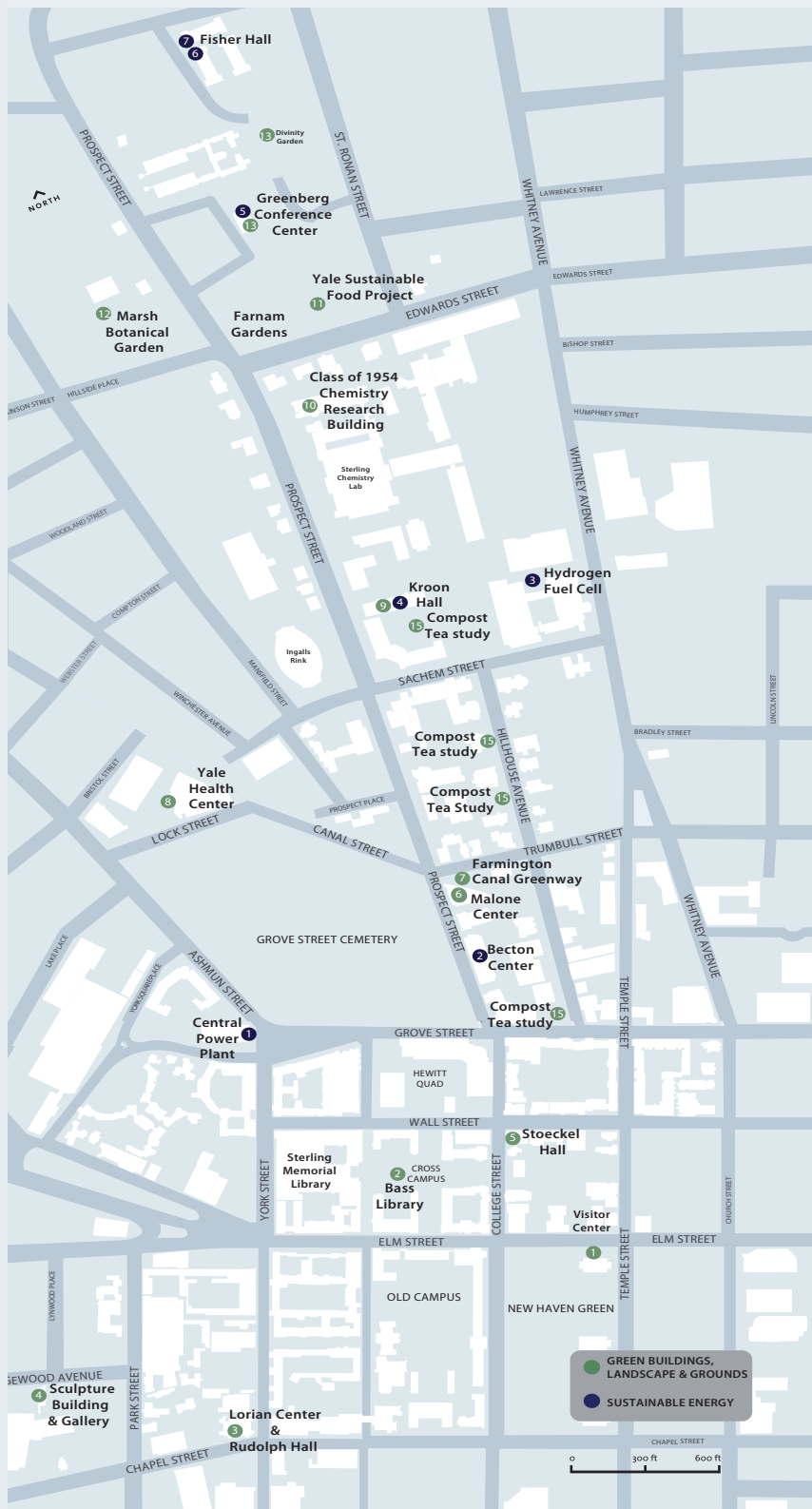




Yale Office of Sustainability
sustainability.yale.edu

Sustainability Tour

self-guided Tour of Yale's Campus



Universities have a critical role to play in curtailing global warming and providing leadership to build a more sustainable world. Our commitment requires vision, perseverance, creativity, innovation, and a willingness to adopt new practices. Yale's commitment to sustainability is evident throughout the University's scenic campus as well as the release of the Sustainability Strategic Plan 2010-2013.

