which is self reported to data from DataQuick which contains market based data. He ended up getting very similar results from both sources in his own work, suggesting that using different sources of data does not necessarily affect results. This question of source data was particularly important for our team as we ended up using assessed value data as we were unable to obtain repeat sales data for Houston, TX. His work included some sited in Texas, and he has had similar problems getting good residential attribute data for properties in Texas as compared to other states. Though Dr. Timmins' work does not necessarily imply that our data will not create different results than actual sales data, it does show that different sources can potentially lead to the same outcomes. In fact, our choice of using assessed data could be more appropriate than repeat sales data, as ultimately the interpretation will be in terms of value created for the city of Houston in terms of increased tax revenue.

Interview 5: Melissa Friedland

Melissa works on National Priority List (NPL) sites exclusively. The difference between NPL/Superfund sites and brownfield sites is significant; in particular, with respect to public participation, there is a standard procedure for engaging the communities on issues of Superfund sites, whereas there is not necessarily a standard procedure for brownfields.

Public Participation

There are a number of ways in which the EPA engages stakeholders. Remedial project managers are generally close to the community and have ideas for how to appropriately engage local interests. Visits to the community, input from community organizations, and meetings with local officials are all vital parts of the EPA's engagement process. The EPA has a very extensive community involvement program that lays out all of the actions that ought to be taken to engage the community. To facilitate engagement, the EPA has conducted a number of activities in different languages, and there is an agreement with the State Department allowing the EPA to publish materials in different languages.

In order to be sensitive to environmental justice issues, the EPA attempts to organize the largest possible stakeholder base and include everyone who might possibly be affected by decisions regarding a particular site. For reuse planning projects, there is great effort made to include a representative sample of the community. Local government officials are important to meet with in order to assess local preferences, but people who live near the site as well as those who are influenced by the site should be represented in the land use committee if one is formed. The goal of making a representative committee is to give those affected most by the decisions made by the committee a voice as well as provide them with the information that they need to take part in the process of thinking about what the future reuse of the site could be.

Many methods are utilized during the engagement process including phone calls, sending people in on foot, and town meetings, to name a few. Usually a land use committee is created, which is created after a series of open meetings, availability sessions, and solicitation of stakeholders. Community Involvement Guidance has recommendations for conducting these approaches. Obviously the approach depends on the specific site and community. For instance, often an important elder in the community who is a member of the local church could serve as a key individual for disseminating information depending on the community structure. There are also considerations with respect to the site itself. For instance, is the site in residents' backyards or is it out of the way? The EPA must take into account the idiosyncrasies of each site to adequately conduct public participation. EPA has a Community Involvement Program with Community Involvement Coordinators who work at each site, are engaged in the site reuse process, and may have been there for many years. The EPA has been developing a "Reuse Directive" which will soon be posted online.

When the EPA is working on a site, they meet with communities and get an idea of what which direction the site is headed in, and in their work on remediating a site, they do not want to do work that will create up barriers precluding reuse. In order to prevent reuse issues from arising, it is very important to know the anticipated land use, because then the EPA can structure its work with that future use in mind. Sometimes reuse is not considered until after the remedy is completed, and that limits some of what can be done with respect to community involvement with respect to reuse.

Institutional Controls

The efforts are primarily focused on making sure that the reuses will not affect the remedy, making sure that the uses are appropriate, and that there is no exposure to contamination. It is important to understand how people need to act on the site to make sure that they do not do anything to damage the remedy and make certain that this information is effectively communicated to those who will be managing the future use of the site. The EPA is not in the position to make decisions about what the reuse will be; the goal of the EPA is to bring the site up to a condition where it can be reused. They will clean up the site to a certain level and be very clear what the reasonably anticipated land use will be. They want to be able to tell that to people so that they do not do something that wipes all of the years of work and study with cleanup.

Every site is completely different and people have different ways of working out institutional controls (ICs). An institutional control could be something as simple as limitations being written into a deed, or it could be someone who works there full time to make sure that ICs are undertaken correctly. There are different kinds of ICs, but the essentially, an IC allows you to protect the integrity of your remedy by preventing people doing things that could destroy the work done to remediate the site. There are a lot of ways of managing ICs. Most frequently they are managed by local governments and states. States have various covenants about how ICs should be managed. Sometimes a remedy that has been in place for a long time has not ever had any institutional controls so they need to be added later. With newer sites, the EPA is trying to think of everything at the same time as a site is being cleaned up, rather than waiting for many years to pass before thinking about institutional controls.

A certain amount of reuse occurs where the EPA is not involved, and often the EPA does not even need to be involved. There is also a certain amount of reuse that might never occur no matter what is done by the EPA, but there is that middle group of sites where the EPA can be helpful in facilitating reuse, so tools have been developed to help make reuse occur more frequently and easily by getting rid of some of the barriers that are often present for these types of sites.

Appendix VI - Regression Runs and Results

Tony Marron Park
"Near" is defined as less than 2,000 feet:

Table 10 ▪ Full sample results — NearT2000

Random-effects GLS regression Number of obs = 133296

Group variable: Acct_Num Number of groups = 11108

R-sq: within = 0.0562 Obs per group: min = 12

between = 0.5227 avg = 12.0

overall = 0.4706 max = 12

Random effects u_i ~ Gaussian Wald chi2(80) = 19363.74

corr(u_i, X) = 0 (assumed) Prob > chi2 = 0.0000

ln_Def_TotV	Coef	Std.Err.z	P > z	[95% Conf. Interval]		
year96	.0244948	.0025084	9.76	0.000	.0195784	.0294113
year97	.008042	.0025084	3.21	0.001	.0031255	.0129584
year98	-.0155023	.0025084	-6.18	0.000	-.0204188	-.0105859
year99	-.0792183	.0025084	-31.58	0.000	-.0841348	-.0743018
year00	-.1000013	.0025084	-39.87	0.000	-.1049178	-.0950848
year01	-.0789897	.0025084	-31.49	0.000	-.0839062	-.0740732
year02	-.1031359	.0025084	-41.12	0.000	-.1080523	-.0982194
year03	-.0868622	.0025084	-34.63	0.000	-.0917787	-.0819457
year06	.0247365	.0025084	9.86	0.000	.0198201	.029653
year07	.0212461	.0025084	8.47	0.000	.0163296	.0261625
NID1	.2151351	.0586194	3.67	0.000	.1002431	.330027
NID2	-.1880199	.072014	-2.61	0.009	-.3291649	-.046875
NID3	-.0426111	.0678752	-0.63	0.530	-.1756442	.0904219
NID4	.2443008	.0547833	4.46	0.000	.1369274	.3516742
NID5	.1459107	.0327883	4.45	0.000	.0816468	.2101747
NID6	.2073501	.0309965	6.69	0.000	.1465981	.2681022
NID7	.2543396	.0294661	8.63	0.000	.1965871	.3120921
NID8	.0494387	.072014	0.69	0.492	-.0917062	.1905836
NID9	.2871383	.0317692	9.04	0.000	.2248718	.3494049
NID10	.205319	.0496129	4.14	0.000	.1080795	.3025584
NID11	.947288	.0859071	11.03	0.000	.7789132	1.115663
NID12	.6742016	.0521127	12.94	0.000	.5720626	.7763406
NID13	.6317118	.0348218	18.14	0.000	.5634624	.6999613

