ECOSYSTEM SERVICES PLAN

Yale University School of Medicine Campus

Yale School of Forestry and Environmental Studies
May 2, 2011
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Executive Summary

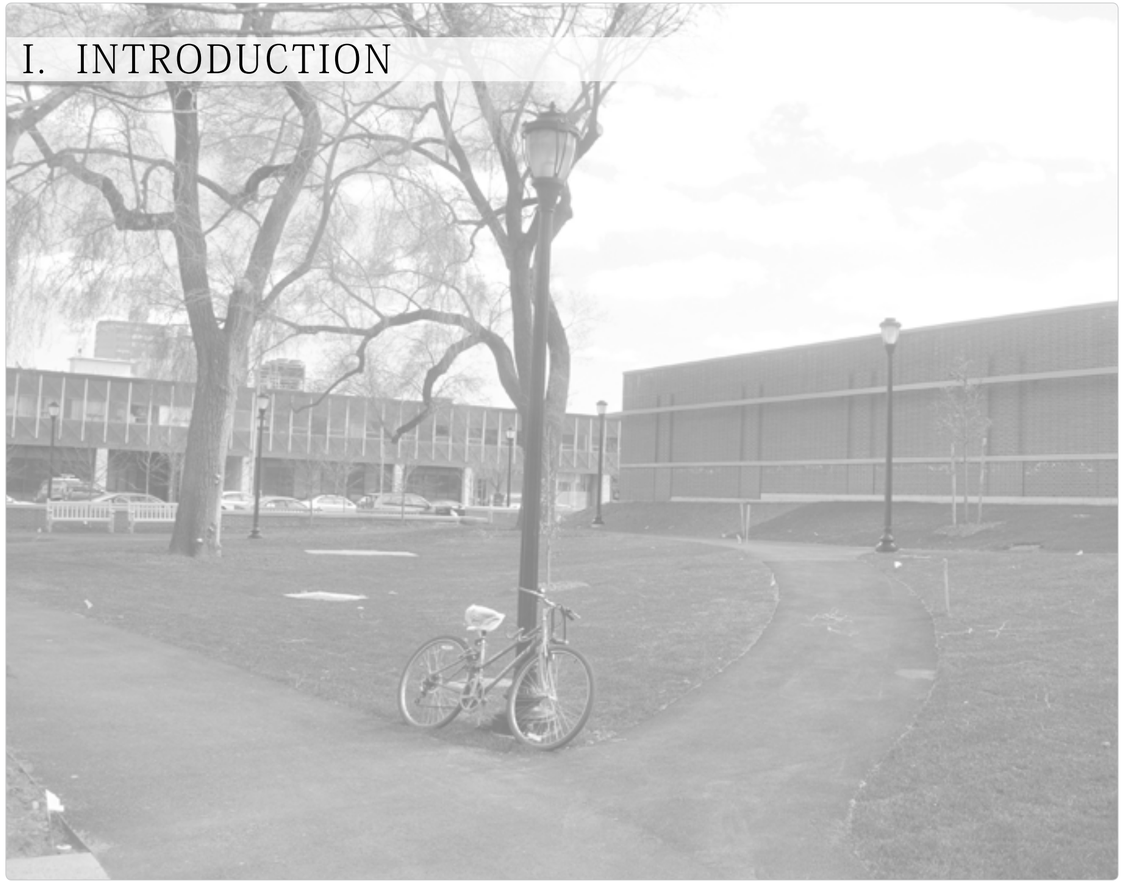
In 2010, Yale University committed to establishing an ecosystem services framework to guide its campus management and future development. In conjunction with that effort, students at Yale's School of Forestry & Environmental Studies completed preliminary analysis to show how ecosystem services management might be applied to water, climate, biodiversity and aesthetics on Yale's campus.

This report is part of the second phase of that effort. Looking specifically at the Yale School of Medicine (YSM) campus, our recommendations seek to integrate the campus's mission, community, and existing landscape. We see great opportunity for green infrastructure, through a series of small-scale but focused interventions, to promote health and healing while also increasing the resiliency and quality of the campus environment. The table below summarizes these recommendations.

Benefits of Proposed Techniques

Techniques	CLIMATE	BIODIVERSITY	WATER MANAGEMENT	AIR QUALITY	PHYSICAL HEALTH	MENTAL HEALTH	ENERGY CONSUMPTION
Street trees & sidewalk planting	Mid	Low	High	Low	Low	High	Mid
Seat walls & raised planters			Low		Low	Mid	
Vegetated parking lots	High	High	High	Mid	Mid	Mid	Mid
Rain gardens & bio swales	Mid	Mid	High		Low	Mid	
Storm water harvesting	Low		High				Mid
Green roofs and terraces	High	Low	High	Low			High
Green walls	Mid	Low	Mid	Low	Mid	Mid	Low
Courtyards	High	Low	High	Low	High	High	Mid
Winter gardens	High	High	Mid	Low	High	High	High

Impact:
Low
Mid
High



I. INTRODUCTION

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"Those who contemplate the beauty of the earth find reserves of strength that will endure as long as life lasts."

–Rachel Carson

Yale University's Sustainability Strategic Plan for 2010-2013 calls for Yale to implement an Ecosystem Services Plan which would improve land management on Yale's campus with regard to water, campus climate, biodiversity, and aesthetics. Yale has already commissioned one set of reports about ecosystem services on its campus (Hsu et al (2011), Carlisle et al (2011), Bouffard et al (2011), Banerjee et al (2011)). These reports recommended a range of strategies that advance Yale's Framework Plan for Campus Planning (2000).

This report presents a preliminary analysis of how the campus of the Yale School of Medicine could be managed using an ecosystem services framework grounded in restorative landscape design—design that draws inspiration from nature to promote health and healing. The findings of this report are based on in-person assessment as well as interviews with some of the campus's key stakeholders—Bruce McCann, the Director of Planning; Phil Sissick, the Director of Grounds Maintenance; and Channing Harris of Towers Golde, the landscape architecture firm responsible for designing most of the medical school campus.

Yale's medical school is one of the premier institutions in the world devoted to the teaching, research, and practice of healthcare. The campus has a legacy of innovative landscape design. This includes the courtyards designed by the legendary Beatrix Farrand in the 1920s and 1930s, and the healing garden that opened with the Smilow Cancer Center in 2009. At the same time, Yale's medical campus has much to learn from contemporary trends in restorative landscape design. This report examines how the landscape of the YSM campus could better reflect the school's academic mission of promoting innovative and experimental approaches to health and healing.

We begin this exploration in Section Two, which introduces the YSM campus. This section lays out our analysis of the current landscape design and the diverse stakeholder groups involved. It also includes our diagnosis of the current landscape's strengths and weaknesses.

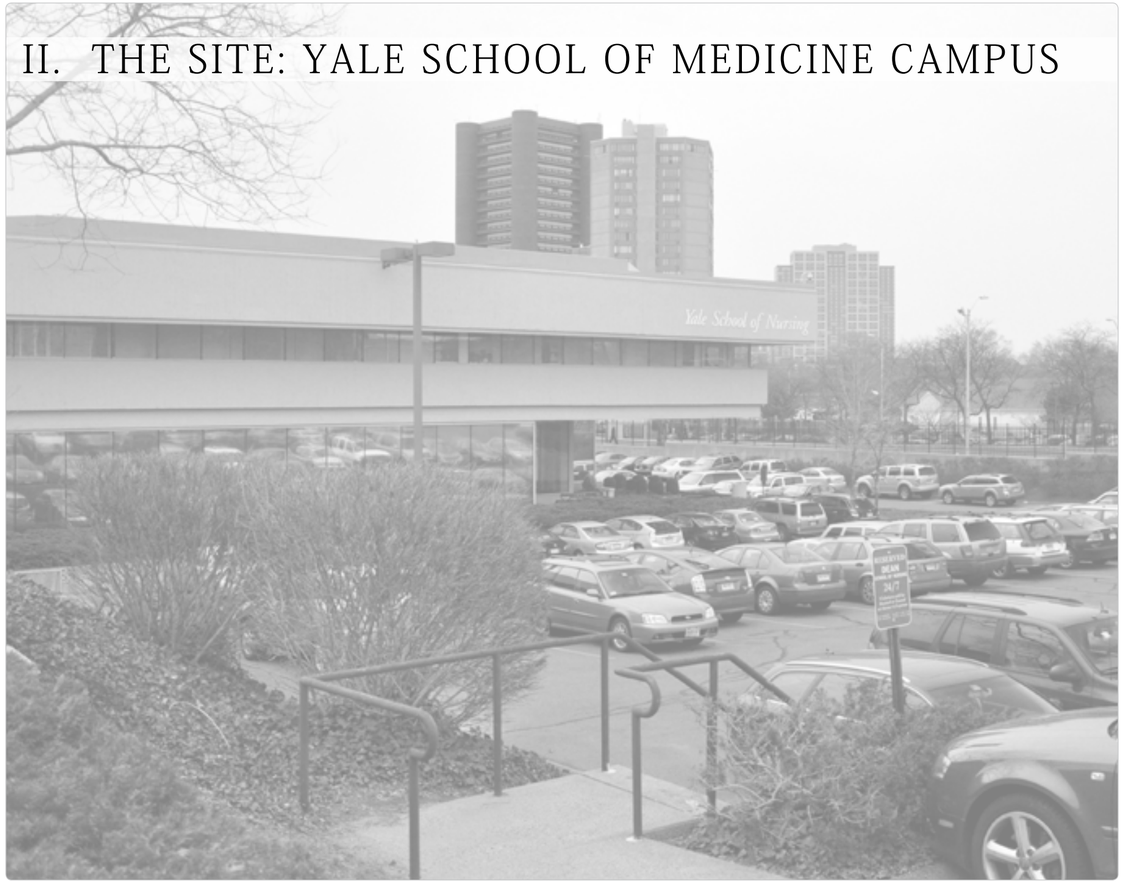
Section Three examines the history of restorative landscapes in medical settings. We discuss scientific validation for restorative landscape design and show how this approach can incorporate the ecosystem service based management recommended by Hsu et al (2011), Carlisle et al (2011), Bouffard et al (2011) and Banerjee et al (2011). This section goes on to describe innovative contemporary approaches to ecosystem services on other medical school campuses such as Philadelphia's Hershey Cancer Center, New York University Medical School's Enid Haupt Glass Garden, the University of California San Francisco's Medical School, and Duke Medical School.

