EVALUATING LANDSCAPE PERFORMANCE

A Guidebook for Metrics and Methods Selection
2018

Landscape Architecture Foundation

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HOW THIS GUIDEBOOK WAS DEVELOPED

Since 2010, the Landscape Architecture Foundation (LAF) has worked with faculty-student research teams, designers, and clients to produce over 150 case studies documenting the environmental, social, and economic benefits of high-performing landscape projects. These Case Study Briefs and the methods used to quantify the benefits are part of the online library of resources in LAF's *Landscape Performance Series*.

In an effort to make landscape performance evaluation more accessible to broader audiences and to improve the research rigor and replicability, LAF commissioned a study in 2013-2014. The two-part study involved the coding and analysis of all metrics and methods used in the first 58 case studies published to the *Landscape Performance Series*. The goal of the second part was to use this information to identify a set of widely applicable metrics and methods for each benefit category and compile the findings into a comprehensive guidebook. The study was completed in late 2014 with a draft of the guidebook containing over 100 metrics in 34 benefit categories.

The final publication of this guidebook builds on and augments the original draft contributed by Jessica Canfield and Bo Yang in 2014. In the four years that elapsed, a number of methods and protocols came into wider use, new tools were released, and old tools became obsolete. An additional 90 *Landscape Performance Series* case studies were produced, which had not been part of the original analysis, broadening the body of performance evaluation work to include new geographies, project typologies, and emerging issues such, as resilience and equity.

Thank you to these LAF supporters

LAF would like to recognize the following organizations for their support and investment in LAF's long-term strategic research initiatives. Their financial support and leadership has helped to get this guidebook in your hands (or on your screen).

JJR ROY FUND

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OJB LANDSCAPE ARCHITECTURE

Railroad Park | Tom Leader Studio

(Photo: Tom Leader Studio)

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Barangaroo Reserve | PWP Landscape Architecture

(Photo: Barangaroo Delivery Authority)

THE CASE FOR LANDSCAPE PERFORMANCE

Climate change. Urbanization. Public health. Species extinction. Economic stability. Social isolation. Equity. The great challenges of our time serve as a reminder of the vital need to balance human and natural systems, resources, and processes. Landscape must be an integral part of any conversation about sustainability, livability, or resilience because no matter how these terms are defined – carbon neutrality, biodiversity, health and happiness, economic vitality – they cannot be achieved without landscape solutions. However, often landscape is not adequately valued in the design and development process.

Today's land development projects must serve multiple functions, address multiple issues, and provide multiple benefits. On top of that, decision-makers, owners, investors, and policymakers are increasingly seeking proof that projects perform and provide return on investment. Landscape performance is a way to provide this evidence for landscape solutions.

Landscape performance can be defined as a measure of the effectiveness with which landscape solutions fulfill their intended purpose and contribute to sustainability. It involves assessment of progress toward environmental, social, and economic goals based on measurable outcomes. Landscape performance draws upon research and knowledge from a wide range of disciplines including landscape architecture, horticulture, ecology, civil engineering, transportation planning, urban economics, other social sciences, and public health.

Measuring and documenting the performance of sustainable landscapes in a way that is understandable and accessible to a wide array of decision-makers has a multi-pronged effect:

1) It leads to more effective management and informs incremental adjustments to improve the performance of built landscape systems.
2) It leads to better future designs that incorporate lessons illuminated through the performance evaluation process.
3) It helps bridge the knowledge gap about the value of landscape solutions in the design, development, and policy realms. Access to evidence of proven benefits reduces risk for investors and allows advocates to better make their case.

Landscape performance is rapidly becoming a vital way to represent and articulate the value of excellent design and provide reliable and valid evidence to justify design decisions, provide quality assurance, and inform ongoing site management and maintenance activities. Landscape performance also supports and aligns with emerging built environment practices, including adaptive management, site commissioning, and performance verification as a pathway for regulatory and rating system compliance.

Embracing performance measures and evaluating the performance of built projects can increase knowledge, support innovation, and elevate the quality of designed landscapes. By validating past research and raising new questions, it also grounds and strengthens the body of more rigorous landscape performance research being conducted within a variety of disciplines and through multidisciplinary collaboration. Continuing to study the connections between landscape and the health of ecosystems, people, and economies increases our understanding and our collective capacity to create a more sustainable, just, and resilient future by using landscape solutions to their fullest potential.

APPROACH TO EVALUATING PERFORMANCE

Performance evaluation involves collecting and analyzing data to answer key questions and gauge success in achieving what matters.

Landscape performance evaluation is typically used to measure the impact of a landscape solution designed to provide multiple benefits. It usually focuses on the change resulting from a specific intervention, such as construction of a new site, renovation of an existing space, or installation of a new feature. Projects well suited for this type of evaluation include urban parks, green streets, schoolyard renovations, waterfront redevelopments, planned communities, campuses, greenways, and ecological restorations. Landscape performance evaluation aims to quantify environmental, social, and economic outcomes to demonstrate the ultimate results of a project in light of its goals and objectives.

Performance evaluation should strive to measure outcomes, not outputs. In landscape projects, examples of outputs are the number of trees planted, area of high albedo pavement, or length of protected bike lanes added. Outcomes are the impacts or achievements of the outputs, or, essentially, the benefits they provide. Examples of landscape performance outcomes are amount of carbon sequestered, localized temperature improvements, or reductions in the number of bike accidents.

Deciding What to Assess

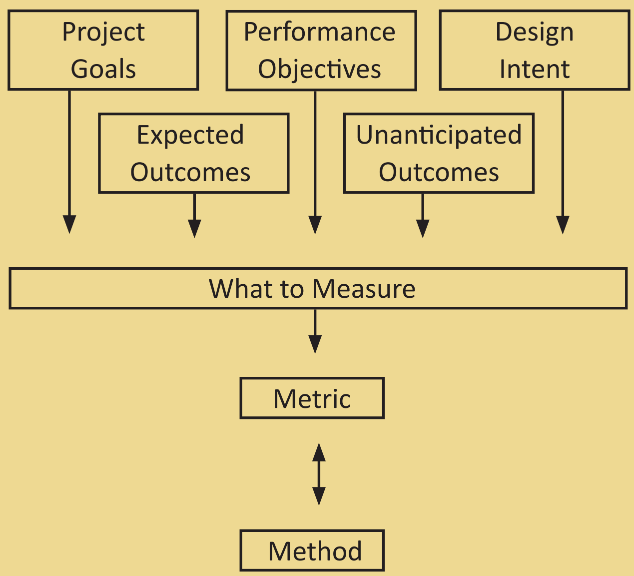
It is essential to understand the overall project goals in order to evaluate performance. Ideally, these goals have been established and explicitly stated, but, all too often, goals are vague and are not documented. Therefore, it is important for the evaluator to diligently investigate to determine what measures are most relevant given what the design was trying to achieve.

Sometimes specific performance objectives have been established. This happens particularly with aspects that are regulated, such as stormwater management. Other times there are very clear benchmarks, such as net zero energy, often driven by the desire to achieve a rating system level or other sustainability criteria. Specific performance objectives are rarely set for social and economic outcomes because they are harder to predict.

Without specific objectives, an evaluator must translate the project goals and design intent to determine measures that will indicate success. Project goals may be articulated by the entity who commissioned the project in the Request for Proposals (RFP) or statement of work.

The design intent – what the designers were trying to achieve with the specific layout, materials, and features installed – will relate to the project goals, but may add a new dimension. For example, the main goals of a public park may be placemaking and economic development, but the design may also include pollinator habitat.

Evaluators should also consider other expected outcomes or co-benefits. For example, the main goals of a streetside bioretention project may be stormwater management and temperature reduction through shading, but the trees and plant material are also sequestering carbon. Unanticipated outcomes are another consideration, especially since the way spaces are used may not be exactly as intended. For example, a water feature designed as a visual amenity may end up attracting children for water play. With landscapes, both use and meaning can evolve over time.



Combined, the project goals, performance objectives, design intent, expected outcomes, and unanticipated outcomes help the evaluator determine what to assess to gauge success.

Metrics and Methods

After determining what to assess, an evaluator must investigate specific metrics and methods. In this guidebook, the term “metric” refers to a single type of data that serves as a proxy for what matters. The term “method” refers to a means of quantifying that metric. For example, for a project with clear flood control goals, flood control performance should be assessed and quantified, but there are a number of ways to do this. Potential metrics include:

- Increase in flood storage capacity
- Decrease in number of flood events
- Decrease in time an area is submerged
- Decrease in cleanup costs

Choosing the appropriate metrics and corresponding methods of evaluation depends largely on time, expertise, resources, and availability of information. This means that potential metrics and methods must be considered based on their practical usefulness as well as their validity. Can scientifically sound data be collected during the given time frame with the available personnel and equipment? Is a particular method valid and reliable in the given circumstances?

The availability of information is usually the single biggest factor in deciding which metrics and methods to use to measure success. Public data sources as well as data and information collected by various project stakeholders should be explored in addition to considering what can be collected through direct measurement. Existing datasets can range from bird counts to property tax assessments and crime data. Evaluators can engage property owners and managers, members of the design team, government agencies, “friends of” groups, and other stakeholders to determine what information already exists.

When choosing metrics, it is also important to consider the ultimate audience for the assessment results. Is it a group of technical experts, a set of informed decision-makers, or the general public? The chosen metrics should match the expertise of the intended audience and be meaningful to the goals and interests of that audience.

Performance metrics do not need to be complex. While some benefits require sophisticated measures, others can be fairly straightforward. For example, if the goal of a university campus renovation project is to improve the image of campus and ultimately increase enrollment, a simple metric might be the percent of survey respondents who say that the campus landscape influenced their decision to enroll at that school.

Comparisons can be an effective way to quantify the impact of a design intervention, such as a reduction in water use or increase in visitor spending. In landscape performance evaluation, three common types of comparisons are:

- Before/After – Comparing a given metric before and after the landscape intervention. This requires baseline information from before the project was implemented.
- Conventional/Sustainable – Comparing a metric for the project to the same metric for a conventionally designed space. This requires a comparable space, either actual or hypothetical.
- Benchmark or Average – Comparing a metric for the project to an accepted standard or average value.

Because landscape performance is concerned with measuring a variety of impacts within a relatively short period of time, its metrics and methods are imperfect. Yet they can be applied in a way that is defensible and replicable to yield valuable information. As part of the assessment process, evaluators should document all of their assumptions and known limitations.

Data Collection

Data can be classified into two types: primary and secondary. Primary data are original data collected by the evaluator and involve various methods, such as administering a survey, measuring air temperatures, or taking water quality samples. Secondary data have been collected by someone other than the evaluator and can include publicly available datasets. Examples include demographic data from the US Census Bureau, energy use from utility bills, traffic counts from a local transportation agency, sales data from a business improvement district, or park visitation figures from the managing entity.

While evaluators should carefully consider and scrutinize the source and collection methods of any secondary data, the most significant information may come from these alternative data sources. Secondary data is not necessarily less reliable than primary data, and it may have been collected over a longer time frame or using more complex tools than are feasible in a primary analysis.

Predictive methods are another source of numerical information. These models and calculations can be used to determine likely outcomes in situations when actual performance cannot be measured. For example, direct measurement of carbon sequestration by trees and forests is extremely involved, but predictive models have been developed to estimate this value. In landscape performance evaluation, predictive models and methods are less desirable than actual measurements because they do not consider all of the nuances of a particular built landscape. However, including some predicted outcomes can allow for a more complete picture of benefits than would be possible through direct measurement alone.

Possible Sources of Data and Information

Background Information

- Project design documents, reports, and photos
- Environmental Impact Assessments
- Historic preservation or cultural documentation

Predictive Models and Calculators

- Project studies related to wildlife, transportation, noise, etc.
- Rating system submittals (LEED, SITES, etc.)
- Online calculators and tools

Secondary Data

- Public agency datasets, records, or publications
- Private entity records or publications
- Utility and other service providers
- Citizen science data

Primary Data

- On-site measurements or monitoring
- Direct observation
- User surveys or interviews

Scale

Unlike buildings, which are closed systems, landscapes are open, complex ecosystems across the boundaries of which water, air, species, and often people flow freely. Very few variables are contained entirely within a project site, and many of a landscape's key outcomes are influenced by outside forces, such as economic or demographic shifts.

Aspects of landscape performance, such as waste reduction or operations and maintenance savings, are usually assessed at the individual site scale or for a particular area of interest on the site. Other aspects, such as species richness or access and equity, have inputs and impacts that transcend site boundaries. These analyses may require data from the larger neighborhood, city, or region. In any case, it is important to consider context and the role of the site in relation to nearby facilities.

Any given landscape project will have both direct and indirect impacts. Landscapes may not be solely responsible for outcomes such as increased physical activity or property values, and it may be impossible to prove a true causal relationship. Nevertheless, these less direct measures are still important to pursue, provided that they are positioned with the appropriate limitations. Similarly, a single landscape project may not achieve overarching goals like improved water quality of a waterway or increased bike ridership, but its contribution to that goal is important in the context of neighborhood- or city-scale initiatives. Careful consideration should be given to the chosen measures and the way they are reported in order to adequately capture impact without significantly overstating or understating the contribution of an individual landscape project.

Timing

Ideally, performance evaluation should be an ongoing process with data collected at least once every 1-3 years to capture how performance changes over time. Certain metrics and methods, such as an analysis of water utility bills, lend themselves to annual review, while others like noise mitigation or visitor spending may be assessed less frequently because they are not expected to change much over time or because the analysis is more involved. Continuous monitoring of many aspects of landscape performance is becoming increasingly possible as sensor technologies and building automation systems evolve.

Optimal timing for an initial performance assessment is 1-5 years after construction is complete. This allows time for natural processes, site programming, and user behaviors to stabilize, yet ensures that institutional memory about the goals and design intent of the project has not been lost. Because the management, maintenance, use, meaning assigned to space, and even the physical environment can evolve over time, it can be problematic to try to evaluate a long-established or historic landscape against its original design intent.

By definition, performance evaluation requires that there are performance objectives to measure against. Because this is often not the case with landscape projects, evaluators are frequently retrofitting the process, spending effort to determine and articulate goals before they can determine what to measure and how to measure it.

To be most effective, measurable goals must be set and performance measurement considered throughout the design process. Performance goals and objectives should be established at the onset or in the early stages of a project so that different design concepts and iterations can be modeled and tested against those goals. In order to show change over time, baseline information must be collected. Ideally, the project design team can propose a set of metrics and methods that would be most effective in evaluating how the project performs once it is built and operating. Data collection practices should be considered and a schedule established as part of a performance evaluation plan. Above all, performance assessment needs to be included in the scope and budget for a project to ensure that post-occupancy monitoring happens.

Final Considerations

At its core, performance evaluation seeks to understand, manage, and improve the performance of a system. The results can demonstrate the success of a project and its environmental, social, and economic impacts. Findings may also show that certain goals or design intent are not being met. In this case, performance evaluation helps to raise issues and inform ideas for how a project might be modified for better results. Many times, the process of performance evaluation uncovers more questions that require further analysis.

Regardless of the results, the real value of performance evaluation lies in sharing the findings and results with others so that they can make better informed decisions on future projects. Understanding the performance of built landscapes will lead to better future designs that utilize landscape solutions to their fullest potential.

Representing Findings

Landscape performance findings should be understandable and relevant for the target audience to be most effective. While some metrics stand on their own, others are not as meaningful without context. In this case, findings can be supplemented using the following techniques.

Report absolute and relative values

- Reduces noise levels for residents by 10 decibels, which cuts the experienced sound level in half.

Use equivalencies

- Reduces annual runoff by 2.7 million gallons, equivalent to 4 Olympic-size swimming pools.

Monetize

- Reduces energy use by 63,000 kWh and saves $3,600 annually by switching to LED light fixtures.

Project out over time

- Sequesters 1.2 million tons of carbon annually in newly-planted trees, which will increase to 16 million tons 25 years after project completion.

Compare to the before condition, conventional scenario, or accepted standard

- Reduces average air temperatures by 1.7° F when compared to nearby areas that closely resemble the site prior to redevelopment.

HOW TO USE THIS GUIDEBOOK

This guidebook was developed as a primer for landscape architecture practitioners, researchers, agencies, park and land managers, instructors, students, and others interested in assessing the performance of built landscape projects. Though it may provide insight for ongoing data collection, tracking, or monitoring activities conducted by site managers, the guidebook presumes that the evaluator is an outsider conducting a one-time snapshot assessment.

The guidebook is intended to be a starting point for the selection of metrics and methods tailored to each individual project and its particular goals. It is geared toward critical and creative thinkers who seek to examine a project holistically and generate quantified findings that will be meaningful to an informed audience with some technical knowledge.

The metrics and methods presented here can be implemented, adapted, or used to generate new ideas to arrive at a set of metrics that can effectively gauge whether the project has been successful in achieving what it was designed to do. This guidebook presents possibilities, not a prescriptive list.

Four main criteria were used in selecting the metrics and methods:

- Ease of use for a nonexpert
- General applicability for a range of project types and scales
- Measurable in a relatively short time frame with limited budget
- Defensible

Guidebook Structure

The guidebook is divided into three main sections: Environmental Benefits, Social Benefits, and Economic Benefits, each with various benefit categories. The categories an evaluator chooses to pursue for a given project should depend on the project goals and design intent. (See Approach to Evaluating Performance.) A cursory examination of the site or site plan can help narrow down the list. For example, the Food Production category only applies if there are vegetable gardens, fruit trees, or other agriculture on the site.

In total, there are 33 benefit categories, each spanning two pages that include a brief introduction to the topic, assessment considerations, a list of potential metrics and methods for measuring performance, resources, and an example of a performance benefit from an actual project.

Assessment Considerations covers any specialized knowledge, equipment, or other tools that may be needed, as well as logistical or practical issues.

Potential Metrics are listed with each metric followed by one or more bullets that each describe a corresponding assessment method.

While some guidance is provided on metric and method applicability, it is up to the evaluator to determine the full validity, appropriateness, and limitations of their chosen assessment techniques, as the context of every project is different.

To illustrate how one of the metrics and methods can be used to produce a quantified performance benefit, an example is presented from the *Landscape Performance Series* Case Study Briefs. The full Case Study Brief and corresponding Methods document can be accessed at LandscapePerformance.org for additional information and a more in-depth description of methods, calculations, limitations, and assumptions.

Worksheets

On the following pages, four printable worksheets are provided for evaluators to use at the outset of a landscape performance assessment. The first sheet can be used to document goals, and the following three sheets can be used to brainstorm potential Environmental, Social, and Economic metrics and the corresponding methods and datasets. These lists of potential metrics can then be narrowed down and refined as evaluators pursue the necessary data and information. Many times particular lines of inquiry, even ones that seem promising, do not work out due to a lack of accessible data. The worksheets can also be used during the design phase of a landscape project to document key metrics and data that will be important to collect as baseline data during the site analysis and over time to gauge the project's success.

Worksheet: Determining Project Goals

Project Name: ______________________

	Environmental	Social	Economic
Project Goals			
Performance Objectives			
Design Intent			
Expected Outcomes			
Unanticipated Outcomes			

Worksheet: Assessing Environmental Performance

Project Name: ______________________________

Example: Saves 10 million gallons of potable water and $34,700 annually by using native plants, which require no irrigation, as compared to turf.

Type of Benefit	Metric	Method/Tool	Data Source(s)
Water Conservation	Reduction in water use associated with plant selection	Compare the amount of water needed to irrigate the sustainable landscape with the irrigation needs of a conventional landscape	Construction documents, planting plan, information from maintenance staff, local utility rate

Worksheet: Assessing Social Performance

Project Name: ______________________________

Example: Improves overall workplace satisfaction, with 87% of employees reporting an improved mood, 67% feeling more able to cope with workplace-related stress, and 53% feeling more relaxed after viewing, walking through, and spending time in the landscape.

Type of Benefit	Metric	Method/Tool	Data Source(s)
Health & Well-Being	Improvement in (1) mood, (2) workplace satisfaction, and (3) quality of life	Conduct a user survey to determine mood improvement associated with the space as compared to before the design intervention	Original survey data

Worksheet: Assessing Economic Performance

Project Name: ______________________

Example: Contributed to an 85% increase in the total assessed value of properties within a half-block of the site from 2011 to 2013. During the same period, gross property values for the entire city increased by only 12%.

