Multi-Productive Landscapes of the Sustainable City:

Opportunities for Managing Resource Needs through Urban Landscapes

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ABSTRACT

This paper aims to link concerns for providing resource needs to city dwellers by considering urban open spaces as a means for creating infrastructural landscapes which limit ecological footprints of cities and provide relief from density. How cities and their inhabitants manage their urban infrastructure is a critical component towards the design of efficient and sustainable use of natural capital, as many infrastructural systems reach the end of their usefulness in an era where population growth demands surpass carrying capacity. This paper will trace historical progressions of western cities' resource management systems, theorize opportunities for alternative and sustainable strategies of landscape infrastructure, and explore opportunities through two United States case studies of New York City sites.

Keywords: *Landscape Architecture, Urban Resource Management, Infrastructural Landscapes, Productive Urban Landscapes, Sustainable Cities*

1. WHY CITIES?

Given the economic vitality of cities, projected global population growth, and movements into cities, increased density is not a question, but a reality. Urban centers, currently home to half of the 6.5 billion individuals on the planet, are expected to grow to two-thirds of 9 billion individuals by 2050 (Girardet, 2005, p. 33). This growth in cities will be fueled by the projected centralization of new technology and service industry employment in cities (Hall, 1995), and will have lasting implications on the sustainability of our global resource use. Density provides opportunities for limited development footprints and reduced commuter travel; however, it also entails a stronger reliance on municipal infrastructure for the provision of basic resources, both input and output. Providing the necessary infrastructure for the provision of water, food, energy and the removal of waste from large populations located within limited footprints is an expensive challenge to urban centers worldwide (Del Porto, 2006), and is compounded by the local concentration of global economic activities (Sassen, 2006), where demand for natural resources and the production of wastes occurs on an industrial scale (McGranahan and Satterthwaite, 2003).

Balanced with the need to provide sustainable and functioning cities is the need to create livable cities, with equal consideration given to the quality of urban life (Jacobs, 1961). This includes consideration of public open spaces which are essential to the maintenance of health and vitality in congested and growing urban populations (Schuyler, 1993). Creating cities and neighborhoods that allow urban residents the opportunity to understand natural processes, as simple as tree growth and water percolation, can aid in reconnecting individuals to natural systems and processes while strengthening the role that open space plays in the function of cities. Open spaces beyond city limits, as well as within, are integral to the provision of many resources in cities. Water, food, and energy sources are rarely located within urban centers, and rarely does waste remain; it is the watersheds, agricultural fields, and mines beyond cities that often provide these vital resources. Too frequently, dichotomies such as town/country or city/hinterland segregate intellectually important connections that exist between the two. Thus, design of the sustainable cities of the future have the additional responsibility to remind urban citizens of the role their daily decisions play towards the sustainability of open spaces within and beyond city limits by engaging in and exposing these processes.

This paper aims to link the concerns for providing the myriad of resource needs to city dwellers by considering urban open spaces as a means for creating infrastructural landscapes which limit ecological footprints of cities and provide relief from density. Design of modern cities requires consideration of integrated resource management design (Harris, 1995) as well as the design of urban form (Lynch, 1981). How cities and their inhabitants manage their urban infrastructure is a critical component towards the design of efficient and sustainable use of natural capital (Wackernagel et. al., 2006), and is a particularly relevant issue for the 21st century, as many infrastructural systems reach the end of their usefulness in an era where population growth demands surpass carrying capacity. Pertaining specifically to the United States, government focus towards infrastructural spending as a mechanism for economic stimulus will also influence designers to reconsider the current infrastructural needs of the modern city (American Recovery and Reinvestment Act, 2009). If landscapes are truly to become the new ordering function of dynamic cities of the future (Waldheim, 2006), and infrastructure comprises the significant new program requirement of these urban landscapes (Mossop, 2006; Tatom, 2006), then the re-conceptualization of urban landscapes as city infrastructure is necessary. Beyond the aesthetic, formalistic, and programmatic evaluation of urban landscapes, there is an emergent need to recognize opportunities for productive or multi-productive resource management. In recognizing infrastructure's role in the management of resources, not only in its finite constructions, this paper will trace historical progressions of western cities' resource management systems to its current condition. It will then theorize opportunities for alternative and sustainable strategies of landscape infrastructure that will manage resources efficiently and improve the quality of habitation within cities themselves, thus contributing to the sustainable and dynamic city of the future. Lastly, through case studies applied to real sites in New York City, scenarios for productive landscapes contributing to the city's resource management will be discussed.