The plan is a framework of goals and targets designed to advance Yale's sustainability efforts. It recognizes the complexity of the University as an organization and focuses on best practices that conserve natural resources, create positive work environments, improve public health, and strengthen partnerships with the New Haven community.

Yale's sustainability goals are more than simply operational. Tomorrow's students will face the challenges of living and working in a very different world: they will need to reconcile the needs of the present with the potential costs to future generations. Therefore, Yale's initiatives fully engage students—in addition to staff and faculty—in creating and maintaining a sustainable campus. As our students graduate from Yale and make their way across the globe, they will take these lessons with them. The impact will grow exponentially.

Building on more than 300 years of dynamic history, Yale continues to set the pace for change. All over this campus, men and women with varied interests develop cutting-edge practices and technologies, contribute to scholarship, and educate leaders who will help to set new standards for a more sustainable 21st century. As you learn more about Yale's efforts, keep in mind how you can bring it back to your organization, your community, and your home.



GREEN BUILDINGS, LANDSCAPES AND GROUNDS AT YALE

1 The New Haven Green

Equal parts, park and town square, the New Haven Green sits right in the middle of a street grid laid out by the city's founder, John Davenport, just after New Haven's founding in 1638.

For centuries the Green has served as New Haven's heart, hosting events such as an annual art and culture festival and a weekly farmers market in the summer. This beautiful urban park also serves as a recreational opportunity for students and downtown residents.

Yale is a constructive and active member of its hometown. The University engages with the City of New Haven on many levels. Yale opens its world-renowned libraries and museums to the public free of charge. It also collaborates with New Haven on projects ranging from poverty reduction to recycling outreach. New Haven is integral to Yale's sustainability efforts.

2 Cross Campus & Bass Library

Welcome to Yale's Cross Campus. Yale has

many green spaces; however what you might not be able to detect are that some of these green spaces are actually green roofs. One such example is Cross Campus. Tucked underneath the grass and walkways at Cross Campus is the Bass Library, which contains 200,000 volumes and is a popular student hangout. It's grassy roof provides more than just shelter from the elements. Having a roof covered in vegetation decreases, or in this case eliminates, storm water runoff as precipitation is absorbed by the soil and drawn up by the plant life. Beyond storm water management, the roof also regulates the building's temperature and reduces operating costs. In addition to the lawn itself, which is a popular spot for springtime study groups and frisbee tossing, the Bass Library houses an underground sustainable cafe that emphasizes locally-grown and organic fare.

3 Loria Center & Rudolph Hall

Erected in 1963 to house the Yale School of Architecture, Rudolph Hall is the brutalist masterwork of Paul Rudolph, who was dean of the school at the time. A recent

comprehensive renovation and expansion project focused on rehabilitating the 122,150 square foot Rudolph Hall and adding a new building, the 85,800 square foot Loria Center. Completed in the fall of 2008, the project received a LEED® Gold rating from the U.S. Green Building Council for its comprehensive renovation.

Sustainable features of the building include low-flow bathroom and kitchen fixtures, dual flush toilets, waterless urinals, a grey water capture and reuse system, large windows and skylights for natural light, sustainable certified wood, use of low volatile organic compounds building and finishing materials, and a 92 percent reduction in construction debris.

Visible from interior facing studios on each floor, Loria Center's fourth floor 2,300 square foot green terrace retains storm water runoff and provides additional building insulation. A patio area adjacent to the terrace provides building occupants an opportunity to enjoy a green space in the middle of an urban area.