Section Four prescribes techniques—such as green roofs, rain gardens, and winter gardens—to build on the strengths and address the weaknesses identified in our site assessment. This section discusses the specifics of the proposed techniques, where they might be appropriate, and how these strategies can achieve multiple ecosystem service benefits.

The Appendix provides additional resources. We review a number of tools, including the Living Building Challenge, the Healthy Building Network, the Sustainable Sites Initiative (SSI), and the Green Guide for Healthcare.

We hope that this report will inspire and assist Yale in implementing a bold, innovative, collaborative ecosystem services approach to restorative design on the School of Medicine campus.

II. THE SITE: YALE SCHOOL OF MEDICINE CAMPUS



II. THE SITE: YALE SCHOOL OF MEDICINE CAMPUS

Campus Overview

Yale's School of Medicine comprises a unique section of the university campus. Not only is it much younger – with many buildings constructed within the last seventy years – but it is also physically separated from the rest of campus by the Oak Street Connector. It is additionally defined by its close integration with Yale-New Haven Hospital. This integration brings a diverse mix of Yale and New Haven community members to the campus year-round.In its landscape, as we discuss in the typologies analysis that follows, the Medical School campus is heavily built up, with few large open spaces.

The combination of these factors presents a unique opportunity for the installation of green infrastructure – and for it to provide substantial ecosystem services benefits to the School of Medicine campus and its community.

Campus History

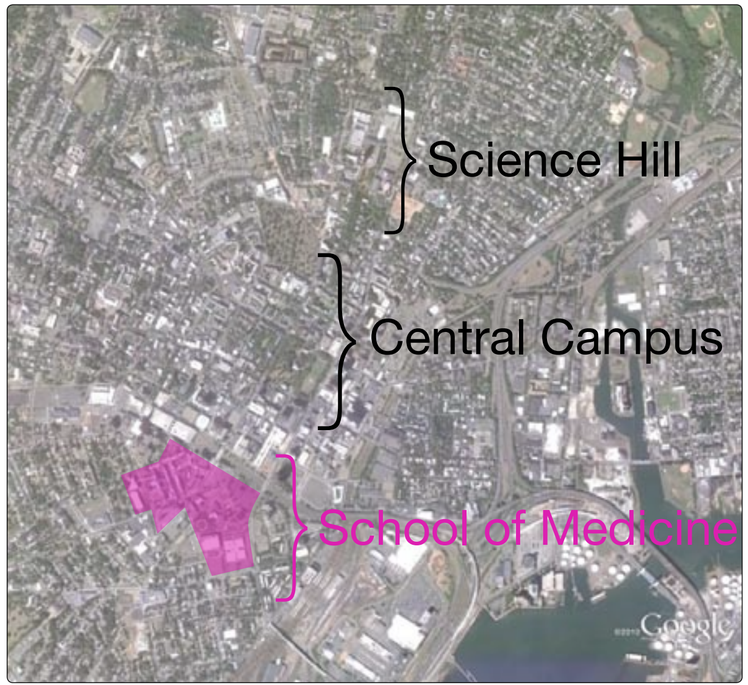
The original Yale School of Medicine was located on lower Hillhouse Street. According to Channing Harris, Senior Associate at Towers Golde, the original school featured an extensive medicinal plants garden. After the campus was moved to its current location, legendary landscape designer Beatrix Farrand introduced her theory of landscape design, represented in the Harkness Courtyard and in the trellis rose garden in the Sterling Hall of Medicine. Farrand emphasized native plants and shrubs in her design. She was also interested in how her plantings could reflect YSM's mission. For example, in the Harkness Courtyard, Farrand planted a sycamore tree supposedly originating from a tree that Hippocrates, the father of medicine, planted on the Greek island where he was born.

Sycamore in Harkness Courtyard

Drawing of Sterling Hall

Location

The Yale School of Medicine is the southernmost precinct in the corridor of Yale University's campus.

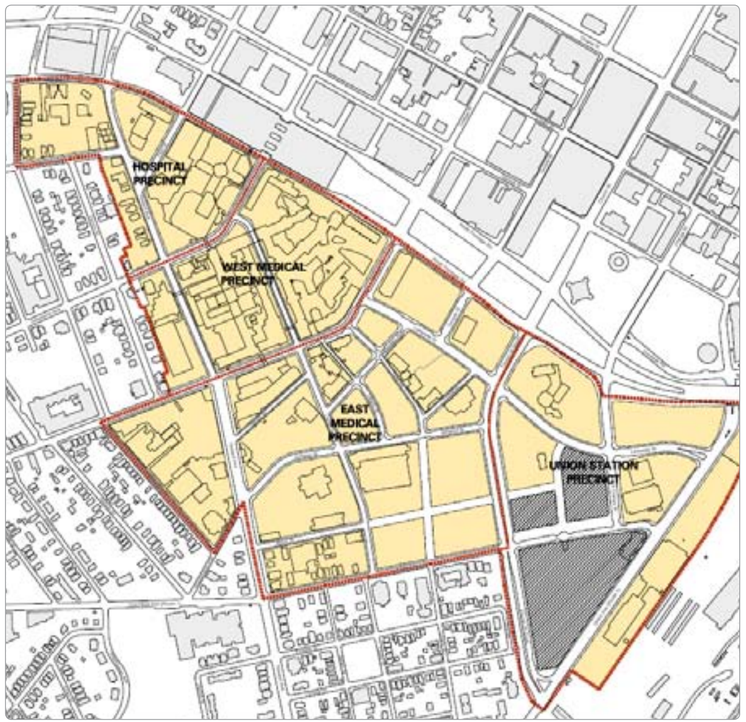


Aerial Photo of New Haven & Yale University

II. THE SITE: YALE SCHOOL OF MEDICINE CAMPUS

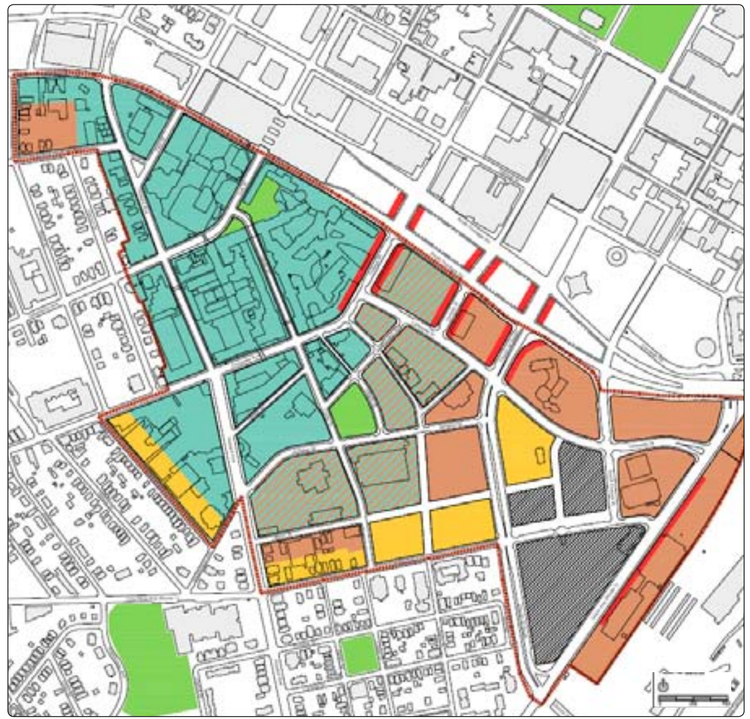
YSM Precincts

The Medical School is divided into four precincts: the Hospital Precinct, the West Medical Precinct, the East Medical Precinct, and the Union Station Precinct. These precincts together cover a large area of 2.5 million gross square feet (GSF) over 40 acres, and include both Yale-owned and Yale-leased properties.