Type of Benefit	Metric	Method/Tool	Data Source(s)
Property Value	Change in assessed value of nearby properties	Use public records to determine the average increase in assessed value for adjacent properties as compared the city as a whole	Local government real property tax data-base website

01. ENVIRONMENTAL BENEFITS

Shanghai Houtan Park | Turenscape

(Photo: Kongjian Yu)

ENVIRONMENTAL BENEFITS

LAND

1. **Land Efficiency & Preservation**
   Limiting site disturbance and making use of existing infrastructure

2. **Soil Creation, Preservation, & Restoration**
   Remediating degraded soils and protecting undisturbed soils

WATER

3. **Stormwater Management**
   Retaining, detaining, and treating runoff on-site

4. **Water Conservation**
   Reducing potable water use

5. **Water Quality**
   Improving physical, chemical, and biological integrity of water

6. **Flood Protection**
   Reducing flood risk to developed areas

7. **Water Body/Groundwater Recharge**
   Replenishing aquifers and surface water bodies

HABITAT

8. **Habitat Creation, Preservation, & Restoration**
   Protecting and restoring functional ecosystems

9. **Habitat Quality**
   Improving ecological integrity

10. **Populations & Species Richness**
    Supporting biodiversity

CARBON, ENERGY, & AIR QUALITY

11. **Energy Use**
    Reducing nonrenewable energy consumption

12. **Air Quality**
    Reducing airborne pollutants

13. **Temperature & Urban Heat Island**
    Reducing localized temperatures and heat island impacts

14. **Carbon Sequestration & Avoidance**
    Capturing, storing, or preventing the release of carbon to the atmosphere

MATERIALS & WASTE

15. **Reused & Recycled Materials**
    Repurposing materials from the site or elsewhere

16. **Waste Reduction**
    Reducing the need for off-site waste disposal

1 Land Efficiency & Preservation

Limiting site disturbance and making use of existing infrastructure

Introduction

Careful location selection and siting are fundamental parts of sustainable design and development. Ecologically intact areas of land are critically important at both site and regional scales, yet they are rapidly becoming fragmented and disappearing.

In order to protect valuable areas that include intact natural systems, functional hydrology, prime farmland, and culturally significant features, new development should be directed toward previously developed or disturbed areas and should seek to protect and preserve undeveloped areas. Compact development that takes advantage of existing or shared infrastructure can also minimize disturbance and improve efficiency. While thoughtful design and construction practices can conserve valuable systems and features, site management and possibly legal protections like easements are important to the preservation of these areas for the long term.

Assessment Considerations

Scale: Limiting disturbance is important for individual sites, but it also important to consider preservation at the regional scale. Does the area connect to other protected areas in the immediate vicinity or region to provide habitat or wildlife corridors? Consider whether the extent of preserved area is sufficient to sustain ecologically, economically, or culturally valuable processes over time.

Methods: To quantify benefits it is important to fully understand the preexisting conditions of a site (the type, extent, and significance of natural or cultural resources) and the measures taken to protect sensitive areas. While field observations may be necessary, the assessment can often be conducted remotely using information from environmental impact assessment reports, site or grading plans, aerial photos, or other project documents.

Difficulty: This assessment can be conducted remotely if the information can be obtained from project documents or aerial imagery.

Timeframe: This assessment can be performed upon project completion, but gathering information over time can help to confirm that preserved areas remain viable.

POTENTIAL METRICS

Area of ecologically, economically, or culturally valuable features protected or left undisturbed

(area or percent of total site)

• Reference project documents to identify areas deemed valuable or significant. Use aerial photographs, GIS analysis, CAD software, or other tools to quantify spatial extent. Compare pre- and post-construction condition. (See Habitat Creation, Preservation, & Restoration and Cultural Preservation.)

Amount of disturbance confined to previously developed portions of the site

(area or percent of total disturbance)

• Reference project documents to identify areas deemed previously disturbed, such as compacted soils, previous building foundations, walkways, or roadways. Use aerial photographs, GIS analysis, or other tools to quantify spatial extent. Compare pre- and post-construction conditions. This metric is most applicable on previously developed sites.

Area of existing topography preserved

(area or percent of total site)

• Reference site grading plan to identify areas where existing topography was unchanged from pre- and post-construction conditions. This metric is most applicable on greenfield sites.

Resources

University of Montana: Wilderness Map

University of Oxford: Local Ecological Footprinting Tool

Photo: D. A. Horchner/Design Workshop

Blue Hole Regional Park

Wimberley, Texas | Design Workshop, 2012

Protects 93 acres or 96% of the undisturbed area of the site, which was identified as potential habitat for 19 different species recognized as endangered, threatened, or of concern.

Project Overview

This informal swimming hole, which had nearly been “loved to death” by overuse, was purchased along with the surrounding 126 acres by the City of Wimberley and turned into a sustainable regional park. The design team created a plan that protected and enhanced the site’s ecologically sensitive areas while accommodating new recreational amenities. New development was located in areas previously disturbed by agricultural and residential use. Today, the park offers an enhanced swimming hole, an extensive interpretive program, and active recreational amenities for thousands of annual visitors.

Method

An in-depth species study, which was done as part of the design process, showed that the site served as potential habitat for a number of species of concern. Discussions with the design team revealed previously disturbed areas of the site. Site plans showed the limits of disturbance for new park amenities. Area takeoffs were then done in AutoCAD to quantify the total undisturbed area before and after construction.

Total undisturbed area after/total undisturbed area before = % undisturbed area preserved

2 Soil Creation, Preservation & Restoration

Remediating degraded soils and protecting undisturbed soils

Introduction

Soils are at the heart of a balanced and stable ecosystem. Healthy soils store water and regulate its flow, cycle nutrients, filter and buffer pollutants, sequester carbon, and sustain plant and animal life. In contrast, soils degraded by compaction, loss of soil structure, nutrient degradation, or contamination can cause erosion and topsoil loss, reduced fertility, flooding, sedimentation in streams, and challenging growing conditions for plants.

Preserving existing healthy soils is the easiest way to maintain their function, given the cost and complexity of soil remediation or replacement. Degraded soils may be improved through a combination of techniques, including amendments, decompaction, aeration, and phytoremediation.

Assessment Considerations

Scale: Soil analysis is usually performed at the individual site scale or for a particular area of interest on-site.

Methods: Soil health is determined through analysis of physical samples. Measured values can be compared to a reference soil or to values observed over time in the same location. Baseline data for preexisting soil may be found in environmental impact assessment reports or other project documents. Soil analysis can be performed either in a laboratory or in the field. Many universities offer testing that can reveal the physical and chemical properties of a soil.

Difficulty: Each soil test has a particular difficulty level and set of limitations. Some must be performed by trained lab technicians while others do not require special training.

Timeframe: If assessing the change in soil health over time, annual or biennial monitoring should be conducted. Monitoring can also help identify deficiencies and imbalances that may develop over time.

POTENTIAL METRICS

Increase in area of fertile or restored soils
(area or percent of total site)

- Identify areas of fertile or restored soils through an environmental assessment report or project documents. Compare total area pre- and post-construction using site plans or aerial photographs.

Improvement in soil health or fertility

- Determine increase in soil organic matter content, soil microbial biomass, and/or soil nutrients (percent of soil composition) by sending samples to be analyzed in a soils lab.
- Determine change in soil pH levels by collecting samples and performing a soil pH test in the field or in a soils lab.
- Determine reduction in levels of soil contaminants by sending samples to be analyzed in a soils lab.

Improvement in soil infiltration rate
(change in rate)

- Measure infiltration time in the field using a single or double ring infiltrometer.

Resources

US Natural Resources Conservation Service (NRCS): Soil Health Assessment

NRCS: Guidelines for Soil Quality Assessment in Conservation Planning

American Society of Landscape Architects Landscape Architecture Technical Information Series: A Landscape Performance + Metrics Primer for Landscape Architects – Soils and Amendments (*free for members*)

Photo: © Elizabeth Felicella

Teardrop Park

New York City, New York | Michael Van Valkenburgh Associates, 2006

Maintains healthy levels of nitrogen without the addition of nitrogen fertilizer and balanced levels of soil microorganisms through the application of compost tea, which encourages 30-50% greater root development.

Project Overview

Nestled within Battery Park City, Teardrop Park offers adventure play and a green sanctuary for urban-dwelling children. Interactive fountains, natural stone for climbing, and lush plantings create a stimulating world of intricate textures for children residing in the nearby apartment buildings. The site experiences intense shade, high winds, and temperature extremes, which influenced the park program and planting design. The park includes fully organic manufactured soils and maintenance regimes that avoid pesticides, herbicides, or fungicides.

Method

During implementation, a laboratory soil analysis was conducted to assess soil fertility. Findings revealed an imbalance of microorganism predator (nematodes, protozoa) and prey (fungi, bacteria) populations. To mitigate the imbalance, compost tea was brewed and added to the site to specifically supplement those microorganisms with low populations.

Subsequent testing confirmed that properly balancing the soil microbial population resulted in stable nitrogen levels.

Findings were based on Battery Park City Parks Conservancy accounts and confirmed through the 2008 Harvard Yard Soil Restoration Project, an 8-month, 1-acre test led by Battery Park City Director of Horticulture, Eric T. Fleisher.

3 Stormwater Management

Retaining, detaining, and treating runoff on-site

Introduction

In a rapidly urbanizing world, stormwater runoff is a leading cause of water pollution. The goal of sustainable stormwater management is to protect and restore functional hydrology through systems designed to emulate natural processes. Sustainable stormwater management practices reduce flooding, prevent erosion, improve water quality, and decrease thermal pollution. They can also contribute to groundwater recharge and add ecological and aesthetic value.

Best management practices (BMPs) for stormwater include bioswales, rain gardens, green roofs, infiltration planters, constructed wetlands, and permeable paving.

Assessment Considerations

Scale: Assessment should consider the impact of the whole system rather than individual BMPs. While usually done at the site scale, some systems manage runoff from off-site. It is also important to consider downstream effects on sewer systems and water bodies.

Methods: Metrics are calculated using equations and models that require various inputs, such as land cover, soil type, local rainfall data, and design parameters for any BMPs on the site. Stormwater management systems are typically designed to meet local regulations for volume control and/or water quality. Since regulations vary, a system may be designed to handle a design storm, store a given amount of rainfall, reduce or maintain peak flows, or treat water to a certain level. This information can usually be found in design documents, model outputs, or documentation submitted to meet regulatory or rating system requirements.

Difficulty: Assessment may involve obtaining local rainfall data, performing calculations, or using models, though simplified stormwater calculators reduce this burden.

Timeframe: This assessment can be conducted upon project completion, although field observations and testing can provide additional insights about performance.

Resources

US Environmental Protection Agency (EPA): National Stormwater Calculator

Center for Neighborhood Technology: The Value of Green Infrastructure (*Water*)

POTENTIAL METRICS

Annual volume and percent of total runoff retained on-site (volume and percent of total)

• Estimate for the entire site or for one or more BMPs using design parameters and a stormwater calculator like the EPA National Stormwater Calculator. This method is most applicable on smaller projects that use BMPs to manage runoff.

Runoff retained for a design storm (volume and frequency/duration of storm)

• Consult project documents or stormwater model outputs, such as SWMM or HydroCAD, for total storage volume and design storm parameters for the site as a whole or a portion of it.

Reduction in peak discharge/runoff rate for a design storm (rate and frequency/duration of storm)

• Consult project documents or stormwater model outputs.

• Use the Rational Method for small drainage areas of up to 200 acres with little flood storage. This method considers only general land cover changes; it does not factor in storage provided by BMPs.

• Use TR-55 Method for small watersheds. This method considers only general land cover changes. It does not factor in storage provided by BMPs.

Reduction in stormwater fees, taxes, infrastructure costs, or treatment costs

• Determine one-time and/or annual stormwater-related fees, taxes, or future infrastructure costs avoided by reducing volume of site runoff.

• Estimate stormwater treatment costs avoided by multiplying the volume retained by treatment cost per gallon, if available, from the local municipality. This only applies if runoff enters a sewer and is sent to a treatment plant.

Photo: Sam Oberter/WRT

Dutch Kills Green

New York City, New York | WRT & Margie Ruddick Landscape, 2011

Prevents over 20.2 million gallons of stormwater from entering the city's combined sewer system annually, avoiding a projected $3.4 million in future capital costs to upgrade stormwater infrastructure.

Project Overview

The Dutch Kills Green project transformed the space at the end of the Queensboro Bridge where three subway lines, two elevated routes, and congested streets surrounded a parking lot. The twelve-lane Queensboro Road was realigned to accommodate bicyclists and pedestrians, and over 35,000 sf of land was reclaimed as usable green space. This eight-block project uses 112,000 sf of planted areas to provide stormwater storage and infiltration.

Method

Using the biofiltration and infiltration equation from the Center for Neighborhood Technology's *The Value of Green Infrastructure* guide, the annual amount of stormwater retained on-site was calculated. Equation inputs were gathered from NOAA Online Weather Data, area takeoffs from site plans, and from HydroCAD modeling software outputs.

New York City recognizes a cost avoidance for green infrastructure strategies and estimates costs for constructing gray infrastructure at $0.62/gal and green infrastructure at $0.45/gal. The multipliers are not site-specific but are based on averages for the City of New York.

Cost Avoidance = Cost of Grey Strategy - Cost of Green Strategy

4 Water Conservation

Reducing potable water use

Introduction

Worldwide, water shortages are common due to the uneven distribution of water resources, natural variability in the water cycle, and human use. With population growth and climate change exacerbating these issues, water conservation is increasingly important, particularly in arid climates. The benefits of water conservation practices include reducing demand on local water sources (aquifers, rivers, lakes, etc.), financial savings, energy savings from reduced pumping and treatment, and generating less runoff or wastewater.

Selection of plants that are native or well-adapted to a site's climate, soil conditions, exposure, and slope can reduce or eliminate the need for irrigation. Other landscape-based strategies for water conservation include efficient irrigation systems, features that recirculate water, and systems that capture and reuse stormwater, greywater, or wastewater on-site.

Assessment Considerations

Scale: Landscape-based water conservation practices are assessed at the individual site scale.

Methods: Water conservation benefits are calculated from water use data or by estimating the demand reduction from plant selection or specific systems. Water consumption for an entire site can be obtained from water utility bills. It can be estimated for different landscape elements like native plants or efficient irrigation using landscape water demand equations, system parameters, or calculators.

Difficulty: This assessment is straightforward. If inadequate data exists to make comparisons, assumptions can be made about the before condition or a comparable conventional landscape.

Timeframe: If using utility bills to make a comparison, having at least a year of data is recommended to account for seasonal variation. Landscapes are usually irrigated during a 1-3 year establishment period even if they will not be regularly irrigated thereafter. Waiting until after the establishment period is recommended to confirm that plants have been weaned from irrigation.

POTENTIAL METRICS

Reduction in potable water consumption
(volume or percent)

• Calculate the overall reduction in water use by using water utility bills to determine annual consumption. Compare this to consumption prior to the project or to that of a conventional landscape. This method takes into account all elements that resulted in water savings.

• Estimate the reduction in water use associated with plant selection by comparing the amount of water needed to irrigate the sustainable landscape with the irrigation needs of a conventional landscape. A number of resources exist to estimate water demand for different plant types.

• Estimate the reduction in water use associated with an efficient irrigation system or closed loop water recirculating feature by using manufacturer information to compare water consumption of the efficient system to that of a conventional system.

Amount of water supplied by non-potable sources
(volume or percent)

• Estimate conservation associated with rainwater harvesting or water reuse by calculating the annual amount of water needed and comparing it to the amount supplied by rainwater, greywater, and/or blackwater.

Annual cost savings from reduced potable water consumption

• Convert the volume of potable water saved to a monetary value using the local utility rate.

Resources

US Environmental Protection Agency: Water Sense Water Budget Tool

US Green Building Council LEED Existing Buildings v3 (2009): Water Efficient Landscaping

University of California: Landscape Water Requirement Calculators

Photo: Adam Barbe

Belo Center for New Media

Austin, Texas | Ten Eyck Landscape Architects, Inc., 2012

Saves an average of 464,900 gallons of potable water and $2,700 annually by using air conditioning condensate and harvested rainwater for irrigation.

Project Overview

The courtyard of the Belo Center for New Media at the University of Texas at Austin features a drought-tolerant native landscape and an innovative water system. Air conditioning condensate and harvested rainwater is collected in four cisterns that can hold almost 30,000 gallons. During storm events, when rainwater falls onto the roof, the first flush enters a biofiltration fountain. When the fountain reaches capacity, a valve redirects the stormwater to the cisterns where it is stored for use in irrigation.

Method

The site's advanced irrigation system is completely digitized; each individual plant has its own emitter. This type of system allowed for accurate data collection of water usage on-site in 2013 and 2014. The amount of water supplied by nonpotable sources was estimated based on subtracting city water used in gallons from irrigation water used in gallons. Data from 2013 and 2014 was averaged. This water savings was converted to annual cost savings using municipal rates for water in the area.

5 Water Quality

Improving physical, chemical, and biological integrity of water

Introduction

Water quality is important for aquatic life, drinking water supply, agriculture, recreational activities (swimming, fishing, boating, etc.), riparian habitat, and aesthetics. In addition to agricultural and industrial practices, urbanization is a major contributor to the degradation of water quality and causes trash, waste, sediment, and other pollutants to enter waterways.

Key land-based strategies to maintain and improve water quality include restoring natural systems and processes along waterways, incorporating green infrastructure to reduce and treat runoff, and minimizing the use of fertilizers and pesticides.

Assessment Considerations

Scale: Water quality may be relevant at the individual site scale, such as when a site encompasses a pond or lake. However, it is also important to consider impacts on the larger hydrologic system, particularly downstream.

Methods: Water quality can be measured by assessing its physical, chemical, and biological properties. An assessment can compare before/after conditions, measure pollutant removal from a treatment train, or show a gradual improvement in water quality of a water body over time. The US Environmental Protection Agency (EPA) provides how-to resources for conducting various water quality assessments. Water samples can be taken or monitoring equipment can be installed to assess many chemical and physical properties. Many universities offer water sample analysis services. Temperature and turbidity can be assessed through field measurements. Indicator or aquatic species can be used in biological assessments.

Difficulty: Grab samples are easy to take, and water quality kits are available to test a range of parameters in the field. Other tests may require specialized equipment or sending samples to a lab. Habitat assessments are fairly straightforward, but species identification can be difficult without prior experience.

Timeframe: This assessment requires sampling and analysis over time. A longer sampling period will provide more reliable results.

POTENTIAL METRICS

Improvement in aquatic habitat

- Use the EPA Rapid Bioassessment Protocols to evaluate habitat condition and/or fish and macroinvertebrate indicator species in wadeable streams and rivers.
- Conduct a study of benthic macroinvertebrates using a regional index of stream integrity. These are often available as part of volunteer stream monitoring efforts.

Reduction in sediment load

- Measure turbidity (amount of light scattered by suspended particles) of a lake, pond, or stream using a turbidity meter, Secchi Disk, or transparency tube.
- Use grab samples to measure total suspended solids in the field or in a lab.

Change in chemical or physical properties of interest

- Use grab samples to measure pH, temperature, dissolved oxygen, salinity, nutrients, heavy metals, or other properties of interest.
- Install sensors to monitor parameters like temperature, pH, conductivity (salinity), dissolved oxygen, and dissolved ions.

Resources

EPA: Monitoring and Assessing Water Quality

EPA: Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers

EPA: State-Specific Water Quality Standards

EarthEcho International: EarthEcho Water Challenge

Photo: Eric Piasecki

The Dell at the University of Virginia

Charlottesville, Virginia | Biohabitats of Maryland & Nelson Byrd Woltz Landscape Architects, 2004

Reduces sediment and nutrient loading downstream. Reduces total suspended solids by 30-92%, phosphate by 23-100%, and nitrate by 50-89% according to water sample data.