1.1 Precedent Urban Resource Cycles

Many of the current resource and waste management concerns in western cities of Europe and North America are recent concerns. Before the Industrial Revolution, the lack of modern technology and its consumption of energy resources necessitated that cities be more integrated with the natural cycles of resource use and waste production (Girardet, 2005). The pre-industrialized condition of the city had a profound connection to its hinterland for provision of resources such as fuel and food. Cultivated crops, grazing land, and fuel-rich forests were located frequently within cities or in close proximity in the form of rural belts. European cities rarely exceeded 30,000 inhabitants on an average of 12.4 acres (5 hectares) of urbanized land (Howe et. al., 2005). The proximity of production and waste yielded advantages for layering multiple resource management systems into a cyclical solution. For example, the system of nutrients from food to waste were maintained symbiotically with locally produced food feeding city inhabitants and the resultant waste returning to agricultural fields to provide fertilization. This balanced system existed for other resources, such as water processes and the continuous exchange of O_2 and CO_2 between plants and animals. In a system where resources are managed cyclically, the need for infrastructure is minimized: Wetlands treat storm-water, food production utilizes waste nutrients, plant materials absorb carbon, and local product use minimizes long-distance transport.

Two European examples of balancing the conditions of waste and nutrient were developed during the turn of the last century, when industrial growth began to concentrate resource management issues in cities. Paris, France and Berlin, Germany were two cities that experienced growth in populations, and subsequently waste, in the mid-19th century. In the case of Paris, Baron Haussmann's reforms of the city, noted for the grand axial alignment of

