

SCAPES 8

FALL
2009

SCHOOL OF CONSTRUCTED ENVIRONMENTS
PARSONS THE NEW SCHOOL FOR DESIGN

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Editors: Joanna Merwood-Salisbury and Brian McGrath
Design: Lisa Maione

Typeset in Arnhem Blond & Berthold Akzidenz Grotesk

Correspondence may be sent to Scapes,
c/o School of Constructed Environments,
Parsons The New School for Design,
25 E 13th Street, 2nd floor, New York NY 10013.

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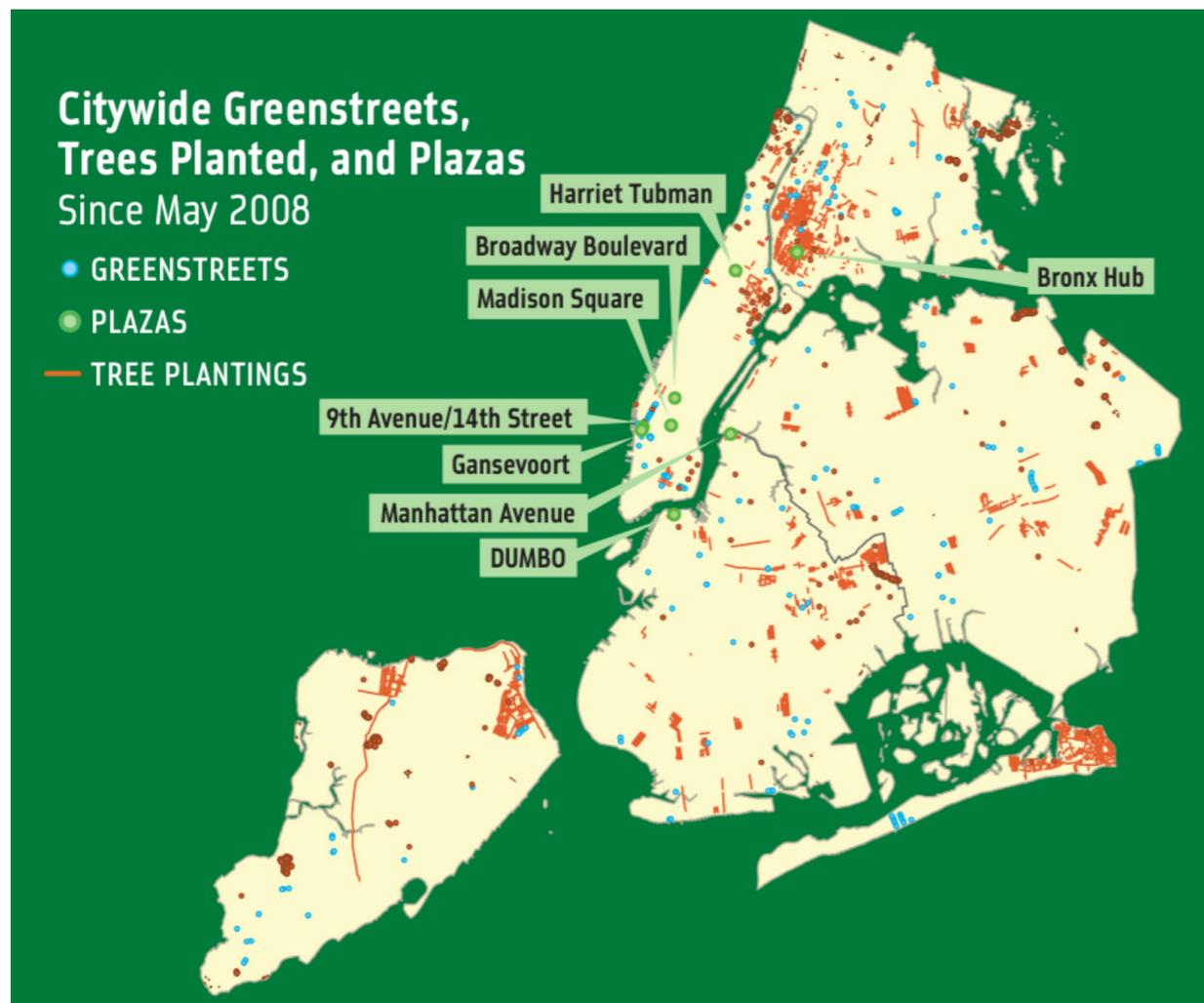
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Solving the Environmental Crisis with a Tree?

P. Timon McPhearson



GREEN AMBITION

What constitutes an improvement in the green infrastructure of cities? Is greening the urban landscape mostly about designing it to display more “greenish” things, or can we ask landscapes to be highly functional as well? And if so, what ecological and sociological functions are most important to pursue when designing urban landscapes? The current priority on climate change mitigation through carbon sequestration and storage in both government and industry is replacing the more recent ecological focus on maximizing biological diversity, though both provide important functions. However, the average citizen may be more concerned with the beauty or openness of a particular green space rather than the city’s need for it to perform critical ecosystem functions, such as the capture of storm water. How should urban designers, planners, and policymakers decide which functions to maximize, and what will be lost in prioritizing one over another? Below I discuss the New York City Human Ecosystem Project, which includes two specific research projects, the NYC Urban Forest Restoration Study and the StEM Project, in the context of the need to maximize ecological functions and services in urban areas over both the short- and long-term. Both projects are designed to study the interaction between social, political, and management goals and the potential of urban ecosystems to meet these goals.