Project Overview

This 11-acre project daylighted and restored 1,200 linear feet of a buried stream and transformed unused land into a state-of-the-art stormwater pond and forebay system. This system manages runoff from up to a 2-year storm event, reduces and delays peak flows, and improves water quality. The park also reintroduces wildlife habitat, provides multiple recreational opportunities, serves as a memorable entrance to the university for visitors, and functions as a demonstration landscape for students and faculty.

Method

A student research team installed monitoring systems at nine locations in The Dell and measured water quality and quantity by establishing base flow conditions and examining conditions during and directly following storms. The team measured temperature, pH, nitrate, nitrite, iron, phosphates, oxygen, alkalinity, conductivity, turbidity, and flow.

Samples were collected during and after storm events through a combination of automatic samplers and grab samples. For each sample, turbidity was measured using an Oakton T-100 Portable Turbidimeter. Depending on the turbidity data, the team decided which samples to analyze for phosphate, nitrate, and nitrite using a CHEMetrics V-2000 Photometer. Concentrations were compared from upstream and downstream sampling points.

6 Flood Protection

Reducing flood risk to developed areas

Introduction

Floods can have devastating consequences, such as loss of life, property and infrastructure damage, and economic disruption. Reducing flood risk to developed areas is critical to health, safety, and the reduction of cleanup and disaster recovery costs.

At the site scale, flooding can be prevented or reduced through effective stormwater management. Along streams and rivers, techniques include earthwork, floodplain restoration, channel reconstruction, sediment removal, and creation of detention areas to slow flows.

Assessment Considerations

Scale: Riverine flooding is best assessed at the watershed scale. Local flooding may be measurable at the individual site scale, depending on magnitude of flooding and size of the site.

Methods: Metrics are based on predictive modeling related to flood frequency, storage capacity, and flow. Most depend on the availability of data prior to the design intervention in order to make comparisons. Flood frequency or recurrence interval and the stage or depth of flood inundation must be known to quantify a reduction in flood risk. The US Federal Emergency Management Agency (FEMA) maintains flood maps and a list of current nationally accepted hydrologic models.

Difficulty: This assessment can be conducted remotely if the information can be obtained from project documents. The metrics involve performing calculations or obtaining outputs from complex models.

Timeframe: This assessment can be conducted upon project completion. Monitoring performance over time, even anecdotally, can help to confirm that the project is achieving the desired level of flood protection.

Resources

FEMA: Flood Map Service Center

FEMA: Hydrologic Models Meeting the Minimum Requirement of National Flood Insurance Program

US Geological Survey: Surface-Water Data for the Nation

The Ohio State University: Determining Discharge of a Stream

POTENTIAL METRICS

Reduction in frequency of localized flooding

- Assess historical records and compare the previous occurrence interval to the projected occurrence interval from hydrologic model outputs.

Increase in flood storage capacity (volume)

- Consult project documents or hydrologic model outputs, such as SWMM or HydroCAD, for total storage volume and design storm modeled.
- Estimate the storage volume for one or more best management practices (floodplains, wetlands, bioretention) using design parameters.

Increase in the conveyance capacity of a stream or river channel (flow rate)

- Consult project documents or hydrologic model outputs, such as SWMM or HydroCAD. This is most applicable when channel capacity had been diminished due to sedimentation and/or erosion.

Reduction in peak discharge at an outlet point (flow rate or stage + size/duration of storm event)

- Measure discharge using stream gauges. This is most applicable when techniques to increase storage have been added upstream or to the drainage area.
- Consult hydrologic model outputs or calculate discharge for a design storm based on channel hydraulics and the continuity equation.

Reduction in costs associated with reduced flood risk

- Estimate future cost avoidance by comparing historical flood frequency to expected flood frequency and recovery costs.
- Estimate savings based on lower flood insurance premiums.
- Compare property values or use the hedonic pricing method to estimate the change in real estate value associated with reduced flood risk.

Photo: Google, Landsat/Copernicus

Napa River Flood Protection

Napa, California | MIG, 1998-2012

Expanded capacity of the river channel through the City of Napa from 30,000 cfs to 43,000 cfs to accommodate 100-year floods.

Project Overview

Between 1862 and 2013, 22 major floods occurred in the Napa Valley. In the 1990s, a coalition of more than 30 organizations and 400 individuals worked together to develop a strategy that combined ecology and engineering to protect the City of Napa while restoring the ecological health of the Napa River. This project restored 1,011 acres of floodplain, wetlands, and riparian habitat through terracing and the breaching of old dikes and levees along 3.5 miles of river. To increase the capacity of the channel to contain a 100-year flood in the downtown Napa section of the river, 1,700 ft of floodwall were constructed and nearly 120 acres of terracing were excavated and seeded with native grasses and trees.

Method

The river channel in downtown Napa was widened. The post-project flood capacity of 43,000 cubic feet per second (cfs) was provided by the Napa County Flood Control and Water Conservation District. The previous flood capacity of 30,000 cfs was sourced from a preliminary analysis that was done in 1996 to develop the flood management plan.

7 Water Body/Groundwater Recharge

Replenishing aquifers and surface water bodies

Introduction

44% of the US population depends on groundwater for its drinking supply,[1] and 63% of public water supply withdrawals are from surface water sources.[2] Water is also withdrawn for agricultural and industrial uses. These interdependent water resources are replenished by precipitation, but the conveyance systems and impervious surfaces associated with urbanization alter the natural recharge process. As a result, many areas experience groundwater depletion, soil salinization, and saltwater intrusion.

Groundwater recharge can be enhanced by increasing pervious surface area or directing stormwater, greywater, or treated wastewater into the ground. Protection of a known recharge zone is also important for groundwater replenishment. Similar techniques can be used to supplement or maintain levels of surface water bodies, such as wetlands, lakes, ponds, rivers, and streams.

Assessment Considerations

Scale: Many factors affect water levels, making it difficult to attribute changes to the project site alone. The pre- and post-construction conditions, context, and design intent should be carefully considered to determine if these metrics are applicable.

Methods: Surface and groundwater levels can be monitored over time to observe trends. Data must be correlated with precipitation records. Monitoring water levels in a range of locations will lead to more accurate assessments. Several types of equipment can be used for monitoring. Choice will depend on desired level of accuracy, ease of measurement, access, and any water quality concerns. Many universities and extension programs have equipment available for loan.

Difficulty: Equipment to measure water levels ranges from simple staff or float gauges that must be read manually to automated systems that take continuous measurements. Monitoring groundwater is only possible if there is a well.

Timeframe: Water levels are best assessed through frequent monitoring over long periods of time due to seasonal fluctuations of weather and precipitation.

POTENTIAL METRICS

Area of recharge zone or shallow water table that is protected (area or percent of total recharge area)

• Reference project documents to identify recharge zone. Use aerial photographs, GIS analysis, or other tools to quantify spatial extent. Compare pre- and post-construction conditions.

Increase in or maintenance of water level of a wetland, lake, pond, river, or stream (depth)

• Monitor water levels using a depth gauge, stream gauges, or a submersible level sensor.

Increase in level of underground water table (depth)

• Monitor groundwater levels in a well with an electric sounding device, such as a coaxial water level meter or flat-tape water level meter. This method is applicable only if a well exists on the site.

Resources

US Department of Agriculture: Groundwater Recharge

US Geological Survey (USGS): Groundwater Levels for the Nation

Oregon Water Resources Department: How to Measure the Water Level in a Well

College of Architecture and Landscape Architecture, University of Arizona | Ten Eyck Landscape Architects

(Photo: Bill Timmerman)

8 Habitat Creation, Preservation, & Restoration

Protecting and restoring functional ecosystems

Introduction

Habitat is an environment or ecosystem that effectively supports the survival and reproduction of a given population. Due to widespread human development, the habitats of many species are becoming increasingly fragmented and may not support historical populations. The term "critical habitat" refers to areas believed essential for the conservation of threatened or endangered species. Habitats for insect pollinators, such as bees and butterflies, are especially important as there is evidence of worldwide declines that could have significant impacts on agriculture and ecosystems.

Sustainable site design should protect known areas of critical habitat and may seek to create or restore habitat by adding necessary physical and biological features. Patch size and connectivity are important considerations to facilitate wildlife movement and other ecological flows.

Assessment Considerations

Scale: Habitat creation is typically assessed at the site scale. It is important to understand the needs of target species and how the site relates to nearby critical habitat and larger corridors.

Methods: Metrics rely on previous documentation of habitat type and extent by ecologists, biologists, or other experts. This information can be found in environmental impact assessment reports, site plans, and other project documents. When possible, field observations should be used to confirm that habitat areas are functioning as planned, especially in cases of habitat creation or restoration. Collaboration with local wildlife experts may be beneficial.

Difficulty: This assessment can be conducted remotely if adequate project documents and plant lists are available. If field observations are used, species identification can be difficult without prior experience.

Timeframe: This assessment can be conducted upon project completion. However, for habitat creation or restoration, waiting 1-2 years is recommended to verify that plants and other systems have established as intended. Observing the site over time will help identify changes in habitat structure or function.

POTENTIAL METRICS

Area of critical habitat created, protected, or restored for species of interest
(area or percent of total site)

- Reference project documents for areas of critical habitat identified on the site. Use aerial photographs, GIS analysis, or other tools to quantify spatial extent.

Increase in continuous habitat area (area)

- Reference project documents to identify areas of habitat reconnected through the removal of physical barriers like roadways or culverts. Use GIS analysis or other tools to quantify spatial extent.

Increase in habitat area for pollinators (area)

- Determine the plant species considered to be habitat for beneficial pollinators or other species of interest within the site's ecoregion. Reference project documents and plant lists to identify pollinator habitat areas on the project site. Use aerial photographs, GIS analysis, or other tools to quantify spatial extent.

Resources

US Fish and Wildlife Service (FWS): Critical Habitat Mapper

FWS: Find Endangered Species

Xerces Society: Pollinator-Friendly Plant Lists

Photo: D. A. Horchner/Design Workshop

High Desert Community

Albuquerque, New Mexico | Design Workshop, 2030 (anticipated completion)

Increased critical bird-breeding habitat for two endangered species, the peregrine falcon and the gray vireo, by 3.7 acres and replaced an additional 3.7 acres of habitat lost in development.

Project Overview

This greenfield development in Albuquerque, New Mexico honors the low-impact design practices of water conservation, wildlife habitat restoration, material recycling, and cultural endowment. The development minimizes construction disturbance by cutting roads into the hillside instead of mass grading and by using a native plant palette for all public areas, rights-of-way, and private areas outside of building envelopes. This project changed water conservation and landscape planting ordinances at city and state levels.

Method

One design goal was to replant double the amount of the original juniper prairie ecotype vegetation that was lost in development. This ecotype provides breeding habitat for the peregrine falcon and the gray vireo.

In order to determine how many acres this would require, the designers digitized the area of juniper prairie ecotype and identified how much of it would be lost to construction and infrastructure development. They then used the vegetative volume index of juniper prairie ecotype vegetation provided by environmental consultants to calculate the volume of vegetation lost. To double the volume, the design replanted double the area using the same volume index. This is the area of critical habitat restored for the species of interest.

The areas were confirmed by doing area takeoffs of project construction documents using AutoCAD.

9 Habitat Quality

Improving ecological integrity

Introduction

Habitat comprises four components: food, water, cover, and space. The quality of these components affects the well-being of individual species as well as the overall ecological integrity of an ecosystem. High-quality habitats provide the necessary physical and biological features to maximize chances at survival and reproduction for a species. A habitat high in quality will generally support greater biodiversity, which, in turn, can help keep the surrounding ecosystem in a natural balance.

In designed landscapes, plant species selection and organization play a key role in creating or restoring habitat. The creation of cover and nesting sites, such as gravel pockets or submerged logs, may also be important depending on the target species.

Assessment Considerations

Scale: Habitat quality can be assessed at the individual site scale; however, habitats transcend property boundaries and can be affected by outside activities.

Methods: To assess habitat quality for a specific species, the habitat attributes for that particular species should be studied, possibly requiring consultation with a wildlife expert. To assess habitat quality more generally, an ecological integrity index can reveal how well an ecosystem is supporting and maintaining natural balance. Various rating indices have been developed for this. Several assign a coefficient to each plant species and require a list of all known plant species on-site.

Difficulty: Fieldwork is likely necessary. Plant index values can be calculated based on lists of plants installed, but actual field inventories are preferable to account for survival, succession, and invasive species colonization. Depending on the site size and the assessor's plant identification skills, consultants or experts may be needed.

Timeframe: This assessment requires evaluation of habitat before and after construction. If fieldwork will be conducted, waiting until after the 1-3 year establishment period for newly-installed plants is preferable. Conducting the assessment annually can help identify trends and management issues.

POTENTIAL METRICS

Increase in ecological integrity as measured by an established rating system

(change in index value)

- Use the Floristic Quality Assessment (FQA) to determine an overall score for the site or designated habitat area. A list of observed plant species is needed. There are various regional versions of this method. This method is limited to regions that have developed plant coefficient lists, although lists can sometimes be adapted to other regions with limitations.
- Use the US Environmental Protection Agency (EPA) Rapid Bioassessment Protocols to conduct a habitat assessment and report the total score. This method applies to wadeable streams and rivers.
- Use the US Fish and Wildlife Service (FWS) Habitat Evaluation Procedures. This method is useful for projects with a stated objective to optimize wildlife numbers for particular species. It requires detailed information on plant species and cover types. Time and budget constraints may limit the use of this method.

Resources

Openlands: Universal FQA Calculator

US Natural Resources Conservation Service: Sampling Vegetation Attributes

EPA: Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers

FWS: Habitat Evaluation Procedures

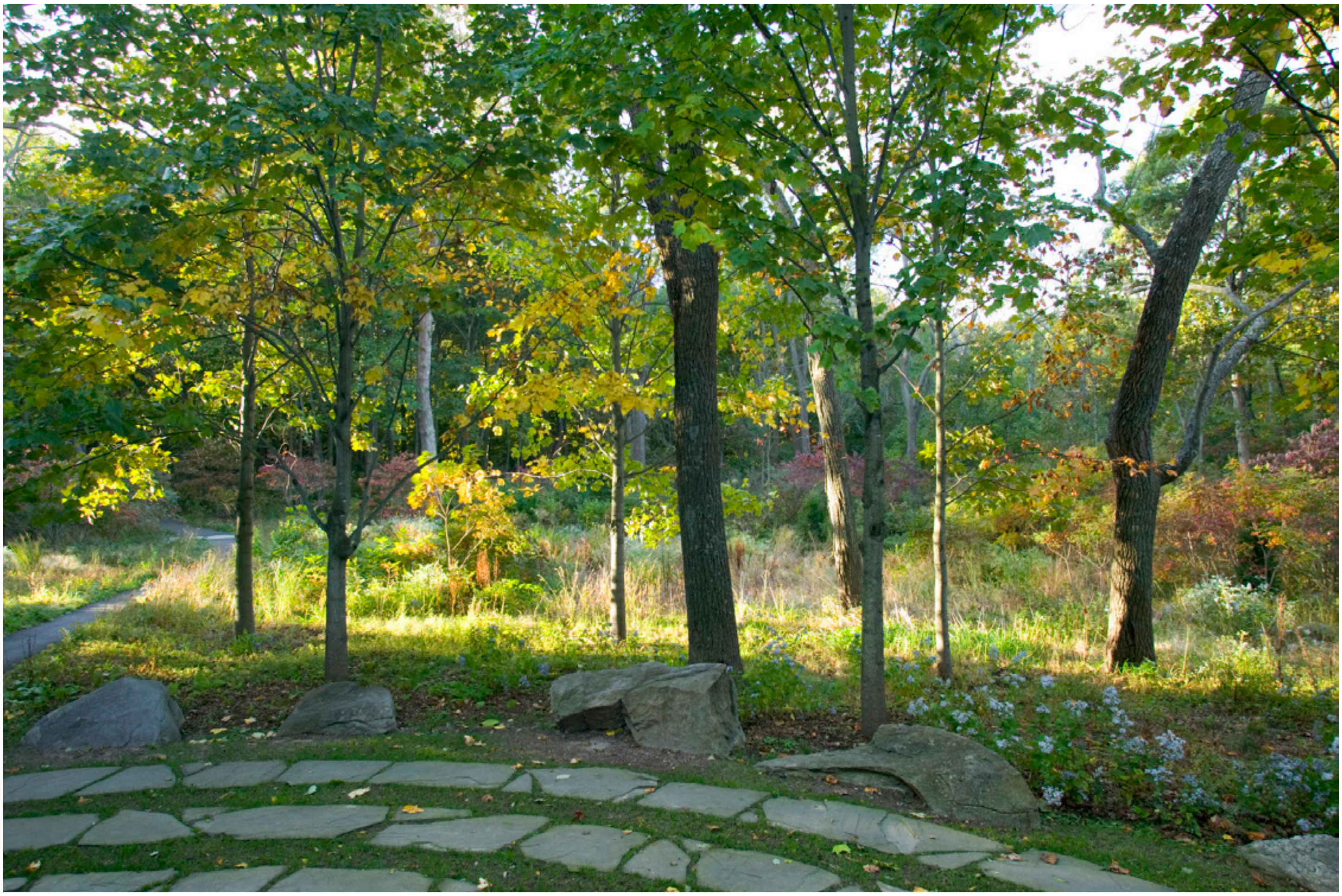


Photo: Bill Cramer

Avalon Park and Preserve

Stony Brook, New York | Andropogon, 2001

Increased the ecological integrity of plant communities by more than doubling Avalon's Plant Stewardship Index to achieve a score of 54, reflecting a high diversity of native plants and sustained removal of invasive species.

Project Overview

This highly disturbed former residential site was designed as a 7-acre memorial and 76-acre preserve with a series of natural gardens that reflect the character of the native northern Long Island landscape, including a rich lowland swamp, beech forest, and wildflower meadow. The full-scale, scientifically accurate restoration of a wide variety of individual, local plant communities was achieved through close cooperation with a native plant ecologist and other scientists. A strong long-term management program prevents the site from being taken over by weeds in this highly urbanized region.

Method

The Plant Stewardship Index (PSI), a regional Floristic Quality Assessment, was used to evaluate the ecological integrity of the native plant communities on the site. The PSI is specific to the Piedmont region.

A list of plant species was compiled for the site, both pre- and post-restoration. The coefficient of conservatism (CC) was looked up for each species. The Total Mean C was calculated by totaling the CCs and dividing this sum by the total number of plant species within the assessed area. Finally, the Total Mean C was multiplied by the square root of the total number of native plants to get the Plant Stewardship Index value.

The PSI values pre-restoration (24.18) and post-restoration (54.05) were compared.

10 Populations & Species Richness

Supporting biodiversity

Introduction

Biodiversity is critical for keeping ecosystems healthy and balanced. Diverse landscapes are more resilient to drought, disease, pests, pollution, and other factors. Species richness, the number of different species present in an ecological community or landscape, is often used as an indicator of biodiversity. Abundance, the number of representative individuals of a species on a particular site, indicates the availability and quality of habitat for that species. Habitat loss and degradation are the main causes of declines in biodiversity and species populations.

Sustainable design that preserves, restores, enhances, or creates habitat can have a positive impact on species richness and/or populations of a given species.

Assessment Considerations

Scale: Species and population counts can be conducted at the site scale, although both plant and animal communities can be affected by off-site activities.

Methods: Metrics require fieldwork or previous documentation of species or population counts by experts. Data from site staff or citizen scientists may be used if they are deemed reasonably reliable. For fieldwork, choice of assessment technique will depend on the species being assessed, type of habitat, time and labor constraints, and level of expertise. The transect is a commonly used sampling method for estimating species richness or abundance, particularly for plants, birds, or terrestrial vertebrates. Pitfall traps may be used to collect and observe arthropods. The US Fish and Wildlife Service and many states offer guidelines and protocols for conducting field surveys for a variety of species.

Difficulty: Fieldwork is likely necessary, depending on existing data. Collaborating with local experts, such as wildlife biologists, ornithologists, or entomologists is recommended.

Timeframe: This assessment requires data on populations or species richness before and after construction. Seasonal variation is an important consideration. Most ecological surveys are carried out over extended periods of time with sampling taking place at regular intervals.