4 Sculpture Building & Gallery

Completed in 2007, the Sculpture Building is a 55,000 gross square foot space that houses offices, studios, classrooms, and machine shops for undergraduate and graduate Sculpture programs for the School of Art. In 2008 it won the International Architecture Award and became first building in Connecticut to receive a LEED® Platinum rating from the U.S. Green Building Council.

Energy efficiency is a fundamental focus of the building design. It is sited to maximize the amount of natural light available, reducing the need for artificial illumination which automatically dims when natural light levels

are sufficient enough, and features large windows throughout the studio spaces. The south and east facades have external shading to control the solar load of the building and occupancy sensors automatically turn off lights. All of these energy reduction features significantly reduce the energy intensity of the building.

Another remarkable feature of the Yale Sculpture Building and Gallery is its incorporation of native plants into the surrounding landscape and green roof. These native green spaces serve as a connective habitat patch for birds moving through the urban corridor of New Haven's many parks. The green roof reduces runoff while decreasing the building's cooling load, limits the buildings contribution to the urban heat-island effect, and provides a pleasant view for those inside the building.

5 Stoeckel Hall

Originally built in 1897, Stoeckel Hall is a unique architectural fixture on campus, but during its 2009 renovation received a LEED® Gold rating. The renovation included water conservation measures that allowed for 36 percent less water consumption, high efficiency lighting, control ventilations and hot water pump loops which save 18 percent of annual energy cost savings compared to baseline buildings. Restoring the façade required extensive masonry, but 90 percent of the original walls and floors were reused, reducing demand for new materials, and 85 percent of the waste produced during construction was recycled.

6 The Malone Center

The Malone Center, home of the Department of Biomedical Engineering, was completed

in 2005 and received a LEED® Gold rating. The building provides 65,000 square feet of laboratories and offices equipped for cutting-edge research—all while consuming 10 percent less power than a standard building of comparable size. Such energy savings are achieved through a combination of new technologies and sustainable design best practices; the building's position and window placement optimize exposure to natural daylight, while occupancy and ambient light sensors regulate artificial light, temperature control, and ventilation.

Water conservation was another major focus of the building design. Laboratory waste water is filtered and used to flush the toilets. Low-flow bathroom fixtures use water sparingly, reducing water use by 85 percent compared to a standard building.

More than seventy-four percent of the building's woodwork comes from sustainably managed forests, and all of the paints, carpets, and other interior finishes were chosen for their low emission of air contaminants. Ninety percent of the building project's construction debris was recycled.



7 Farmington Canal Heritage Trail & Transportation Options at Yale

The foot of Malone's north-facing glass façade rests at the edge of the historic Farmington Canal Heritage Trail, an 84-mile biking and pedestrian trail that follows the meandering path of a former canal. Originally constructed in the 1820's as a waterway linking towns between New Haven and Northampton, Massachusetts, the canal was converted to a railway in the mid-1800's. Portions of this railway were in use up until the 1980's, but during the 1990's, the railroad right-of-way was converted to a rail trail for recreational use. In 2006, Yale contributed toward the completion of the final two blocks of the trail, from Hillhouse Avenue to the Audubon Arts District.

In addition to its contribution to renovating a small part of the Farmington Canal, Yale established the Office of Transportation Options with the goal of reducing the environmental and financial impact of the University's transportation needs while enhancing the quality of life for all users of New Haven's streets. The office works



to reduce the number of single-occupancy commuter vehicles and the size of the Yale fleet. Their tools include a bike share program; enhancing facilities for bicyclists; offering "commuter counseling" and other incentives for using transit, bicycling, walking, Zipcar, and ride-sharing.