On Earth Day 2007 New York City’s Mayor, Michael Bloomberg, announced an ambitious multi-decadal plan, PlaNYC 2030, to make New York City more sustainable by 2030¹. PlaNYC includes 127 ambitious sustainability initiatives including a goal to plant one million trees in New York City by 2017². Since then the MillionTreesNYC (MTNYC) campaign has allocated \$400 million over ten years to the NYC Parks and Recreation Department (NYC Parks) to expand the City’s urban forest by 2000 acres by adding another 400,000 trees to public and private land and planting 220,000 street trees, which will, with additional partnerships including the New York Restoration Project, collectively add 20 percent more tree canopy cover to the city. Since its launch, public, private and non-profit organizations have rallied nearly 4,000 citizen volunteers to plant trees across New York City in what has become an unprecedented tree planting campaign and citywide environmental movement. Now in its third year, the city has already added over 200,000 young trees to existing urban parks, private lands, and city streets (Figure 1). But what will this extra tree canopy do for New Yorkers, other biological species, and the climate? Is the time duration of a small-scale urban trigger such as a citywide tree planting campaign sufficient to increase long-term sustainability

1 — PlaNYC 2030 Full Report, 2007. Available at: http://www.nyc.gov/html/planyc2030/downloads/pdf/full_report.pdf
 2 — MillionTreesNYC 2030. Available at: <http://www.milliontreesnyc.org/>

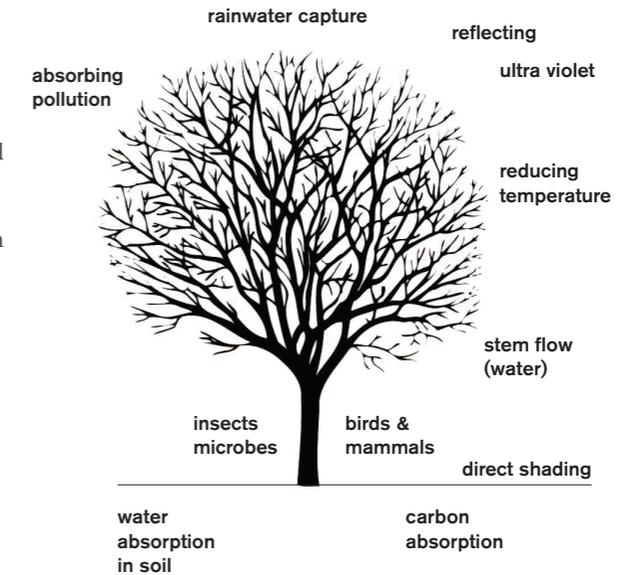


Figure 1

in New York City’s ecosystems? In the case of enlarging and restoring urban forests to make NYC more sustainable, many of the publically touted benefits of trees will not be felt until well after 2017. Indeed, it is not yet clear that merely planting trees will achieve any of the ambitious goals set forth in PlaNYC. The one million new trees must first survive the early years of city life in order to function as intended.

Planting lots of trees, especially a million trees, will potentially provide New Yorkers important health, economic and environmental benefits. However, there are many assumptions behind the rhetoric to this effect seen on MTNYC billboards and placards across NYC. A solid understanding of the benefits of tree planting for urban sustainability requires careful socio-ecological study, something we have very little of in New York City. Additionally, the momentum behind the MTNYC campaign has made it slow to organize and carry out related research in a scientifically rigorous manner because the campaign has had other priorities, namely its need to meet ambitious annual planting goals (~100,000 trees/year). This has meant that research has been relegated to a status lower than getting trees planted. Though city officials and park managers understand that evaluation of existing planting strategies and site designs are critical to the long-term success of the MTNYC campaign, providing mechanisms, incentives, and opportunity for such research has been slow, even though the motivation

clearly exists amongst Parks personnel. This is not surprising given the pressure put on small departments to deliver results in short periods of time.³ To their credit, MTNYC has a specific Research and Evaluation Subcommittee of their Advisory Board and has already hosted, in collaboration with The New School, *MillionTreesNYC*, *Green Infrastructure*, and *Urban Ecology: Building a Research Agenda* in April 2009, which brought together nearly 100 researchers and practitioners to develop a research strategy for the MTNYC campaign. One of the outcomes of this research workshop was a critical examination of the goals of MTNYC and the strategy currently employed to meet them⁴. The result was a consensus that we need to understand urban ecosystems much better than we do. It also became clear that there is an important role for The New School to play in both civic engagement and primary research in order to broaden and increase the accessibility of knowledge on the urban forests and environmental stewardship.