POTENTIAL METRICS

Increase in species richness for a taxon of interest
(number or percent change)

- Use data from field observations to calculate the change in the number of observed species over time. This may be done for a kingdom (such as plants), class (such as birds), order (such as primates), or other taxonomic group.
- Use eBird to find data on local bird sightings. A citizen science tool, this global online database allows local birders to collect observations on the presence and abundance of bird species and submit their data.

Increase in abundance of a species of interest
(number or percent change)

- Use data from field observations to calculate the change in the number of a species over time. Abundance can be measured by number of individuals observed, species presence, density, frequency, or biomass. Species of interest should be threatened, vulnerable, or indicator species.

Resources

Cornell Lab of Ornithology: eBird

University of Idaho: Point Intercept Sampling Techniques

University of Hawai'i: Measuring Abundance, Transects and Quadrats

US Bureau of Land Management: Measuring and Monitoring Plant Populations

Photo: User BlueCanoe/Wikimedia Commons/CC-BY-SA-3.0

Magnuson Park

Seattle, Washington | The Berger Partnership, 2012

Increased the Pacific chorus frog larvae population by 255% and increased the number of observed species of dragonfly and damselfly from 18 to 21 between 2010 and 2011.

Project Overview

The Magnuson Park Wetlands and Active Recreation project replaced 12 acres of impervious concrete with high-performance wetlands and new sports fields. The native Pacific chorus frog was selected as a target species, providing a framework for the entire design. Exacting grading created rice paddies that provide habitat for the Pacific chorus frog while limiting colonization of the paddies by the invasive bullfrog. The species-specific design helped improve overall biodiversity within a park that meshes ecological and human needs.

Method

The changes in both the population of Pacific chorus frog larvae and the number of species of dragonfly and damselfly were calculated using counts documented in the Magnuson Monitoring Reports from year 1 (2010) and year 2 (2011). Larvae were counted in the rice paddies and ponds on a single day in the spring. The presence of dragonflies and damselflies in the park from May to October each year was observed and recorded by an expert.

11 Energy Use

Reducing nonrenewable energy consumption

Introduction

In the US and worldwide, over 80% of energy consumption is supplied by fossil fuels.[3] Reducing energy use or using renewable energy can lower or eliminate emissions, reduce costs, and contribute to broader energy portfolio or greenhouse gas emission goals. Reducing fossil fuel consumption can also have positive impacts on local air quality and public health.

Site and landscape elements play a role in reducing energy use. Shade trees, green walls, and green roofs can shade and insulate buildings, thereby reducing the heating and cooling load. Energy efficient lighting, fixtures, and other systems require less energy to operate than conventional systems. Photovoltaic cells, which are increasingly integrated into building materials, and wind turbines can generate renewable energy on-site.

Assessment Considerations

Scale: Energy use is typically assessed for an individual site or portion of a site.

Methods: Metrics in this category rely on comparisons to baseline energy use or to that of conventional development. Actual energy use can be obtained from utility bills, or it can be estimated for different landscape elements using equations, system parameters, or calculators. If a site generates energy through renewable sources, system performance information can be used to estimate the reduction in nonrenewable energy use.

Difficulty: This assessment is straightforward. If inadequate data exists to make comparisons, assumptions can be made about the before condition or a comparable conventional site.

Timeframe: If using utility bills to make a comparison, having at least a year of data is recommended to account for seasonal variation.

POTENTIAL METRICS

Reduction in annual energy use
(kWh/year or percent)

- Calculate the overall reduction in energy use by using utility bills to determine annual consumption. Compare it to consumption prior to the project or to that of a conventional site. This metric takes into account all elements that result in energy savings.
- Estimate the reduction in energy use associated with a green roof by using a green roof energy calculator like the GreenSave Calculator. Compare energy use of the installed system to that of a conventional roof.
- Estimate the reduction in energy use associated with efficient lighting or other landscape elements by using manufacturer information to compare energy consumption of the efficient system to that of a conventional system.

Amount of or reduction in annual energy use due to renewable sources (kWh/year or percent)

- Estimate the reduction in nonrenewable energy use associated with on-site generation by calculating the amount of energy needed and comparing it to the amount produced by solar panels, wind turbines, or other renewable sources.

Annual cost savings from reduced energy use

Convert the amount of energy saved to a monetary value using the local utility rate. Reduction in energy use can also be converted into carbon avoided. (See Carbon Sequestration & Avoidance.)

Resources

US Energy Information Administration: Average Retail Price of Electricity

Green Roofs for Healthy Cities: GreenSave Calculator (*members only*)

Photo: Jamie Fogle/Design Workshop

Cherry Creek North Improvements and Fillmore Plaza

Denver, Colorado | Design Workshop, 2011

Reduces annual energy consumption for outdoor lighting by 223,000 kWh, saving $12,700 in energy costs each year.

Project Overview

The 16-block Cherry Creek North retail district was originally designed to be Denver's premier outdoor shopping area, but it suffered a slow decline over the years. Fillmore Plaza, in the heart of the district, was redesigned with a new streetscape that strengthens the retail environment, preserves the district's history and character, improves identity, beautifies the area, provides new lighting, improves signage, and creates spaces for shoppers to relax and linger. The redesigned Fillmore Plaza is now a vibrant hybrid street closed off to traffic during planned pedestrian-focused events.

Method

Power consumption data from 2008 to 2011 was sourced from the lighting consultant's power consumption spreadsheet. 2008 usage and cost was subtracted from 2011 usage and cost.

Additionally, LED bulbs have a much longer lifespan, usually greater than 50,000 hours, which is at least four times that of conventional outdoor lighting. As a result, the district does not have to replace bulbs as often, which in turn reduces maintenance and off-site storage costs. These costs total approximately $1,000 per year according to the Cherry Creek North Business Improvement District.

12 Air Quality
Reducing airborne pollutants

Introduction

Ambient air quality has a significant impact on human and environmental health. Emissions from industry, power generation, motor vehicles, and other forms of combustion contribute to unhealthy concentrations of pollutants, formation of ozone, acid deposition, and visibility impairment.

Compact development can reduce emissions of pollutants and pollution-forming compounds by promoting nonmotorized forms of transportation and reducing vehicle trips and miles traveled. Trees and other vegetation can absorb and intercept air pollutants. Their cooling effects also play a role since the reactions that form key pollutants like ground-level ozone and secondary particulate matter are temperature dependent.

Assessment Considerations

Scale: Because air quality is typically a neighborhood, city or regional issue, it is challenging to isolate the impacts of an individual site. However, the benefits of specific interventions can be estimated using predictive models.

Methods: Measuring air quality directly requires specialized equipment. Because many factors affect outdoor air quality, including weather, topography, and fluctuations in emissions, it is very difficult to attribute measured air quality changes to site-scale design interventions. Therefore, the metrics here focus on the estimated pollutant removal rates of specific practices, namely woody vegetation. Plant lists or an inventory of individual trees is needed, or, for large sites with more extensive vegetation, sampling can be done.

Difficulty: This assessment can be conducted remotely if adequate project documents and plant lists are available. If fieldwork is done, plant species identification can be difficult without prior experience.

Timeframe: This assessment can be conducted upon project completion, though if several years have passed, fieldwork is recommended to confirm tree species and size. Because air pollution removal by trees depends on canopy size, these benefits will increase as the trees mature.

POTENTIAL METRICS

Amount of air pollutants removed by woody vegetation (weight/year)

• Use the US Forest Service (USFS) i-Tree suite of tools to estimate air pollutant removal by trees and shrubs. Tool selection will depend on the scale of vegetation and desired accuracy. The desktop application i-Tree Eco gives hourly air quality improvement for O_3, NO_2, SO_2, CO, and PM_{10}. It can be used with data for individual trees, complete inventories, or random plot samples. The web-based i-Tree products use aerial imagery or data for individual trees to estimate air pollutant removal and avoidance (from reduced energy needs). These tools can also forecast future benefits based on projected tree growth over time.

Resources

USFS: i-Tree Applications

US Environmental Protection Agency: Air Quality Index (AQI)

Photo: Richard Cavalleri/Shutterstock.com

Millennium Park

Chicago, Illinois | Ed Uhlir, Terry Guen Design Associates, & Gustafson Guthrie Nichol, 2004

Removes 426.9 lbs of air pollutants each year through the addition of 550 trees, a service with an estimated value of $1,000 per year.

Project Overview

Millennium Park is one of the world's largest green roofs, sitting atop two multi-level parking garages and a commuter rail line. Formerly the site of rail yards and a parking lot, Millennium Park has become a beloved local, national, and international destination, fostering an increase in tourism and redevelopment in a previously underutilized part of the city. After construction, green space on the site increased by 62% and the number of trees increased by 400%. Approximately half of the park's total surface area, or 12.24 acres, is covered in permeable surfaces.

Method

The American Forests Air Quality Calculator was used to assess the quantity of air pollutants removed by trees in Millennium Park. Pollutants removed included 191.4 pounds of ozone, 128.7 pounds of particulate matter, 67.2 pounds of nitrogen dioxide, 28.1 pounds of sulfur dioxide, and 11.5 pounds of carbon monoxide. The calculator also provided the value of these services in dollars.

In this case, the benefits were calculated for newly-planted trees based on the planting plan and the tree size at installation. Because the study was done in 2011, an actual tree survey would have yielded more accurate results, since the benefits increase with canopy size.

Though this specific calculator is no longer available, the i-Tree suite offers similar functionality.

13 Temperature & Urban Heat Island

Reducing localized temperatures and heat island impacts

Introduction

Urban heat islands are developed areas that are significantly warmer than surrounding rural areas. Changes in land cover are the main cause since urban areas contain less vegetation and higher concentrations of roads and buildings that absorb more solar radiation. The elevated temperatures can have negative impacts, particularly in summer, including increased energy demand for cooling, higher levels of emissions and air pollutants, and heat-related illness and mortality.

Sustainable design can lower a site's contribution to the urban heat island effect and increase the thermal comfort of users. Techniques include planting trees and vegetation, incorporating green roofs and green walls, and using high-albedo materials for roofs and pavements. Shade structures and cooling features like water walls and misters can also help to improve user comfort.

Assessment Considerations

Scale: Because urban heat islands are complex regional phenomena, it is very difficult to quantify the impact of a single site. Nevertheless, localized temperature reductions can be measured at the site scale.

Methods: Metrics compare measured surface or air temperatures or the solar reflectance index (SRI) of materials used. Temperatures can be measured throughout the site or can focus on a particular area of interest. Temperature monitors and handheld thermometers are widely available and should be selected based on intended use, cost, and desired level of accuracy. Since all sites include a variety of surfaces and microclimates, a research strategy is needed to ensure that temperature data and findings are meaningful. Weighted averages based on the area of a particular surface can be used to compare the entire site to the before condition or to a conventionally designed site.

Difficulty: Assessment of material reflectivity can be conducted remotely. Temperature readings must be taken on-site. Processing data involves calculations and possibly mapping site surfaces to determine area weighted averages. If inadequate data exists to make comparisons, assumptions can be made about the before condition or a comparable conventional site.

POTENTIAL METRICS

Reduction in air temperature (degrees or percent)

• Measure air temperatures throughout the site or in a particular area of interest. Compare them to the before condition or to air temperature readings taken in a conventionally-designed space, possibly using weighted averages by area of each surface type. Air temperature is a better proxy for human comfort than surface temperature unless people come into direct contact with the surface, such as a bench or playground slide.

Reduction in surface temperature (degrees or percent)

• Measure surface temperatures throughout the site or in a particular area of interest. Compare them to the before condition or to surface temperatures of a conventionally-designed space, possibly using weighted averages by area of each surface type.

Increase in reflectivity of materials (SRI)

• Reference project documents to determine the SRI values of roof, pavement, and other surface materials on the site. Compare them to the before condition or to SRI values of a conventionally-designed space, possibly using weighted averages by area of each surface type.

Timeframe: Assessment of material reflectivity can be performed upon project completion. Any temperature readings should be taken in the summer and should ideally include the time of day when temperatures are at their peak. More frequent measurements and a longer monitoring period will give a more complete picture of temperature impacts.

Photo: Charles Mayer Photography

Central Wharf Plaza

Boston, Massachusetts | Reed Hilderbrand, 2007

Reduces the average ground-level temperature of the plaza by 10°F with a tree canopy cover that shades 94% of the site.

Project Overview

This small plaza, shaded by 25 mixed-species oaks, connects Boston's Rose Fitzgerald Kennedy Greenway with the waterfront of the Inner Harbor. Standing in stark contrast to wide-open, nearly treeless areas covering the Greenway, the plaza's closely spaced large oaks create a micro-forest on the small site. Employing exemplary planting practices, the below-grade infrastructure supports the project and the health and density of trees in the plaza with sand-based structural soil allowing for an unobstructed root zone.

Method

To determine the cooling effect of the tree canopy, the air temperature of the plaza was compared to the air temperature of an adjacent park with a similar surface but with no vegetative cover. An ambient thermometer, with an accuracy of ±2°F, was used to take readings approximately 12 inches above the ground. Multiple locations across the surface were assessed and averaged. All temperature readings were taken for both sites during the same time period on the same summer day.

14 Carbon Sequestration & Avoidance

Capturing, storing, or preventing the release of carbon into the atmosphere

Introduction

Reducing carbon emissions and sequestering carbon are essential in the global fight against climate change. Carbon sequestration is the capture of carbon dioxide (CO_2) from the atmosphere and long-term storage of the carbon in a stable state, such as plant biomass.

Landscape-based carbon sequestration occurs through biological processes and can include reforestation, wetland and prairie restoration, and no-till agriculture. Carbon emissions can be lowered through strategies that reduce energy and fuel consumption for operations and maintenance and through neighborhood design that promotes nonmotorized transportation.

Assessment Considerations

Scale: Landscape-based practices to sequester carbon and reduce emissions are usually assessed at the site scale.

Methods: Metrics are based on estimates and predictive models. The US Forest Service (USFS) has tools to estimate carbon storage and annual sequestration in trees and forests. The US Department of Agriculture (USDA) and others offer carbon calculators for farm and ranchland. Avoidance can be calculated from the measured or estimated reduction in nonrenewable energy or fuel use.

Difficulty: Sequestration can be estimated remotely if adequate project documents and plant lists are available. If fieldwork is done, plant species identification can be difficult without prior experience. Calculating avoidance is straightforward if the reduction in energy or fuel use is known. If inadequate data exists to make comparisons, assumptions can be made about the before condition or a comparable conventional site.

Timeframe: This assessment can be conducted upon project completion. For carbon sequestration by trees, if several years have passed, fieldwork is recommended to confirm tree species and size.

Resources

USFS: i-Tree Applications

USDA: COMET-Farm

US Environmental Protection Agency (EPA): Greenhouse Gas Equivalencies Calculator

POTENTIAL METRICS

Amount of atmospheric CO_2 sequestered (weight/year)

• Use the USFS i-Tree suite of tools to estimate carbon sequestration by trees and shrubs. The desktop application i-Tree Eco can be used with data for individual trees, complete inventories, or random plot samples. The web-based i-Tree products use aerial imagery or data for individual trees. These tools can also forecast future benefits based on projected tree growth over time.

• Use values from published research to estimate carbon sequestration for a particular ecosystem type, such as a wetland or prairie.

• Use USDA COMET-Farm or another farm carbon calculator to estimate carbon sequestration and emission reductions associated with conservation practices for cropland, pasture, and rangeland.

Reduction in CO_2 emissions from maintenance or energy savings (weight/year)

• Use an estimator like the EPA Greenhouse Gas Equivalencies Calculator to convert energy savings to carbon dioxide equivalent. (See Energy Use.)

• Calculate the reduction in fuel use for mowing or other maintenance compared to fuel use prior to the project or on a conventional site. Use an estimator like the EPA Greenhouse Gas Equivalencies Calculator to convert to carbon dioxide equivalent. (See Operations & Maintenance Savings.)

Reduction in CO_2 emissions from a reduction in vehicle miles traveled (weight/year)

• Estimate the reduction in trip frequency and distance for private automobiles. Use an estimator to convert this to a carbon dioxide equivalent. (See Transportation.)

In areas where carbon markets exist, carbon sequestration and avoidance can also be converted to a monetary value.

Photo: Studio-MLA

South Los Angeles Wetland Park

Los Angeles, California | Psomas & Studio-MLA, 2011

Sequesters an estimated 1.8 tons of atmospheric carbon annually in trees and shrubs, the carbon equivalent of driving a single passenger vehicle almost 4,000 miles.

Project Overview

South Los Angeles Wetland Park represents the transformation of a former bus yard and brownfield at the center of a densely populated community into a functional and attractive California landscape. The park, which is located within the Los Angeles River watershed, captures and treats urban stormwater runoff through a wetland with riparian and emergent marsh habitat at the center. It also addresses environmental justice and social equity by creating a neighborhood-rejuvenating amenity in a historically underserved community. The 4.5 acres of wetland and 4.5 acres of upland habitat support 40 different species of plants.

Method

i-Tree Canopy was used to estimate annual carbon sequestration of trees and shrubs.

First, the project area was defined in Google Earth through the i-Tree Canopy web application. In order to create an accurate data set, a number of classes were added to the analysis. Categories included tree, hardscape, building, water, shrub, grass, and permeable non-grass. The project location was selected as Los Angeles County, California, and was denoted as urban.

Points were added on the satellite imagery until all classes present in the park were represented with an error margin of ±1.75%. Then, a report was created with the resulting values, and the EPA Greenhouse Gas Equivalencies Calculator was used to determine the carbon dioxide equivalent.

15 Reused & Recycled Materials

Repurposing materials from the site or elsewhere

Introduction

Reusing and recycling materials can help reduce a project's cost and ecological footprint by reducing the need for virgin materials and waste disposal. Adapting or reusing materials and objects found on-site can also add historical or cultural value.

Sustainable site design can incorporate materials with recycled content, such as composite decking made from plastic bags or concrete made from fly ash. Materials found on or near the site can be incorporated into the design or construction. For example, historical or industrial elements can be retained as heritage features. Demolition materials like concrete, bricks, and asphalt can be repurposed as fill. Cleared vegetation can be processed into timber or mulch. Site furniture, decorative elements, and playscapes can be fabricated from found objects.

Assessment Considerations

Scale: Reused and recycled materials are typically assessed for an individual site or portion of a site.

Methods: To quantify benefits, information about the type and extent of reused and recycled materials must be known. This may be available in material specifications, site or grading plans, documentation submitted to meet rating system requirements, or other project documents. Material costs and costs of comparable virgin materials can be sourced from project documents or from local suppliers.

Difficulty: This assessment can be conducted remotely if adequate information is available. It involves performing simple calculations.

Timeframe: This assessment can be conducted upon project completion.

POTENTIAL METRICS

Amount of material saved from waste disposal
(weight or volume)

- Reference project documents to calculate the amount of material that was reused on the site instead of being sent to a landfill or other disposal site. This value can also be converted to carbon emission avoidance provided that all energy and transportation costs are accounted for.

Amount of virgin material saved
(weight or volume)

- Reference project documents to calculate the amount of virgin material that would have been needed in the absence of the reused or recycled materials. This metric is most applicable when recycled materials replace natural resources like timber, stone, or gravel.

Cost savings for reusing materials on-site

- Estimate the cost savings from recycled or repurposed materials compared to purchasing new materials. This should consider labor, equipment, and transportation costs in addition to material costs. (See Construction Cost Savings.)

Resources

California Department of Housing and Community Development: Recycled Content Value Calculations Worksheet

Roadway Fill Volume, Cost, and Weight Calculator

US Green Building Council LEED Existing Buildings v3 (2009): Materials and Resources Calculator

Photo: Christian Borchert/McGregor Coxall

Ballast Point Park

Sydney, New South Wales, Australia | McGregor Coxall, 2009

Diverted approximately 22,212 tons, about twice the weight of the Eiffel Tower, of construction material from landfills by repurposing it to create gabion retaining walls.

Project Overview

Located in Sydney's Inner Harbor, this waterfront park engages with the site's mutilayered history from original indigenous villages, to colonial use as a ballast quarry for ships, as a home for early colonizers, and finally as an oil terminal. The park design was driven by a desire to maximize sustainable design principles and innovative techniques, such as on-site material recycling. The reuse of the site's rubble "ballast," from which the site takes its name, was a deliberate choice by the designers who considered it a poetic, yet pragmatic solution to add to the sustainable credentials of the park.

