MONARCHS IN METROPOLIS:

A CASE STUDY OF THE COOK+FOX ARCHITECTS GREEN ROOF

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Introduction

New York City, like other metropolises of many millions of people, has both great environmental advantages and serious ecological impacts. While well-known for its relatively low energy use per capita and highly successful public transportation system, in the summer the city becomes a sweltering landscape of concrete, brick, and steel. Veins of traffic pulse through its streets, exhaling carbon dioxide and other gasses that accumulate into a layer of ground-level ozone. Its roofscape, spotted with the city's iconic wooden water tanks, when viewed from above is largely a field of black tar surfaces, soaking up sun and shedding water to the pavement below. Solar radiation striking these dark surfaces is absorbed and re-radiated as heat, turning the city into an urban "heat island" an average of 7 degrees hotter than the surrounding region (1). The power grid strains to meet the demand for summer cooling, with daytime peaks forcing the electric utility to turn on polluting, older power plants at the expense of air quality and greenhouse gas emissions.

New York City also struggles to handle a high volume of stormwater with an aging sewer infrastructure. In the city's combined sewer system, stormwater runoff mixes with sanitary sewage, which then flows to 14 treatment plants throughout the five boroughs. During rains of appreciable size – in Manhattan, as little as ½ inch – the volume of stormwater overwhelms the capacity of these treatment facilities. The result is a Combined Sewer Overflow (CSO), in which partially treated sewage flows directly into local waterways. Beaches are frequently ordered to close after summer storms, and many marine environments remain unusable for recreation and unhealthy to fish and other aquatic life.

CSO outflow at Stuyvesant Cove Park, one of hundreds around the city
Photo: Jamie Paquette, Solar1

In the summer of 2006, Cook+Fox Architects decided to set a greener, healthier example with a roof that absorbs stormwater, lowers surface temperature, and benefits both the local ecosystem and the human environment. Having grown rapidly, the firm had recently moved to a new office on Avenue of the Americas at West 20th Street. Located in the 8th floor penthouse of a former upscale department store, in the Ladies' Mile Historic District, the new space looked onto a sizeable terrace-level rooftop. Though coated in black tar and formally off-limits, the roof held great potential as a platform for promoting urban sustainability.

Roof terrace at 641 Avenue of the Americas, before green roof installation

As architects for the Bank of America Tower at One Bryant Park, on track to be the first high-rise office tower to achieve LEED Platinum certification from the US Green Building Council, it was only natural for the firm to design its new office to meet the highest standards in green building. The goal was to create a healthy, productive, and inspiring workplace that would showcase a range of sustainable materials and design strategies. In December 2006, the new Cook+Fox office was officially awarded Platinum certification under LEED for Commercial Interiors (CI). The green roof, while only a small component of the LEED process, has become a highlight of the office and a valuable educational tool for clients, visitors, and employees.

Project Summary	
Location	New York, NY
Year Completed	2006
Size	3600 SF
Type	extensive modular bag system
Plants	sedums, talinum
Cost	$10/SF
Maximum Weight	17 pounds/SF
Green Roof System	Green Roof Blocks
Landscape Design	Jost Greenhouses
Plant Supplier	Emory Knoll Farms
Soil Supplier	McEnroe Organic Farm