YSM Zoning

The diversity of the campus community is evident from its zoning. The map shows proposed zoning as outlined in the YSM Master Plan. While this differs slightly from existing conditions, it illustrates the diversity of current uses, including medical, commercial/mixed-use, residential/mixed-use, and open space. The zoning clearly highlights the density of YSM's built environment and the broad range of use in this part of the Yale campus.



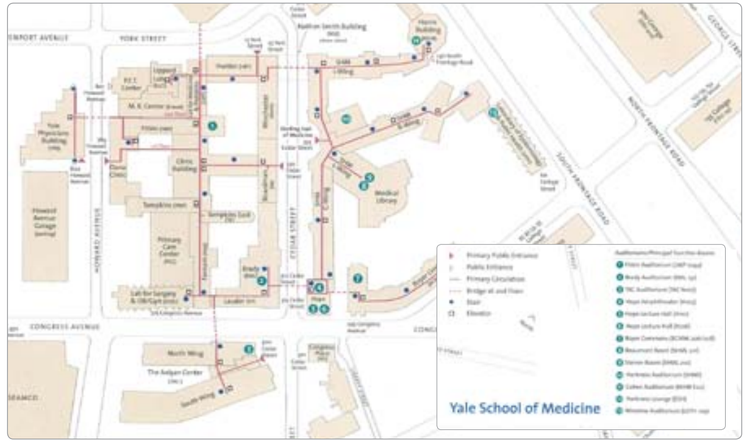
- Green Space
- Residential Mixed-use
- Medical or Commercial
- Medical
- Commercial Mixed-use
- Mandatory Ground Floor Rental Zone

Area of Focus

Given the size and scope of the Yale School of Medicine campus, we are focusing on the zone most commonly associated with YSM, outlined on the map to the right. This area is dominated by the School of Medicine, but also stretches out past Amistad Park to include the School of Nursing.

Internal Site Circulation

The high degree of internal building connectivity on the YSM campus is unique. The red lines on the map show these internal connection patterns. Some of the connections are via tunnels and others are via enclosed bridges. The fact that many people rarely leave the building increases the importance of green viewsheds from the building corridors and interior spaces. It also begs the question of whether an improved experience on the streets could draw people out, creating a reinforcing positive cycle of experience on the YSM campus landscape.



Bridge over Congress Ave.

Bridge over York St.

YSM Campus Strengths & Weaknesses

Strengths

Physical:

- Abundant existing planting beds
- Abundant courtyards
- Historic precedent for medicinal gardens
- Absence of a dominant aesthetic
- Consistent street tree canopy
- Thriving heart to campus: Cedar St.
- Pleasant pedestrian experience on Cedar Street

Procedural:

- Openness to experimentation
- Diverse, year-round community

Weaknesses

Physical:

- Low plant stocking in planting beds
- Low street tree species diversity
- Heavy contribution to CSOs
- Heavy potable water use
- Damaging snow/ice removal practices
- Absence of a dominant aesthetic
- Inconsistent design quality
- Limited access to many buildings
- Unpleasant pedestrian experience on many streets
- Frequent blank street walls
- Streets with uneven activity levels on each side
- Underutilization of many courtyards

Procedural:

- Insufficient design funds
- Insufficient maintenance funds
- Disconnect between designers and maintenance staff
- Safety and hazard risks associated with medical equipment
- Problematic maintenance
- Continued adherence to outdated landscape design

Cedar Street

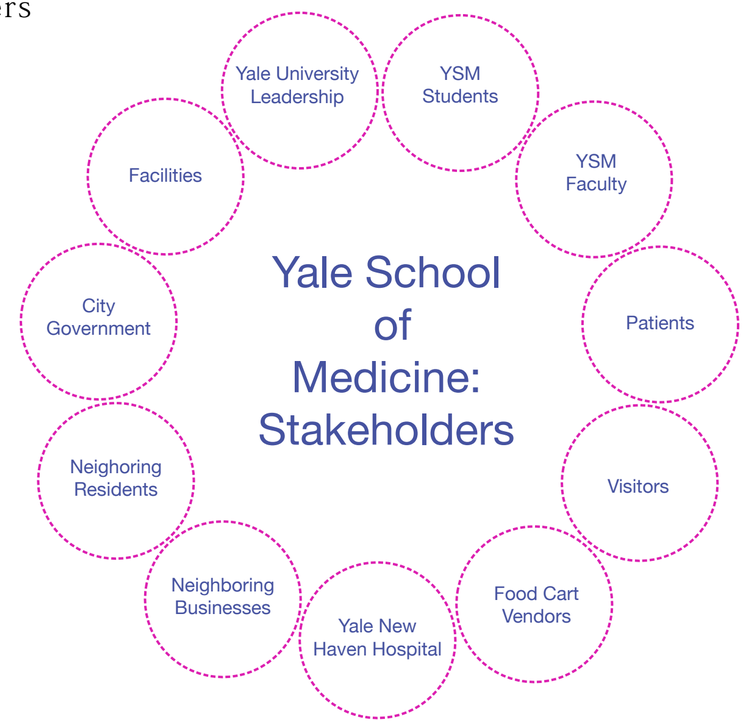
Nursing School

Leadership & Stakeholders

To make recommendations for changes to the YSM campus, and to ensure the buy-in to make them a reality, it is essential to understand the campus's user groups. As is demonstrated in the diagram to the right, these stakeholders range from medical school students to patients to hospital staff to the people running the food carts lining Cedar Street. It also includes less obvious stakeholders, such as the maintenance staff, the City of New Haven, and the Yale University Corporation.

All of these users interact with the space in different ways and are driven by different interests. For example, patients want a pleasant aesthetic experience and ease of access. Yale University wants to maintain its brand and to ensure the safety of the campus community. New Haven needs to comply with federal stormwater regulations and to ensure the maintenance of the city streets. These differences become more important when we recognize the varying degrees of influence held by each group.

These factors play a key role in informing the priority placed on different ecosystem service benefits for the YSM campus.



II. THE SITE: YALE SCHOOL OF MEDICINE CAMPUS

Site Typologies

Typologies are a useful tool for understanding the disparate parts of a site. For this analysis, we identified seven site typologies on the YSM campus: planting beds, exposed parking lots, courtyards & rooftops, plazas, blank street walls, fences, and street trees & tree pits.

Cedar Street, Eastern Side

Cedar Street, Western Side

Site Typology: Planting Beds

The planting beds on the YSM campus are unusual in both their ubiquity and their generous size. Unfortunately, their prevalence is not matched by an abundance of healthy plants within them. The stocking of the planting beds ranges from beautiful and full to sad and empty. Reasons cited for this include poor selection of vegetation, excess salt used to control ice, and poor maintenance.

Nursing School, Parking Lot Entrance

Nursing School, Parking Lot Interior

Site Typology: Parking Lots

Unlike most of the other areas of Yale's campus, there are many exposed parking lots at the School of Medicine. These heavily used parking lots have a negative impact on the pedestrian experience of the campus. In addition, their impermeable paving creates huge quantities of stormwater runoff that goes directly into the city's sewer system.
Many of these lots are slotted for future campus building development.

School of Nursing

Lot CP2, Intersection of College Ave. & Congress Ave.

Lot 97, Intersection of Washington Ave. & Congress Ave.

Lot 97, Intersection of Washington Ave. & Congress Ave.

II. THE SITE: YALE SCHOOL OF MEDICINE CAMPUS

Site Typology: Courtyards & Rooftops

Much like Central Campus, the YSM campus has many courtyards. Some are open to the street on one side and publicly accessible, while others are fully enclosed and available only to the Yale community. Usage of these outdoor spaces varies in accordance with their design and accessibility. Some see heavy use in the warmer months, while others are not used at all. Most of the courtyards suffer from problematic maintenance. Many of them are the roofs of underground structures, making them green roofs as well.

The Rose Garden, Sterling designed by Beatrix Farrand

Anlyan Center

MR Imaging Research Center

Harkness Memorial

Site Typology: Courtyards & Rooftops

In addition to a multitude of courtyards, there are many underutilized flat roofs across the YSM campus. Many of these roofs are visible from taller surrounding buildings. Some of them are accessible from adjoining buildings.

One of these roofs has in fact been designed and planted as a roof garden, though it is not currently accessible.