Method

Material quantity was estimated by examining project records. Waste reduction was calculated based on the use of the following recycled materials in the rubble-faced gabion walls: construction waste rubble, site soils, and rubble from a construction waste recycling facility.

The original design intent was to have the construction waste rubble produced by the site's demolition work processed for reuse on-site. However, it was significantly less expensive for the rubble to be shipped off-site for processing. An equivalent amount of processed and graded construction waste rubble was then returned to the site from the recycling facility.

16 Waste Reduction

Reducing the need for off-site waste disposal

Introduction

In 2015, about 262 million tons of municipal solid waste were generated in the US. Of this, 138 million tons were landfilled, 34 million tons were combusted, and 91.2 million tons (45%) were recycled or composted. Construction and demolition waste is more than twice this amount, with 548 million tons of debris generated in 2015.[4] Reducing the amount of waste sent to landfills or incinerators saves money, energy, and natural resources.

Site design and ongoing management practices can minimize the amount of waste generated, encourage recycling, and provide for the composting of yard and food waste either on- or off-site. Thoughtful design and construction practices can reduce construction waste by balancing cut and fill volumes, salvaging reusable materials, and employing source reduction techniques.

Assessment Considerations

Scale: Waste reduction is typically assessed for an individual site or portion of a site.

Methods: Metrics rely on tracking waste reduction measures and the amount of materials disposed of, recycled, or composted. These waste streams can also be estimated from the type and frequency of maintenance activities. Construction waste reduction can be determined from site or grading plans, documentation submitted to meet rating system requirements, or other project documents.

Difficulty: This assessment can be conducted remotely if adequate information is available. For sites that do not diligently track waste management practices, determining the amount of waste reduced, recycled, or composted may be challenging.

Timeframe: Assessment of construction waste reduction can be conducted upon project completion. If assessing reductions from ongoing management practices, having at least a year of data is recommended to account for any seasonal variation.

POTENTIAL METRICS

Amount of organic waste composted annually
(weight or volume/year or percent of total)

- Consult waste management documents or maintenance records to determine or estimate the amount of vegetative material that is composted, chipped, or used as mulch on-site or collected for off-site composting or processing.
- Consult waste management documents to determine the amount of food waste that is composted on- or off-site.

Amount of municipal solid waste recycled annually
(weight or volume/year or percent of total)

- Consult waste management documents or maintenance records to determine or estimate the amount of material that is recycled. This is most applicable for sites with active recycling programs and collection facilities.

Reduction in construction waste
(weight or volume)

- Reference project documents to determine the amount of waste avoided compared to the waste from conventional design and construction processes. (See Reused & Recycled Materials and Construction Cost Savings.)

Reduction in energy and greenhouse gas emissions from waste reduction (weight or unit of energy)

- Use the US Environmental Protection Agency (EPA) Waste Reduction Model (WARM) to estimate energy and emission reductions associated with waste reduction, recycling, and composting compared to a baseline scenario. (See Carbon Sequestration & Avoidance.)

Resources

EPA: Waste Reduction Model

US Green Building Council LEED v4: Construction and Demolition Waste Calculator

Photo: The Morton Arboretum

The Morton Arboretum: Meadow Lake & Main Parking Lot

Lisle, Illinois | The Morton Arboretum, 2005

Reduces organic waste by composting 100% or 138 cu yds of the site's plant debris and clippings annually.

Project Overview

The Morton Arboretum Meadow Lake and Permeable Main Parking Lot replaced a degraded retention pond and asphalt parking lot with a functioning wetland system and permeable lot whose stormwater flow is now integrated with aquatic ecology. To promote sustainable practices, the Morton Arboretum composts all of its healthy yard waste for use on-site. The arboretum maintains three compost bins in which clippings from the entire grounds are placed. When these bins become full, maintenance crews haul the compost to the arboretum's general composting collection site. The compost is used to supplement topsoil creation.

Method

SITES 8.3 documentation was used to determine the amount of debris collected on site and composted.

The arboretum reports that approximately 1.5 dump trailers worth of landscape material is gathered from the site on a weekly basis during the months of collection, April to October. Each trailer holds 3 cu yd of waste, which adds up to 137.6 cu yd of material composted for soil making annually.

02. SOCIAL BENEFITS

Uptown Normal Circle and Streetscape | Hoerr Schaudt

(Photo: Scott Shigley/Hoerr Schaudt Landscape Architects)

SOCIAL BENEFITS

1 Recreational & Social Value

Promoting play, relaxation, and interaction

2 Cultural Preservation

Retaining or restoring culturally significant features, areas, practices, or views

3 Health & Well-Being

Supporting physical health, mental health, and quality of life

4 Safety

Improving safety and reducing crime and perceptions of danger

5 Educational Value

Fostering knowledge and awareness

6 Noise Mitigation

Reducing actual or perceived levels of undesirable sound

7 Food Production

Supporting urban agriculture

8 Scenic Quality & Views

Improving the visual quality of an area

9 Transportation

Fostering walking, biking, mass transit, and other alternative modes

10 Access & Equity

Creating or improving access to facilities and amenities

A Note on Surveys

Surveys are frequently used as a means to assess social benefits. In addition to demographic information, surveys can gauge frequency and type of use and perceptions related to quality of life, sense of place, safety, and health benefits.

Surveys must be designed and conducted using applicable, valid, and defensible survey methods, which may require consultation with an expert. The survey instrument (questionnaire, response options, and background information) must be accurate and valid, which usually requires pilot testing. It must be designed to accurately measure the variable of interest and yield consistent results.

The sample size and response rate should be sufficient to provide an accurate representation. Survey length and clarity will impact response rate, as will the method of distribution and collection. In addition to in-person intercept surveys, surveys can be distributed via websites, email, social media, and QR codes.

Most user surveys are done using convenience sampling, asking those who are easiest to contact or reach. While easy and cost-effective, this sampling method may not accurately represent the population of interest.

Best practices require the informed consent of respondents, and parental/guardian consent in the case of children or other vulnerable subjects. Those affiliated with a research institution will need to obtain approval from an institutional review board (IRB), which reviews and approves research involving human subjects, including surveys.

Resources

University of Wisconsin: Collecting Evaluation Data

Checkmarket: Sample Size Calculator

Web Center for Social Research Methods

1 Recreational & Social Value

Promoting play, relaxation, and interaction

Introduction

Parks, plazas, trails, campuses, and other outdoor spaces provide places for an array of recreational, social, and community functions, particularly in urban areas. As urbanization and density intensify across the globe, it is increasingly important to create spaces for recreation and socialization as part of the urban fabric.

Well-designed landscapes help to foster these experiences by encouraging outdoor activity, promoting social interaction, providing facilities for passive and active recreation, offering access to nature, and creating a sense of community.

Assessment Considerations

Scale: Recreational and social value is typically assessed for an individual site or portion of a site, such as a playing field, community green, or seating area. It is important to consider the context and the role the site plays in relation to other facilities in the vicinity.

Methods: Metrics require fieldwork or previous documentation of visitation or use. If counts or records are not available, time-lapse photography, direct observation, or surveys can be used to determine extent and type of use. Surveys can also yield information about quality of experience. For surveys and site observations, the instruments and protocols need to be found or developed, possibly requiring training or consultation with an expert. Several established methods exist. (See p. 51, A Note on Surveys.)

Difficulty: This assessment can be conducted remotely if adequate records are available. Surveys or observation studies require expertise and time to create and implement.

Timeframe: Site observations and surveys can be conducted upon project completion but may be more accurate after several seasons when visitation and use patterns stabilize. Ideally, data on visitation and use should be gathered over a full year to account for seasonal variation.

Resources

Active Living Research: System for Observing Play and Recreation in Communities (SOPARC)

Gehl Institute: Public Life Tools

POTENTIAL METRICS

Site visitation or use (number/year)

- Consult records from the site owner, operator, or other entity that tracks use of the site. Museums, gardens, and educational institutions frequently track visitation, as do government agencies and business improvement districts. If the project was an improvement to an existing site, the change in visitation or use prior to and after the project can be reported.
- Use direct observation to obtain visitor counts by collecting representative samples.
- Use time-lapse photography to count the number of users over a period of time of interest.

Visitors engaged in recreational or social activities (number or percent of total)

- Use direct observation, following the Gehl Institute's Public Life Tools, SOPARC, or other observational methods.
- Conduct a survey of users to determine the quantity, quality, or frequency of their use of the site for recreational or social activities.

Quality of the visitor experience

- Conduct a survey of site users to determine the nature and quality of their experience.

Extent of facility use

- Reference project documents to identify facilities that directly support recreation or social interaction, such as trails, playing fields, and picnic tables. Use records, observations, or survey data to compare use to the intended capacity. Extent of use can be calculated and expressed as the amount of time facilities are used or the percent of capacity in use during peak times.

Photo: Landscape Architecture Foundation (Andrew Louw, CSI 2013)

Simon and Helen Director Park

Portland, Oregon | OLIN, 2009

Attracts an average of 1,495 people per day during summer months, 96% of whom engage in recreational activities.

Project Overview

This project converted a parking lot the size of a city block into an urban plaza in the center of downtown Portland. The park hosts a range of amenities and activities and has become a popular destination. As a European-style urban piazza, the park is unique within the City of Portland and offers diverse programming and rental space for events. The plaza has a water feature with arching jets, movable tables, permanent seating, and an on-site cafe.

Method

User data was collected on site in summer 2013 using the Public Space Public Life (PSPL) observation method developed by Jan Gehl. The PSPL method includes both pedestrian counts and stationary observation.

Park users were observed on 3 separate site visits in 2013 (two weekdays and one weekend day between June and November). Evaluators collected information about duration and time of use, user age, gender, purpose (recreation or work), type of activity (necessary, optional, social), position (sitting, standing), location within the park, and other pertinent information.

The PSPL method is useful because it does not require institutional review board (IRB) when making observations in a public space and it offers potentially compelling metrics about social performance, although it is time-intensive.

2 Cultural Preservation

Retaining or restoring culturally significant features, practices, or values

Introduction

Cultural landscapes are natural, historical, or designed sites associated with certain people, events, activities, or cultural values. They recognize history, express regional identity, offer narratives of culture, and promote understanding of heritage, place, and community.

Though these benefits are often overshadowed by other more tangible benefits, cultural preservation can be an important element of many projects. Sustainable site design should seek to preserve, enhance, and restore meaningful cultural landscapes, support or reinterpret their historic use, and educate or create awareness about their importance.

Assessment Considerations

Scale: Cultural preservation is typically assessed for an individual site or portion of a site. Because a site can be part of a larger culturally significant area or network of sites, it is important to consider the context and the role that cultural landscape elements play in relation to other cultural and historic resources in the vicinity.

Methods: Metrics rely on previous documentation of the type, extent, and significance of cultural resources and the measures taken to protect or restore them. Local historic preservation regulations may require this, or cultural assets may be documented by religious, tribal, or cultural preservation groups. While field observations may be helpful, the assessment can usually be conducted using information from local or national historic preservation reports, heritage site submissions, or other project documents. User surveys can complement this by yielding information on visitors' understanding of heritage and quality of experience.

Difficulty: This assessment can be conducted remotely if adequate information can be obtained from project documents. If users are surveyed, surveys require expertise and time to create and implement. (See p. 51, A Note on Surveys.)

Timeframe: This assessment can be conducted upon project completion. If quantifying the production of goods, having data for multiple years is recommended to account for variation.

POTENTIAL METRICS

Area or quantity of culturally valuable elements protected or restored (area or amount)

• Reference project documents or preservation records to identify areas deemed valuable or significant. Use aerial photographs, GIS analysis, CAD software, or other tools to quantify spatial extent or number. Compare pre- and post-construction conditions. (See Land Efficiency & Preservation.)

Quality of the visitor experience

• Conduct a survey of visitors to determine the nature and quality of their experience engaging with the cultural features on the site. This could be an assessment of visitor perceptions or increased awareness or understanding. (See Educational Value.)

Quantity of cultural goods produced

• Consult site management or operation records to determine the number of culturally significant goods, such as bottles of wine or woven straw hats, produced from the landscape as a result of preservation, restoration, or enhancement.

Resources

UNESCO: World Heritage List

US National Park Service (NPS): National Register Database and Research

American Society of Landscape Architects: Historic American Landscapes Survey

Photo: Castiglion del Bosco

Castiglion del Bosco

Montalcino, Siena, Italy | EDSA, 2009

Preserved and restored approximately 400 cypress trees lining the entry drive into the estate. The 800-year-old trees are an important element of the distinctive visual identity of the Val d'Orcia region, which is designated as a UNESCO World Heritage Site.

Project Overview

Encompassing 4,500 acres of Tuscan countryside, the 800-year-old Castiglion del Bosco estate is characterized by an iconic traditional working landscape of forests, farms, and fields with dark green cypress trees juxtaposed against the pale, rounded hills. This resort project was designed to ensure the continuation of the wine production at the estate while transforming it into a world-class vacation destination.

Method

UNESCO documents were reviewed to understand the cultural value of the site in general and the importance of the cypress trees in particular.

Construction documents were consulted to determine how arborists' recommendations were carried out to preserve and restore existing healthy trees, remove unhealthy trees and invasive plants, and plant new trees to replace those lost.

To estimate the number of trees along the drive, the total length of the drive (1 mile) was multiplied by the approximate average distance between trees (25 feet) along both sides of the drive to reach a total of 422 trees.

3 Health & Well-Being

Supporting physical health, mental health, and quality of life

Introduction

There is a well-established and ever-growing body of research on the cognitive, emotional, and physical benefits provided by landscapes and greenery. These benefits include healthier childhood development, increased physical activity, recovery from stress, improved concentration, faster healing, and a more positive outlook.

Landscape design can foster these outcomes by creating places for active recreation, respite, and access to nature. While designing for health is done most intentionally in health care and educational settings, incorporating accessible green spaces and views of trees, green roofs, and other vegetation can be done on sites of any size. Streetscapes, living environments, and urban parks are especially important because most health and well-being benefits are derived from everyday experiences.

Assessment Considerations

Scale: Health and well-being benefits are typically assessed for an individual site or portion of a site. It may also be important to consider the role the site plays in relation to other facilities in the vicinity.

Methods: Metrics require fieldwork or access to previously documented health data and indicators. Surveys can be used to gather information about how the site influences users' physical health and well-being. Direct observations can be used to document level of physical activity. A validated method for observing physical activity has been developed for a number of different environments (SOPLAY, SOPARNA, SOPARC).

Difficulty: Health and medical data is protected by strict privacy rules. When available, it is often aggregated at the city or regional level, which is not conducive to determining the impact of a particular site. Because the issue of health is a sensitive topic, users may be less willing to participate in surveys or undergo observation. Surveys or observation studies require expertise and time to create and implement. (See p. 51, A Note on Surveys.)

Timeframe: Surveys and site observations can be performed upon project completion but may be more accurate after several seasons when visitation and use patterns stabilize. If health data or indicators are used, the data should be reported over time period that is sufficient to show a clear trend of improvement.

POTENTIAL METRICS

Improvement in mood, level of satisfaction, or quality of life

- Conduct user surveys, interviews, or focus groups to determine the improvement associated with being in, viewing, or having access to the space. Users can be asked to compare their experience before and after a design intervention or to compare to a conventionally-designed space.

Improvement in physical health or activity

- Conduct a survey of users to determine a self-reported improvement in health or physical activity as a result of having access to the space.
- Use existing health data to determine a decrease in negative indicators, such as asthma rates, or an increase in positive ones, such as level of physical activity, that can be clearly linked to the site.

Level of physical activity

- Use direct observation to document level of physical activitiy following SOPARC, SOPLAY, SOPARNA, or other observational methods.

Resources

Active Living Research: System for Observing Play and Leisure Activity in Youth (SOPLAY)

Active Living Research: System for Observing Physical Activity and Recreation in Natural Areas (SOPARNA)

Active Living Research: System for Observing Play and Recreation in Communities (SOPARC)

US Department of Health and Human Services: Healthy People 2020

US Centers for Disease Control: Health Impact Assessment

Photo: Ralph Daniel Photography

Atlanta BeltLine Eastside Trail

Atlanta, Georgia | Perkins + Will, Inc., 2012

Promotes physical activity for 90% of 100 surveyed trail users, and 70% of surveyed users self-reported that they exercise more since the opening of the trail.

Project Overview

The Eastside Trail is the first constructed segment of the Atlanta BeltLine, an adaptive reuse of a 22-mile corridor of abandoned railroad right-of-way that winds through neighborhoods and new public spaces established as part of the BeltLine. The 2.2-mile Eastside Trail provides a prime location for recreation and has become a vibrant setting for community events, volunteer activities, sports, and philanthropic events, such as charity races. When the entire Atlanta Beltline is complete by 2030, it will serve as a comprehensive exemplar of transformative, multi-phased landscape infrastructure.

Method

A convenience survey of trail users was conducted during site visits on a Sunday and Monday in early June 2014. 100 consenting participants completed hard copies of the survey, and the responses were subsequently entered into an online database for data analysis.

The first question reported in this benefit was: “How do you benefit from the Eastside Trail (check all that apply)?” with 90 users selecting the option “Active lifestyle.”

The second question was “Do you exercise more since the Eastside Trail has opened?” with 70 users responding "Yes."

4 Safety

Improving safety and reducing crime and perceptions of danger

Introduction

Landscape design can have a significant effect on both actual and perceived levels of crime, danger, and safety for those using, passing through, or overlooking a particular site.

A number of landscape interventions can improve transportation safety, particularly for pedestrians and cyclists. These include bike lanes, marked or raised crosswalks, curb extensions, street trees, and other traffic calming measures. In parks and other open spaces, safety can be enhanced by the clustering of activity areas, clear circulation and wayfinding, visibility and sightlines, nighttime lighting, and other design and maintenance principles known to deter crime. Activities and programming can promote use, which typically increases informal surveillance and feelings of safety.

Assessment Considerations

Scale: Safety can be assessed at the intersection, block, site, or community scale, depending on the design intervention being studied.

Methods: Determining changes in actual safety requires access to data on traffic incidents or crime. Prior transportation studies may contain information on past conditions and behaviors. Field observations can be used to document changes in traffic speed, jaywalking, or other behaviors that impact safety. Surveys can yield information about perceptions of safety.

Difficulty: This assessment can be conducted remotely if adequate records are available. Many factors contribute to actual and perceived crime and safety, which may make it difficult to attribute changes to the project alone. Surveys or observation studies require expertise and time to create and implement. (See p. 51, A Note on Surveys.)

Timeframe: Site observations and surveys can be conducted upon project completion, but may be more accurate after several seasons when use patterns stabilize. If traffic incident or crime data are used, the data should be reported over a time period that is sufficient to show a clear trend of improvement.

POTENTIAL METRICS

Reduction in traffic incidents (number/year)

- Use data from local transportation or police departments to determine the change in the number of incidents before and after a landscape intervention or to compare to incidents at a conventionally-designed site.

Reduction in speed (rate or percent)

- Measure vehicle speeds in a particular area of interest. Compare them to speeds before the landscape intervention or to speeds measured on a different portion of the same roadway or in a nearby conventionally-designed space.

Reduction in crime (incidents/year)

- Use data on violent and/or property crime from local police departments to determine the change in the number of incidents before and after a landscape intervention.

Perception of safety

- Conduct a survey of site users or of those who live or spend time in the vicinity to determine if the space is perceived as safe or whether the design intervention changed their perceptions about safety.

Resources

CrimeReports

International CPTED Association: Crime Prevention Through Environmental Design

Photo: OLIN/Karl-Ranier Blumenthal

Canal Park

Washington, District of Columbia | OLIN, 2012

Contributes to an 18% decrease in vehicular speed through the park compared to the adjacent block by narrowing streets and extending park paving materials to create table-top sidewalks.