NID14	.6031434	.0511156	11.80	0.000	.5029587	.7033282
NID15	.6321818	.0417618	15.14	0.000	.5503301	.7140334
NID16	.4730661	.0292788	16.16	0.000	.4156808	.5304514
NID17	.4390803	.032725	13.42	0.000	.3749405	.5032201
NID18	.2582213	.0307965	8.38	0.000	.1978612	.3185814
NID19	.3686922	.0301587	12.23	0.000	.3095822	.4278022
NID20	.3439964	.0384784	8.94	0.000	.26858	.4194127
NID21	.2190354	.0320286	6.84	0.000	.1562605	.2818104
NID22	.1815448	.0364806	4.98	0.000	.1100442	.2530453
NID23	.1682531	.0313885	5.36	0.000	.1067328	.2297734
NID24	.4962306	.0401076	12.37	0.000	.417621	.5748401
NID25	.5921834	.0358166	16.53	0.000	.5219842	.6623827
NID26	.7843694	.0316945	24.75	0.000	.7222492	.8464896
NID27	.3624837	.0378222	9.58	0.000	.2883536	.4366138
NID28	.6339786	.0364804	17.38	0.000	.5624783	.7054788
NID29	.7260578	.0330848	21.95	0.000	.6612127	.7909029
NID30	-.0582082	.0462149	-1.26	0.208	-.1487878	.0323714
NID31	.0737919	.0543682	1.36	0.175	-.0327678	.1803517
NID32	.1378692	.0424412	3.25	0.001	.054686	.2210523
NID33	.3350603	.0433313	7.73	0.000	.2501325	.4199881
NID34	-.0276518	.0382251	-0.72	0.469	-.1025716	.0472679
NID35	.0645105	.0396806	1.63	0.104	-.013262	.142283
NID36	-.3493767	.0310587	-11.25	0.000	-.4102507	-.2885028
NID37	-.4514515	.0343182	-13.15	0.000	-.518714	-.384189
NID38	-.5213861	.0343182	-15.19	0.000	-.5886486	-.4541236
NID39	-.638936	.0418935	-15.25	0.000	-.7210458	-.5568262
NID40	-.6605208	.0372234	-17.74	0.000	-.7334772	-.5875643
NID41	-.6060705	.035874	-16.89	0.000	-.6763822	-.5357587
NID42	-.2959893	.1815951	-1.63	0.103	-.6519091	.0599305
NID43	-.4785771	.0374417	-12.78	0.000	-.5519614	-.4051927
NID44	-.4797808	.0326625	-14.69	0.000	-.5437982	-.4157634
NID45	-.4753054	.0387411	-12.27	0.000	-.5512366	-.3993742
NID46	-.6389524	.0436483	-14.64	0.000	-.7245014	-.5534034
NID47	-.5710399	.0438109	-13.03	0.000	-.6569076	-.4851722
NID48	-.4616078	.0786952	-5.87	0.000	-.6158476	-.3073681
NID49	-.2403778	.0436483	-5.51	0.000	-.3259268	-.1548288
NID50	-.0796435	.0354296	-2.25	0.025	-.1490843	-.0102027

NID51	-.2380254	.0609705	-3.90	0.000	-.3575255	-.1185254
NID52	.0263235	.0547833	0.48	0.631	-.0810498	.1336969
NID53	-.1023801	.0372234	-2.75	0.006	-.1753366	-.0294237
NID54	-.2428976	.0390137	-6.23	0.000	-.3193631	-.1664322
NID55	1.378266	.1223284	11.27	0.000	1.138507	1.618026
NID57	.0216179	.0482785	0.45	0.654	-.0730061	.1162419
NID58	.1452245	.0354834	4.09	0.000	.0756783	.2147706
NID59	.0237495	.072014	0.33	0.742	-.1173954	.1648944
NID60	-.0635138	.0292308	-2.17	0.030	-.1208051	-.0062225
NID61	-.1149136	.0354296	-3.24	0.001	-.1843544	-.0454728
NID62	.2676939	.0556523	4.81	0.000	.1586175	.3767704
NID63	-.2103788	.0517716	-4.06	0.000	-.3118493	-.1089083
NID64	.0601159	.0297644	2.02	0.043	.0017787	.118453
NID65	.1773885	.0296115	5.99	0.000	.1193509	.235426
NID66	.0883486	.0448489	1.97	0.049	.0004463	.1762508
NID67	-.5588203	.0367407	-15.21	0.000	-.6308307	-.4868099
NID68	-.1800093	.0373681	-4.82	0.000	-.2532494	-.1067691
near	-.154951	.0326829	-4.74	0.000	-.2190084	-.0908937
treat_years	-.0874001	.0025126	-34.79	0.000	-.0923247	-.0824756
impact	.1190858	.0098639	12.07	0.000	.0997529	.1384187
_cons	9.963407	.0236033	422.12	0.000	9.917145	10.00967

"Near" is defined as less than 5,000 feet:

Table 11 ▪ Full regression results — NearT5000

Random-effects GLS regression Number of obs = 133296

Group variable: Acct_Num Number of groups = 11108

R-sq: within = 0.0581 Obs per group: min = 12

between = 0.5236 avg = 12.0

overall = 0.4716 max = 12

Random effects u_i ~ Gaussian Wald chi2(80) = 19665.89

corr(u_i, X) = 0 (assumed) Prob > chi2 = 0.0000

ln_Def_TotV	Coef.	Std.Err.	Z	P > z	[95% Conf. Interval]	
year96	.0244948	.0025059	9.77	0.000	.0195833	.0294064
year97	.008042	.0025059	3.21	0.001	.0031304	.0129535
year98	-.0155023	.0025059	-6.19	0.000	-.0204139	-.0105908

year99	-.0792183	.0025059	-31.61	0.000	-.0841299	-.0743067
year00	-.1000013	.0025059	-39.91	0.000	-.1049129	-.0950897
year01	-.0789897	.0025059	-31.52	0.000	-.0839013	-.0740781
year02	-.1031359	.0025059	-41.16	0.000	-.1080474	-.0982243
year03	-.0868622	.0025059	-34.66	0.000	-.0917738	-.0819506
year06	.0247365	.0025059	9.87	0.000	.019825	.0296481
year07	.0212461	.0025059	8.48	0.000	.0163345	.0261576
NID1	.1873714	.0587483	3.19	0.001	.0722268	.3025161
NID2	-.2157835	.0720961	-2.99	0.003	-.3570894	-.0744777
NID3	-.0703747	.0679704	-1.04	0.300	-.2035942	.0628447
NID4	.2165372	.0549288	3.94	0.000	.1088788	.3241956
NID5	.1181471	.0330857	3.57	0.000	.0533003	.1829939
NID6	.1795865	.0313143	5.73	0.000	.1182115	.2409615
NID7	.2265759	.0298032	7.60	0.000	.1681627	.2849891
NID8	.0216751	.0720961	0.30	0.764	-.1196307	.1629809
NID9	.2593747	.032078	8.09	0.000	.196503	.3222464
NID10	.1775553	.0497837	3.57	0.000	.0799812	.2751295
NID11	.9195244	.0859518	10.70	0.000	.7510619	1.087987
NID12	.646438	.0522707	12.37	0.000	.5439893	.7488867
NID13	.6039482	.0350982	17.21	0.000	.5351569	.6727395
NID14	.5753798	.0512786	11.22	0.000	.4748756	.6758839
NID15	.6044181	.0419807	14.40	0.000	.5221376	.6866987
NID16	.4453025	.0296183	15.03	0.000	.3872516	.5033534
NID17	.4113167	.0330231	12.46	0.000	.3465927	.4760407
NID18	.3631155	.0354291	10.25	0.000	.2936758	.4325552
NID19	.3409286	.0304869	11.18	0.000	.2811754	.4006817
NID20	.3424099	.038443	8.91	0.000	.2670629	.4177568
NID21	.351796	.0389643	9.03	0.000	.2754275	.4281646
NID22	.296521	.042731	6.94	0.000	.2127697	.3802723
NID23	.2749918	.0381341	7.21	0.000	.2002502	.3497333
NID24	.4684669	.0403386	11.61	0.000	.3894047	.5475292
NID25	.5644198	.0360836	15.64	0.000	.4936973	.6351423
NID26	.7566058	.0320042	23.64	0.000	.6938788	.8193328
NID27	.3347201	.0380714	8.79	0.000	.2601014	.4093387
NID28	.606215	.0367413	16.50	0.000	.5342033	.6782267
NID29	.6982942	.033379	20.92	0.000	.6328725	.7637158
NID30	-.0859718	.0464048	-1.85	0.064	-.1769235	.0049799