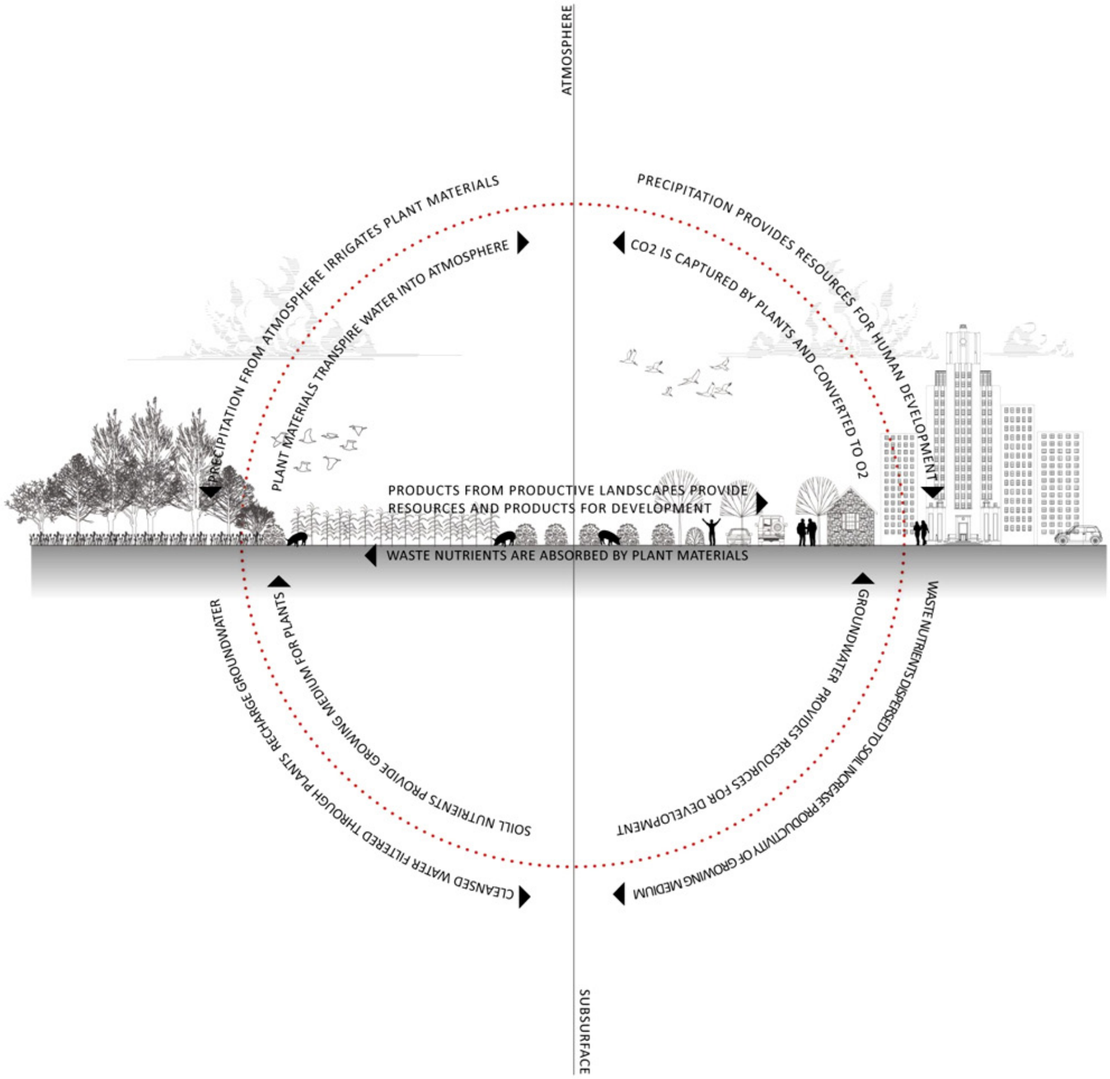

Figure 1:
Diagram of the pre-industrial resource cycle

boulevards, were truly remarkable for their efforts in public infrastructure. In fact, the restructuring of Paris' formerly medieval layout was an attempt to organize an underground sewer system that was meant to purge the city of its own waste. But transport of this waste from the city was only the first step. The municipal sewage treatment facility, located outside the city at Gennevilliers, provided the opportunity to convert that waste into product, and thus protect the watershed from increased contamination. As noted by Sabine Barles and Laurence Lestel in their study of Paris' waste management systems from 1830-1939, "…using urban nitrogen to improve agricultural yield, France could rise to the challenge of feeding its growing population while reducing contamination from the discharge of nitrogen into rivers" (Barles and Lestel, 2007, p. 802). By fertilizing porous sandy soils with the excrement of Paris' sewers, over 12,355 acres (5,000 hectares) was able to produce in turn 40,000 heads of cabbage, 60,000 artichokes, or 200,000 pounds of sugar beat per year. At its height the agricultural fields of Gennevilliers could treat 1,400,000 cubic feet (40,000 cubic meters) of sewage a day (Steel, 2008). Following the First World War, the rise of chemical based fertilizers replaced the use of organic methods in Paris, resulting in increased pollution and degradation of water quality. Barles and Lestel writes, “As the economic and agricultural value of sewage disappeared—and as hygienic concerns about sewage receded in conjunction with improvements in public health—the environmental question alone no longer seemed important enough to justify new and costly efforts to protect the Seine from nitrogen and organic pollution (Barles and Lestel, 2007, p. 807).”

Berlin’s waste-water treatment system from the mid-19th century lasting until the mid-20th century also utilized the opportunity to convert waste to product by recognizing nutrient resource cycles. The treatment system, known as sewage farms, utilized a series of terraces, embankments, and overflows to treat domestic, commercial, industrial, and precipitation waste water in either grasslands or cultivation beds, allowing plant material to metabolize waste nutrients and cleanse water before reintroduction into watershed. The sewage farms were located within the city, and crop yields were initially high. Following the urban development and population growth Berlin encountered after the Industrial Revolution, sewage farms became overtaxed by higher volumes of waste water, a necessity for higher yields of cultivated crops, and the closure of other sewage farms (Berlin Senate Department for Urban Development, n.d.). Berlin now utilizes waste-water treatment plants as is common in most industrialized urban centers today.

1.2. Current Urban Unilateral Resource Flows

Under current conditions, cities utilize increasing amounts of built infrastructural systems, such as the wastewater treatment plants which replaced Berlin’s sewage farms or the fields at Gennevilliers. In these systems the cycles of nutrient flow from waste to product are rarely capitalized in urbanized areas. Instead, complex systems of industrial and chemical processes have replaced the organic landscape operations. These engineered solutions cause the demise of forest and wetland habitats, air quality, and water quality in both sub-grade and surface conditions. In separating resource cycles including water and nutrients, unilateral flows of energy and product pour into cities, but the waste is directed outward to watersheds, atmosphere, and remote landscapes far from the city source. The result is increased infrastructural demand on the modern city and an intellectual disconnect between resources and the landscapes that produce them. Transmitters of these increasing distanced sources and demands include highways for transport of products, aqueducts for the supply of drinking water, sanitary lines to remove waste nutrients, and processing plants to treat waste, which all rely on energy resources to fuel the incessant flows of product and waste in and out of cities.