URBAN ENVIRONMENTAL STEWARDSHIP

Young urban trees, those most at risk of mortality during the first five years, are exactly the trees that are being planted in the re-greening effort currently underway across New York City (NYC). Afforestation⁵ plantings in city parks and on degraded or existing parkland are typically small two-gallon container trees that are ½ -1m tall and 1-2 cm in diameter. MTNYC volunteers and contractors strategically plant these susceptible trees in the fall and spring months to avoid harsh drought conditions in the summer. However, expectations are that without adequate care, many of these trees will fail to survive the first year.

Street trees are similarly stressed, living in extremely harsh conditions where they are tucked into “tree pits” cut into sidewalks, with little room for roots to expand. With thousands of young street trees already being planted, it is crucial to establish the required level of stewardship as soon as possible. Turning young trees into large old trees is important if they are to function as we hope, which is to say as small-scale climate mitigation machines. We already know that large, mature trees are more effective than small, young trees at controlling surface water runoff, storing carbon, capturing atmospheric pollution, surviving seasonal drought conditions, and providing increased thermoregulation through shading (which is crucial to reducing urban heat island effects).⁶ (Fig. 2)

The MTNYC trees will take at least 10 years, and

3 — This is even more understandable when one realizes the relatively small staff of ecologists employed at the NYC Parks Department, Natural Resource Group office.

4 — You can download the full 2009 Workshop Report at: <http://www.milliontreesnyc.org/research>

5 — Afforestation is the process of establishing new forests on previously unforested land. In the case of New York City, this involves planting trees on degraded and abandoned urban soils, which are typically fill material from city construction and dredging projects, though this type of forest restoration is also taking place on lawns and old fields in parks across the city.

likely more, to realize many of the proposed benefits, and only if they survive the initial mortality that strikes most young urban trees. The city also needs to maintain its current forest of five million existing trees. In candor, these challenges are simply too large for a city government to handle alone, even with a well trained, well-funded NYC Parks department. New Yorkers will have to take more responsibility for caring and protecting their forest if they want a cleaner, healthier, more sustainable city, a fact which is already clear to a small group of motivated individuals at MTNYC, NYC Parks, Trees New York, other area non-profits, and more recently StEM⁷.

StEM

Individuals, small community organizations, and businesses all need to play an increasingly important role in helping cities like NYC care for the street trees, parks, waterways, and open spaces that make up the urban environment. The StEM (Stewardship and Environmental Mapping) Project was initiated in 2008 at the New School's Tishman Environment and Design Center to address the need for research on, and increased stewardship of, the urban forest. Since then StEM has been working to develop the ecological and digital infrastructure to both track and motivate urban forest stewardship through the most up-to-date, publicly available, interactive and open-source map of the socio-ecological dynamics of urban trees. StEM's overarching goal is the development of a robust community-based urban forest stewardship network to more fully grow and promote a healthy, mature forest throughout all of New York City's neighborhoods. To achieve this the StEM Project is primarily focused at the scale of the individual street tree. By focusing on the small scale of an individual tree, we intend to influence the functioning of the urban forest at the scale of the entire city by linking socio-ecological relationships through web-based mapping, coupled human ecosystem research, community organization, and efficiently and engagingly designed information architecture.

The StEM project is essentially an experiment in design, mapping, and socio-ecological research to create the baseline data and working digital infrastructure for social engagement with the green infrastructure (i.e. trees) of the city. The evolving tree map will serve multiple functions, including: 1) Providing stewards with the information necessary to manage their individual contributions; 2) Allowing stewards to share information on the work they've done to help individual trees thrive; 3)

6 — Nowak, D. J., Hoehn, Robert E., Crane, Daniel E., Stevens, Jack C., and Jeffrey T. Walton. 2007. Assessing urban forest effects and values, New York City's urban forest. Resource Bulletin NRS-9. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.

7 — StEM is a non-profit project (co-founded by the P. Timon McPhearson, Philip Silva, Liz Barry, and Griffin Johnston) of the Open Space Institute that works collaboratively with the New School's Tishman Environment and Design Center to connect activist citizens with each other and their environment. The early pilot is currently being updated at <http://www.stemproject.org/>

Creating opportunities for social networking amongst stewards in order to develop more vibrant and lasting community-based stewardship efforts; and 4) Building a growing database of the long-term ecological effects of socially connected tree stewards on the urban forest.

StEM's evolving mapping and data management tools are therefore designed to empower NYC's volunteer and professional environmental stewards to coordinate their efforts and collaborate on the large project of caring for and assessing, in real-time, the state of the city's forest. Urban environmental stewards with complimentary interests and overlapping local scale geographies will be able to use StEM's platform to connect and share resources, ultimately facilitating increased structure and functioning of urban ecosystems.