Project Overview

Canal Park is a linear 3-block urban park in the Capitol Riverfront neighborhood of Washington, DC. Formerly a parking lot for District school buses, the site was the historic site of the Washington City Canal that linked the Anacostia and Potomac rivers. The design evokes this heritage through a linear rain garden and three pavilions reminiscent of the floating barges that were once seen in the canal. Raised table-top intersections were implemented to slow traffic and prioritize pedestrian safety on the two streets that cross through the park.

Method

The average speed of vehicles traveling through the park on L Street was compared to the average speed of vehicles traveling through the adjacent block on the same street. On-site measurements were taken to determine the length of L Street between intersections where it crosses the park (89.25 ft) and the length between the next intersections outside of the park (192.5 ft).

Time-lapse photography taken over the course of one day at the park was analyzed to estimate the time it took for vehicles to travel the distances measured. Data was collected for over 100 vehicles for each section of L Street to determine the average speed of vehicles passing through. Vehicles passing through the park had an average speed of 17.3 ft/s, and vehicles passing through the adjacent block had an average speed of 21 ft/s.

5 Educational Value
Fostering knowledge and awareness

Introduction

Landscapes provide incredible opportunities for engagement and learning. This education is more formal at botanic gardens, cultural sites, demonstration projects, and other sites expressly designed as teaching landscapes. Informal education occurs when people learn spontaneously from spending time in a landscape.

Site design can foster learning by revealing ecological flows or cultural narratives. Many landscapes incorporate interpretive signage, plaques, or facilities for audio or self-guided tours. Educational materials and complementary programming can further enhance the educational value of a site. Augmented reality and other technologies are opening up new possibilities for educational experiences.

Assessment Considerations

Scale: Educational value is usually assessed for an individual site or installation.

Methods: Metrics in this category require fieldwork, previous documentation of visitation or use, or access to website or provider data. Museums, gardens, educational institutions, and government agencies frequently keep records of visitation and program participation. Direct observation can gauge use of educational facilities. Surveys can yield information about knowledge acquired.

Difficulty: This assessment can be conducted remotely if adequate records are available. Surveys or observation studies require expertise and time to create and implement. (See p. 51, A Note on Surveys.)

Timeframe: Site observations and surveys can be conducted upon project completion. Ideally, data on visitation and use of educational materials should be collected over a full year.

POTENTIAL METRICS

Site visitation (number/year)

• Consult records from the owner, operator, or other entity that tracks visitation. This metric is most applicable for sites, such as memorials or demonstration projects, where all visits can be assumed to have an educational purpose.

Number of or attendance at educational events (number/year)

• Consult records from the owner or other entity that programs and tracks use of the site for educational purposes. This may include tours, school group visits, and educational programming.

Extent of facility use (percent use or duration of time)

• Reference project documents to identify facilities that directly support education, such as signage. Use observations or survey data to determine extent of use, which can be expressed as the percent of visitors who use the educational facilities or the amount of time they spend using them.

Number of people accessing educational materials

• Consult records from the owner or other entity to determine use or distribution of educational materials like pamphlets or audio tour equipment.

• Use analytics or provider data to determine the number of users accessing landscape-related online content, videos, apps, or other educational media.

Increase in knowledge

• Conduct a survey of users to determine a self-reported increase in knowledge or educational value gained from visiting the site.

• Conduct a survey of users to determine understanding of key concepts presented. Before/after surveys can be used to measure knowledge attributable to the site visit as opposed to prior knowledge.

Photo: Landscape Architecture Foundation

Brian C. Nevin Welcome Center, Cornell Plantations

Ithaca, New York | Halvorson Design Partnership, 2011

Achieves learning objectives, with 68% of 71 survey respondents correctly answering at least 7 out of 9 questions about the site's bioswales.

Project Overview

The Cornell Plantations is a university-based public garden network with 4,000 acres of natural and designed landscapes in and around Cornell University's campus, dedicated to environmental preservation and education. The Nevin Welcome Center project is part of a comprehensive landscape reorganization of the heart of the Botanical Garden. Its surrounding landscape serves as a pedestrian-friendly gateway to the adjacent 25-acre Botanical Garden. The Welcome Center features a lush horticultural display with interpretive signage that articulates some of the ecosystem services provided by the bioswale and other green infrastructure on site.

Method

The Cornell Plantations established a set of learning objectives for visitors, including benchmarks like, "most visitors will realize that water is much cleaner when it leaves the bioswale than when it entered" and "most visitors will recognize that a bioswale is a more sustainable alternative to a conventional drainage culvert system."

In order to evaluate a visitor's understanding of green infrastructure practices, staff developed a visitor survey that included a short quiz with true or false questions to assess whether or not the project's bioswale-related learning objectives were achieved.

Of 71 survey respondents who took the survey between early June and late July 2014, 48 respondents (68%) answered at least 7 questions out of 9 correctly.

6 Noise Mitigation

Reducing actual or perceived levels of undesirable sound

Introduction

In an increasingly urban world, outdoor ambient noise exceeds acceptable levels in many cities and communities. Noise pollution has been linked to sleep disturbances, impaired childhood development, annoyance, stress, and even cardiovascular disease. While road, rail, and air traffic is the biggest source of noise in urban environments, other sources include construction, industry, and recreational activities.

Landscape interventions, such as berms, walls, and techniques to lower vehicle speeds, can reduce noise levels. Vegetation can attenuate noise, though thick bands are needed for a significant effect. Trees and plants, water features, and the birds and wildlife these features attract generate sounds that mask undesirable noise. In addition, research shows that, in the presence of vegetation, people perceive noise levels to be lower than they actually are.[5]

Assessment Considerations

Scale: Noise is typically assessed for an individual site or area of interest on a site.

Methods: Metrics in this category require fieldwork or previous documentation of noise levels. When noise mitigation is a central goal, noise studies or modeling are often done as part of the project delivery process. To measure noise, a Class 1 or Class 2 sound level meter is needed. Smart phone applications can give approximate levels but are less reliable. Season, time of day, weather conditions, and other factors affecting ambient noise must be considered. Surveys can yield information about perceptions of noise.

Difficulty: This assessment requires fieldwork unless a noise study has already been conducted. Measurement of noise levels is straightforward, but, because decibels are logarithmic, calculations involve more complicated math. Surveys require expertise and time to create and implement. (See p. 51, A Note on Surveys.)

Timeframe: Fieldwork and surveys can be conducted upon project completion. If vegetation is a key noise mitigation strategy, timing should consider seasonal variation. Noise attenuation from vegetation will increase over time as plants grow and fill in.

POTENTIAL METRICS

Ambient noise levels (decibels)

- Measure sound levels for an area of interest with a sound meter. Compare to design standards or local thresholds. Alternately, measured sound can be compared to pre-construction levels or to measured levels in a comparable location without a landscape intervention.
- Reference documents from a previous sound study or modeling conducted for the site and report the change in noise levels. Such a study is common if experts in environmental acoustics are involved in a project.

Remember that decibels are logarithmic and cannot be manipulated without converting back to a linear scale or using a decibel calculator.

Perception of undesirable noise

- Conduct a survey of users to determine their perceptions about noise in an area of interest. This metric is useful when undesirable noise is not reduced but rather masked by pleasant noises, such as the sound of leaves in the wind or falling water.
- Conduct a survey of site users or those who spend time in the vicinity to determine whether the design intervention changed their perceptions of noise.

Resources

Purdue University: Noise Sources and Their Effects

NoiseMeters, Inc.: Decibel Calculator

Photo: Sahar Coston-Hardy/SALT Design Studio

Chester Arthur School

Philadelphia, Pennsylvania | SALT Design Studio, 2017

Reduces average noise level from 87 decibels to 81.5 decibels, achieving a clearly noticeable reduction.

Project Overview

Chester Arthur School is a public K-12 school in the densely populated Graduate Hospital neighborhood of Philadelphia. Pre-construction, the schoolyard was almost entirely asphalt, offered little physical or intellectual stimulation to students, and released 99% of stormwater runoff directly into Philadelphia's combined sewer system. The new schoolyard design incorporates the school's fledgling STEM curriculum into outdoor, interactive learning. Post-construction, the schoolyard is quieter and more verdant, offers habitat for neighborhood wildlife, and encourages much higher usage and activity levels on site by students and neighborhood residents.

Method

Decibel readings were taken before and after construction by the firm with the SkyPaw Decibel 10th: Professional Noise Meter App on two separate iPhone 6 devices at a single point in each of nine zones defined on site. Decibel readings were taken every hour for four days, from 9am-7pm, during weekend and school days.

Data collectors stood in the center of each zone, with one facing inwards towards the site, and the other facing the street. Decibel levels were then averaged (after being converted into their linear values) across observation periods and between the two devices to arrive at a single decibel average for each area.

A 3 decibel increase or decrease is the threshold of human ability to perceive a change, while a 5 decibel change is clearly noticeable to an average person.

7 Food Production

Supporting urban agriculture

Introduction

Interest in urban agriculture has been steadily rising as a means to promote nutrition, address food security, reduce transportation and storage needs, and provide economic opportunity. Urban agriculture typically uses intensive and more sustainable production methods. The resulting crops are usually consumed by the producers, grown for local restaurants, or sold in local farmers markets.

Landscapes can incorporate food production as garden plots, on rooftops, or as community gardens. Production of vegetables, herbs, and fruits is most common, though urban agriculture can also encompass beekeeping, poultry, aquaponics, and livestock. New food production techniques are emerging, like vertical farming, indoor farms, and high-tech growing methods.

Assessment Considerations

Scale: Food production is usually assessed for an individual site or portion of a site.

Methods: Metrics rely on estimates or previous documentation of yields or market value. Site visits, data from site plans, and photographs can be used to corroborate information obtained from site managers and users.

Difficulty: This assessment can be conducted remotely if adequate information is available. It involves performing simple calculations.

Timeframe: This assessment can be conducted at the end of a year or growing season. For new urban agriculture operations, it may be preferable to wait until the second year or growing season once operations have stabilized. Year-to-year yields will depend on weather, disease, pests, and other factors. Conducting the assessment annually can help to gauge average production.

POTENTIAL METRICS

Amount of food produced (weight or volume)

- Consult records from the site owner, land manager, or other entity that tracks food production on the site to determine the amount of food produced in a season or annually.
- Use the Grow Your Own Vegetables Value Calculator or similar tool to estimate yields based on the land area devoted to different types of crops.
- Conduct a survey of community garden users to determine the type and yield of crops they plant.

Monetary value of food produced

- Consult records from the site owner or land manager related to the sale of food produced on-site.
- Use local prices from a grocery store or farmers market to calculate the value of food produced.
- Use the Grow Your Own Vegetables Value Calculator or similar tool to estimate the market value based on the total weight produced of different types of crops.

Number of meals provided or food recipients

- Consult records from the site owner or operator. This metric is applicable when food is prepared and consumed on the site or given to an entity that distributes it to others, such as a food pantry or soup kitchen.

Resources

PlanGarden: Grow Your Own Vegetables Value Calculator

Photo: Scott Shigley/Hoerr Schaudt Landscape Architects

Gary Comer Youth Center

Chicago, Illinois | Hoerr Schaudt Landscape Architects, 2006

Produces 1,000 lbs of fruits and vegetables annually. Food from the rooftop contributes to meals for 175 children each day, is distributed among 4 local restaurants, and is sold at a local farmers market.

Project Overview

Located on Chicago's South Side, the Gary Comer Youth Center offers extracurricular activities and hands-on learning opportunities in a positive and safe environment. The elevated courtyard, located above the gymnasium and cafeteria and encircled by the broad windows of the third floor, gives youth and seniors access to the outdoors and creates a hospitable microclimate for its working garden. The roof garden functions as an outdoor classroom for a variety of courses related to food preparation that help students prepare for careers.

Method

The annual yield is based on the amount of food harvested in 2009 and 2010. The 2009 yield and number of distribution points, including the number of lunches provided each day, were reported in the summer 2009 publication of Edible Chicago.

2010 yields and distribution points were verified through an interview with the Gary Comer Youth Center Garden Manager in July 2011.

8 Scenic Quality & Views

Improving the visual quality of an area

Introduction

Aesthetics, the creation and appreciation of beauty and other perceptual experiences, plays a central role in the design of the built environment. Individual aesthetic preferences are embedded in complex webs of meaning derived from personal experience, sociocultural surroundings, and wider political and economic contexts. Yet, there are many commonalities in how humans perceive the scenic quality of landscapes and the types of views they prefer.

While aesthetic considerations are part of any well-designed landscape project, views and visual quality are often prioritized in areas of high scenic or cultural value. Thoughtful site design can preserve, restore, and enhance these aspects. Design elements like walls, trees, and other vegetation can block or screen unwanted views.

Assessment Considerations

Scale: Scenic quality may be assessed for an individual site or portion of a site or for a larger corridor, recreation area, or viewshed of which the project is part.

Methods: Quantification of landscape aesthetics is a notoriously thorny research issue. Best methods integrate quantitative and qualitative data. Metrics in this category are based on indices, modeling or image analysis, or user surveys. The US Forest Service (USFS), Wyoming Bureau of Land Management (WBLM), National Park Service, and other federal agencies have developed protocols to assess visual quality. Local and regional guidelines also exist. Impacts on views can be determined from photography or model simulations. Surveys can yield information about perceptions of aesthetic quality.

Difficulty: This assessment can be conducted remotely if adequate imagery or models are available. Fieldwork is required for a visual quality assessment. Surveys require expertise and time to create and implement. (See p. 51, A Note on Surveys.)

Timeframe: This assessment can be conducted upon project completion. If vegetation is a key screening strategy, timing should consider seasonal variation. Views screened and framed by vegetation will change over time as plants grow and fill in.

POTENTIAL METRICS

Score on an established visual quality scale

- Use a federal agency’s scenic quality assessment or visual impact assessment protocol to determine a score or change in score prior to and after the project.
- Use a local or regional index and thresholds to evaluate the scenic quality of a roadway, corridor, shoreline, or recreation area. The score can be compared to that of the before condition or to a comparable location without a design intervention.

Percent of unwanted views screened or desirable views retained

- Use digital photography and image analysis software to determine the areas of screened and retained views to calculate the percent.
- Use modeling and 3-D simulation software to estimate the areas of screened and retained views before and after the design intervention.

Perception of aesthetic value

- Conduct a survey of visitors to determine their perceptions of aesthetic quality for a site or area of interest.
- Conduct a survey of site users or those who spend time in the vicinity to determine whether and how the design intervention changed their perceptions about scenic quality or aesthetic value.

Resources

USFS: A Handbook for Scenery Management

WBLM: Visual Resources Clearinghouse

Photo: Design Workshop

Park Avenue/ US 50, Phase 1 Redevelopment

South Lake Tahoe, California | Design Workshop, 2003

Increased the total visible area of the natural environment by 10%. For all views of the Carson Range that were blocked by new development, the design created new views in other areas of the project site.

Project Overview

The town of South Lake Tahoe had experienced sprawl, which created traffic congestion, limited connectivity to recreational assets, and negatively impacted the scenic quality of Lake Tahoe and the region. Residents, officials, and developers jointly devised development regulations to address this. Visual clutter, including billboards and irregular street walls, were replaced with consistent signage, awnings, and overhangs, which protect and enhance views of the Carson Range.

Method

The redevelopment had a goal of no net loss of views of the Carson Range. To reach this goal, designers created a set of 26 3-D computer simulations that included the redevelopment plan's proposed new buildings and removal of existing buildings. Specific viewpoints in these simulations were converted into line drawings, transferred onto transparency sheets, and overlaid onto photographs of existing conditions taken from the same viewpoints. Then, using a planimeter, they measured the visible natural landscape area under the existing conditions and the proposed conditions. The net gain or loss was calculated. To ensure accuracy, both areas were measured twice and then averaged.

It should be noted that this assessment was conducted with model simulated views and not images of the built landscape.

9 Transportation

Fostering walking, biking, mass transit, and other alternative modes

Introduction

For nearly a century, the dominance of the personal automobile has defined the form of American cities and nonurban settlements. Dependence on the automobile has led to sprawling development patterns, traffic congestion, increased fossil fuel consumption, air and noise pollution, and higher rates of accidents.

Site planning and design can encourage alternative modes of transportation by creating compact and connected road networks, incorporating pedestrian and bicycle infrastructure, designing for mass transit and ride-hailing services, and using other complete streets treatments. Landscape projects can also provide missing links and connections for a transportation network.

Assessment Considerations

Scale: Landscape-based transportation benefits are assessed at the site, neighborhood, city, or regional scale, depending on type of design intervention being studied.

Methods: Metrics rely on observations, surveys, or previous documentation of transportation choices. Local transportation departments and mass transit authorities frequently collect ridership data. If counts will be conducted, equipment like a time-lapse camera or infrared sensors can facilitate the process. Surveys can yield information about modes, travel distances, and changes in transportation choices.

Difficulty: This assessment can be conducted remotely if adequate records or project documents are available. Counts or surveys require expertise and time to develop and implement. (See p. 51, A Note on Surveys.)

Timeframe: This assessment can be conducted upon project completion but may be more accurate after several seasons when use and travel patterns stabilize. Counts or observations should be done on a typical day, or ideally over a longer period of time to account for daily, weekly, and seasonal variation.

Resources

Institute of Transportation Engineers and Alta Planning: National Bicycle and Pedestrian Documentation Program

Transportation Research Board: Guidebook on Pedestrian and Bicycle Volume Data Collection

POTENTIAL METRICS

Increase in walking, biking, or mass transit use (number/day or mode-share)

- Consult records or counts from a local transportation department or mass transit authority to determine the number of users of a given mode. Compare to data collected prior to the project or to a local average or typical condition.
- Use direct observation or surveys to count users of different modes for a representative sample. Use this data to estimate mode-share and compare to a local average or typical condition.
- Install counting devices or sensors to count pedestrians or cyclists over a period of interest.
- Use video or time-lapse photography to estimate the number of users of a given mode over a period of time of interest.
- Conduct a survey of site users to determine their mode of transportation or whether the design intervention affected their mode choice.

Reduction in vehicle miles traveled

- Consult records from a local transportation department. Compare pre- and post-project data.
- Conduct a survey of those who live, work, or attend school on the site to determine if private vehicles are used less for daily trips than they were prior to the project or compared to a local average. Estimate the reduction in vehicle miles traveled.
- Convert mode-share data into an estimated reduction in vehicle miles traveled based on assumptions about trip origin and distance.

Increase in key connections

- Reference project documents to identify key linkages that were created as part of the project. This metric is most applicable when sections of trail, sidewalk, bike lanes, or bridges provide connections that had been missing from a larger network.

Photo: D.A. Horchner/Design Workshop

Daybreak Community

South Jordan, Utah | Design Workshop, 2004-2025

Reduces auto trips with 88% of neighborhood students currently walking or riding bikes to school. This is expected to reduce auto trips by 2.3 million miles a year at build-out.

Project Overview

This 4,127-acre mixed-use community project was planned on surplus mining land and will accommodate over 20,000 residential units, approximately 9.1 million sf of commercial space, and 20,000 jobs at build-out. The extensive park and open space areas integrate stormwater management with natural systems. The community is a sustainable new urbanist development with walkable streets, an extensive trail system, native and drought-tolerant plants, habitat conservation areas, and amenities made out of recycled materials.

Method

A 2010 study by the University of Utah's Department of Family and Consumer Studies showed that 88% of students in Daybreak walked to school.

US Census Bureau data was used to determine the current proportion of households with children, and this was used to project the number at build-out. This provided an estimate of 14,360 families (71.8% of 20,000 total residential units).

To determine annual trip miles that would be driven, a half-mile trip was estimated twice daily for 180 school days for each of the 14,360 families, totaling 2,584,800 miles. Because 88% of students walk to school, the number of trip miles saved is 2,274,624.

It should be noted that this assessment utilized projected populations at build-out.

10 Access & Equity

Creating or improving access to facilities and amenities

Introduction

Access to high-quality parks, bike and pedestrian facilities, open space, and other landscapes is an important social and environmental justice issue. Access is especially crucial for underserved populations, such as minority groups, children, the elderly, people with disabilities, and the poor. In addition to physical access, inclusivity is important to address social and psychological barriers.

Access and equity can be improved by locating parks and infrastructure in underserved and disadvantaged areas, creating new connections, and ensuring that facilities are universally accessible. The design process, programming, and ongoing outreach play key roles in ensuring that sites are inclusive and serve the needs of diverse users.