NID31	.0460283	.0545155	0.84	0.398	-.0608201	.1528767
NID32	.1117073	.0426268	2.62	0.009	.0281602	.1952544
NID33	.4670791	.0486093	9.61	0.000	.3718066	.5623517
NID34	.0925277	.0431679	2.14	0.032	.0079202	.1771352
NID35	.1688589	.0450738	3.75	0.000	.0805158	.257202
NID36	-.3771403	.0313758	-12.02	0.000	-.4386358	-.3156449
NID37	-.4792151	.0345997	-13.85	0.000	-.5470292	-.411401
NID38	-.5491497	.0345997	-15.87	0.000	-.6169638	-.4813356
NID39	-.6666996	.0421114	-15.83	0.000	-.7492365	-.5841628
NID40	-.6882844	.0374777	-18.37	0.000	-.7617394	-.6148293
NID41	-.6234815	.0359585	-17.34	0.000	-.693959	-.5530041
NID42	-.3237529	.1814832	-1.78	0.074	-.6794534	.0319476
NID43	-.5063407	.0376942	-13.43	0.000	-.58022-.4324615	
NID44	-.5075444	.0329613	-15.40	0.000	-.5721473	-.4429415
NID45	-.503069	.0389828	-12.90	0.000	-.5794739	-.4266641
NID46	-.666716	.0438542	-15.20	0.000	-.7526687	-.5807633
NID47	-.5988035	.0440158	-13.60	0.000	-.6850728	-.5125343
NID48	-.4893714	.0787583	-6.21	0.000	-.6437348	-.3350081
NID49	-.2681414	.0438542	-6.11	0.000	-.3540941	-.1821887
NID50	-.1074071	.0357003	-3.01	0.003	-.1773783	-.0374359
NID51	-.265789	.0610902	-4.35	0.000	-.3855236	-.1460545
NID52	-.0014401	.0549288	-0.03	0.979	-.1090985	.1062183
NID53	-.1301437	.0374777	-3.47	0.001	-.2035988	-.0566887
NID54	-.2706613	.0392532	-6.90	0.000	-.3475961	-.1937264
NID55	1.350503	.1223014	11.04	0.000	1.110796	1.590209
NID57	-.0061457	.0484565	-0.13	0.899	-.1011186	.0888272
NID58	.1174608	.0357535	3.29	0.001	.0473853	.1875364
NID59	-.0040141	.0720961	-0.06	0.956	-.1453199	.1372917
NID60	-.0912774	.029571	-3.09	0.002	-.1492356	-.0333193
NID61	-.1426772	.0357003	-4.00	0.000	-.2126484	-.072706
NID62	.2399303	.0557938	4.30	0.000	.1305764	.3492841
NID63	-.2381424	.0519313	-4.59	0.000	-.3399259	-.136359
NID64	.0323523	.0300976	1.07	0.282	-.026638	.0913425
NID65	.1496248	.0299467	5.00	0.000	.0909303	.2083194
NID66	.060585	.0450472	1.34	0.179	-.0277058	.1488758
NID67	-.428178	.0427317	-10.02	0.000	-.5119306	-.3444254
NID68	-.0584984	.0425186	-1.38	0.169	-.1418333	.0248366

Near	-.1824616	.0279088	-6.54	0.000	-.2371619	-.1277613
treat_years	-.0958706	.0025587	-37.47	0.000	-.1008856	-.0908557
Impact	.0635195	.0032167	19.75	0.000	.057215	.069824
_cons	9.993288	.0240354	415.77	0.000	9.94618	10.0404

“Near” is defined as less than 8,000 feet:

Table 12 ▪ Full regression results — NearT8000

Random-effects GLS regression Number of obs = 133296

Group variable: Acct_Num Number of groups = 11108

R-sq: within = 0.0580 Obs per group: min = 12

between = 0.5220 avg = 12.0

overall = 0.4702 max = 12

Random effects u_i ~ Gaussian Wald chi2(80) = 19573.74

corr(u_i, X) = 0 (assumed) Prob > chi2 = 0.0000

ln_Def_TotV	Coef.	Std.Err.Z	P > z	[95% Conf. Interval]		
year96	.0244948	.0025061	9.77	0.000	.0195829	.0294067
year97	.008042	.0025061	3.21	0.001	.0031301	.0129539
year98	-.0155023	.0025061	-6.19	0.000	-.0204142	-.0105904
year99	-.0792183	.0025061	-31.61	0.000	-.0841302	-.0743064
year00	-.1000013	.0025061	-39.90	0.000	-.1049132	-.0950894
year01	-.0789897	.0025061	-31.52	0.000	-.0839016	-.0740778
year02	-.1031359	.0025061	-41.15	0.000	-.1080478	-.098224
year03	-.0868622	.0025061	-34.66	0.000	-.0917741	-.0819503
year06	.0247365	.0025061	9.87	0.000	.0198246	.0296484
year07	.0212461	.0025061	8.48	0.000	.0163342	.026158
NID1	.2050786	.0609082	3.37	0.001	.0857007	.3244565
NID2	-.1980764	.0739045	-2.68	0.007	-.3429266	-.0532262
NID3	-.0526676	.0698724	-0.75	0.451	-.1896149	.0842797
NID4	.2342443	.0572208	4.09	0.000	.1220936	.3463951
NID5	.1358543	.0366821	3.70	0.000	.0639587	.2077498
NID6	.1978611	.0346644	5.71	0.000	.1299201	.2658021
NID7	.2447701	.0333624	7.34	0.000	.179381	.3101592
NID8	.0393822	.0739045	0.53	0.594	-.1054679	.1842324
NID9	.2770818	.0357729	7.75	0.000	.2069683	.3471954
NID10	.1952625	.0522852	3.73	0.000	.0927853	.2977396
NID11	.9372315	.0875142	10.71	0.000	.7657068	1.108756
NID12	.6641452	.054666	12.15	0.000	.5570018	.7712885
NID13	.6216554	.0385128	16.14	0.000	.5461717	.6971391

NID14	.5930869	.0537151	11.04	0.000	.4878074	.6983665
NID15	.6223098	.0447843	13.90	0.000	.5345342	.7100855
NID16	.4630096	.0335777	13.79	0.000	.3971986	.5288207
NID17	.437037	.0329155	13.28	0.000	.3725238	.5015501
NID18	.2582213	.0308166	8.38	0.000	.1978219	.3186207
NID19	.3683616	.0301831	12.20	0.000	.3092037	.4275194
NID20	.3439963	.0385035	8.93	0.000	.2685309	.4194618
NID21	.2190354	.0320495	6.83	0.000	.1562196	.2818512
NID22	.1586548	.036014	4.41	0.000	.0880687	.2292408
NID23	.1361737	.0302767	4.50	0.000	.0768325	.1955149
NID24	.4962305	.0401338	12.36	0.000	.4175698	.5748913
NID25	.5921834	.0358399	16.52	0.000	.5219385	.6624284
NID26	.7772461	.0337768	23.01	0.000	.7110448	.8434473
NID27	.3555529	.0394993	9.00	0.000	.2781356	.4329701
NID28	.6328344	.0365518	17.31	0.000	.5611942	.7044747
NID29	.7260578	.0331064	21.93	0.000	.6611705	.7909451
NID30	-.0678967	.0488709	-1.39	0.165	-.163682	.0278886
NID31	.0650391	.0562459	1.16	0.248	-.0452009	.1752791
NID32	.1377725	.0424691	3.24	0.001	.0545346	.2210103
NID33	.3350603	.0433595	7.73	0.000	.2500772	.4200433
NID34	-.0276519	.0382499	-0.72	0.470	-.1026204	.0473167
NID35	.0300408	.0386777	0.78	0.437	-.045766	.1058476
NID36	-.3509679	.0311871	-11.25	0.000	-.4120936	-.2898423
NID37	-.4570599	.0355383	-12.86	0.000	-.5267137	-.3874061
NID38	-.5235134	.0345155	-15.17	0.000	-.5911625	-.4558644
NID39	-.6391223	.0419219	-15.25	0.000	-.7212876	-.5569569
NID40	-.6605208	.0372476	-17.73	0.000	-.7335247	-.5875168
NID41	-.6060705	.0358974	-16.88	0.000	-.676428	-.5357129
NID42	-.3060458	.1824522	-1.68	0.093	-.6636456	.0515541
NID43	-.4886336	.0408999	-11.95	0.000	-.568796	-.4084712
NID44	-.4898373	.0365695	-13.39	0.000	-.5615122	-.4181624
NID45	-.4853618	.0420943	-11.53	0.000	-.5678651	-.4028586
NID46	-.6490088	.0466557	-13.91	0.000	-.7404523	-.5575654
NID47	-.5810964	.046808	-12.41	0.000	-.6728384	-.4893544
NID48	-.4716643	.0804369	-5.86	0.000	-.6293178	-.3140108
NID49	-.2504342	.0466557	-5.37	0.000	-.3418777	-.1589908
NID50	-.0896999	.039064	-2.30	0.022	-.1662639	-.013136