The modern conception of cities, where technological advances privilege developed landscapes, necessitates elaborate infrastructural systems of finite life spans that are now coming to an end of their usefulness or are overtaxed and need to be replaced. Additionally, it is increasingly expensive and complicated to construct, maintain, and manage the engineered solutions employed by cities to handle resource demands. In many urban conditions, these systems fail altogether. An example of this is illuminated in the all-too-common Combined Sewer Outfall (CSO) that is utilized in many western cities. The root of this problem lies in the ‘big pipe’ system where all waste water, whether storm-water, sewage water, or industrial waste water, are combined into a single system that must utilize ultra-filtration at waste water treatment plants (Del Porto, 2006). Because storm-water is a component of this waste water collection process, excess amounts of rainfall can cause overflow conditions that threaten to creep back into domestic water lines. As a result, outfalls commonly discharge excess contents of sewage into water bodies in and around urban areas. These CSOs are responsible for the dumping of untreated effluents, toxins, and heavy metals into rivers, lakes and estuaries, even in small storm events (Montalto et. al., 2007). The Gowanus Canal in the Brooklyn borough of New York City, recently designated a Superfund site by the United States Environmental Protection Agency, is an example of the long-term effects of CSO dumping into an urban water body.

Other examples of faulty or overtaxed systems of modern infrastructure include: transport systems for cars, product distribution, mass-transit, etc.; energy production, including fossil fuel consumption; waste management systems, including landfills and sanitary sewers; food production and distribution; and, water sources and distribution. These infrastructural systems are in constant need of upgrade and repair as increased volumes of product and waste demands become concentrated in urban centers. Furthermore, increasingly constructed and engineered solutions create conditions where the management of resources is hidden from city inhabitants and the condition of ‘out of sight, out of mind’ prevails. The lack of visibility associated with these processes allows many city dwellers to take for granted the availability of resources and ease of waste disposal, and as a result wasteful use practices become common-place. In her article, *Waste Landscapes*, landscape architect Mira Engler poignantly describes the progression of waste management in cities encouraging a contemporary ignorance of the processes involved: “In the first few decades of the 20th century, American cities’ automated, centralized sanitation networks were pushed outside city limits, screened, or buried underneath the streets. When waste was removed from the range of human senses, it ceased to be an eyesore, a bad odor, an obstacle to traffic, or a bothersome annoyance. Indeed, engineers had done such a good job of removing waste that citizens could take these services for granted. By the 1960s, most Americans knew less about the basic city sanitation system, the support mechanism that allows urban culture to be possible, than ever before (Engler, 1995, p. 13).”

Additionally, the ignorance of the waste removal procedures by many western urban dwellers includes a misunderstanding of the waste-nutrient