8 Yale Health Center

Serving 36,000 students, faculty, staff, retirees, and their dependents, Yale Health Center's 147,000 square foot building opened in August 2010. The LEED® Gold certified building features a large atrium that provides ample natural light, rooftop gardens, sustainably sourced materials, and a variety of energy saving technologies. The interior environment was a primary focus for this building thus ventilation rates, temperature controls, lighting, and ample views to the outdoors were carefully designed to achieve optimal indoor environmental quality and promote occupant well-being. Carbon dioxide sensors ensure that fresh air is supplied when CO₂ concentration levels are high. Finishes, such as interior paints, sealants, and adhesives, have low volatile organic compound content to reduce toxicity and noxious odors.

There are six green roofs throughout the building with a meditation garden located on the rooftop terrace. Featuring native, self-sustaining plants, the garden space provides staff and patients a quiet place to relax while also reducing storm water runoff and a reduction in the heat island affect. The building was also one of the first in Connecticut to receive the Green Guide for Health Care.

9 Kroon Hall

Housing Yale's School of Forestry and Environmental Studies, Kroon Hall's design and construction goes above and beyond industry standard. Receiving a LEED® Platinum rating in 2010, the building's shape - a combination of New England barn and cathedral nave - reduces interior temperature fluctuations and provides building occupants with plenty of natural daylight.

The building materials for Kroon were also carefully chosen. Fifty percent of the wood used in construction was harvested from nearby Yale-owned, sustainably managed forests. Structural concrete was made from recycled blast-furnace slag, preventing more than 4,000 tons of carbon from being emitted into the atmosphere.

With the goal of achieving excellent indoor air quality, all adhesives, paints, and carpets contain no or low-volatile organic compounds, which minimizes off-gassing of toxic vapors.

A rainwater-harvesting system on the south side of Kroon Hall collects storm water runoff from the building's roof and from portions of the surrounding grounds. Once collected, the water is held in a settling tank which allows the majority of the sediment to settle out. From there, the water is moved to a storage tank and slowly re-circulated through the aquatic treatment pond. The pond employs wetland plants such as cattails, iris's, and lotus's to remove impurities, including nitrogen, phosphates, and particulates, before the water is reused for either irrigation or toilet flushing. The pond also provides students, staff and faculty an enjoyable place to relax.

These features and dozens of other sustainable building techniques combined to

make a remarkably functional, beautiful, and sustainable facility in which to educate the world's future environmental leaders.

10 1954 Chemistry Research Building

Completed in 2005, the 105,000 square foot state-of-the-art Class of 1954 Chemistry Research Building was Yale's pilot LEED® project and paved the way for future green building initiatives at the University. Receiving a LEED® Silver rating from the U.S. Green Building Council in 2006, its sustainable features include: reusing water from the reverse osmosis system; low-flow water fixtures; an energy efficient ventilation system and the use of heat exchangers to harvest wasted energy; low volatile organic compound finishes and paints; and recycled construction and demolition waste.

11 Yale Sustainable Food Project & Dining Service

Welcome to the Yale Sustainable Food Project, Yale's very own organic garden. The farm was launched in 2001 with the help of renowned chef Alice Waters. The farm offers a hands-on collaborative learning experience for students and members of the community. It is also a valuable resource for learning about food cultivation and connecting students to their environment.

Produce from the farm is harvested by a volunteer crew comprised mostly of students, who come for the rewarding work, camaraderie and the pizza baked on-site in the Farm's brick oven, using farm-harvested ingredients. Additionally, during the summer, the Yale Farm sells produce at one of New Haven's farmers' markets.

Yale's undergraduates are also introduced to sustainable food via Yale's dining facilities.

Yale's commitment is for 40% of the ingredients used to prepare the 15,000 meals served daily in the dining halls to meet at least one of four criteria: local, eco-sensitive, fair, and humane. That translates into healthier, tastier food, happier students, and a reduced carbon "foodprint." Additionally, throughout the year, the Dining Hall team educates students about the benefits of sustainably grown and prepared food.