Assessment Considerations

Scale: Use, accessibility, and inclusiveness are typically assessed at the site scale. Equity and access to facilities are typically assessed at the neighborhood, city, or regional scale and must consider existing facilities, context, population demographics, and design intent.

Methods: Metrics rely on population and spatial information or fieldwork. Most parks departments have readily-available information about facilities, and the US Census Bureau has data on neighborhood demographics. Direct observation and surveys can be used to collect information on use or perceptions. On-site convenience surveys may not be sufficient to assess access and inclusion, which must take into consideration not only those using the space but also those who are not.

Difficulty: Level of service assessment can be conducted remotely if adequate information is available. Surveys or observation studies require expertise and time to create and implement. (See p. 51, A Note on Surveys.)

Timeframe: This assessment can be conducted upon project completion. Site observations and surveys can be conducted upon project completion but may be more accurate after several seasons when use patterns stabilize.

Resources

Trust for Public Land: ParkScore

US Census Bureau

POTENTIAL METRICS

Increase in level of service

- Consult studies or use data from local parks departments, census data, and spatial analysis to determine the level of service, such as acres of parkland per 1,000 residents or playgrounds within a 10-minute walk. Compare pre- and post-construction conditions or compare to local or regional averages or level of service standards. This metric is most relevant for new facilities in underserved communities.

Site or facility use by target population

- Consult records from the owner, operator, or other entity that programs and tracks use of the site. If the project was an improvement to an existing site, the change in visitation or use prior to and after the project can be reported.
- Use direct observation to count visitation or use by collecting representative samples. This method is most applicable for sites specifically designed to meet the needs of a target population, such as a universally accessible playground.

Perception of inclusiveness

- Conduct a survey of site users and those who live or spend time in the vicinity to determine if the space is perceived as inclusive or whether the design intervention changed their perceptions of it. The survey should include demographic questions to assess if populations of interest are being served.

Quality of the visitor experience

- Conduct a survey of site users or of those from a population of interest, such as people with disabilities or those experiencing homelessness, to determine the nature and quality of their experience. Questions should focus on issues of access and inclusion.

Photo: Lamb Studio

Vista Hermosa

Los Angeles, California | Studio-MLA, 2008

Increased the number of publicly-accessible soccer fields in the neighborhood from 2 to 3, which represents 2.6 soccer fields per 100,000 residents, as compared to the county-wide ratio of 4 per 100,000 residents.

Project Overview

Located at the edge of a dense urban neighborhood, Vista Hermosa was the first public park constructed in downtown Los Angeles in over 100 years. Formerly a hazardous gas field, the park provides residents of the previously park-poor, primarily Latinx neighborhood with opportunities for active and passive recreation along with access to nature and its restorative qualities. The site's new soccer field is regulation-size and made of synthetic turf. All stormwater runoff from the soccer field is collected in a 20,000-gallon cistern.

Method

The 2016 Los Angeles Countywide Parks and Recreation Needs Assessment was used to determine soccer field averages for both Los Angeles County and the United States.

Westlake neighborhood data came from the report's Westlake section, which provided the soccer field count for the neighborhood and the area's population.

03. ECONOMIC BENEFITS

AT&T Performing Arts Center: Sammons Park | SmithGroup

(Photo: SmithGroup)

ECONOMIC BENEFITS

1. **Property Value**
   Adding value to the site or adjacent properties

2. **Operations & Maintenance Savings**
   Reducing ongoing costs associated with operations and upkeep

3. **Construction Cost Savings**
   Reducing one-time costs associated with project implementation

4. **Job Creation**
   Providing employment as part of construction or ongoing operations

5. **Visitor Spending & Earned Income**
   Generating revenues from those who visit and use the site

6. **Tax Revenue**
   Generating revenues through property and sales taxes

7. **Economic Development**
   Catalyzing real estate and business investment

1 Property Value

Adding value to the site or adjacent properties

Introduction

Property values are perhaps the most tangible indicator of the economic performance of a site. While higher property values can benefit the owner and tax base, they can also lead to lack of affordability and displacement.

The outdoor environment has a significant impact on the value of commercial, residential, and other types of development. This includes areas on the property itself as well as streets, nearby spaces, and views. Research has correlated property value increases to a number of specific landscape elements including street trees, green roofs, and high quality plantings, as well as walkability, proximity to a park or open space, and high-quality views.

Assessment Considerations

Scale: Property value may be assessed for a specific site or for sites in the vicinity of a landscape intervention. The analysis should consider data for the neighborhood, city, or region as a whole over the same time period to account for wider real estate and economic trends.

Methods: In the US, assessed value and other property information are in the public record, and many municipalities make these available online. Sales prices may be in the public record and can be found on many property listing websites. Automated valuation models like those offered on Zillow and Redfin predict a home's value based on recent sales and area list prices, but these should be used judiciously because many will estimate a value even when data is limited. Property managers can provide information on residential and commercial rents. If different properties are being compared, they should be similar in location, size, and amenities. When comparing over time, properties may show an increase, stabilization, or smaller decline than comparative properties, depending on the overall market.

Difficulty: This assessment can be conducted remotely if adequate data is available. Many factors contribute to property values, sales prices, and rents, which may make it difficult to attribute changes to the project alone.

POTENTIAL METRICS

Increase in assessed value, sales price, or rent (total or percent)

- Use data from public records, property listings, or a property manager to determine the increase in the value of a property with on-site landscape improvements as compared to the before condition or to a comparable property.

Average increase in assessed value, sales price, or rental rates of nearby properties (total or percent)

- Use data from public records, property listings, or a property manager to determine the average increase in value for properties adjacent to a landscape improvement as compared to the before condition or to similar properties not neighboring the improvement.

Timeframe: This assessment can be performed upon project completion if a property is fully sold or rented out when it delivers. More commonly, the assessment should be performed a year or more after project completion once property assessments, sales prices, or rental rates have had time to adjust. The data should be reported over a time period that is sufficient to show a clear trend that is to some extent attributable to the project.

Resources

Zillow

Redfin

Nationwide Environmental Title Research (NETR): Public Records Online Directory

Photo: John Gollings/Hargreaves Associates

Renaissance Park

Chattanooga, Tennessee | Hargreaves Associates, 2006

Catalyzed a 821% increase in aggregate land value within a quarter mile of the park between 2005 and 2013, compared to a 319% increase within the same North Shore Neighborhood but further from the park over the same period.

Project Overview

Renaissance Park is a 22-acre urban brownfield redevelopment project within Chattanooga's nationally-recognized Tennessee River Park. The project transformed a blighted post-industrial site known to be leaching contaminants into surface and groundwater resources into a celebrated public park that has been a catalyst for reinvestment in Chattanooga's growing Northshore neighborhood.

Method

Current and historical data from the Hamilton County assessor's office were examined and revealed stable land values within the study area leading up to the commencement of the park's construction in 2004-2005.

An 821% increase in the aggregate land value of 338 properties within a quarter mile of the park was observed between 2005 and 2013. This growth was benchmarked against the 319% increase in the aggregate land value of the 973 parcels within the North Shore Neighborhood that are outside of the study area during the same period.

A significant spike was noted between 2009 and 2010, which is the first year in the county records that 245 new condominiums were reflected in tax records. If land values associated with these new condominiums is removed, a significant increase of 477% remains.

2 Operations & Maintenance Savings

Reducing ongoing costs associated with operations and upkeep

Introduction

Design decisions can result in significant savings over the life of a project due to reduced energy and water use, lower maintenance and labor costs, and savings on other aspects of operating and maintaining the space.

Thoughtful site and planting design can create resilient, self-sustaining landscapes that require less maintenance and fewer inputs than conventional plantings. Sustainable energy and water infrastructure lead to costs savings through avoidance. Choices of landscape materials, efficient fixtures, and smart systems can save on operating and replacement costs.

Assessment Considerations

Scale: Operations and maintenance savings are typically assessed for an individual site or portion of a site.

Methods: Metrics rely on utility bills, maintenance records, or estimates. Reductions in water, energy, and fuel use can be converted into cost savings using applicable rates. Plant maintenance needs can be estimated based on species type and application, such as turf grass lawns which require regular mowing. General parameters for life span and replacement needs can be used to make comparisons for many landscape elements, such as perennial versus annual plants or LED versus halogen bulbs.

Difficulty: This assessment involves performing simple calculations. If inadequate data exists to make comparisons, assumptions can be made about the before condition or a comparable conventional landscape.

Timeframe: This assessment can be performed upon project completion if the savings are based on estimates. If using utility bills or maintenance records, having at least a year of data is recommended to account for seasonal variation.

Resources

OpenEI: US Utility Rate Database (*Electric Utility Rates*)

University of North Carolina at Chapel Hill: Financial Sustainability and Rates Dashboards (*Drinking Water and Wastewater*)

POTENTIAL METRICS

Savings on water costs

• Calculate the overall potable water cost savings by using utility bills to determine the total annual cost. Compare it to the cost prior to the project or to potable water costs at a conventional site.

• Convert estimated water use reductions associated with plant selection or a particular system on the site, such as an efficient irrigation system, to a monetary value using a local utility rate. (See Water Conservation.)

• Calculate annual cost savings associated with on-site stormwater management using utility bills or rate/fee structure documents. (See Stormwater Management.) This metric only applies in jurisdictions that impose stormwater fees based on actual or estimated runoff.

Savings on energy costs

• Calculate the overall energy cost savings by using utility bills to determine the total annual cost. Compare it to the cost prior to the project or to energy costs at a conventional site. (See Carbon Sequestration & Avoidance.)

• Convert estimated energy use reductions associated with a particular system on the site, such as a green roof or solar panels, to a monetary value using a local utility rate. (See Energy Use.)

Savings on maintenance costs

• Consult records from the site owner or operator to determine actual or estimated maintenance costs. Compare to costs prior to the project or to a conventional site.

• Estimate the labor and fuel costs for landscape maintenance activities like mowing. Compare to costs prior to the project or to a conventional site.

• Estimate savings from longer life span or lower replacement costs of sustainable plants, materials, and systems compared to conventional ones.

Photo: SmithGroup

Carmel Clay Central Park

Carmel, Indiana | SmithGroup, 2007

Saves $54,000 in annual maintenance costs by introducing native plant species in open areas instead of turf.

Project Overview

The town of Carmel has the second-largest concentration of commercial office space in Indiana but had no parks before the Parks District was formed 21 years ago. As real estate pressures expanded, residents expressed a desire for a park on the site of the last remaining local farm. Clay Central Park is a 161-acre park that is now known as the "crown jewel" of the park system and includes 60 acres of woodland, 40 acres of restored prairie, 6.5 acres of wetlands, and more than four miles of trails. The park provides opportunities for recreation and relaxation for the city's 80,000 residents and draws visitors from neighboring Indianapolis and other cities.

Method

An interview with the Director of Carmel Clay Parks and Recreation revealed that annual maintenance costs for turf areas were $1,400 per acre and maintenance costs for prairies and natural areas were $50 per acre annually. The park has approximately 15 acres of turf and 40 acres of prairie/natural area.

To show how much is saved by the prairie acreage, the 40 acres of prairie was multiplied by cost per acre to reveal the total maintenance cost if it had been a conventional turf landscape ($56,000) as well as the cost for the prairie landscape ($2,000).

The difference between the two totals reveals the amount saved annually by planting native vegetation instead of turf on 40 acres of the site.

3 Construction Cost Savings

Reducing one-time costs associated with project implementation

Introduction

Siting, design, and staging decisions have a direct impact on construction costs. While some sustainable solutions have higher upfront costs, many have similar costs or can even result in construction cost savings.

Limiting clearing and grading, balancing cut and fill volumes, and repurposing demolition materials as fill can save on earthwork costs. Repurposing materials from the existing site can be more economical than importing or disposal. Green infrastructure to manage stormwater and flooding is usually less expensive than conventional pipes and holding tanks. Other sustainable material choices may have lower upfront costs.

Assessment Considerations

Scale: Construction cost savings are typically assessed for an individual site or portion of a site.

Methods: Construction cost savings can be determined as costs avoided or by comparing actual or estimated costs to the material and/or installation costs of a conventional material or system. A number of rule-of-thumb estimates for earthwork, transportation, and disposal are available online. Contractors may also be able to provide estimates. Material costs can be obtained from suppliers. Local sources should be consulted whenever possible.

Difficulty: This assessment can be conducted remotely if the information can be obtained from project documents. It involves performing simple calculations.

Timeframe: This assessment can be performed upon project completion.

POTENTIAL METRICS

Reduction in earthwork costs

• Reference project and construction documents to determine the area or volume of earthwork avoided through siting, design, and material decisions. Estimate the cost savings using local cost estimates for excavation, grading, imported fill, and/or off-site disposal.

Reduction in hauling and disposal costs

• Convert the amount of waste avoided through design decisions or material reuse to a cost savings using local disposal rates. (See Reused & Recycled Materials and Waste Reduction.)

Reduction in materials costs

• Reference project documents to determine sustainable systems and materials used. Compare the actual or estimated cost of one or more of these to the cost of a conventional system or material, such as reclaimed wood versus new lumber. Ideally, this comparison should also factor in any additional transportation or installation costs.

Photo: Kodiak Greenwood

Cavallo Point

Sausalito, California | Office of Cheryl Barton, 2008

Saved nearly $140,000 in earthwork costs during construction by using the building pads of 14 demolished non-historic buildings to support new structures.

Project Overview

This "post-to-park" transformation of Fort Baker to Cavallo Point was designed to reduce the environmental and economic burdens on the new owner, the National Park Service. Reusing existing infrastructure and reverting much of the landscape to native plantings helped reach the client's goal of financial sustainability. Adaptive reuse of this National Landmark District resulted in a state-of-the-art conference center, the restoration of endangered habitat, and the regeneration of public open space.

Method

Construction documents were consulted to determine that 14 building pads with an average size of 2,200 sf were reused on the site. Constructing a building pad typically involves a four foot depth of fill and off-haul, which costs $30 per cubic yard to remove on sloped sites such as Cavallo Point.

Volume of building pad material was calculated using these numbers and equalled 8,800 cu ft or 326 cubic yards.

The number of cubic yards was then multiplied by the cost per cubic yard to equal $136,900.

4 Job Creation

Providing employment as part of construction or ongoing operations

Introduction

Land development projects involve many person-hours for design, construction, and project management, with more time required for projects that are larger or more complex. Though these direct jobs are temporary, many developments also create permanent jobs in operations and maintenance or contribute to indirect job creation.

Designed landscapes often result in the creation of full-time permanent employment for land and facilities managers, site operators, concessionaires, maintenance crews, and other support staff. Because many jobs in landscape operations and maintenance do not require prior experience or specialized education, these positions may also provide a social benefit by offering transitional jobs or employment opportunities for vulnerable groups, such as people with disabilities, ex-offenders, and recent immigrants.

Assessment Considerations

Scale: Job creation is typically assessed for an individual site or development project.

Methods: Temporary jobs in design and construction can be determined from records of personnel or person-hours devoted to a project. Alternatively, the number of jobs can be estimated using project expenditures. A number of researchers and organizations have developed national and regional estimates of jobs created per amount spent on construction, capital, or infrastructure investment. The type and number of permanent or seasonal jobs created can be obtained from site or property managers.

Difficulty: This assessment can be conducted remotely if adequate information can be obtained from project documents, project managers, or site management.

Timeframe: Temporary jobs created during the design and construction process can be assessed upon project completion. The creation of ongoing jobs can be assessed once permanent or seasonal staff has been hired and positions established. Having data for multiple years is recommended to confirm that the jobs are stable from year to year.

POTENTIAL METRICS

Number of temporary jobs created during design and construction

- Reference project documents or consult records from the project manager to determine the number of jobs or person-hours worked. Convert these to full-time equivalent jobs.
- Consult records from the site owner or project manager to obtain project expenditures. Use a regional or national ratio to estimate the number of jobs created per amount spent on construction, capital, or infrastructure investment.

Number of permanent or seasonal jobs created

- Consult records from the site owner or operator to determine the number of permanent or seasonal staff positions created as a result of the project.

Photo: OJB Landscape Architecture

Klyde Warren Park

Dallas, Texas | OJB Landscape Architecture, 2012

Creates 8 full-time and 5 part-time jobs in maintenance and operations, in addition to approximately 68 temporary jobs that were created during design and construction.

Project Overview

Klyde Warren Park is a landmark central open space that spans the eight lane, sunken Woodwall Rogers Freeway, bridging Dallas' Uptown and Arts District neighborhoods. It is the world's largest suspended infrastructure to contain a park and provides new programmed public space that physically, socially, and culturally connects two bustling districts. Complex technical engineering solutions structurally support massive loads above the busy freeway while allowing for an open, flexible park layout with sufficient soil to support a variety of trees and plantings.

Method

The Park at Dallas Foundation provided archival data for full-time and part-time jobs created.

To estimate job creation during construction, the Consulting Project Manager provided construction person-hours, which were used to calculate indirect jobs.

Total construction person-hours and consultant hours were divided by a 40-hour work week, and the resulting number of 40-hour work weeks were divided by 130 construction weeks to estimate 68 temporary jobs created.

5 Visitor Spending & Earned Income

Generating revenues from those who visit and use the site

Introduction

Exemplary places have the ability to attract local, regional, national, and international visitors. Particularly popular, well-known, or iconic sites can draw hundreds of thousands or even millions of visitors per year, which can have a significant impact on the economy of a city or region.

A number of parks, trails, public spaces, and other designed landscapes serve as a primary draw for tourists. Many sites generate earned income through entrance and parking fees or fees for particular activities, such as bike rentals, guided tours, or amusement rides, as well as revenue from on-site concessions or retail establishments. Sites may also have sports fields or specific areas that can be rented for picnics, parties, weddings, or special events.

Assessment Considerations

Scale: Earned income is typically assessed at the individual site scale. For visitor spending, because a site can be part of a larger tourist area or network of sites, it is important to consider the context and the role the site plays in relation to other facilities in the vicinity.

Methods: Earned income can be determined from site operator or concessionaire records of sales, rentals, or fees collected. Net revenue can be calculated if expenses associated with providing the service and/or operating and maintaining the space are considered. If the project was an improvement to an existing site, the change in revenue prior to and after the project can be reported. If an economic impact study has been previously conducted for the site, city, or region, it may include an estimate of visitor spending. The site's contribution to visitor spending for a larger area can be estimated if the percentage of tourists that visit the site is known.

Difficulty: Assessment of earned income is straightforward and involves performing simple calculations. Visitor spending is a more complicated metric, typically calculated from a per visitor spending average for various visitor segments. Therefore, it can be challenging to try to translate visitor spending for a city or region into the spending impact of a particular site.

POTENTIAL METRICS

Revenue or net revenue from entrance or parking fees

• Consult records from the site owner or operator to determine annual revenue from fees charged at the site.

• Estimate entrance or parking fee revenues collected based on the fee amount and site visitation. (See Recreational & Social Value.)

Revenue or net revenue from sales

• Consult records from the site owner, operator, or concessionaire to determine sales revenues from restaurant or retail establishments, activity fees, equipment rentals, or other goods and services sold on or adjacent to the site.

Revenue or net revenue from facility rentals

• Consult records from the site owner or operator to determine revenues from use permits or rental of on-site spaces or facilities.

Proportion of site visitors that patronize local businesses (percent)

• Conduct a survey of users to determine whether they patronize on-site or nearby businesses when visiting the site. Questions can also ask about the nature of their spending.

Total visitor spending

• Reference economic impact analyses for the site, city, or region that include estimates of direct visitor spending. If source data are available, they may be useful in translating city or regional spending into an estimate attributable to the site, particularly if the percentage of tourists who visit the site is known.

Timeframe: This assessment should be conducted a year or more after project completion when visitation and use patterns stabilize. Having at least a year of data is recommended to account for seasonal variation.

Photo: Wyss Associates

Mount Rushmore Visitor Services Redevelopment

Keystone, South Dakota | Wyss Associates & DHM Design, 2001

Generates an average of $3,895,000 in annual parking revenue and contributes to Mount Rushmore's impact on the regional economy, totaling $346 million in visitor spending annually.