Green roof on Positron Emission Tomography (PET) Center

Sterling Courtyard and Parking

Winchester

LEPH Courtyard

II. THE SITE: YALE SCHOOL OF MEDICINE CAMPUS

Site Typology: Plazas

Unique to the YSM campus are two outdoor plazas with seating, both at the intersection of Cedar and York Streets. These plazas are successful spaces, in part because of high pedestrian activity in the area and in part because of the food carts lining Cedar Street.

Even more unique is the interior plaza in the Yale-New Haven Hospital, located in the ground floor atrium of the building. Although this is not strictly part of the YSM campus, it is a notably successful feature of the facility and one through which medical students on rotation have the opportunity to interact. With ample light coming through the glass ceiling, a central water feature, real trees, ample seating, and a location at the intersection of significant foot traffic, this indoor plaza functions year round as the main gathering place of the hospital.

Corner of Cedar and York

Corner of Cedar and York

Indoor Plaza of Yale-New Haven Hospital

Indoor Plaza of Yale-New Haven Hospital

Site Typology: Blank Street Walls

An abundance of featureless street walls has a significant negative impact on the feeling of the YSM campus. These blank walls are neither restorative nor welcoming. In addition, the lack of windows at eye level has implications for safety.

Despite the generous width of many sidewalks on the YSM campus, these blank street walls foster an unpleasant pedestrian experience.

Harkness, York St.

Boyer Center, Congress Ave.

Yale Psychiatric Hospital, Cedar St.

Cancer Center, York St.

II. THE SITE: YALE SCHOOL OF MEDICINE CAMPUS

Site Typology: Fences

More than any other part of Yale's campus, YSM has an abundance of fences. We do not seek to analyze the need for security, but there is no doubt that these fences have a negative impact on the pedestrian experience of the campus.

Many of the fences, in particular the fence surrounding the Yale School of Nursing, are clearly meant to limit access to the campus. The aesthetic of these fences is unforgiving, creating a pedestrian experience that is neither restorative nor welcoming.

Nursing School Locked Entrance

Nursing School Yard

Corner of York and Howard

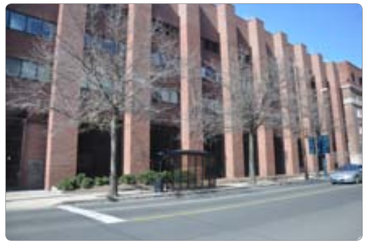
Corner of York and Howard

Site Typology: Street Trees & Tree Pits

YSM's campus benefits from consistent stocking of trees on almost every street. These trees provide beauty, shade, stormwater uptake, and bird habitat. However, there is little variation in tree species throughout the campus, and almost none within individual blocks.

The majority of the street trees are planted in older style tree pits that result in limited access to water. The use of pavers to cover many tree pits adds to the stress of the trees by compacting the soil and further limiting water access. This reduced permeability also increases stormwater runoff into the city's sewer system and Long Island Sound.

On College Street, new, trench style tree pits provide greater rooting area for trees and a larger surface area for infiltration. However, due to the paved surface treatment of these pits, they contain no planting apart from the trees. The photo on the bottom, right hand side of the page shows one of these new tree pits.



LSOG, Congress Ave.

Howard Avenue

Typical Tree Pit

New Tree Pit, College St.

II. THE SITE: YALE SCHOOL OF MEDICINE CAMPUS

Site Diagnosis

Assessing the typologies, strengths, and weaknesses of the YSM campus leads us to the following conclusions:

- There is substantial small, wasted space.
- The campus is visually and physically closed off to users.
- There is room for aesthetic improvement.
- There is a lack of connectivity between disparate parts of the campus and between the people who use it.
- There is a loss of historical continuity.

We can address these issues with the recommendations laid out in Section Four. These recommendations build on our view, based on the analysis in this report, that the medical school is not about big green spaces. It is about a finer grain: the smaller moments of a student taking a break from the library; a patient walking from the parking garage to the hospital; a member of the university staff walking from her office to the food carts for lunch.

III. RESTORATIVE DESIGN & ECOSYSTEM SERVICES

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Historical Precedents

Historically, medical facilities have placed high value on the curative properties of nature. For example, the Santa Nuova hospital in Florence, Italy, placed patients' beds in cloister gardens. America's great landscape architect, Frederick Law Olmsted, drew on this tradition when he designed extensive green spaces in modern American cities (Gerlach-Spriggs et al, 1998). Olmsted was visionary for his integration of ecosystem function with public recreation.

Landscape architect Nancy Gerlach-Spriggs of the New York Botanical Gardens noted that: "Gardens have played an integral role in the evolution of humane medical care. Gardens have a mythology, a poetry, and a history, strongly linked to...the processes of healing, renewal, and ultimately dying. The persistent appearance of healing gardens in times and places of medical innovation suggest that...human beings feel a biological need for contact with the natural." Gerlach-Spriggs' claim is grounded in biologist Edmund Wilson's 1984 biophilia hypothesis, which suggests that humans have evolved to have an affinity with nature.

Cloister Garden in Europe

III. RESTORATIVE DESIGN & ECOSYSTEM SERVICES

Scientific Validation

Science suggests that there is good reason for the ancient human belief in the curative properties of nature. For example, Ulrich (1984) published a pioneering experiment on the effect of window views on patient recovery rates. As described by Judith Heerwagen (2010): "Half the patients had a window that looked out onto a brick wall while the others viewed an outdoor landscape with trees. All patients had the same kind of surgery, with the two different view groups matched for age, gender, and general health conditions. Ulrich found that patients with the tree view used less narcotic and milder analgesics, indicating lower pain experience. They also stayed in the hospital for a shorter time period and had a more positive post-surgical recovery overall than did patients who had the view of the brick wall. A decade of subsequent research by Ulrich and colleagues at Texas A&M University, largely in laboratory experiments, reinforces the findings from the hospital study."

Heerwagen (2010) also finds scientific justification for the therapeutic value of sunlight, which stabilizes circadian rhythms, improves mood, and alleviates alertness and neurological well-being. Walch et al (2005) find that hospital patients who stay in sunlit rooms have more rapid rates of recovery, have less pain, consume fewer strong pain-killers, and remain in the hospital for less time than patients who stay in rooms with little or no sunlight. Based on her research, Heerwagen writes, "The benefits of sunlight can be experienced in even brief walks outdoors on a sunny day or through design of spaces that integrate daylight and sun into the interior." Cooper-Marcus and Barnes (1995) find that gardens can reduce stress, promote mental and emotional well-being, and heighten mood. And Rappe (2005) and Ulrich (2002) find that neurologically-impaired patients have better mobility, dexterity, confidence, and social skills after spending time gardening. Ulrich (2002) suggests that a diversity of foliage, flowers, nature sounds (like bird songs), a water feature, and wildlife will improve a garden's ability to bestow calmness and reduce stress.

Contemporary Restorative Design

Today, planners and architects are advancing a new idea grounded in history and science: redefining and transcending the traditional garden through restorative design. The Laflin Design Group explains, "A Restorative Environment is defined as having or exhibiting healing powers to bring back a state of health, soundness, or vigor. Every healthcare facility, large or small, possesses an untapped source of healing in the surrounding landscape. The restorative healthcare design studio focuses on using space and design to relieve the stress and anxiety of patients, their families and the staff." Citing studies indicating that natural lighting may reduce the length of a patient's stay in a medical facility by 15 to 20 percent, architect Leon Drachman (2010) writes, "Current trends in healthcare design place more emphasis on improving the physical environment in which patients are treated — the quality of space, natural light, a patient's autonomy, and a visual link to the landscape."

III. RESTORATIVE DESIGN & ECOSYSTEM SERVICES

Restorative Design and Ecosystem Services

With its focus on health, restorative design relies heavily on the ecosystem services of aesthetics, water, climate, and biodiversity. Ulrich's (2002) finding that a garden rich in biodiversity and water has enhanced healing properties suggests that these elements play a key role in restorative design. In addition, foliage influences campus climate and improves air quality.

It is worth noting that restorative designs do not always prioritize energy efficiency or stormwater treatment. An ideal ecosystem services based approach to Yale's landscape design would consciously incorporate these factors as well, applying restorative design principles to energy efficiency (e.g. planting trees to passively cool buildings) and stormwater management (e.g. treating and reusing stormwater on-site through rain gardens and bioswales).

Contemporary Restorative Design on Medical Campuses

Many of the Yale School of Medicine's peer institutions are putting in place innovative landscapes grounded in the philosophy of restorative design. We outline some notable examples on the following pages, including Philadelphia's Hershey Cancer Center, UCSF Medical School, and Duke Medical School. These case studies emphasize successful implementation of healing gardens, winter gardens, green roofs, and green parking lots. Each of the case studies examines the types of restorative design employed. We also discuss the ecosystem services implications of the designs and consider their relevance for YSM's campus.