NID51	-.2480819	.0631771	-3.93	0.000	-.3719067	-.124257
NID52	.0162671	.0572208	0.28	0.776	-.0958837	.1284178
NID53	-.1124366	.0406999	-2.76	0.006	-.1922069	-.0326663
NID54	-.2519785	.0417549	-6.03	0.000	-.3338165	-.1701404
NID55	1.36821	.1235024	11.08	0.000	1.12615	1.61027
NID57	.0115614	.0510191	0.23	0.821	-.0884341	.1115569
NID58	.135168	.0391128	3.46	0.001	.0585084	.2118276
NID59	.013693	.0739045	0.19	0.853	-.1311571	.1585432
NID60	-.0731978	.0332429	-2.20	0.028	-.1383526	-.008043
NID61	-.12497	.039064	-3.20	0.001	-.201534	-.0484061
NID62	.2576374	.0580544	4.44	0.000	.143853	.3714219
NID63	-.2204353	.0543405	-4.06	0.000	-.3269407	-.1139299
NID64	.0500594	.0340025	1.47	0.141	-.0165843	.1167032
NID65	.172035	.0308908	5.57	0.000	.1114901	.23258
NID66	.0857497	.0450779	1.90	0.057	-.0026013	.1741007
NID67	-.5588203	.0367646	-15.20	0.000	-.6308775	-.486763
NID68	-.1800093	.0373924	-4.81	0.000	-.2532971	-.1067214
Near	-.0215209	.016415	-1.31	0.190	-.0536937	.0106519
treat_years	-.1062102	.0027228	-39.01	0.000	-.1115468	-.1008736
Impact	.0458578	.0023757	19.30	0.000	.0412017	.050514
_cons	9.978166	.0287576	346.97	0.000	9.921802	10.03453

Mandell Park

"Near" is defined as less than 2,000 feet:

Table 13 ▪ Full regression results — NearM2000

Random-effects GLS regression Number of obs = 186312

Group variable: Acct_Num Number of groups = 13308

R-sq: within = 0.0123 Obs per group: min = 14

between = 0.6698 avg = 14.0

overall = 0.6305 max = 14

Random effects u_i ~ Gaussian Wald chi2(80) = 28993.86

corr(u_i, X) = 0 (assumed) Prob > chi2 = 0.0000

ln_Def_TotV	Coef.	Std.Err.	z	P > z	[95% Conf. Interval]	
year96	.0063568	.0022843	2.78	0.005	.0018797	.0108339
year97	.0075868	.0022843	3.32	0.001	.0031097	.0120638
year98	-.000311	.0022843	-0.14	0.892	-.004788	.0041661
year99	-.0104311	.0022843	-4.57	0.000	-.0149082	-.0059541
year00	-.0122472	.0022843	-5.36	0.000	-.0167243	-.0077702
year01	.0014695	.0022843	0.64	0.520	-.0030075	.0059466
year02	.0050191	.0022843	2.20	0.028	.000542	.0094961
year03	.0174531	.0022843	7.64	0.000	.012976	.0219301
year04	.0195934	.0022843	8.58	0.000	.0151163	.0240705
year05	.0504928	.0022843	22.10	0.000	.0460158	.0549699
year06	.0222831	.0022843	9.76	0.000	.017806	.0267601
year07	.0178252	.0022843	7.80	0.000	.0133481	.0223023
NID1	2.221561	.2087223	10.64	0.000	1.812473	2.630649
NID2	.7852572	.1872143	4.19	0.000	.4183239	1.152191
NID3	.2301131	.0412147	5.58	0.000	.1493338	.3108924
NID4	.3868784	.0385043	10.05	0.000	.3114114	.4623453
NID5	.680584	.0388391	17.52	0.000	.6044608	.7567071
NID6	.263721	.0404486	6.52	0.000	.1844431	.3429988
NID7	.6542805	.0384669	17.01	0.000	.5788868	.7296741
NID8	-.1814409	.0401521	-4.52	0.000	-.2601376	-.1027442
NID9	-.03475	.0461421	-0.75	0.451	-.1251868	.0556868
NID10	.440525	.0648038	6.80	0.000	.3135118	.5675381
NID11	-.0961109	.0423254	-2.27	0.023	-.1790671	-.0131547

NID12	-.0579478	.0419968	-1.38	0.168	-.14026.0243643	
NID13	-.067797	.0339975	-1.99	0.046	-.1344309	-.0011631
NID14	-.0978619	.0388768	-2.52	0.012	-.1740591	-.0216648
NID15	.081484	.0679546	1.20	0.230	-.0517045	.2146725
NID16	-.1248537	.041709	-2.99	0.003	-.2066019	-.0431056
NID17	-.1881091	.0455455	-4.13	0.000	-.2773766	-.0988416
NID18	.0910464	.0393937	2.31	0.021	.0138362	.1682567
NID19	-.3285374	.0764997	-4.29	0.000	-.478474	-.1786009
NID20	-.343941	.0403276	-8.53	0.000	-.4229817	-.2649003
NID21	-.4543614	.0443267	-10.25	0.000	-.5412402	-.3674827
NID22	-.3959148	.0421687	-9.39	0.000	-.4785638	-.3132657
NID23	-.5087118	.0465702	-10.92	0.000	-.5999876	-.417436
NID24	-.1742176	.0560529	-3.11	0.002	-.2840792	-.0643559
NID25	-.2252428	.0382681	-5.89	0.000	-.3002469	-.1502387
NID26	-.1527423	.0364706	-4.19	0.000	-.2242233	-.0812613
NID27	-.1416906	.0363443	-3.90	0.000	-.2129241	-.0704571
NID28	.5484367	.0415516	13.20	0.000	.4669971	.6298763
NID29	.1377815	.0459777	3.00	0.003	.0476669	.2278962
NID30	-.4376148	.080499	-5.44	0.000	-.5953899	-.2798396
NID31	-.0267822	.0396144	-0.68	0.499	-.1044251	.0508607
NID32	1.202689	.0418304	28.75	0.000	1.120703	1.284675
NID33	1.624529	.075611	21.49	0.000	1.476334	1.772724
NID34	1.845625	.0515344	35.81	0.000	1.74462	1.946631
NID35	1.874736	.0854051	21.95	0.000	1.707345	2.042126
NID36	.5518957	.0385803	14.31	0.000	.4762797	.6275116
NID37	1.204491	.0372017	32.38	0.000	1.131577	1.277405
NID38	-.0666952	.0504833	-1.32	0.186	-.1656406	.0322502
NID39	.1056842	.2935029	0.36	0.719	-.4695709	.6809393
NID40	-.3817834	.0432792	-8.82	0.000	-.4666091	-.2969576
NID41	-.4377719	.0381643	-11.47	0.000	-.5125726	-.3629712
NID42	-1.596627	.0899029	-17.76	0.000	-1.772834	-1.420421
NID43	-2.116237	.0899029	-23.54	0.000	-2.292444	-1.940031
NID44	-1.103494	.1342297	-8.22	0.000	-1.36658	-.8404088
NID45	-.9147084	.2087223	-4.38	0.000	-1.323797	-.5056203
NID46	-1.010755	.1591127	-6.35	0.000	-1.32261	-.6988995
NID47	-.921085	.0463959	-19.85	0.000	-1.012019	-.8301507
NID48	-.6554225	.0510694	-12.83	0.000	-.7555167	-.5553282