Project Overview

Located in the Black Hills of South Dakota, the iconic Mount Rushmore National Memorial attracts nearly 2 million visitors per year. Prior to the redesign of the Visitor Services area, the memorial was being "loved to death" as its infrastructure was inadequate for both predicted and desired visitorship, particularly parking accommodations, pedestrian and vehicular circulation, and access to the sculpture. The redesign created low-profile terraced parking that increased the number of parking spaces from 120 to 600, added new interpretive facilities, and widened trails to accommodate users of all abilities and welcome a steadily increasing flow of visitors to the memorial.

Method

The 2007-2014 annual reports of the Mount Rushmore Society, which operates the parking facility, were consulted to determine the average annual parking revenue generated by the two new parking garages.

A 2013 National Park Service report was consulted for the estimated the impact of the park on the regional economy. A 2013 on-site National Park Service survey asked participants to record expenditures in the park and within a 100-mile radius, and the report divided visitors into segments to show differences in spending for lodging and other daily expenditures among local visitors, day trip visitors, motel visitors, and campers.

Total spending within the local region was calculated by multiplying the number of visitor trips for each segment by the average spending per trip, for an estimated total of $345,969,000 spent by Mount Rushmore visitors in the region in 2013.

6 Tax Revenue

Generating revenues through property and sales taxes

Introduction

In the US, most local government entities impose a tax on real property. All but five states impose sales taxes on various goods and services, and many cities and counties have additional local sales taxes. These taxes are important sources of revenue for state and local governments.

Because the outdoor environment affects property values, landscape interventions can raise the assessed value and therefore the tax collected for a site or its adjacent properties. Landscape and infrastructure projects can also catalyze economic development or redevelopment in the surrounding area, which in turn increases the property tax base. Visitor spending at on-site or nearby businesses also generates sales tax revenue.

Assessment Considerations

Scale: Tax revenue may be evaluated for a specific site or for sites in the vicinity of a landscape improvement. The analysis should consider data for the neighborhood, city, or region as a whole over the same time period to account for wider real estate and economic trends.

Methods: In the US, assessed property value is public record, and many municipalities make the assessed value as well as the annual property tax amount available online. The amount of sales tax collected and paid by a particularly entity can only be obtained from the records of that business; it is not public information. Business improvement districts or other economic development entities may gather sales revenue information for an entire district, which can be used to estimate sales tax revenues. Tax revenue increases attributable to landscape should come from an increase in property value or overall sales, not from a change in tax rate. If property or sales tax revenues will be evaluated for establishments outside of the site boundaries, evaluators will need a strategy to determine which properties are influenced by the landscape intervention.

Difficulty: This assessment can be conducted remotely if adequate data is available. Many factors contribute to property values and the sale of goods and services, which may make it difficult to attribute changes to the project alone.

POTENTIAL METRICS

Increase in property tax revenue from a site (total or percent)

• Consult public records or records from the site owner or property manager to determine the increase in property taxes for a site before and after a landscape intervention. Property taxes can be calculated from assessed value and the local property tax rate. (See Property Value.)

Increase in property tax revenue from nearby properties (total or percent)

• Consult public records or records from site owners or property managers to determine the increase in property taxes before and after a landscape intervention for properties nearby or adjacent to the improvement. This can include existing properties, as well as any new development or redevelopment. (See Property Value.)

Increase in annual sales tax revenue (total or percent)

• Consult records from the site owner, operator, concessionaire, and/or nearby businesses to determine total annual sales taxes paid for goods and services sold on or near the site. (See Visitor Spending & Earned Income.) Compare total sales tax revenue before and after the landscape intervention.

Timeframe: Evaluation of property tax revenues is most commonly performed a year or more after project completion once property assessments have had time to adjust. The data should be reported over a time period that is sufficient to show a clear trend that is to some extent attributable to the project.

Assessment of sales tax revenues should be conducted a year or more after project completion when visitation and use patterns stabilize. Having at least a year of data is recommended to account for seasonal variation.

Photo: D.A. Horchner/Design Workshop

Bagby Street Reconstruction

Houston, Texas | Design Workshop, 2013

Contributed to a $53 million (26%) increase in collected property taxes from 2013 to 2015.

Project Overview

The Bagby Street Reconstruction is a 12-block transformation of a vehicular road that connects downtown to the medical district in the heart of Houston. The neighborhood is mixed-use with numerous multifamily and commercial developments. Instead of following the conventional approach of a universal cross-section for the entire corridor, the design uses block-by-block context-sensitive design solutions tailored to each specific location with common materials, planting, lighting, and signage providing continuity along the entire corridor. The Bagby Street Reconstruction has established a new benchmark for streets in Houston and beyond.

Method

Property tax revenue data from the Bagby Street corridor from 2012-2015 was analyzed. This data was obtained from the Midtown Redevelopment Authority. Dollar amounts were adjusted for inflation using the United States Department of Labor CPI Inflation Calculator.

Total appraised value, adjusted for inflation, was used to calculate dollar amount and percent increase.

7 Economic Development

Catalyzing real estate and business investment

Introduction

Quality of life and quality of place play a key role in attracting and retaining people and businesses. Therefore, designed landscapes can be an important part of an economic development or revitalization strategy for a neighborhood, city, or region.

Landscape projects can catalyze development by reclaiming unusable or underutilized land through environmental remediation, provision of flood or storm surge protection, adaptive reuse of obsolete infrastructure, renovation of derelict spaces, and creating access. Public parks and plazas, trail systems, waterfront redevelopments, and streetscape improvements can increase the desirability of nearby real estate and spur additional investment in projects and businesses.

Assessment Considerations

Scale: Real estate and business investment may be assessed for a specific site or for sites in the vicinity of a landscape improvement. The analysis should consider data for the neighborhood, city, or region as a whole over the same time period to account for wider real estate and economic trends. If the landscape project occurred in conjunction with rezoning, additional development, or other factors, it should be framed as a contributor to, rather than the cause of, increased investment.

Methods: Metrics rely on documentation of real estate investment or business growth. Municipal governments and other economic development entities frequently track this type information. Often an economic impact analysis is conducted to justify the costs of major landscape and infrastructure projects, and these studies include projections for new development and investment that will be catalyzed.

Difficulty: This assessment can be conducted remotely if adequate data is available. Many factors contribute to real estate investment and business growth, which may make it difficult to attribute changes to the project alone.

POTENTIAL METRICS

Amount of additional investment or projects catalyzed

- Consult records from the municipal government, economic development authority, or private developers to determine built or planned real estate development projects that were catalyzed by the landscape intervention.
- Reference economic impact analyses that include projections for real estate development or investment that will be catalyzed by the project.

Increase in occupancy or decrease in vacancy rate (percentage points)

- Use data from the property owner or manager to determine the change in residential or commercial occupancy rates before and after a landscape intervention. This can apply to a property with on-site landscape improvements or to properties adjacent to a landscape project like a streetscape or plaza. Occupancy rates can also be compared to typical rates for the region or market.

Number of new businesses established

- Consult records from the municipal government, business improvement district, or another economic development entity to determine the number of new businesses that were opened or expanded as a direct result of the landscape intervention.

Timeframe: This assessment can be performed upon project completion if it is based on projections. Waiting several years can help to confirm that the anticipated investment has begun. The data should be reported over a time period that is sufficient to show a clear trend that is to some extent attributable to the project.

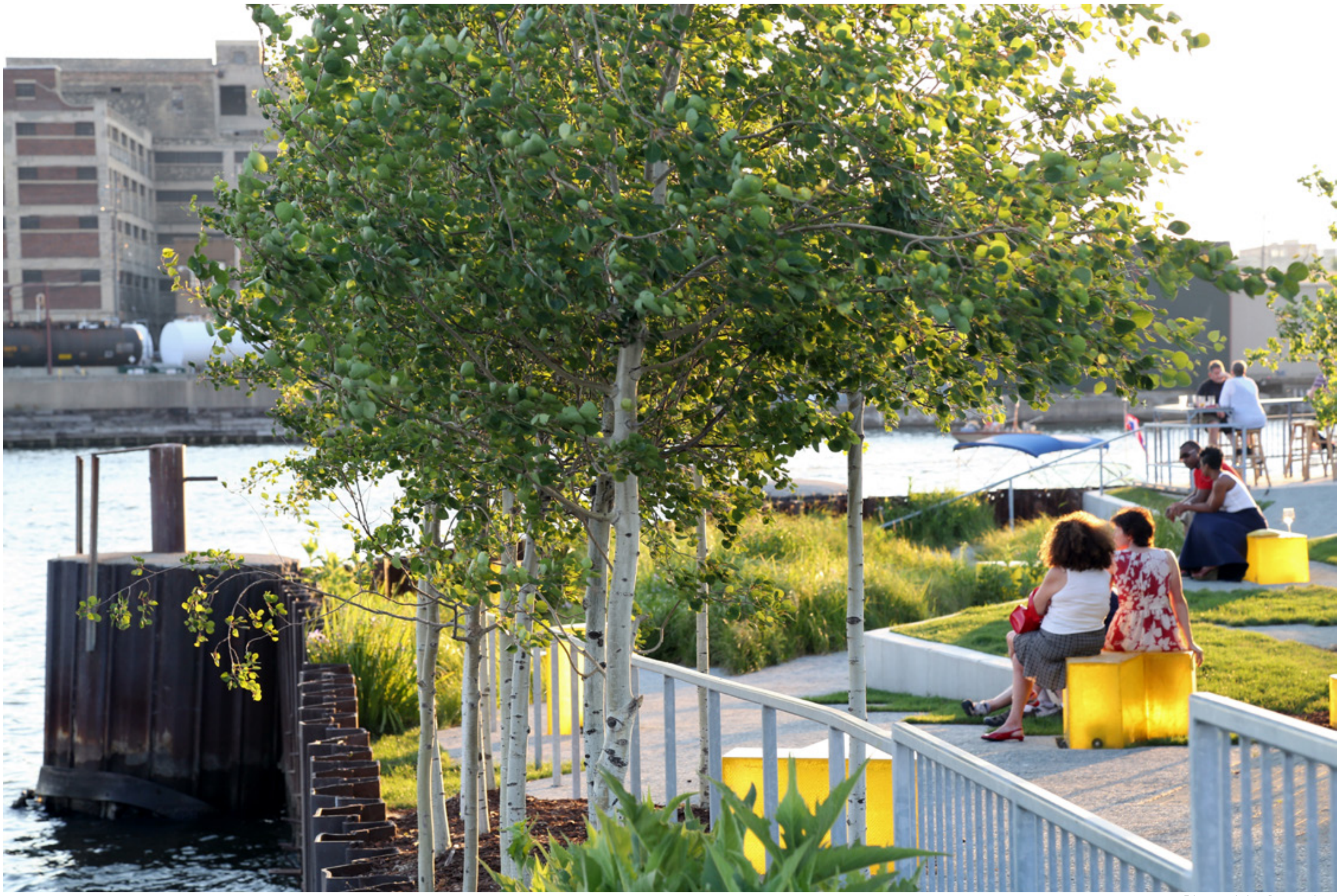


Photo: John December

Erie Street Plaza

Milwaukee, Wisconsin | Stoss Landscape Urbanism, 2010

Contributes to the economic development of the expanding Third Ward district, with 243 condominium units planned and adjacent mixed-use development attracting more than $120 million in investment capital in a previously derelict area.

Project Overview

Erie Street Plaza is a former parking lot at the confluence of the Milwaukee River and the Federal Channel that has been turned into one of a series of civic spaces along the Milwaukee Riverwalk, a three-mile pedestrian and bicycle corridor that connects downtown Milwaukee to the emerging Third Ward and Beerline Districts and lakefront. The plaza is a well-used, inventive, and ecologically-sensitive public space.

Method

The Milwaukee Department of City Development provided information on the number and value of condominium units and mixed-use developments planned in the district surrounding the park.

The Harbor Front and Hansen's Landing mixed-use development was planned to have 160 condominium units and a total investment of approximately $65.9 million. The Marine Terminal Lofts development was planned to have 83 condominium units and total investment of approximately $54.4 million.

Because this planned development had not yet been constructed at the time of the assessment, the figures could not be verified with actual constructed values.

04. ENDNOTES, SELECTED BIBLIOGRAPHY, & CREDITS

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CASE STUDY RESEARCH TEAMS

This guidebook uses examples from the *Landscape Performance Series* Case Study Briefs, a searchable database of over 140 exemplary built projects with quantified environmental, social, and economic benefits. The majority of Case Study Briefs are produced through the Landscape Architecture Foundation's *Case Study Investigation* (CSI) program, which funds select faculty-student teams to participate in a unique 6-month training and research collaboration, working with designers to assess performance and document each project.

Atlanta BeltLine Eastside Trail
https://doi.org/10.31353/cs0720
CSI Research Fellow: Brad Collett, University of Tennessee, Knoxville
Research Assistants: Angelike G. Angelopoulos and Luis D. Venegas
Firm Liaison: Valdis Zusmanis, Perkins + Will

Avalon Park and Preserve
https://doi.org/10.31353/cs0060
CSI Research Fellow: Kristina Hill, University of Virginia
Research Assistant: Michael Geffel

Bagby Street Reconstruction
https://doi.org/10.31353/cs1000
CSI Research Fellow: Allan W. Shearer, University of Texas at Austin
Research Assistant: Neive Tierney
Firm Liaisons: Alex Ramirez, Steven Spears, and Allyson Mendenhall, Design Workshop

Ballast Point Park
https://doi.org/10.31353/cs1220
Research Fellows: Simon Kilbane and Andrew Toland, University of Technology Sydney
Research Assistant: Kane Pham
Firm Liaisons: Philip Coxall, Ann Deng, and Benjamin Radjenovic, McGregor Coxall

Belo Center for New Media
https://doi.org/10.31353/cs1010
CSI Research Fellow: Allan W. Shearer, University of Texas at Austin
Research Assistant: Neive Tierney
Firm Liaison: Dan Sharp, Ten Eyck Landscape Architecture

Blue Hole Regional Park
https://doi.org/10.31353/cs0450
CSI Research Fellow: Jessica Canfield, Kansas State University
Research Assistant: Elise Fagan
Firm Liaisons: Allyson Mendenhall, Steven Spears, and Emily Risinger, Design Workshop

Brian C. Nevin Welcome Center, Cornell Plantations
https://doi.org/10.31353/cs0840
CSI Research Fellow: Michele A. Palmer, Cornell University
Research Assistant: Mujahid D. Powell
Firm Liaison: Tobias Wolf, Wolf Landscape Architecture

Canal Park
https://doi.org/10.31353/cs0870
Researcher: Jennifer Salazar, University of Maryland
Firm Liaisons: Michael Miller, Meghan Talarowski, and Karl-Rainer Blumenthal, OLIN

Carmel Clay Central Park
https://doi.org/10.31353/cs0470
CSI Research Fellow: M. Elen Deming, University of Illinois
Research Assistant: Paul Littleton
Firm Liaison: Patrick Brawley, SmithGroup

Castiglion del Bosco
https://doi.org/10.31353/cs0260
CSI Research Fellow: Victoria Chanse, University of Maryland
Research Assistant: Jennifer Salazar
Firm Liaisons: Richard D. Centolella and Derek Gagne, EDSA

Cavallo Point
Firm: The Office of Cheryl Barton

Central Wharf Plaza
https://doi.org/10.31353/cs0270
CSI Research Fellow: Victoria Chanse, University of Maryland
Research Assistant: Jennifer Salazar
Firm Liaisons: Eric Kramer and Ryan Wampler, Reed Hilderbrand

Cherry Creek North Improvements and Fillmore Plaza
https://doi.org/10.31353/cs0400
CSI Research Fellow: Bo Yang, Utah State University
Research Assistants: Yue Zhang and Pamela Blackmore
Firm Liaisons: Allyson Mendenhall, Jamie Fogle, and Todd Johnson, Design Workshop

Chester Arthur School
https://doi.org/10.31353/cs1310
Firm: Andrew Jacobs, Steve Buck, and Sara Pevaroff Schuh, SALT Design Studio

Daybreak Community
https://doi.org/10.31353/cs0190
CSI Research Fellow: Bo Yang, Utah State University
Research Assistant: Amanda A. Goodwin
Firm Liaison: Allyson Mendenhall, Design Workshop

The Dell at the University of Virginia
https://doi.org/10.31353/cs0090
CSI Research Fellow: Mary Hughes, University of Virginia
Research Assistant: Erica Thatcher
Firm: Biohabitats, Inc. and Nelson Byrd Woltz Landscape Architects

Dutch Kills Green
https://doi.org/10.31353/cs0610
CSI Research Fellow: Roxi Thoren, University of Oregon
Research Assistant: Andrew Louw
Firm Liaison: Eric Tamulonis, WRT Design

Erie Street Plaza
https://doi.org/10.31353/cs0430
CSI Research Fellows: Maria Bellalta and Aidan Ackerman, Boston Architectural College
Research Assistant: Jaryd McGonagle
Firm Liaison: Scott Bishop, Stoss Landscape Urbanism

High Desert Community
https://doi.org/10.31353/cs0200
CSI Research Fellow: Bo Yang, Utah State University
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Klyde Warren Park
https://doi.org/10.31353/cs0590
CSI Research Fellow: Taner R. Ozdil, University of Texas at Arlington
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Firm Liaison: Cody Klein, OJB Landscape Architecture

Magnuson Park Wetlands and Active Recreation
https://doi.org/10.31353/cs0370
CSI Research Fellow: Nancy Rottle, University of Washington
Research Assistants: Delia Lacson and Jessica Michalak

Millennium Park
https://doi.org/10.31353/cs0100
CSI Research Fellow: Dennis Jerke, Texas A&M University
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The Morton Arboretum: Meadow Lake and Permeable Main Parking Lot
https://doi.org/10.31353/cs0760
CSI Research Fellow: Mary Pat Mattson, Illinois Institute of Technology
Research Assistant: Sarah Hanson
Firm Liaison: Susan L.B. Jacobson, The Morton Arboretum

Mount Rushmore Visitor Services Redevelopment
https://doi.org/10.31353/cs0960
CSI Research Fellow: Matthew James, South Dakota State University
Research Assistants: Bailey Peterson and Erika Roeber
Firm Liaison: Patrick Wyss, Wyss Associates, Inc.

Napa River Flood Protection Project (1998-2012)
https://doi.org/10.31353/cs0520
CSI Research Fellow: G. Mathias Kondolf, University of California, Berkeley
Research Assistant: Shanna Leigh Atherton
Firm Liaison: Daniel Iacofano, MIG

Park Avenue/US 50, Phase 1 Redevelopment
https://doi.org/10.31353/cs0410
CSI Research Fellow: Bo Yang, Utah State University
Research Assistants: Yue Zhang and Pamela Blackmore
Firm Liaisons: Allyson Mendenhall, Richard Shaw, and Dori Johnson, Design Workshop

Renaissance Park
https://doi.org/10.31353/cs0660
CSI Research Fellow: Brad Collett, University of Tennessee, Knoxville
Research Assistant: Jessica Taylor
Firm Liaison: Gavin McMillan, Hargreaves Associates

Simon and Helen Director Park
https://doi.org/10.31353/cs0630
CSI Research Fellow: Roxi Thoren, University of Oregon
Research Assistant: Andrew Louw
Firm Liaison: Karl-Rainer Blumenthal, OLIN

South Los Angeles Wetland Park
https://doi.org/10.31353/cs1130
CSI Research Fellow: Kelly Shannon, University of Southern California
Research Assistant: Christina Hood
Firm Liaison: Sarah Curran, Psomas

Teardrop Park
https://doi.org/10.31353/cs0080
CSI Research Fellow: Kristina Hill, University of Virginia
Research Assistant: Michael Geffel

Vista Hermosa
https://doi.org/10.31353/cs1140
CSI Research Fellow (2016): Kelly Shannon, University of Southern California
CSI Research Fellow (2012): Barry Lehrman, California Polytechnic State University Pomona
Firm Liaison: Claire Latané, Mia Lehrer + Associates
Client Liaison: Lisa Soghor, Santa Monica Mountains Conservancy/Mountains Recreation and Conservation Authority