Hershey Cancer Center, Penn State

Overview

The Milton S. Hershey Medical Center campus at Penn State was constructed in the 1960s. In 2009, it saw the addition of the new 175,000 square foot Penn State Cancer Institute. The goal of the instititute is to "affect a paradigm shift that houses cancer research and cancer care together in an inspirational, interactive setting" (WAN 2011). Its design reflects this goal. *World Architecture News* (WAN) commended the design for strengthening the campus's sense of community by using an arc to bring more than thirty diverse buildings into one structure. It also noted: "An essential design principle provides all occupants with strong connections to nature" (2011).

Healing Gardens

Cancer treatment patients at the Hershey Medical Center are housed in suites, all of which face a healing garden. "The garden, designed with native vegetation to present year-round interest, gives all patients access to the outdoors, intimate views, daylight and controlled levels of privacy or interaction" (WAN 2011). Hershey's landscape design firm Hargreaves notes that the healing garden also touches additional people through its location between the pre-existing hospital emergency department and the new infusion bays of the cancer center, and adjacent to waiting areas, treatment zones, and research facilities. Hargreaves writes, "The design is inspired by the geology of the surrounding hills and an agricultural heritage. The landforms were achieved by stacking 1- to 2-inch-thick layers of rigid insulation covered with a maximum of six inches of soil so as not to exceed weight limits" (2010).

Courtyards

The medical complex is connected through four courtyards: the healing garden, the hospital courtyard, the children's courtyard, and the children's roof terrace. Each of these courtyards is built above a structure, making them green roofs as well. The main hospital courtyard was inspired by the Japanese principle of ma, which "evokes calm and reverence ...[through] curved sloping forms." It contains café tables to draw people in. The children's courtyard provides a formal garden with raised planters of hedges and flowering vines as well as a playground, a maze, and a café seating area for families. Hargreaves writes, "In order to accommodate the multiple activity levels and types of play, the design uses raised planters to separate and unify these spaces. The system rests atop the roof structure via a system of grating and pedestals, and the planters are lined with rigid insulation to help prevent roots from freezing." The children's roof terrace features a "raised 'island' boardwalk for a Big Wheel tricycle circuit" above "a gradient of wide bands of sedum [which] showcase seasonal change." The plantings are pre-grown off-site and installed on the terrace in panels.

Oher Restorative & Ecosystem Features

The Hershey campus is USGBC-LEED certified, and "exceeds energy performance criteria by 15%" (WAN 2011). Additionally, "a bright, central five-story atrium visually connects patients, researchers and administrative staff. The innovative configuration permits an unprecedented openness between disparate occupancies, even deep below grade…Post-occupancy evaluations report increased patient access to treatment options along with a vastly improved care experience. Staff report a marked augmentation of inter- and intra-disciplinary interactions, cross-collaborations and improved organizational efficacy" (WAN 2011). The Hershey Center's website also emphasizes that "The architecture of the building itself allows for a great deal of natural light...to help our patients and visitors feel more at home."

Measuring & Monitoring

In addition to USGC-LEED certification, the Hershey campus is a case study for the Green Guide for Health Care (see Appendix for more detail on the Guide). According to Hargreaves, both Hershey's Medical School and the Penn State Center for Green Roof Research are conducting parallel studies on patient recovery rates and maintenance requirements for the green roofs.

Relevance for the YSM campus

With its incorporation of a new building into a sprawling existing campus, its courtyard-green roofs, and its emphasis on measuring and monitoring, the Hershey campus provides an exemplary vision highly relevant to the Yale campus.

Rendering of Building Entrance

Courtyard (Daytime)

Courtyard (Nighttime)

Enid Haupt Glass Garden, NYU Medical Center

Overview

New York University's Howard A. Rusk Institute of Rehabilitation Medicine features the 1,700 square foot Enid Haupt Glass Garden, constructed in 1958. Originally intended for war veterans and polio patients, today the landscape around the greenhouse has "gardens designed to evoke natural rhythms that are restorative and encourage healing" (McGowan 2010). According to the garden's website, it is "a place where patients, visitors and staff enjoy the soothing, natural environment of plants, water birds, and beauty as a retreat from the hospital atmosphere."

The greenhouse's horticultural therapy program reaches heart patients, Alzheimer and aphasia patients, autistic children, HIV+ children, disabled children, and children from the neighborhood. McGowan writes, "100,000 people visit the gardens and greenhouse annually (it's open every day of the year)–many are hospital staff and family of patients."

Ecosystem Services

With its emphasis on water, foliage, and birds, the Haupt Glass Garden incorporates the ecosystem services of water and biodiversity—but approaches them primarily from an aesthetic lens.

Measuring and monitoring

"Research is a component in most of the garden's programs. Over the past 20 years, the Garden has made the most of its resources by identifying groups with special needs, then partnering with them to integrate theory and practice" (McGowan 2010).

Relevance for the YSM campus

The Haupt Glass Garden is an exemplary year-round garden that has successfully existed on the East Coast for five decades. Although it does not have a broad approach to ecosystem services beyond the aesthetic, Yale could look at the maintenance costs of the greenhouse when evaluating whether to build a winter garden on the Yale campus.

Trellis

Courtyard

III. RESTORATIVE DESIGN & ECOSYSTEM SERVICES

Conservatory

Duke University Medical Campus

Overview

Several years ago, Duke University partnered with Hospitals for a Healthy Environment (H2E) to make wide-ranging changes in its operations and landscape management. Its medical campus has recently built a plethora of gardens and green roofs intended to advance the university's mission of "research, education, and quality patient care." In this endeavor, the university cites decades of research proving the restorative benefits of exposing patients to outdoor environments. According to a Duke press release which describes a green roof/healing garden ten stories above ground: "[T]hrough the vision of Duke Medicine engineering and operations workers, the courtyard is fresh and inviting. Trees and flowers grow. Birds chirp. And patients, visitors, and staff find benches and outdoor refreshment just steps from the hospital's frenetic corridors." The press release quotes Tim Pennigar, the engineering & operations staffer who oversaw the new courtyard:"It was a wasted space and now it's a place that people want to be in. But the biggest change has been in our thinking—we are recognizing there is a connection between the built environment and healing."

Other Gardens on the Medical Campus

Duke's Medical School campus includes a variety of other gardens as well. The Seese-Thornton Garden of Tranquility at the Duke Cancer Institute includes walkways, flowering trees, and art. The Duke Raleigh Hospital has the Duke Raleigh Gardens, completed last year. According to the press release, "The gardens include a water feature, walking paths, and native North Carolina plants. Over the coming months the gardens will grow to complete the vision of a place of enjoyment and tranquility for patients, visitors and staff." The Duke Center for Integrative Medicine in Durham has buildings with "outdoor garden rooms connected along a winding path through the facility. The path leads outdoors to a garden where a winding labyrinth is set out in small stones." According to the Center's designer, Turan Duda of Duda/Paine Architecture, "This journey is meant to reinforce the experience one has at Duke Integrative Medicine." Duke also has a Medical Garden featuring medicinal plants used over the centuries.

Ecosystem Services

While all of Duke's green roofs and gardens address the ecosystem service of aesthetics, the university is also thinking about storm-water management and energy. In 2008, Duke built a new sedum-based vegetative roof as "an experiment aiming to show how innovating thinking with plants can prevent pollution, regulate runoff, and conserve energy" (Schreiner 2008). However, Duke also values the sedum-carpet roof for its aesthetic qualities. Tim Pennigar celebrates the seasonal color-change of the sedum.

In addition, Duke's membership in Hospitals for a Healthy Environment (H2E) requires it to eliminate mercury use and reduce waste and energy. Since 2003, Duke has reduced the amount of mercury in its waste-stream by 95 percent. Since mercury in the wastestream affects not only water quality but also fish and other wildlife, Duke is addressing the ecosystem services of water and biodiversity in a new and measurable way (Bishop 2007).

Duke is also working to reduce its construction waste. By conserving the embodied energy in these materials, the university is indirectly benefiting the ecosystem service of climate. In the construction of Duke Life Flight's new heliport, "workers salvaged many components from the old roof for reuse on other projects. They brought the roof ballast stone to nearby Duke Forest for road stabilization, and used the insulation to re-roof the laundry facility at Durham Regional Hospital and the Civitan Building on Duke's campus" (Bishop 2007).

Duke's changes are also benefiting its employees, as is demonstrated through reduced sick days. According to a press release, "Eliminating toxic cleaning products cuts down on sick days for employees by improving the air quality... and reducing their exposure to harsh chemicals such as quaternary ammonium chlorides and butoxyethanol" (Bishop 2007).

Lessons for YSM

Duke's experimental approach of trying several different green roofs and its commitment to its historical medicinal garden can serve as precedents for future YSM efforts. Yale can also learn from Duke's decision to make Tim Pennigar, the chief of engineering and facilities, the spokesman for these green roofs. Pennigar's key role suggests some degree of successful collaborative decision-making with room for adaptive management.