NID49	-.6431415	.0428674	-15.00	0.000	-.72716	-.5591231
NID50	-1.129284	.0460594	-24.52	0.000	-1.219559	-1.03901
NID51	-1.089583	.0396397	-27.49	0.000	-1.167275	-1.011891
NID52	-1.070989	.0974773	-10.99	0.000	-1.262041	-.8799368
NID53	-.7718941	.0546786	-14.12	0.000	-.8790621	-.664726
NID54	-.2178463	.0710012	-3.07	0.002	-.3570061	-.0786865
NID55	-.5067602	.0573376	-8.84	0.000	-.6191398	-.3943806
NID56	-.4292544	.0551183	-7.79	0.000	-.5372843	-.3212244
NID57	-.544535	.0584086	-9.32	0.000	-.6590138	-.4300562
NID58	-.8007727	.0458171	-17.48	0.000	-.8905726	-.7109728
NID59	-.8724264	.0494138	-17.66	0.000	-.9692756	-.7755771
NID60	-.7755562	.0974773	-7.96	0.000	-.9666082	-.5845042
NID61	-1.614135	.0490442	-32.91	0.000	-1.71026	-1.51801
NID62	-1.298678	.0816286	-15.91	0.000	-1.458668	-1.138689
NID63	.472975	.0366997	12.89	0.000	.4010449	.5449052
NID64	.5435232	.0390952	13.90	0.000	.4668979	.6201485
NID65	1.215888	.2403289	5.06	0.000	.7448516	1.686924
NID66	.7751029	.0469316	16.52	0.000	.6831187	.8670871
NID67	.3871193	.0371277	10.43	0.000	.3143504	.4598882
NID68	.2077123	.0396397	5.24	0.000	.1300198	.2854047
NID69	.2354726	.0489244	4.81	0.000	.1395825	.3313627
NID70	.3608832	.0402981	8.96	0.000	.2819004	.4398659
NID71	.6609682	.0406198	16.27	0.000	.5813549	.7405816
NID72	.4351892	.0407993	10.67	0.000	.3552241	.5151543
NID73	.0078199	.0503382	0.16	0.877	-.0908411	.106481
Near	-.1406117	.0214848	-6.54	0.000	-.1827212	-.0985023
treat_years	.0266509	.0022988	11.59	0.000	.0221454	.0311564
Impact	-.0509911	.0045506	-11.21	0.000	-.0599102	-.042072
_cons	11.80329	.0314397	375.43	0.000	11.74167	11.86491

"Near" is defined as less than 5,500 feet:

Table 14 ▪ Full regression results — NearM5500

Random-effects GLS regression Number of obs = 186312

Group variable: Acct_Num Number of groups = 13308

R-sq: within = 0.0123 Obs per group: min = 14

between = 0.6688 avg = 14.0

overall = 0.6295 max = 14

Random effects u_i ~ Gaussian Wald chi2(80) = 28951.04

corr(u_i, X) = 0 (assumed) Prob > chi2 = 0.0000

ln_Def_TotV	Coef.	Std.Err.z	P > z	[95% Conf. Interval]		
year96	.0063568	.0022845	2.78	0.005	.0018792	.0108344
year97	.0075868	.0022845	3.32	0.001	.0031092	.0120644
year98	-.000311	.0022845	-0.14	0.892	-.0047885	.0041666
year99	-.0104311	.0022845	-4.57	0.000	-.0149087	-.0059536
year00	-.0122472	.0022845	-5.36	0.000	-.0167248	-.0077697
year01	.0014695	.0022845	0.64	0.520	-.003008	.0059471
year02	.0050191	.0022845	2.20	0.028	.0005415	.0094966
year03	.0174531	.0022845	7.64	0.000	.0129755	.0219306
year04	.0195934	.0022845	8.58	0.000	.0151158	.024071
year05	.0504928	.0022845	22.10	0.000	.0460153	.0549704
year06	.0222831	.0022845	9.75	0.000	.0178055	.0267606
year07	.0178252	.0022845	7.80	0.000	.0133476	.0223028
NID1	2.269011	.2093193	10.84	0.000	1.858753	2.67927
NID2	.8327075	.1878776	4.43	0.000	.4644742	1.200941
NID3	.2775635	.0440962	6.29	0.000	.1911364	.3639905
NID4	.4343287	.0415739	10.45	0.000	.3528454	.515812
NID5	.7405515	.0389056	19.03	0.000	.6642979	.8168051
NID6	.3114309	.0433108	7.19	0.000	.2265434	.3963184
NID7	.7346517	.036405	20.18	0.000	.6632992	.8060041
NID8	-.103486	.0382317	-2.71	0.007	-.1784188	-.0285532
NID9	.0343815	.045022	0.76	0.445	-.05386.1226229	
NID10	.4879753	.0666752	7.32	0.000	.3572942	.6186564
NID11	-.0265235	.0409699	-0.65	0.517	-.1068231	.0537761
NID12	.0235076	.040112	0.59	0.558	-.0551104	.1021256
NID13	-.035343	.0336354	-1.05	0.293	-.1012672	.0305812
NID14	-.0589284	.0384207	-1.53	0.125	-.1342316	.0163748

NID15	.0912191	.0679413	1.34	0.179	-.0419434	.2243817
NID16	-.0433983	.0398106	-1.09	0.276	-.1214256	.0346289
NID17	-.1075532	.0438527	-2.45	0.014	-.193503	-.0216034
NID18	.1627861	.0378125	4.31	0.000	.0886749	.2368973
NID19	-.2810871	.0780922	-3.60	0.000	-.4341451	-.1280292
NID20	-.2898431	.0416032	-6.97	0.000	-.3713838	-.2083024
NID21	-.4006573	.0455732	-8.79	0.000	-.489979	-.3113355
NID22	-.3479899	.0448657	-7.76	0.000	-.4359251	-.2600548
NID23	-.4612615	.0491391	-9.39	0.000	-.5575723	-.3649506
NID24	-.1117017	.0557813	-2.00	0.045	-.2210311	-.0023723
NID25	-.144456	.0361914	-3.99	0.000	-.2153898	-.0735222
NID26	-.0759583	.0343928	-2.21	0.027	-.143367	-.0085496
NID27	-.0931086	.0391823	-2.38	0.017	-.1699045	-.0163126
NID28	.6298921	.0396456	15.89	0.000	.5521882	.707596
NID29	.2140574	.044368	4.82	0.000	.1270978	.301017
NID30	-.3901644	.0820143	-4.76	0.000	-.5509095	-.2294194
NID31	.0206682	.0426042	0.49	0.628	-.0628346	.1041709
NID32	1.250139	.0446723	27.98	0.000	1.162583	1.337695
NID33	1.67198	.0772218	21.65	0.000	1.520628	1.823332
NID34	1.893076	.0538675	35.14	0.000	1.787497	1.998654
NID35	1.922186	.0868352	22.14	0.000	1.751992	2.09238
NID36	.5994463	.0416159	14.40	0.000	.5178805	.6810121
NID37	1.251942	.0403704	31.01	0.000	1.172817	1.331066
NID38	-.0192448	.0528627	-0.36	0.716	-.1228538	.0843642
NID39	.1531346	.2939342	0.52	0.602	-.4229659	.729235
NID40	-.334333	.0460319	-7.26	0.000	-.4245539	-.2441122
NID41	-.3903216	.0412592	-9.46	0.000	-.4711881	-.309455
NID42	-1.549177	.0912629	-16.97	0.000	-1.728049	-1.370305
NID43	-2.068787	.0912629	-22.67	0.000	-2.247659	-1.889915
NID44	-1.056044	.1351477	-7.81	0.000	-1.320928	-.7911592
NID45	-.8672581	.2093193	-4.14	0.000	-1.277516	-.4569999
NID46	-.9633044	.15989	-6.02	0.000	-1.276683	-.6499258
NID47	-.8736346	.0489739	-17.84	0.000	-.9696218	-.7776475
NID48	-.6079721	.0534228	-11.38	0.000	-.7126789	-.5032654
NID49	-.5956912	.0456448	-13.05	0.000	-.6851534	-.506229
NID50	-1.081834	.0486553	-22.23	0.000	-1.177197	-.9864716
NID51	-1.042133	.0426278	-24.45	0.000	-1.125682	-.9585838