The StEM Project in its pilot form was conceived as an interactive, high-resolution map-based field guide to The New School area trees. A focused mapping component of StEM was brought to the Parsons undergraduate Architectural Design program in order to utilize and pique student mapping and design skills to create the first map of New School area trees. A collaborative Parsons studio was launched in spring 2009, which involved 24 undergraduates in collecting initial street tree distance measurements, photos, and tree diameter measurements.⁸ Students used species identification data from a 2005 NYC Parks tree census (facilitated via collaboration with NYC Parks) to map the ecology of trees in a large geographical footprint around the New School stretching east/west from Broadway to 6th Avenue and north/south from 14th Street to Washington Square Park North. The initial student map (Figure 2) was important in establishing a working dataset for StEM to test the various technical issues involved in coding and organizing the database structure to deal with many dozens of interrelated ecological variables, map distances, and user profile data. It also demonstrated to the broader StEM team the ease and efficiency with which high-resolution map data can be gathered by students acting as citizen scientists to help researchers and practitioners better understand the functioning of the urban forest. This New School area map is currently being re-sampled to increase accuracy of both geographic and ecological measurements, to verify species identification of the ~600 street trees in the New School footprint, and will soon be available on a redesigned home for StEM at stemproject.org.

The StEM project has since expanded into a non-profit organization working under the auspices of the Open Space Institute⁹ involving designers, ecologists, social networking and mapping professionals (including a critical partnership with OpenGeo.org), and web

8 — The studio was run in collaboration with Parsons Bachelor of Fine Arts in Architectural Design Program faculty Natalie Fizer, Michael Morris, and Shai Turner, and Eugene Lang Ecologist Timon McPhearson, who collectively taught a Parsons studio (“TREE”) to showcase the important of trees to urban architecture while engaging students in the living biota of the built environment.

9 — The Open Space Institute works to protect and preserve open space at <http://www.osiny.org/>

designers and developers to solve what is now understood to be a significant urban problem: how to both provide data to and receive data from a small, socially disconnected urban environmental stewardship corps that is actively caring for trees. Similarly, StEM's goal is not to merely track but also to enhance environmental stewardship in New York City, as the current level is wholly inadequate to solve the dilemma of the one million new, highly vulnerable trees on which New Yorkers have placed large ecological, environmental, and economic demands. The need for citizen-based urban forest stewardship has yet to reach an audience equal to the task. And yet there are more citizens than trees in New York City, a ratio that is likely to remain in effect for the foreseeable future. If every person took responsibility for caring for a single tree in their neighborhood, we could safely assume that tree mortality rates would decline and the ecological, environmental and economic benefits we receive from trees would increase.

TREES AS ENVIRONMENTAL CLEANUP MACHINES

Trees are not simply landscaping agents in the city. They are the major structural and functional elements in terrestrial ecosystems including urban ecosystems. Walk into any terrestrial system on Earth and look up. If you can observe a large living structural element it is probably a tree. Trees are homes to birds, mammals, invertebrates, and microbes, all of which perform important ecological services. Trees also provide cities with a long list of additional ecological benefits including: regulating local surface and air temperatures, filtering pollution from the local atmosphere which may positively impact the health of urban residents, trapping rainwater during heavy storms which prevents pollution to local waterways, and storing and sequestering atmospheric carbon dioxide which offsets New York's contribution to global climate change. One recent study by scientists at the U.S. Forest Service put the economic value of NYC's forest at over \$5 billion.¹⁰ Indeed, many of the city's plans to offset urban contributions to global and regional climate change assume that the urban forest will grow, mature and store an ever-increasing amount of carbon, as well as provide many other ecosystem services.

Urban environments are notoriously difficult places to live for many biological species, including trees. Urban trees suffer from a vast array of damaging pollutants from acid rain washing over their leaves to being doused with bleach water as part of morning sidewalk cleaning routines. Road salt application in the winter and prolonged heat spells in the summer can create extreme drought-like

10 — Nowak, D. J., Hoehn, Robert E., Crane, Daniel E., Stevens, Jack C., and Jeffrey T. Walton. 2007. Assessing urban forest effects and values, New York City's urban forest. Resource Bulletin NRS-9. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.

conditions for trees living in city streets. Street trees are particularly susceptible to stress due to the small spaces in sidewalks where they are forced to grow, their highly compact and acidic soils, and the many injuries they suffer from living in such close proximity to urban life (see Figure 3).

Young urban trees (<5 years) are probably the most at risk with extremely high mortality rates (up to 30% in a recent study) in New York City due largely to common urban stressors (heat, salt, pollution), but also from lack of individual care during the first five years of their lives. With climate change predicted to increase the frequency of extreme heat events in NYC¹¹, newly planted young trees may fail to reach maturity and perform ecologically, environmentally, and economically as intended. Can the urban forest reliably function at the level urban sustainability campaigns such as PlaNYC expect and predict? What are the best planting strategies to maximize the many functional demands we place on trees as environmental cleanup machines? These questions are currently unanswerable because the study of urban systems as human ecosystems has only recently been established as a legitimate field of inquiry. We simply do not know what species of tree will best meet all the challenges of urban environments, or how best to design new parks to maximize both carbon sequestration and beauty (or other desirable functions). Meeting the functional design challenges of where and how to add 2000 acres of forest to New York City are the same challenges urban ecologists face as they seek to understand how urban ecosystems function and how best to maximize those functions in the face of climate change and urban population growth. Ecologists, urban planners, and designers alike are asking: How do we simultaneously accommodate more urban dwellers and design cities as sustainable ecosystems (CASE¹²)?