UCSF Medical Center at Mission Bay

Overview

This new medical center, which aims for LEED Gold certification, is slated to be completed in 2014. The new center has "a design that supports new ways of advancing health and contributes to healing through connections to nature and sustainability. Design, construction, operations, and purchasing strategies for the new complex will integrate the best green practices available….It is anticipated that the center will incorporate discoveries from evidence-based design, a body of knowledge which demonstrates the built environment can positively effect healing, health, safety and well-being" (McDonough + Partners).

Ecosystem Services

Patient rooms at the UCSF Medical Center will be almost entirely free of known toxicity and will ensure daylight and views throughout the building. UCSF will feature more green roofs and healing gardens than almost any other U.S. hospital located in a city. The building and landscape design also features rain and stormwater collection and reuse on-site for landscape irrigation.

Relevance for YSM

The UCSF Medical Center demonstrates how extensive green infrastructure can be used to improve the human experience, manage water, and improve biodiversity and climate in a dense urban environment.

Rendering of Roof Gardens & Courtyards

III. RESTORATIVE DESIGN & ECOSYSTEM SERVICES

Bird's Eye View Rendering of Parking, Entrance, and Buldings

Smilow Cancer Center, New Haven

The Smilow Cancer Center's healing garden provides an example of a restorative landscape in YSM's backyard. According to the Cancer Center's website, the garden was built in "[R]ecognition of nature's healing qualities...The sights and sounds of our garden can reduce anxiety and stress and have a restorative effect on the physical and mental health of our patients." Channing Harris, senior associate at Towers Golde, noted that the design was also informed by a survey of nurses and patients, a majority of whom said they wanted to feel like they were back on their decks in their suburban backyards. With these goals, Towers Golde built a hybrid design: a garden that is half suburban backyard and half Zen garden.

While descriptions of the garden emphasize human well-being without mentioning other ecosystem services, the garden does provide a variety of benefits, such as reduced stormwater runoff and increased biodiversity through the vegetation and the birds attracted to the garden. Climate is not benefited in this case, as the designers sought to make the garden accessible year-round through a floor using heated coils to melt snow and ice.

View of Healing Garden from Inside Smilow Cancer Center

Gazebo in Healing Garden

Water Feature in Healing Garden

III. RESTORATIVE DESIGN & ECOSYSTEM SERVICES

Conclusion

The examples we have provided are by no means exhaustive. The Palomar Medical Center in San Diego, California features a 1.4 acre "living roof" and an emphasis on natural light and foliage on patient terraces. Palomar also touts its green roof's biodiversity, water filtration, and insulation benefits. The Advocate Good Shepherd Hospital in Barrington, Illinois features a variety of gardens, including water features and native plantings. The Resurrection Medical Center in Chicago, Illinois also incorporates healing features into its landscape, with a healing garden, water features, and emphasis on natural light. And the Oregon Health & Science University (OHSU) building incorporates a wide range of energy- and water-saving features as well as eco-roofs on terraces and bioswales along sidewalks and in the parking lot.

Good Shepherd Hospital

Palomar Medical Center

OHSU Roof Garden

Resurrection Medical Center

IV. RECOMMENDATIONS

IV. RECOMMENDATIONS

Overview

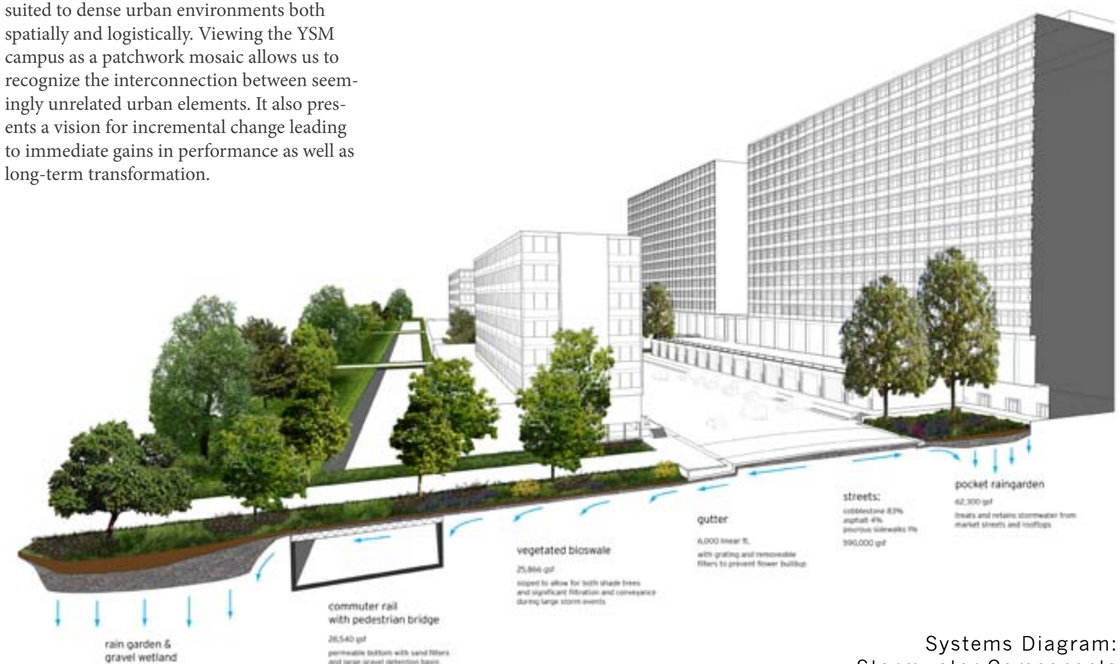
Yale's School of Medicine campus has great potential to build on its own historical landscape tradition and develop a campus theme of restorative landscape design and ecosystem services. Drawing inspiration and techniques from existing precedents, we have developed the following portfolio of recommendations, fine-tuned for the YSM campus. These recommendations are designed to ensure that the scale of proposed typologies reflect the scale of existing site typologies.

Recommendation Framework

- An over arching goal of **restorative landscape design** to promote health and healing;
- **Ecosystem-services based strategies** that will each provide a suite of benefits – including water management, increased biodiversity, reduced carbon footprint and energy use, improved human health and comfort, and aesthetic value; and
- Typologies designed to be implemented in a network **mosaic** of **fine-grained** patches. This approach suits the spaces available on campus, augmenting its strengths and addressing its weaknesses. This small-scale mosaic approach will also ease implementation and reduce the financial and human resources required.

Mosaic of Patches

As the systems diagram below illustrates, smaller scale landscape interventions are well suited to dense urban environments both spatially and logistically. Viewing the YSM campus as a patchwork mosaic allows us to recognize the interconnection between seemingly unrelated urban elements. It also presents a vision for incremental change leading to immediate gains in performance as well as long-term transformation.

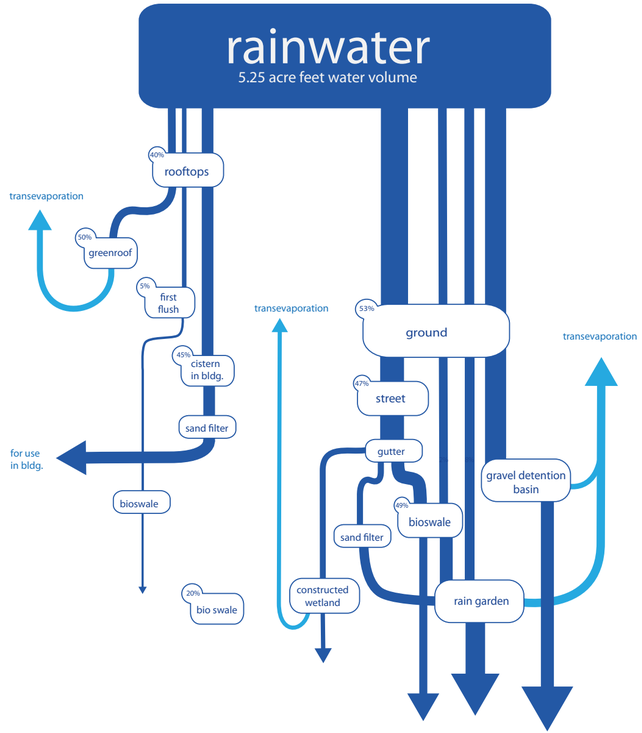


Systems Diagram:
Stormwater Components

Network Systems

The concept of networks is integral to creating resilient and efficient urban systems. Much of the benefit derived from the green infrastructure techniques proposed in the following pages stem from their ability to serve multiple functions within a small footprint.

Through an understanding of network-wide flows of water, nutrients, people, and activity, we can better manage campus resources.



Network Flow Diagram:
Tracking Stormwater Flow and Treatment

Techniques for Maximizing Ecosystem Services

Based on the typologies study in our site assessment, and our recommendations framework, we propose here nine techniques to increase the benefits possible from ecosystem services on the YSM campus and beyond.