Further efforts to streamline operations and reduce the number of deliveries to campus have additionally reduced the impact of dining at Yale. Yale Dining also offers weekend field trips to nearby farms that provide products for the student menus. Furthermore, Yale Dining is working to reduce pre- and post-consumer solid waste from its dining halls by 30 percent below 2009 levels by 2013.

12 Marsh Botanic Garden

Marsh Gardens sits on eight acres at the northern end of Yale University's campus. Bequeathed to the University by Othniel C. Marsh (1832-1899), paleontologist and natural history professor, the Gardens have provided support for research and instruction for Yale's undergraduate and graduate studies programs, including Forestry and Environmental Studies; Evolutionary and Ecological Biology; Molecular, Cellular and Developmental Biology and others.

The garden's outdoor displays include remnants of the original design by Beatrix Farrand, whose relationship with Yale University began in 1923 and lasted for decades. The display areas also include naturalistic plantings on the hillsides using American native wildflowers, grasses and woody plants. The perennial and annual

beds near the greenhouses provide spring, summer and fall color.

13 Maurice R. Greenberg Conference Center

Consisting of an amphitheater, a dining room, seminar rooms, classrooms, office spaces, and a catering kitchen, this 13,647 square foot conference center hosts international leadership programs and connects via passageway to the existing adjacent Betts House. The Greenberg Conference Center received LEED® Gold certification for its innovative green design which incorporates energy efficiency and renewable energy features, locally sourced materials, storm water runoff mitigation mechanisms, and excellent indoor air quality for building occupants.

Careful specifications by the architect and sourcing by the contractor ensured both recycled content and locally-sourced materials were installed in the project. More than 40 percent (based on cost) of materials used were from regional locations. Over 50 percent of the wood used is from certified as sustainable by the Forest Stewardship Council. Additionally, construction and demolition debris was recycled resulting in an 86 percent reduction of total construction waste diverted by landfills.

14 Yale Divinity School Garden

Built by Divinity School students during the summer of 2009 the garden and compost is managed by students throughout the year. The project is a part of the Divinity School's effort to include the environment in the study of theology. Growing sweet corn, tomatoes, peppers, scallions, carrots, lettuce, herbs and native flowers, the garden's goods are often

used by the Berkeley Center for community dinner following Eucharist Services. The garden allows students to get their hands dirty and equips burgeoning religious leaders with the knowledge to further dialogue about the importance of sustainability in local communities. In addition to the garden, the Divinity School has embarked upon a process of developing a Sustainability Action Plan for its campus and administration.

15 Compost Tea Study

See those blue markers before you laid out in a four square grid? These markers identify plots of soil that are being used to assess the impact of using compost tea as a soil amendment. Utilizing the campus as a living laboratory, the compost tea study is a collaborative initiative between students and faculty from the School of Forestry and Environmental Studies, Yale Grounds and Maintenance, and the Office of Sustainability. The joint pilot project will monitor four different treatment protocols at eight test sites across campus. It will compare the effects of a compost tea amendment, made from Yale's composted food waste, versus current treatment methods on the ecology of Yale's soils. The above and below ground response to the four treatments will be assessed by students. Healthy soils absorb more water, filter urban pollutants, and sequester carbon from the atmosphere. Measuring both soil and vegetation responses will not only provide information relevant to ecosystem function but also will have useful implications for landscape management on campus.

SUSTAINABLE ENERGY AT YALE

1 Yale's Central Power Plant

Constructed in the neo-gothic style, Yale's Central Power Plant has been meeting campus energy needs since 1918. The plant originally used coal to meet the University's growing energy needs; however, today the plant is a cogeneration facility that is primarily fueled by natural gas. The plant provides electricity, steam heating, and chilled water to buildings on Yale's main campus.

Steam and chilled water for heating and cooling are distributed through a series of linked pipes that make up 14 linear miles of steam tunnels, which pass under and interconnect nearly every central campus structure. Most of the steam and chilled water eventually returns to the plant, where they are cleaned of impurities.