THE URBAN DILEMMA

The need to understand the intricacies of urban ecosystems emerges from two trends.¹³ First, urban ecosystems are home to an increasing fraction of humanity. Hence, most people's experience of nature is urban.¹⁴ It is hard to overstate this fact. It follows then that cities must manage to better exemplify environmental principles¹⁵ and find ways of existing in long-term sustainable relationships with their urban environment. Second, cities have a disproportionate impact on both regional and global systems.¹⁶ For example, the sprawl of many cities threatens agricultural lands and puts stress on neighboring wild and managed areas.¹⁷ There are already some 110,000 square kilometers in the United States that are impervious

11 — Climate Risk Information. 2009. New York City Panel on Climate Change. Available at: http://www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf
12 — P. Newman and I. Jennings. 2008. *Cities as Sustainable Ecosystems*. Island, Washington, D.C.
13 — Pickett, S. T. A., M. L. Cadenasso, J. M. Grove, P. M. Groffman, L. E. Band, C. G. Boone, W. R. Burch, C. S. B. Grimmond, J. Hom, J. C. Jenkins, N. L. Law, C. H. Nilon, R. V. Pouyat, K. Szlavecz, P. S. Warren, and M. A. Wilson. 2008. Beyond urban legends: An emerging framework of urban ecology, as

to water¹⁸ and urban lands affect a much larger area than this by altering climate, hydrology, and atmospheric chemistry.¹⁹ Among the many human activities that cause habitat loss, urban development produces some of the greatest local species extinction rates²⁰ and frequently eliminates a large majority of native species.²¹ Certainly, the increased energy use by humans in and around cities is a significant driver of changes in ecosystem function in the largest sense.²² At the same time, densely populated cities like NYC can be a net benefit to global ecosystems because they provide efficiencies that can limit the human impacts of more dispersed, resource-intensive settlement patterns. All these facts point to the need for a different manner of urban living, which in turn requires that we develop a more nuanced understanding of urban ecosystems, and improve and adaptively use socio-ecological theory to explain and predict their dynamics.²³

THE STUDY OF HUMAN ECOSYSTEMS

Urban ecosystem research is still a nascent field of scientific inquiry. Urban ecology has progressed primarily from the focused long-term study of two cities, Baltimore and Phoenix, over the last two decades, which are now producing important empirical observations of the relationship between urbanization and ecosystems.²⁴ Though these two long-term ecological research (LTER) sites now define the current field of urban ecology, it remains to be seen whether the findings from these studies, in particular the Baltimore Ecosystem Study (BES), are indeed generalizable and applicable to New York City.

The first on-the-ground study of cities as human ecosystems arguably began in New York City with the establishment of a long-term urban-rural gradient study in the

illustrated by the Baltimore Ecosystem Study. *Bioscience* 58(2):139-150.
14 — Miller JR. 2005. Biodiversity conservation and the extinction of experience. *Trends in Ecology and Evolution* 20: 430-434.
15 — Berkowitz AR, Nilon CH, Holweg KS, eds. 2003. *Understanding Urban Ecosystems: A New Frontier for Science and Education*. New York: Springer.
16 — Collins JP, Kinzig A, Grimm NB, Fagan WF, Hope D, Wu J, Borer ET. 2000. A new urban ecology. *American Scientist* 88: 416-425.
17 — Berube A, Forman B. 2001. Living on the edge: Decentralization within cities in the 1990s. *Living Cities Census Series* 2002: 1-11.
18 — Elvidge CD, Milesi C, Dietz JB, Tuttle BT, Sutton PC, Nemani R, Vogelmann JE. 2004. U.S. constructed area approaches the size of Ohio. *EOS: Transactions of the American Geophysical Union* 85: 233-240.
19 — Pickett STA, Cadenasso ML, Grove JM, Nilon CH, Pouyat RV, Zipperer WC, Costanza R. 2001. Urban ecological systems: Linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. *Annual Review of Ecology and Systematics* 32: 127-157.
20 — (McKinney 2002)
21 — See Luniak M, Pisarski B. 1994. State of research into the fauna of Warsaw (up to 1990). *Mem. Zool.* 49:155-65; and Marzluff, JM. 2001. Worldwide urbanization and its effects on birds. Pages 19-47 in Marzluff JM, Bowman R, Donnelly R, eds. *Avian Ecology in an Urbanizing World*. Norwell (MA):Kluwer.
22 — Pickett, S. T. A., M. L. Cadenasso, J. M. Grove, P. M. Groffman, L. E. Band, C. G. Boone, W. R. Burch, C. S. B. Grimmond, J. Hom, J. C. Jenkins, N. L. Law, C. H. Nilon, R. V. Pouyat, K. Szlavecz, P. S. Warren, and M. A. Wilson. 2008. Beyond urban legends: An emerging framework of urban ecology, as illustrated by the Baltimore Ecosystem Study. *Bioscience* 58(2):139-150.
23 — Pickett, S. T. A., M. L. Cadenasso, J. M. Grove, P. M. Groffman, L. E. Band, C. G. Boone, W. R. Burch, C. S. B. Grimmond, J. Hom, J. C. Jenkins, N. L. Law, C. H. Nilon, R. V. Pouyat, K. Szlavecz, P. S. Warren, and M. A. Wilson. 2008. Beyond urban legends: An emerging framework of urban ecology, as