Street Trees & Sidewalk Planting

The YSM campus benefits from wide sidewalks and ample existing street trees. However, there is little consistency in the treatment of tree pits and ground cover.

Increasing the pervious surface surrounding tree pits, exploring the use of ground-level shrubbery or other hardy vegetation instead of pavers, and connecting tree pits to stormwater infrastructure provide low-cost, low-maintenance ways to increase rainwater infiltration, improve the longevity and health of existing street trees, and improve the quality of the streetscapes.

Low Maintenance Storm Water Planters,
Rush University Medical Center

IV. RECOMMENDATIONS

Planted Tree Pit, New York City

Tree Pit, Portland

Planted Tree Pit, New York City

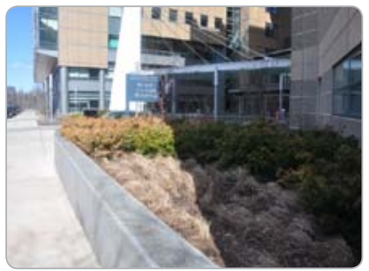
Seat Walls & Raised Planters

Increased stocking of existing planters and raised beds with low maintenance species can increase the vibrance of the outdoor environment for building inhabitants and pedestrians while also increasing biodiversity and ecosystem health.

Raised planters and seat walls provide a double benefit, creating a social space on sidewalks and plazas while also allowing for deeper soil depths and protecting plants from salt, snow plowing, trampling, and other forms of abuse.

Seat Wall, Galen Center

Salt Resistant Planting, NYC



Smilow Center Raised Planters, New Haven

Greenstreets with native plants, New York City

Green Parking Lots

Rain gardens, planted berms, and bioswales can be easily integrated into existing parking lots across the YSM campus without a loss of parking volume.

Vegetated stormwater infrastructure in parking lots passively addresses issues of water quantity and quality. Filtration, detention and infiltration of parking lot runoff is particularly important due to the relatively high levels of trace metals, oil, grease, and salts present. Treating this source of water pollution through green infrastructure is a cost effective way to reduce loads on treatment plants and pollution in Long Island Sound.

Planting trees can provide additional benefits. By shading cars and lowering parking lot temperatures, trees can reduce evaporative emissions of hydrocarbons that leak from fuel tanks and hoses, the source of nearly 20 percent of all HC emissions. Shading parking surfaces also provides additional health benefits by mitigating urban heat island effect and improving air quality.

Rain Garden, Antioch

Rain Garden, Buffalo

Vegetated Swale and Buffer, Portland

Shaded Parking, Long Island

Planted Swale, OHSU Portland

Rain Gardens & Bioswales

Rain gardens can easily be installed in existing planting beds and courtyards across the YSM campus. They should contain vegetation and soil structure dually able to absorb large influxes of water after rain and snow events and to withstand dry conditions without irrigation.

These structures can play an important role in connecting stormwater to appropriate sinks (soil, cistern, treatment tank, or sewer). They can be designed to cover a range of scales, from plazas to sidewalks to a single downspout.

The climate of New Haven allows for a variety of hardy local species to be used in rain gardens. Extensive testing of soil types, liner assemblies, and appropriate vegetation has been undertaken by the New York City Parks Department as part of their Green Infrastructure program.

Findings from this and other regional projects would be appropriate resources based on similarities in both climate and urban conditions.

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Green Roofs

Rooftops are an unsung resource. They present a currently untapped opportunity for small interventions with high returns on the YSM campus. Green roofs are particularly appealing as they layer multiple ecosystem services into a simple assembly that can be adapted to accommodate a wide range of site conditions, programmatic needs, aesthetic preferences, and budgets.

Applying green roof assemblies to existing structures can improve the performance of building systems and significantly reduce building energy consumption through increased insulation and evaporative cooling of vegetation and soils.

Green roofs also help to mitigate storm water runoff and can be an importance component of rainwater collection for use in building operations or landscaping.

Finally, green roofs are particularly attractive in educational and healthcare settings due to the beneficial effect of gardens on mental health and physical well-being. Installing green roofs on lower levels of buildings, such as on terraces, couples benefit from direct access with views from interior spaces.

Yale University
Smilow Cancer Center

OHSU roof terrace

Palomar West Medical Center
Medicinal Roof Garden

ESRI Headquaters Green Roof

IV. RECOMMENDATIONS

Queens Botanical Garden Green Roof

Green Walls

Unappealing street walls, security fencing, and blank building facades can be amended with the addition of green wall- and green facade-systems. These systems, be they tray-, container- or wire armature-based, can be layered on top of existing walls with minimal structural additions.

Primary drivers for incorporating green walls into the design of existing walls and facades include an improved sidewalk micro-climate for pedestrians, aesthetic value, stormwater runoff mitigation, and improved ambient air quality.

Green walls are also an attractive option for increasing streetscape vegetation since they are free of many of the challenges faced by surface level planting beds (e.g. salt, snow piling, traffic, general neglect). Paneled systems may be an attractive option because they can be stocked before installation, are easier to repair or replace, and can support a wide variety of vegetation.

University Citywalk

Patrick Blanc Green Wall, Belgium

Low-cost Temporary Green Wall, Union Square, NYC

IV. RECOMMENDATIONS

Vancouver Aquarium

Courtyards

The in-fill nature of growth on the YSM campus has created dozens of small, interesting courtyards providing interior building spaces with light, fresh air, and views.

Presently underutilized, these courtyards can further serve the campus community by providing calming outdoor spaces for rest, recreation, contemplation, and social gatherings. Much in the way that Central Campus sees the college courtyards as integral to their identity, the YSM campus should celebrate the presence of its courtyards and invest in their design and maintenance.

Increased vegetation, upgraded pavers, integrated stormwater management, shading, and spaces for year-round activity would increase the value and benefit of these spaces. Even courtyards that remain physically inaccessible are important visual amenities for building users, particularly in winter months. These spaces will additionally accrue all of the ecosystem services associated with green roofs.

Paley Plaza, NYC

Parc Andre Citroen, Paris

Tahari Courtyards, Milburn NJ

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Tahari Courtyards

Winter Gardens

Winter gardens, or covered gardens, can be designed for new construction projects or integrated into existing buildings on the YSM campus by enclosing existing courtyards.

The primary goal of the winter garden is to provide year-round green space and a pleasant outdoor environment for building inhabitants. Additionally, the warm, climatically controlled environment of the winter garden can aid in stabilizing adjacent building temperatures, leading to reduced building energy consumption. The winter garden uses natural ventilation and convection to achieve these goals in winter and summer months.

Winter gardens are particularly helpful for increasing human health and mental well-being in stressful and difficult work environments. They provide individuals with the ability to find a peaceful and healthy space separate from the lab, office, or clinic.

IBN Institute for Forestry and Nature Research, Wageningen, The Netherlands

IBN Atrium in Summer

IBN Office Spaces

IV. RECOMMENDATIONS

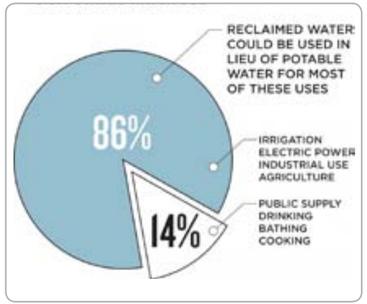
IBN Institute for Forestry and Nature Research, Wageningen, The Netherlands

Rainwater Storage

Cisterns, tanks, filtration basins, and surface ponds are just some of the many mechanisms through which rainwater storage can be integrated into site management.

Stormwater falling on the medical campus should be seen as a resource—a valuable material to be conserved for use in building heating and cooling, building services, and landscape irrigation.

Presently much of the water which falls on the YSM campus simply drains untreated into an unseen complex of sewers and stormwater drains before being sent either to sewage treatment plants or directly into Long Island Sound. In FY 2008, the Sterling Power Plant (serving YSM and Yale-New Haven Hospital) and the YSM buildings used 29 percent of the potable water consumed by Yale University as a whole (Iverson 2010). Rainwater harvesting on other parts of campus is explored at length in the Yale University Utility Master Plan (2010). That analysis could be expanded for application on the YSM campus.