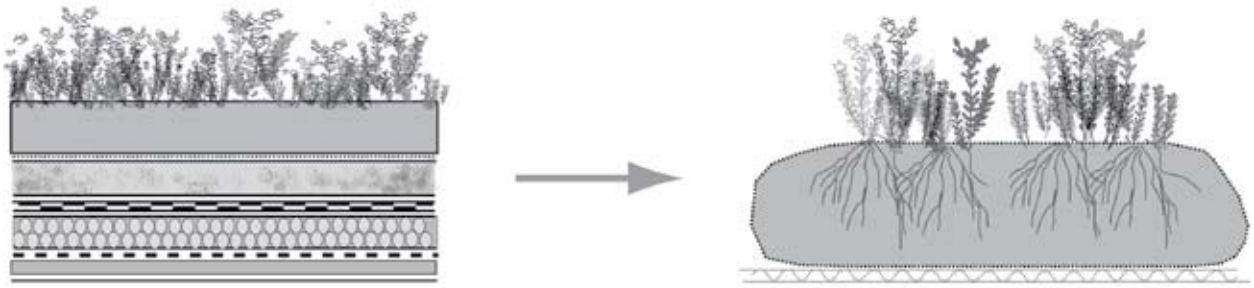
Design Considerations

The Cook+Fox office is a 12,000 square foot penthouse within a 19,000 square foot building footprint, leaving (minus elevator and mechanical spaces) a terrace of approximately 5600 square feet, visible from almost the entire floor. Workstation partitions were purposely kept low, preserving direct lines-of-sight to the outdoors. The roof terrace receives primarily northern and eastern exposure, and is highly visible from the office's front entrance and reception area.

Floor plan of Cook+Fox Architects office, including 3600 SF green roof

The firm wanted a green roof that would be lightweight, flexible, low-maintenance, and affordable. Built in 1902 of sturdy masonry construction, the roof was judged capable of handling an additional load; however, the firm and its landlord wanted to minimize additional weight. While the owners of the building were open to the proposed green roof, they were concerned about the integrity of the roof membrane and building drainage system. For these reasons, Cook+Fox was interested in a flexible system that could be altered later if necessary. With a non-rectilinear area for planting, small modular units also offered the best options for creating a green roof in a custom shape.

Of the modular systems researched, the Green Paks nylon bag module offered a significant cost savings over aluminum or plastic trays, which ranged from $18 to $20 per square foot. Filled with a mix of expanded shale (80%) and compost (20%), the bags weigh approximately 11 lbs per square foot when dry, or 17 lbs per square foot fully saturated. Cook+Fox designed its project in collaboration with Green Roof Blocks, a St. Louis, Missouri-based roofing company, but was able to contribute most of the labor needed for installation, substantially reducing the cost of the project to $10 per square foot. Finally, the firm wanted a landscape design that could survive



Built-in-place extensive green roof

Green Paks roof

exclusively on rainwater, in addition to withstanding the heat, wind, sun exposure, and occasional periods of drought or prolonged wet weather New York City experiences. A landscape plan that required no potable water for irrigation would also help the project achieve a credit under LEED.

Funding for the green roof was made possible by NYSERDA, a New York State public benefit corporation that provides research and incentives in energy efficiency, alternative energy, and environmental protection. Thanks to NYSERDA's Energy $mart Loan Fund, the project received a low-interest loan for the green roof, as well as funding for energy efficiency upgrades.

New York City Average Precipitation

Month	Mean Total Precipitation (in)	Mean Number of Precipitation Days
Jan	3.2	8.3
Feb	3.0	7.6
Mar	3.6	9
Apr	3.9	8.6
May	3.8	9.2
Jun	3.7	8.7
Jul	3.8	7.8
Aug	3.4	7.4
Sep	3.3	6.6
Oct	2.9	6.1
Nov	3.7	8.1
Dec	3.4	8.7
Total	**41.7**	**96.1**

Source: World Meteorological Organization

Installation

Early August 2006 brought one of the summer's worst heat waves, when surface temperatures on the Cook+Fox roof were recorded at 175° Fahrenheit. Days later, representatives from Green Roof Blocks and Jost Greenhouses traveled from St. Louis to supervise the installation of the green roof. Some 5000 plant seedlings arrived separately, transported from Emory Knoll Farms in Maryland by biodiesel-powered truck. Over 800 Green Paks, each weighing approximately 55 pounds and filled with growing medium at McEnroe Organic Farm in Millerton, New York – whose owners are longtime friends of the firm – were trucked to Manhattan and met by 25 volunteers from Cook+Fox. Work teams hoisted the bags to the 8th floor, out a window, and onto the roof, where they were laid down over a half-inch drainage mat, which also acts as a root barrier protecting the roof membrane below. Once laid flat, the bags measured four inches high; holes were made and a slow-release plant food added to prepare the bags for planting.