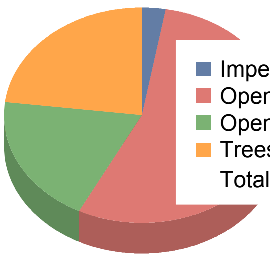
NID52	-1.023538	.0987337	-10.37	0.000	-1.217053	-.8300239
NID53	-.7244437	.0568831	-12.74	0.000	-.8359326	-.6129549
NID54	-.167967	.0723333	-2.32	0.020	-.3097377	-.0261963
NID55	-.4570122	.0590022	-7.75	0.000	-.5726544	-.34137
NID56	-.3809846	.0571393	-6.67	0.000	-.4929757	-.2689936
NID57	-.4947172	.0597385	-8.28	0.000	-.6118026	-.3776318
NID58	-.7533224	.0484259	-15.56	0.000	-.8482354	-.6584093
NID59	-.8243947	.0517111	-15.94	0.000	-.9257466	-.7230428
NID60	-.7281059	.0987337	-7.37	0.000	-.9216204	-.5345914
NID61	-1.566685	.05149	-30.43	0.000	-1.667603	-1.465766
NID62	-1.251228	.0831234	-15.05	0.000	-1.414147	-1.088309
NID63	.5204254	.0399082	13.04	0.000	.4422067	.598644
NID64	.5909735	.0421219	14.03	0.000	.5084162	.6735309
NID65	1.263338	.2408502	5.25	0.000	.7912802	1.735396
NID66	.8225532	.0494818	16.62	0.000	.7255708	.9195357
NID67	.4345697	.0403022	10.78	0.000	.3555789	.5135604
NID68	.2551626	.0426278	5.99	0.000	.1716138	.3387115
NID69	.282923	.051376	5.51	0.000	.1822279	.383618
NID70	.3672824	.040288	9.12	0.000	.2883194	.4462455
NID71	.6796127	.0405216	16.77	0.000	.6001918	.7590336
NID72	.5166446	.0388563	13.30	0.000	.4404876	.5928016
NID73	-.051047	.0495303	-1.03	0.303	-.1481246	.0460306
Near	-.0340051	.0200149	-1.70	0.089	-.0732336	.0052234
treat_years	.0267274	.002299	11.63	0.000	.0222215	.0312334
Impact	-.0523415	.0045465	-11.51	0.000	-.0612524	-.0434305
_cons	11.75582	.0351306	334.63	0.000	11.68697	11.82468

Analysis Report

for

Baseline

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures: All other buildings	8.8	2.9%
Open Space - Grass/Scattered Trees	167.9	54.8%
Open Space - Grass/Scattered Trees: Grass cover < 50%	59.7	19.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	70.3	22.9%
Total:	306.7	100.0%

Tree Canopy: 70.3 acres (22.9%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Houston***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	251	123
Ozone:	2,821	$9,967
Nitrogen Dioxide:	1,254	$4,430
Particulate Matter:	2,946	$6,950
Sulfur Dioxide:	1,128	$974
Totals:	**8,401**	**22,444**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**3,026**
Tons Sequestered **(Annually)**:	**24**

Analysis Report

for

Baseline

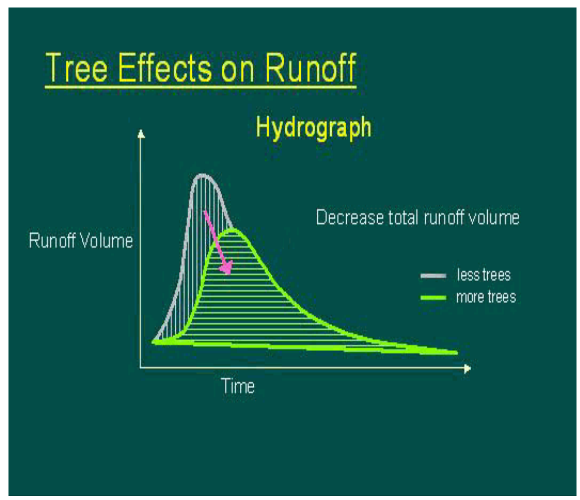
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

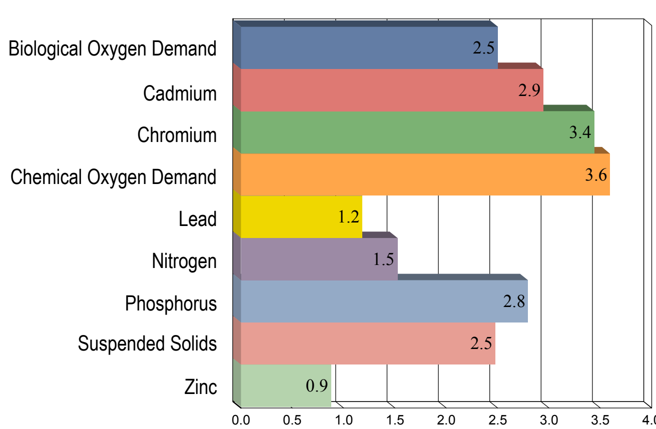
2-yr, 24-hr Rainfall in inches:	4.75
Curve Number reflecting existing conditions:	84
Curve Number of replacement land cover:	84
Dominant soil type: **D**	
Replacement land cover type used:	
Open Space - Grass/Scattered T	
Additional cu. ft. storage needed:	72,468
Construction cost per cu. ft.:	$2.00
Total Stormwater Savings:	**$144,937**
Annual Costs (based on 20-year financing at 6% interest)	**$12,636**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings

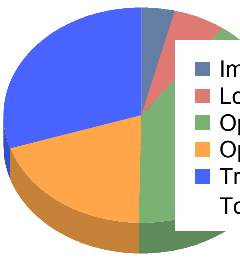


Analysis Report

for

Baseline: Recreation and park

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures: All other buildings	12.0	3.9%
Low Impact Development: Porous Pavement - Properly Maintained	18.4	6.0%
Open Space - Grass/Scattered Trees	124.2	40.5%
Open Space - Grass/Scattered Trees: Grass cover < 50%	59.8	19.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	92.3	30.1%
Total:	306.7	100.0%

Tree Canopy: 92.3 acres (30.1%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Houston***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	329	162
Ozone:	3,703	$13,084
Nitrogen Dioxide:	1,646	$5,815
Particulate Matter:	3,868	$9,124
Sulfur Dioxide:	1,481	$1,278
Totals:	**11,028**	**29,463**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**3,973**
Tons Sequestered **(Annually)**:	**31**

Analysis Report

for

Baseline: Recreation and park

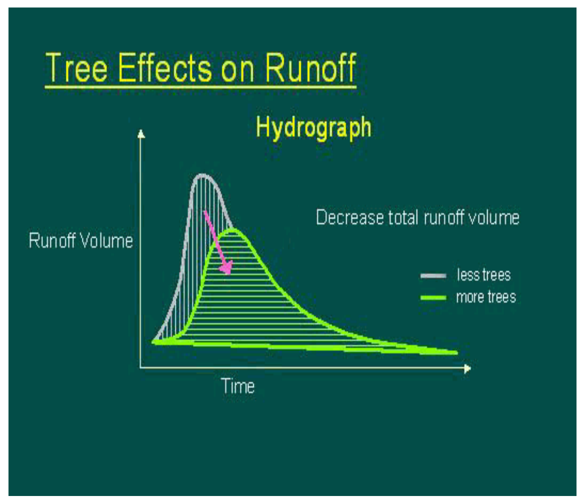
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

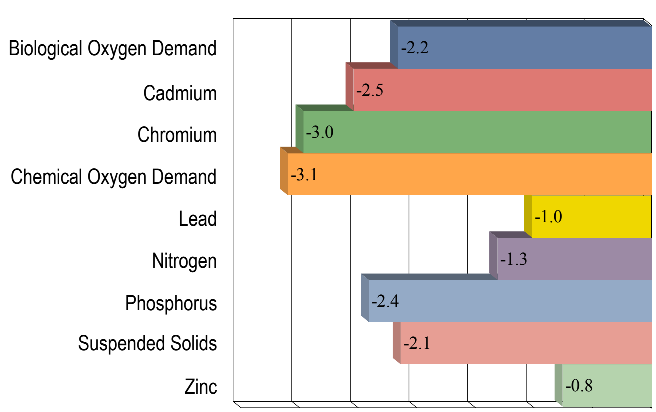
2-yr, 24-hr Rainfall in inches:	4.75
Curve Number reflecting existing conditions:	84
Curve Number of replacement land cover:	83
Dominant soil type: **D**	
Replacement land cover type used:	
Open Space - Grass/Scattered T	
Additional cu. ft. storage needed:	-61,927
Construction cost per cu. ft.:	$2.00
Total Stormwater Savings:	**$-123,855**
Annual Costs (based on 20-year financing at 6% interest)	**$10,798**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings

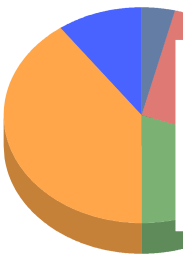


Analysis Report

for

Baseline: Storm water management

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures: All other buildings	12.0	3.9%
Open Space - Grass/Scattered Trees	81.6	26.6%
Open Space - Grass/Scattered Trees: Grass cover < 50%	59.8	19.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	122.7	40.0%
Water Area	30.7	10.0%
Total:	306.7	100.0%

Tree Canopy: 122.7 acres (40.0%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use "externality" costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state's Public Services Commission.