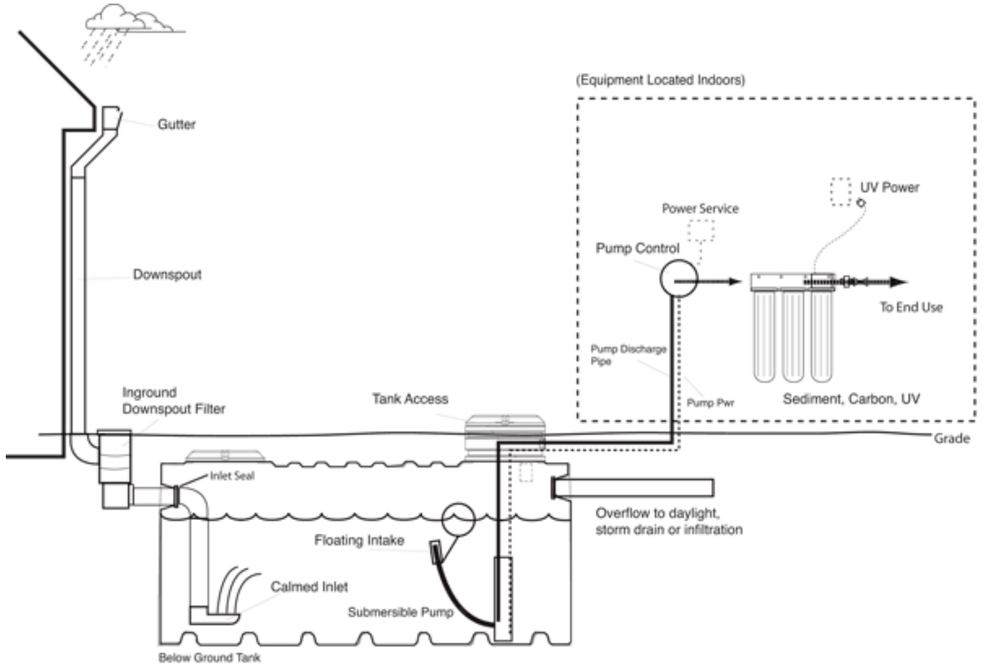
U.S. Potable Water Use

20,000 Gallon Cistern

15,000 Gallon Cistern

Rain Blocks

IV. RECOMMENDATIONS



Source: BRAE Engineering

Zones of Opportunity

The following maps indicate areas in which techniques discussed previously could be implemented based on assessment of existing conditions.

Open Space

YSM's campus contains a range of existing open spaces both within building complexes and adjacent to the street.

Applicable Techniques:

- Seat walls and raised planters
- Stormwater harvesting
- Green roofs
- Winter gardens
- Courtyards

Public plazas

Courtyards

Amistad Park

Streetscape

This map shows existing trees and planting beds.

Applicable Techniques:

- Trees and sidewalk planting
- Seat walls and raised planters
- Rain gardens and bioswales

Street trees

Planting beds

Building Mass

This map shows existing exposed rooftops and overall above ground building mass.

Applicable Techniques:

- Green roofs
- Green walls
- Courtyards
- Winter gardens
- Stormwater harvesting

Building

Parking garage

Parking

A large portion of the western half of the YSM campus is dominated by highly utilized parking lots.

Applicable Techniques:

- Rain gardens and bioswales
- Stormwater harvesting
- Trees and planting

Surface parking

Covered garage

Moving Forward

The primary goal of this section has been to illustrate a framework and techniques through which YSM can maximize the ecosystem service benefits provided through its landscape design.

Given the strengths of YSM's existing infrastructure (e.g. street planter beds, wide sidewalks, courtyards) and the unique spatial layout of its campus, we have chosen to emphasize a palette of small-scale interventions that can be readily deployed across the campus. We hope that the technique descriptions presented here, as well as in the ecosystem services reports produced in the first phase of this project (Hsu et al (2011), Carlisle et al (2011), Bouffard et al (2011), Banerjee et al (2011)), will help to inform early discussions about landscape design options going forward.

We are confident that the techniques presented in this report are feasible and appropriate for use on the YSM campus. However, we have purposefully not presented a hierarchy of options for which techniques to select. Similar to the landscape design ethos of "right plant, right place," each technique is site specific and serves a particular function(s) in relation to its context. Each installation should therefore be chosen based on that site's specific goals, physical characteristics, buy-in, and funding potential. The table in the Executive Summary of this report highlights some of these points of differentiation. The next step is to invest in the additional analysis and design charrettes required to turn these ideas into a reality.

We hope that the assessment, vision, and toolkit presented in this report will help to inspire a new approach to restorative landscape design and ecosystem services management on the Yale School of Medicine campus.

IV. RECOMMENDATIONS

Benefits of Proposed Techniques

Techniques	CLIMATE	BIODIVERSITY	WATER MANAGEMENT	AIR QUALITY	PHYSICAL HEALTH	MENTAL HEALTH	ENERGY CONSUMPTION
Street trees & sidewalk planting	Mid	Low	High	Low	Low	High	Mid
Seat walls & raised planters			Low		Low	Mid	
Vegetated parking lots	High	High	High	Mid	Mid	Mid	Mid
Rain gardens & bio swales	Mid	Mid	High		Low	Mid	
Storm water harvesting	Low		High				Mid
Green roofs and terraces	High	Low	High	Low			High
Green walls	Mid	Low	Mid	Low	Mid	Mid	Low
Courtyards	High	Low	High	Low	High	High	Mid
Winter gardens	High	High	Mid	Low	High	High	High

Impact:
Low
Mid
High

V. APPENDIX: RESOURCES & REFERENCES

V. APPENDIX: RESOURCES & REFERENCES

Resources

A number of tools and frameworks exist to promote landscape and healthcare facility best practices. These include the Healthy Building Network's prerequisites and its Living Building Challenge; the Sustainable Sites Initiative (SSI) from the American Landscape Architects' Association, which Yale is currently reviewing; and the Green Guide for Health Care (GGHC), which Yale uses to evaluate its medical buildings. We also discuss "Tool C," a questionnaire intended to foster collaborative decision-making, and Martha Tyson's methodology for designing restorative landscapes.

Healthy Building Network and the Living Building Challenge

The Cascadia Green Building Council (GBC) aspires to go above and beyond LEED certification. Unlike LEED, it emphasizes the sustainability of the landscape around a building in addition to the building itself. Cascadia has popularized the "living building challenge," which recognizes new buildings for emphasizing "beauty and inspiration; site; materials, energy; indoor quality; and water."

Cascadia's GBC commends the Healthy Building Network's PHAROS protocol "as the best framework for evaluating sustainable materials and the most progressive tool for consumer benefit." This protocol has certain prerequisites that may be particularly relevant for the Yale School of Medicine campus:

- Prerequisites 10-11: Net Zero Water, Sustainable Water Discharge (all water must be filtered on site).
- Prerequisite 12: A Civilized Work Environment. Every occupiable space must have operable windows that provide access to fresh air and daylight.
- Prerequisite 13: Healthy Air Quality.
- Prerequisites 15-16: Beauty and Spirit, Inspiration and Education.

Sustainable Sites Initiative (SSI)

The American Landscape Architecture Association's 2009 Benchmarks and Performance Standards for the Sustainable Sites Initiative emphasizes many of the same prerequisites mentioned above. It is of note that SSI can apply to both existing and newly-constructed landscapes, whereas the Healthy Building Network's standard is most appropriate for new buildings. SSI is valuable for providing detailed checklists that focus on enhancing ecosystem services—particularly on monitoring and evaluating a site's performance and for assessing its restorative qualities. These types of tools are also provided by the Green Guide for Health Care.

The Green Guide for Health Care (GGHC)

The Green Guide for Health Care attempts to bring together concepts of healing with the design, construction, and operation of healthcare facilities. In 2001, The American Society of Healthcare Engineering recognized the rapid pace of healthcare construction and saw the need to develop a toolkit that would adapt existing LEED guidelines to the specific needs and concerns of the healthcare industry. Specifically, it sought to protect health at three scales:

- The immediate health of building occupants,
- The health of the surrounding community, and
- The health of the larger global community and natural resources.

Reflecting these goals, the guide addresses issues including energy and water use, chemical use, and the control of infections. The Green Guide currently works on a voluntary, self-certifying basis. Work is already in progress, however, to formalize certification

Resources

through the release of LEED for Healthcare. This release will build on the many parallels that already exist between LEED and the Green Guide, but will adapt the point allocation and add new credits to tailor it to the needs and concerns of healthcare facilities.

Yale currently uses The Green Guide to review and evaluate its medical buildings on campus.

There is significant overlap between the items on GGHC's checklists and the ecosystem services concerns laid out by the Sustainable Sites index. For example, both SSI and GGHC give buildings credit for containing outdoor landscape spaces for relaxation and inspiration in addition to rewarding indoor air quality, energy efficiency, and on-site stormwater management.

Tool C

Tool C is a questionnaire intended to engage diverse stakeholders on a variety of proposed ecosystem service based strategies. See Banerjee et al (2011) for a more detailed explanation.

The Healing Landscape

Martha M. Tyson, landscape architect and author of *The Healing Landscape: Therapeutic Outdoor Environments* (1998) suggests a methodology for designing restorative landscapes through incorporating users' behaviors. She suggests conducting behavioral research in order to assess how current design affects users' "physical, emotional, cognitive, and social functioning and life satisfaction." She also suggests determining individual user characteristics and behaviors and the impacts of the proposed design on user groups. Her book includes a section on experimental design, and on designing questionnaires, checklists, and rating scales for evaluating how people perceive and interact with their environment.

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