late 1980s by McDonnell and Pickett (1990). It has taken the intervening period to develop the supporting theory and for the dialogue between different disciplines to mature.²⁵ As the most densely populated city in the U.S., a long-term study of NYC as a coupled natural-human system could yield important advances in urban ecosystem theory while adding significantly to the growing empirical understanding of the dynamic interplay of patterns and processes that influence the functioning of urban ecosystems generally. New York City is only now beginning to initiate such a study, which is to say, a large scale, interdisciplinary, socio-ecological study of the city as an ecosystem. A recent collaboration between The New School, Columbia University, Rutgers University, the U.S. Forest Service, and NYC Parks will begin examining the dynamics of forest stewardship activity and its impact on urban ecosystems in a study funded by a \$300,000 grant from the National Science Foundation (NSF) in 2009, part of the new NSF ULTRA-Ex (Urban Long-term Research Areas Exploratory Award) program. Researchers at The New School are also involved in the creation of a multi-collaborator, interdisciplinary study of NYC as a system called the NYCHE Project.

THE NYCHE PROJECT

The New York City Human Ecosystem (NYCHE) Project, an initiative of The New School's Tishman Environment and Design Center,²⁶ is an attempt to understand the complex socio-ecological system of New York City based in part on the Human Ecosystem Framework (HEF) model developed in the Baltimore Ecosystem Study (BES).²⁷ The NYCHE Project is a multi-institutional, interdisciplinary, long-term study of the coevolving socio-ecological dynamics of the human ecosystem that is New York City. Focused NYCHE research includes the StEM Project and the NYC Urban Forest Restoration Study, a long-term study of the effects of the urban forest restoration efforts of the MTNYC campaign on the functioning of urban forests.²⁸ The NYC Urban Forest Restoration Study includes scientists from The New School, Yale University, Columbia University, Cornell University, and the U.S. Forest Service who teamed up in 2008 with NYC Parks to study the short and long-term impacts of the MTNYC tree planting strategy on forest ecosystem structure and functioning. Core research questions include the following: What planting strategies should managers employ to maximize

illustrated by the Baltimore Ecosystem Study. *Bioscience* 58(2):139-150.
24 — See Collins JP, Kinzig A, Grimm NB, Fagan WF, Hope D, Wu J, Borer ET. 2000. A new urban ecology. *American Scientist* 88: 416-425; Grimm, N.B., M. Grove, S.T.A. Pickett and C.L.Redman. 2000. Integrated approaches to long-term studies of urban ecological systems. *Bioscience*, 50: 571-584; Pickett, S. T. A., M. L. Cadenasso, J. M. Grove, P. M. Groffman, L. E. Band, C. G. Boone, W. R. Burch, C. S. B. Grimmond, J. Hom, J. C. Jenkins, N. L. Law, C. H. Nilon, R. V. Pouyat, K. Szlavecz, P. S. Warren, and M. A. Wilson. 2008. Beyond urban legends: An emerging framework of urban ecology, as illustrated by the Baltimore Ecosystem Study. *Bioscience* 58(2):139-150.
25 — Pickett, S. T. A., M. L. Cadenasso, J. M. Grove, P. M. Groffman, L. E. Band, C. G. Boone, W. R. Burch, C. S. B. Grimmond, J. Hom, J. C. Jenkins, N. L. Law, C. H. Nilon, R. V. Pouyat, K. Szlavecz, P. S. Warren, and M. A. Wilson. 2008. Beyond urban legends: An emerging framework of urban ecology, as illustrated by the Baltimore Ecosystem Study. *Bioscience* 58(2):139-150.

ecosystem functioning such as atmospheric carbon absorption by urban terrestrial ecosystems? How well do heterogeneous urban forests sequester and store carbon? What are the short and long-term effects of climate change on urban ecosystem structure and functioning? How will newly forested urban land affect invasive species dynamics at the scale of the city and the region? Will current forest management practices increase or decrease biodiversity? These are some of the questions the NYC Urban Forest Restoration Study will address over the next ten years in order to provide basic scientific data to inform park design, forest management, and climate mitigation decision-making by policymakers, land managers, and practitioners in NYC. The study ultimately examines the effect of forest restoration efforts on the dynamics of urban ecosystems in order to evaluate best management strategies for maximizing functions and services in complex urban biological systems.