Meanwhile, another team of volunteers prepared the plants and gently dug them into the shale-and-soil aggregate, placing six seedlings per bag. Eight species of sedum and one talinum (Flameflower) had been chosen for their tolerance to temperature extremes, sun and wind exposure, and long periods without rain. To foster the greatest biodiversity and resilience in the new ecosystem, the team mixed the sedums so that no two individuals of the same species were planted next to each other. The young plants then received a thorough initial watering. For the next six weeks,

watering continued by hand and with sprinklers approximately twice a week; bags were given a chance to dry out between soakings, mimicking the succulents' natural wet-dry cycle.

LIST OF SPECIES

Sedum sexangulare – Six Sided sedum
Sedum album – Jelly Bean sedum
Sedum middendorffianum diffusum
Sedum stenopetalum (native)
Talinum calycinum – Flameflower
Sedum spurium – John Creech
Sedum Kamtschaticum – Russian Stonecrop
Sedum divergens
Sedum spurium fuldaglut – Dragon's Blood sedum

Fortunately, late August and September temperatures were less extreme, and regular summer rains reduced the task of watering. By the end of September, temperatures had started to fall and the plants had grown enough to begin sustaining themselves. Following the landscape installation, the roof was finished with high-albedo pavers around the outer perimeter and smooth gravel along the curving window wall. As the plants grow outward into a thick mat of vegetation, the modular nature of the Green Pak system will be sustained, thanks to UV-stable nylon bags that do not degrade under continuous exposure to the sun.

Results and Implications for New York City

From the first day of the green roof installation, its cooling effects could be observed. On days with air temperatures over 90 degrees, when adjacent rooftop surface temperature reached 145° F, temperatures measured over the green roof never exceeded 100° F – even with the immature growth stage of the plants. Plant respiration, together with evaporation of water held by the green roof bags, combined to drastically reduce the heat retained by the roof. This kind of naturally-cooled micro-climate lowers a building's cooling load and can also extend the life of the roof membrane, which typically needs replacing every 20 years due to sun and weather exposure.

From a larger hydrological perspective, New York is a dense hardscape broken only by Central Park, Prospect Park, and smaller neighborhood and pocket parks scattered throughout the city. Many cities with similar terrain are now exploring innovative ways of re-constructing "green infrastructure" – integrating vegetation, wetlands, and open space into the urban environment – as a comprehensive and cost-effective approach to controlling stormwater and pollutants. Since CSO discharges are typically 15-20% sewage and 80-85% stormwater, better stormwater infiltration can greatly reduce pressure on wastewater treatment facilities (2). Green urban infrastructure features can include green roofs, street planters, water-detention swales, permeable paving, and rainwater collection systems (3). In addition to restoring the natural water cycle, these features simultaneously filter out air pollution and cool the city. In 2006, the New York City Regional Heat Island Initiative, a collaborative involving Columbia University, Hunter College, and Science Applications International Corporation (SAIC), concluded that "a combined strategy that maximizes the amount of vegetation in New York City by planting trees along streets and in open spaces, as well as by building living (green) roofs (i.e. ecological infrastructure), offers more potential cooling than any individual strategy" (1).

To many, restoring ecosystems to the point of supporting wildlife may seem like a lost cause in a place like New York City. However, even small areas of open space can support thriving populations of microorganisms, flora, and fauna, and these oases of biodiversity help sustain larger urban ecosystems. Almost immediately after installation, Cook+Fox discovered insect life returning to the green roof. Dragonflies were the first to appear, followed by moths, gnats, and flies. In early

The Cook+Fox roof is the largest green space for blocks in several directions

September, the first bird was spotted; later, two hawks were noticed using the roof railing as a perch. Later that month, staff became concerned when dozens of orange, grub-like insects were observed attached to the leaves of Sedum kamtschaticum or Russian Stonecrop. Further investigation revealed that these “parasites” were in fact ladybug pupae, a beneficial insect and great early indicator of the health of the rooftop micro-ecosystem. Throughout the fall, monarch butterflies often visited; the city occupies a strategic stopover in their semiannual migration.