Nearest Air Quality Reference City: ***Houston***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	437	215
Ozone:	4,921	$17,388
Nitrogen Dioxide:	2,187	$7,728
Particulate Matter:	5,140	$12,125
Sulfur Dioxide:	1,969	$1,699
Totals:	**14,655**	**39,154**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree's dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**5,279**
Tons Sequestered **(Annually)**:	**41**

Analysis Report

for

Baseline: Storm water management

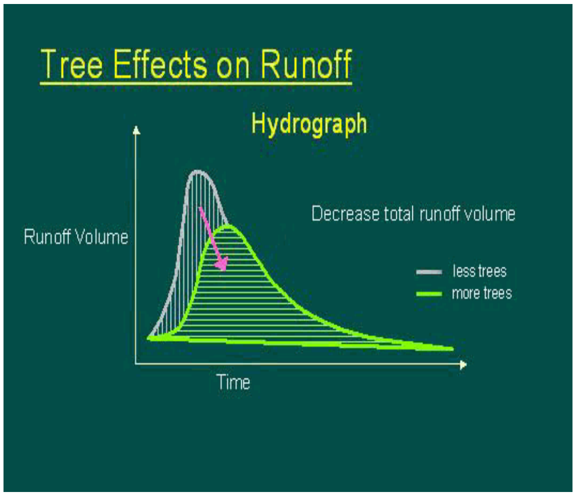
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

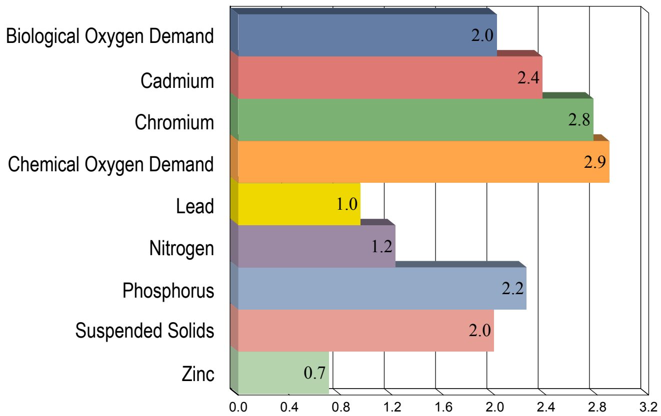
2-yr, 24-hr Rainfall in inches:	4.75
Curve Number reflecting existing conditions:	84
Curve Number of replacement land cover:	84
Dominant soil type: **D**	
Replacement land cover type used:	
Open Space - Grass/Scattered T	
Additional cu. ft. storage needed:	58,251
Construction cost per cu. ft.:	$2.00
Total Stormwater Savings:	**$116,502**
Annual Costs (based on 20-year financing at 6% interest)	**$10,157**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings

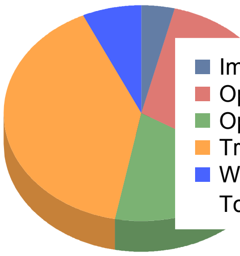


Analysis Report

for

Baseline: Wild life habitat

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures: All other buildings	12.0	3.9%
Open Space - Grass/Scattered Trees	90.8	29.6%
Open Space - Grass/Scattered Trees: Grass cover < 50%	59.8	19.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	122.7	40.0%
Water Area	21.5	7.0%
Total:	306.7	100.0%

Tree Canopy: 122.7 acres (40.0%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Houston***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	437	215
Ozone:	4,921	$17,388
Nitrogen Dioxide:	2,187	$7,728
Particulate Matter:	5,140	$12,125
Sulfur Dioxide:	1,969	$1,699
Totals:	**14,655**	**39,154**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**5,279**
Tons Sequestered **(Annually)**:	**41**

Analysis Report

for

Baseline: Wild life habitat

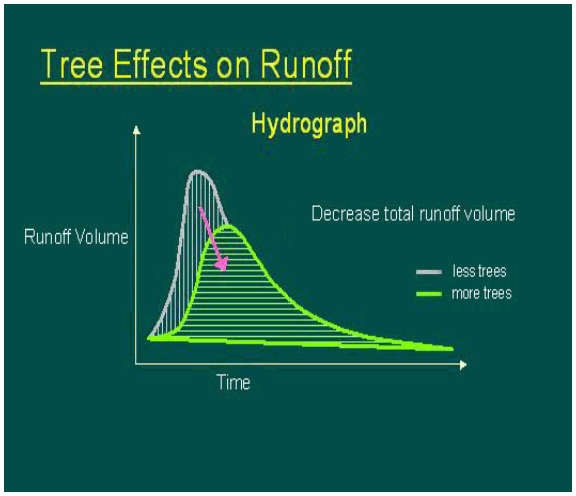
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

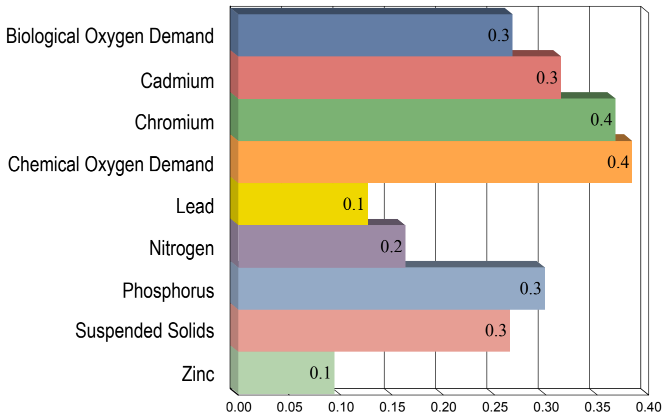
2-yr, 24-hr Rainfall in inches:	4.75
Curve Number reflecting existing conditions:	84
Curve Number of replacement land cover:	84
Dominant soil type: **D**	
Replacement land cover type used:	
Open Space - Grass/Scattered T	
Additional cu. ft. storage needed:	7,706
Construction cost per cu. ft.:	$2.00
Total Stormwater Savings:	**$15,412**
Annual Costs (based on 20-year financing at 6% interest)	**$1,344**



Water Quality (Contaminant Loading)

Trees filter surface water and prevent erosion, both of which maintain or improve water quality. American Forests developed the CITYgreen water quality model using data from the US Environmental Protection Agency (EPA) and Purdue University's L-Thia spreadsheet water quality model. The water quality model estimates the change in the concentration of pollutants in runoff during a typical storm event, by replacing the tree canopy in a specified study area with the user-defined replacement land cover (specified in the CITYgreen Preferences) and comparing the results. The model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD).

Percent change in contaminant loadings

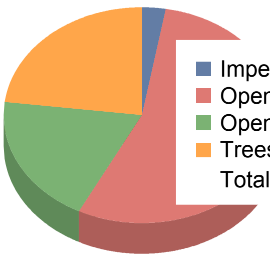


Analysis Report

for

Baseline with solar panel

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures: All other buildings	8.8	2.9%
Open Space - Grass/Scattered Trees	167.9	54.8%
Open Space - Grass/Scattered Trees: Grass cover < 50%	59.7	19.5%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	70.3	22.9%
Total:	306.7	100.0%

Tree Canopy: 70.3 acres (22.9%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use “externality” costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state’s Public Services Commission.