THEORY: PATCH DYNAMICS

Thinking of cities as ecosystems allows us to have a holistic understanding of the relationships between social structure, order and norms—not just as sociological concerns, but also as key contributors to the biophysical functioning of our cities.²⁹ The NYCHE Project once fully operational will expand the biophysical and social knowledge base for how we think of cities. It will expand previous theoretical work from BES motivated by conceptual frameworks including ecological, hydrologic and social patch dynamics, the HEF model, the role of invasives in community organization, socio-spatial theory, resilience, biocomplexity, and urban design theory. The questions driving the NYCHE Project require the quantification of spatial heterogeneity in the New York metropolitan area. This research uses patch dynamics as an organizing framework for integrating empirical scalar data (including research plots) into the theoretical frameworks of the study. Patch dynamics are a conceptual approach to ecosystem analysis that emphasizes dynamics of heterogeneity within a system. Diverse patches of habitat created by human and/or natural disturbance regimes are critical to understanding structural and functional aspects of systems. Patches have a definite shape and spatial configuration, or heterogeneity. Urban ecosystem research uses patch dynamics to bridge the gap between the temporal

26 — Tishman Environment and Design Center launched a new Environmental Studies program at The New School in 2008. Available at: <http://www.newschooledu/environmentalstudies/>
27 — The Baltimore Ecosystem Study is perhaps the most important scientific investigation of an urban ecosystem to date and is still ongoing. Available at <http://beslter.org/>
28 — By ecological functions I mean examining how effective tree planting is at boosting biodiversity, creating ecological conditions for systems to resist invasive species, enhancing carbon capture by sequestering and storing atmospheric carbon dioxide in both soils and plants, resisting damaging effects of urban pollutants, removing atmospheric pollution which should in turn have positive benefits for human health (cleaner air), and absorbing stormwater and thereby reducing pollution loading to our rivers, streams, lakes, ponds, and reservoirs.

and spatial scales and is used in the NYCHE Project to link plot and landscape scale data over time.

Urban ecosystem research approaches are often focused on emphasizing socio-economic, ecological, or physical features as patch delimiters. The eventual goal in NYC is to integrate approaches and develop a synthetic patch delimitation scheme for the entire study area, including all five boroughs. The patch dynamics approach will be used as an organizing framework for integrating data in the NYCHE Project across scales in order to determine relationships between social and ecological drivers of change³⁰. To address the core research questions of the NYC Urban Forest Restoration Study, team members began by defining ecological and physical patches at the plot scale as the most effective place to begin collecting fine resolution ecological data on the dynamics of urban forests. Of course, the spatial structure of human, natural, and physical patches in urban areas changes through time due to social, economic, behavioral, successional, erosional, and other forces. Therefore, it was recognized early on that it is crucial to investigate the temporal dimension through long-term research to understand the linkages, feedbacks, controls, and cycles in patchiness in urban ecosystems³¹.

METHODOLOGICAL APPROACHES TO STUDYING HUMAN ECOLOGICAL SYSTEMS

Long-term study of forest restoration and regeneration is critical to understanding New York City as a human ecosystem because so much of the system is forested, or about to be forested. Research activities such as the NYC Urban Forest Restoration Study that are plot based, ground scale approaches are crucial to evaluating both the success of the current tree planting effort, but also to provide recommendations for future design and management strategies at much larger scales. This research capitalizes on the MTNYC campaign to reorganize tree-planting events into structured long-term experimental study plot treatments.³² The focus of the study is a plot scale analysis that has already installed (and begun baseline vegetation and soil monitoring on) dozens of long-term permanent plots in parks across all five boroughs of NYC. Parks in this effort so far include Highbridge, Pelham Bay, Spring Creek, Kissena, Willow Lake, Old Place Creek, Marine Park, Clove Lakes, Alley Pond, Canarsie, and Roy Wilkins. We will add approximately another 5 sites in Fall 2010. The combined target is to establish a minimum of 40 permanent field plots in parks across NYC over the next five years that will be consecutively monitored annually for a minimum of ten years. This will require significant sustained

29 — Machlis, G.E., Force, J.E., and Burch, W.R. Jr. 1997. "The human ecosystem. 1. The human ecosystem as an organizing concept in ecosystem management." *Society and Natural Resources* 10(4):347–367; Burch, William and Donald DeLuca. 1984. *Measuring the Social Impact of Natural Resource Decisions*. Albuquerque, NM: Univ. of New Mexico Press.
30 — i.e. forest patch origin, plant diversity, and adjacent land use type on species composition and abundance over time.