Converting the Central Power Plant in 1995 to a cogeneration facility has significantly increased the efficiency of the University's energy production and reduced the amount of energy that Yale buys from the local utility provider, United Illuminating.



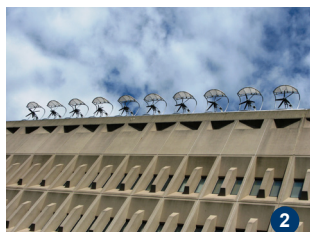
2 Becton Micro Wind Turbines

As you look up at the roof of the Becton Engineering and Applied Science Center you cannot miss the subject of this stop in the tour: ten micro wind turbines peer down at you from the roof's edge. Each of these micro wind turbines can capture a breeze as light as seven miles per hour as it travels up the face of the building and then convert it into electricity.

Manufactured by AeroVironment, Inc. and installed in March 2009, the ten 1 kilowatt turbines will produce an estimated 25 megawatt hours of energy over the course of the year—enough to power two average Connecticut homes.

3 Hydrogen Fuel Cell

Located behind the Peabody Museum and the Class of 1954 Environmental Science Center, is a 250 kilowatt Fuel Cell. Built by the FuelCell Energy Company, a Danbury, Connecticut based company, the fuel cell was awarded to Yale in 2003 from the Connecticut Clean Energy Fund. This state sponsored initiative was part of an effort to promote Connecticut's fuel cell industry. Yale



is committed to publicizing the fuel cell as a demonstration site for 10 years.

While designed to run on hydrogen, Yale's fuel cell is actually powered by natural gas, 80 percent of which is usable hydrogen. The fuel cell takes in natural gas and water and produces water, electricity, and hot air. Initially, the hot air produced as a by product of the chemical reaction inside the fuel cell was wasted, but the Yale Office of Facilities designed a heat exchanger, which uses the hot air to heat the building. The fuel cell produces 40-50 percent of the electricity for the Science Center.

4 Kroon Hall (solar photo-voltaic, concentrated solar thermal tubes, geothermal heat pumps)

One initiative that is helping Yale to achieve its aggressive greenhouse gas emission reduction goal is the installation of solar photo-voltaics systems on buildings across campus. Visible at Kroon Hall, is a 105 Kilowatt solar system which produces approximately 120,000 kilowatt hours a year, which is equivalent to powering approximately 14 homes in Connecticut. Another solar feature of the building are four sets of evacuated solar hot water tubes which are incorporated into the south façade of the building. These tubes generate enough hot water for the entire building. More efficient than conventional solar hot water systems, each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin's coating absorbs solar energy but inhibits radiative heat loss. Thermal conduction and convection losses are almost nothing (under 2 percent) because of the vacuum gap allowing

the systems to produce approximately 40 percent more hot water than a conventional system.

Geothermal heat pumps, also considered a renewable energy source, fulfill the heating and cooling demands of the building. The air is heated and cooled using water that flows through deep geothermal wells to regulate its temperature, rather than relying on traditional fossil fuels. Combined with the solar array on the roof and the solar hot water system, and an abundance of natural light, these features aim to reduce carbon impact of the building.

5 Geothermal Heat Pumps at the Greenberg Conference Center

Geothermal heat pumps at Yale's Greenberg Conference Center contribute to the buildings low energy intensity and are the primary mechanical system for the facility's heating and cooling system. Geothermal heat pumps transfer heat from the earth by pushing water that flows through deep geothermal wells. In the winter, the warmer temperature of the earth is transferred into the building while in the summer the heat from inside the building is discharged into the ground resulting in a highly efficient heating and cooling system.

7 Fisher Hall Solar Photo-voltaic System

Installed in 2007 on the Divinity School's Fisher Hall, this 40kW solar system was the University's first solar installation. Consisting of 255 solar panels, the system generates approximately 45,000 kilowatt-hours of electricity annually which covers about 17 percent of the hall's energy demand.