Nearest Air Quality Reference City: ***Houston***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	251	123
Ozone:	2,821	$9,967
Nitrogen Dioxide:	1,254	$4,430
Particulate Matter:	2,946	$6,950
Sulfur Dioxide:	1,128	$974
Totals:	**8,401**	**22,444**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree’s dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**3,026**
Tons Sequestered **(Annually)**:	**24**

Analysis Report

for

Baseline with solar panel

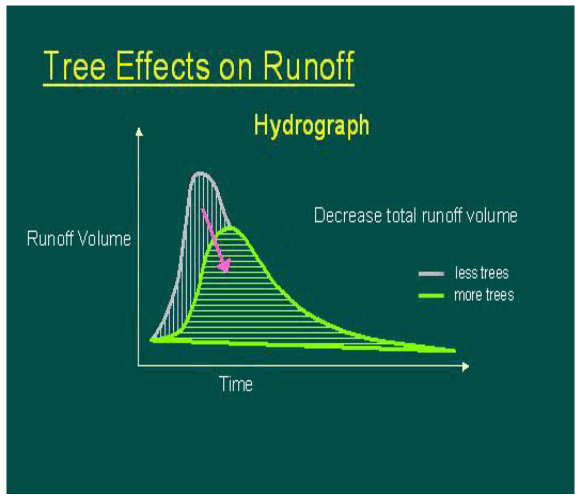
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

2-yr, 24-hr Rainfall in inches:	4.75
Curve Number reflecting existing conditions:	84
Curve Number of replacement land cover:	84
Dominant soil type: **D**	
Replacement land cover type used:	
Open Space - Grass/Scattered T	
Additional cu. ft. storage needed:	72,468
Construction cost per cu. ft.:	$2.00
Total Stormwater Savings:	**$144,937**
Annual Costs (based on 20-year financing at 6% interest)	**$12,636**



Water Quality (Contaminant Loading)

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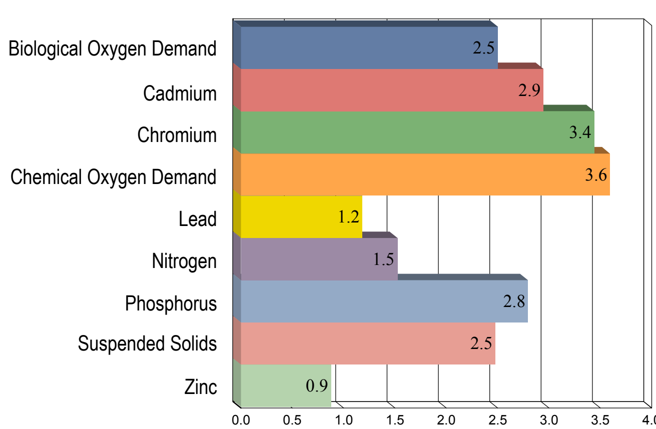
Percent change in contaminant loadings

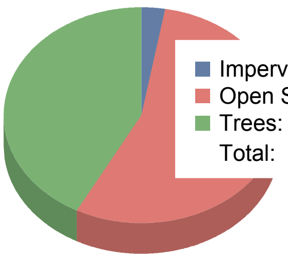


Analysis Report

for

Baseline

Land cover in acres and percentages



Impervious Surfaces: Buildings/ structures: All other buildings	8.7	2.9%
Open Space - Grass/Scattered Trees	168.7	55.0%
Trees: Forest litter understory: No grazing, forest litter and brush adequately cover soil	129.2	42.1%
Total:	306.7	100.0%

Tree Canopy: 129.2 acres (42.1%)

Air Pollution Removal

By absorbing and filtering out nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10), trees perform a vital air cleaning service that directly affects the well-being of urban dwellers. CITYgreen estimates the annual air pollution removal rate of trees within a defined study area for these five pollutants based on research conducted by David Nowak, PhD, of the U.S. Forest Service. Economists use "externality" costs, or indirect costs borne by society such as rising health care expenditures and reduced tourism revenue to determine the dollar value of air pollutant removal. The externality costs used in CITYgreen are set by each state's Public Services Commission.

Nearest Air Quality Reference City: ***Houston***

	Lbs. Removed/yr	Dollar Value/yr.
Carbon Monoxide:	461	226
Ozone:	5,184	$18,314
Nitrogen Dioxide:	2,304	$8,140
Particulate Matter:	5,414	$12,771
Sulfur Dioxide:	2,073	$1,789
Totals:	**15,436**	**41,241**

Dollar values are based on 2009 dollars

Carbon Storage and Sequestration

Trees remove carbon dioxide from the air through their leaves and store carbon in their biomass. Approximately half of a tree's dry weight is carbon. For this reason, large-scale tree planting projects are recognized as a legitimate tool in many national carbon-reduction programs. CITYgreen estimates the carbon storage capacity and sequestration rates of trees within a defined study area. The carbon storage and sequestration model was developed using research conducted by David Nowak, E. Gregory McPherson, and Rowan Rowntree of the U.S. Forest Service.

Tons Stored **(Total)**:	**5,561**
Tons Sequestered **(Annually)**:	**43**

Analysis Report

for

Baseline

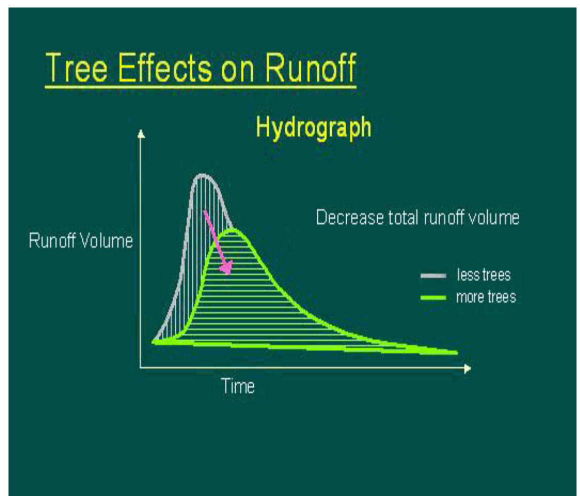
Stormwater Management

Water Quantity (Runoff Volume)

Trees decrease total runoff volume, helping cities to decrease their stormwater management costs. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. To do this, CITYgreen uses a model developed by the Natural Resources Conservation Service (NRCS) called TR-55, based on a system of curve numbers. Curve numbers are an index of potential runoff within a specified drainage area. Curve numbers range from 30 to 100, with a higher number indicating greater runoff potential.

CITYgreen calculates two curve numbers for the stormwater analysis: one reflecting existing land cover conditions and the other reflecting the replacement of tree canopy in the study area by a user-defined replacement land cover (specified in the CITYgreen Preferences.) The difference in curve numbers and local rainfall determine the change in storage volume between the two different land cover scenarios (with and without trees). To determine the dollar amount of stormwater-related savings resulting from tree canopy, this calculated volume is then multiplied by the user-specified local construction cost.

2-yr, 24-hr Rainfall in inches:	4.75
Curve Number reflecting existing conditions:	81
Curve Number of replacement land cover:	83
Dominant soil type: **D**	
Replacement land cover type used:	
Open Space - Grass/Scattered T	
Additional cu. ft. storage needed:	129,144
Construction cost per cu. ft.:	$2.00
Total Stormwater Savings:	**$258,288**
Annual Costs (based on 20-year financing at 6% interest)	**$22,519**



Water Quality (Contaminant Loading)

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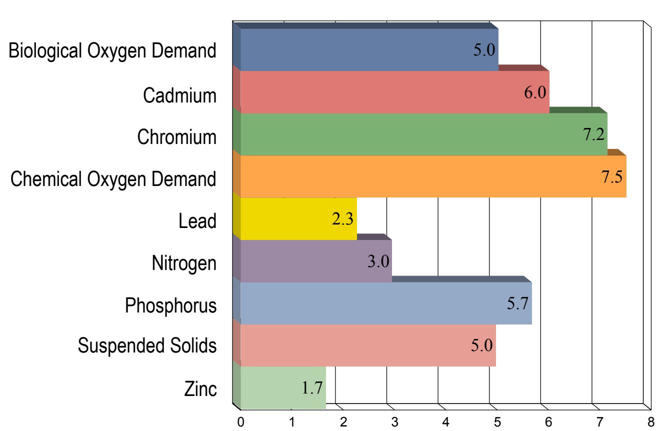
Percent change in contaminant loadings



Appendix VIII - Additional Maps

Bellfort Site Context Map

Harris County Context Map