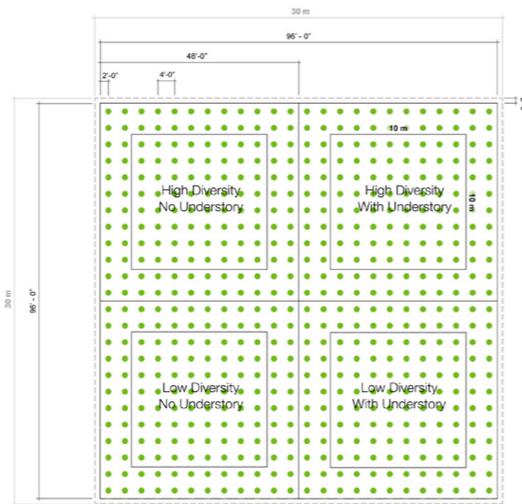


Figure 3
Experimental field plot plan.

commitment from NYC Parks, current academic collaborators, funders, and a host of volunteers.

The methodological approach to evaluating long-term ecological dynamics of highly heterogeneous systems requires simplicity. Local scale study plots need to be large enough to capture relevant dynamics but small enough to be sampled intensely and efficiently on an annual basis. Researchers chose 30m² plots (Figure 3) because they are large enough to satisfy ecological research goals but small enough to fit into forest restoration plantings of the MTNYC campaign. Evaluating park planting and management designs requires clear experimental treatments with adequate replication to be confident that empirical results will reflect real world dynamics, and yet simple enough that they can be replicated across many different sites in very different park settings across the large land area of New York City. Researchers chose a nested plot design with high and low tree diversity treatments in order to allow scientists to evaluate the importance of varying levels of tree diversity on ecosystem functioning while also evaluating the utility of individual tree species and species combinations. Buffer areas of 2.5m around each subplot were established to minimize edge effects between subplot treatments (Figure 5). Additionally, plots were designed to adapt to current planting practices of the NYC Parks Department, which in both volunteer and contractor planted forest restoration sites plant trees ~ 4ft on center. Tree planting in research plots is spaced similarly with the expectation that as the canopy closes subsequent tree mortality will be a natural process of competition for light, nutrients and water.

31 — Pickett STA, Cadenasso ML, Grove JM, Nilon CH, Pouyat RV, Zipperer WC, Costanza R. 2001. Urban ecological systems: Linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. *Annual Review of Ecology and Systematics* 32: 127–157.

32 — MTNYC hosts large, organized planting days in April and October. You can sign up to plant trees at: <http://www.milliontreesnyc.org/>

Analysis of current vegetation at the plot scale is a fundamental part of the patch analysis approach that is being used to characterize the spatial structure of the urban ecosystem. Researchers in this study are collaboratively monitoring tree survivability, growth, and time to canopy closure, but more importantly they are also assessing the rest of the vegetated community either preexisting in sites, or recruited to sites over time. Vegetation analysis is important to biodiversity, aesthetic, climate modification and pollution and water absorption functions of soil in the urban ecosystem and will thus provide a basis for further ecosystem function studies in the future. This study will supply the critical ecological data for comparison across patches within the NYC park system, yet will also allow comparison of forest dynamics between New York City and other urban centers. By looking at a large number of heterogeneous sites across the city, researchers hope to begin to build, literally from the ground up, a comprehensive picture of the ecological dynamics of New York City as a cohesive ecosystem.

DESIGNING SUSTAINABLE URBAN LANDSCAPES

Can urban trees really achieve the ambitious goals we set for them? It is possible, but only with a concerted effort to find out. Designing sustainable urban landscapes requires at least three issues be addressed.

1. To judge the effectiveness of urban improvements such as tree planting, we need proper and well-designed scientific research. Urban ecological research in New York City must take a front seat in the challenge to make New York City more sustainable. This will require government and private foundations to sponsor research over short and long time frames to provide the fundamental science that policymakers, managers and practitioners need in order to make decisions that can predictably achieve the noble sustainability goals set forth in PlaNYC 2030.

2. Designers must actively make use of available ecological science. Urban ecology is most useful when it is applied to the problems it was originally designed to address. Urban ecosystem research has the potential to provide important data on how best to maximize various functions we all want from the ecological infrastructure of the city, but only if urban designers commit to doing the hard work of understanding and incorporating research results into their creative enterprises. Similarly, urban ecologists must commit to interdisciplinary dialogues that make use of the storehouse of knowledge designers and practitioners working in urban areas already have.

3. The average New York citizen will need to become a more engaged, environmentally aware, and hopefully activist participant in the urban ecosystem if it is to mature into the environmental cleanup machine it is currently envisioned to be. Projects like StEM are an important effort to develop novel methods to reach across traditional divisions between humans and the environment they depend on.

Finally, it is important to evaluate whether the global challenge to plant trees (laudable indeed) is a true cure to our environmental ills or merely another, if better, bandwagon that puts a green facade on a continued global cultural practice of unsustainable living. Sustainable living may indeed involve more tree planting, but it also requires a shift from twice a year volunteer planting days³² to a sustained daily engagement and committed stewardship of the vast diversity of environmental resources we already enjoy. The StEM Project and the NYC Urban Forest Restoration Study, both part of the growing NYCHE Project at The New School, are studies in how to leverage the tools and goals of government managers with urban ecosystem research and design in order to maximize the ecological functions and services of the green infrastructure of the city. ♦

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