Pupal stage of Coccinellidae, shortly before maturing into adult ladybugs

As one of the few sizeable green roofs in Manhattan, the project offers an excellent opportunity for ongoing research on planted roofs in dense, urban areas. Cook+Fox is collaborating with the nonprofit Gaia Institute to study water retention and growth rates of the sedums, using methodology developed by the Southern Illinois University - Edwardsville Green Roof Collaborative. Growth variables include wind shear, solar load, shading, and edge effects. The Gaia Institute has also set up a 95 square foot experimental zone to test the success of various soil aggregate compositions, including Gaia Soil™, a proprietary, ultra-lightweight mix of finished compost and post-consumer expanded polystyrene foam.

LARGE GREEN ROOFS IN NYC

Silvercup Studios	Long Island City	35,000	SF
Bronx County Building	Bronx	10,000	
The Solaire - 20 River Terrace	Manhattan	9,400	
GrandParent Family Apartments	Bronx	8,000	
Tribeca Green	Manhattan	5,860	
Saint Simon Stock R.C. Elementary School	Bronx	3,500	

Biophilia: Benefits of Restoring the Human Environment

Because the green roof is at the 8th floor terrace level, not overhead above the 8th floor, Cook+Fox does not capture the energy savings associated with the cooling effects of the green roof; instead, these savings benefit the tenants of the 7th floor. Also, because of its size, the green roof turned out to be only a minor contributor to LEED Platinum certification. The size of the green roof (3600 SF) relative to the entire building footprint (19,000 SF) was well under 50%, making it very difficult to earn a Heat Island Reduction credit under LEED. Even so, the partners of the firm have observed that installing and caring for a green roof was one of the best decisions made throughout the entire project. As Rick Cook explained to *Metropolis* magazine in November 2006, "Every business knows how destructive it is when people are unhappy…and how productive – and profitable – it is when the staff is invested" (4).

The field of research known as *biophilia* – a term popularized by E.O. Wilson and defined as "love of life" or the innate kinship that humans feel toward the natural world – explores what it means to design the built environment to foster positive connections with nature (5). Contact with the natural world, both literal and symbolic, has been shown to reduce stress and even enhance employee health and productivity. In an office environment, biophilic design strategies can translate into reduced absenteeism and turnover, and lead to a more productive, creative work environment.

Like an artificial – but very much living – horizon, the green roof at Cook+Fox breaks up the urban backdrop of tall buildings and densely packed vehicles. This restorative green plane is a constant presence in the office, drawing the outside environment into the sightlines of the workplace. The roof also marks the changing seasons and the time of day: in summer, Flameflower (Talinum calycinum) open their small purple flowers every day at mid-afternoon; observers are naturally more aware of dry spells, frost snaps, and other weather impacts on the micro-ecosystem out the window. In addition to illustrating ecological concepts to clients and visitors, the green roof has become a defining feature for the entire office. In a city where daily contact with open space is often a rare amenity, even a small patch of greenery can start knitting the urban ecosystem back together and give living things a place in the human environment.

Tiny Flameflowers bloom daily at mid-afternoon

Conclusion

Green roofs may soon have their day in the New York City sun. In December 2006, Mayor Michael Bloomberg announced PlaNYC: an initiative to look toward the future and make the investments necessary to sustain a growing city. By 2030, New York will have added another one million people, and the city's water, energy, and transportation infrastructures are already almost 100 years old. A key element of the Mayor's long-term planning is environmental sustainability—considering the challenges of protecting air and water quality in a city of nine million and the potential impacts of climate change and rising sea levels. With high-level support for sustainability issues, it is an excellent time to spread awareness of the benefits of green roofs in New York. Organizations such as the Gaia Institute, Earth Pledge, and Sustainable South Bronx have helped by supporting pilot projects that explain the benefits of urban green roofs to wider audiences. Given the interrelated nature of the city's water, energy, and air quality issues, green roofs hold great promise as an effective, integrated solution.

Looking north over green roof toward Empire State Building, fall 2006

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Resources

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Sustainable South Bronx, www.ssbx.org

Earth Pledge, www.earthpledge.org

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University of Virginia Stormwater Management Plan, http://keats.admin.virginia.edu/stormwater/home.html

Cook+Fox Architects, www.cookplusfox.com