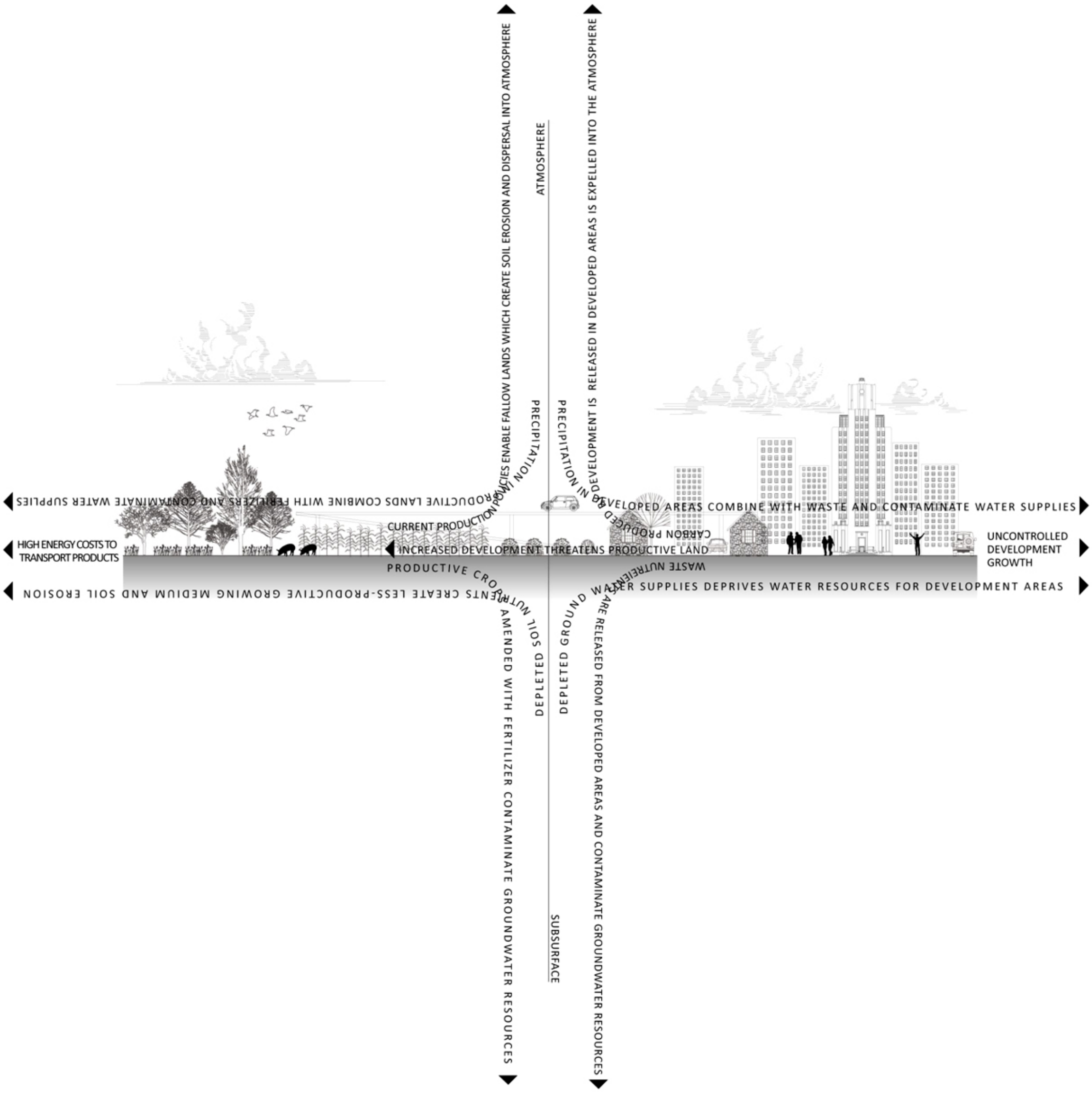

Figure 2:
Diagram of the modern city’s unilateral flows of inputs and outputs

resource cycle. The result is a fear that is expressed at the individual's own natural waste. Richard Meier refers to this as the 'American Bathroom Syndrome,' and highlights that the fear is embedded within our codes, regulations, and standards for water and sewage treatment infrastructure (Meier, 1995, p. 459). This prevents opportunities for the design of more integrated systems of waste and resource management, as laws prohibit a useful conversion of waste into food sources, demonstrated by pre-industrial cities.

1.3. Recreating the Cycle: Re-Defining City Infrastructure

Considering past and present conditions of resource management, the creation of new urban infrastructure systems that function cyclically to manage resources is clearly needed. The term infrastructure itself should be critically reconsidered so that its connection with the concrete and steel entanglements of highways and sewer systems can be reduced, coordinated, or eliminated. At a time when western governmental priorities are refocused on infrastructural investment, we must remind ourselves of the real meaning of the term: systems that manage resources within cities for the people that inhabit them. Engagement of resource based strategic thinking beyond the limitations of current finite constructions can help facilitate design of alternate and sustainable overlapping urban systems that improve the quality of life within cities themselves. Urban design projects have the capacity to be economically, ecologically, and socially productive by actively engaging in addressing current resource management issues. By breaking the practice of continuous maintenance and replacement projects, and embracing a holistic approach to innovative infrastructural design, landscapes in urban settings can become self-sustaining systems which complete the broken resource cycle.

In considering faulty 'big pipe' systems in cities, which result in failed infrastructure systems such as CSOs, alternatives should reintroduce complexity into the management of wastes. This involves recognizing the differences between storm-water waste (gray water) and effluent waste (black water), and finding opportunities for their wastes to be perceived as a resource. For example, gray water can be safely utilized for irrigation purposes and black water, with minimum treatment, can be re-introduced into nutrient cycles in food cultivation, as demonstrated by the gardens of Gennevilliers or Berlin's sewage farms. This system of 'effluent specific' treatment and re-use does require smaller, local management and a greater complexity in supply and removal pipes, however, as David Del Porto, founder of the Ecological Engineering Group which promotes building resource efficiency, so aptly states, "nature's model shows us that complexity is the best way to manage resources" (Del Porto, 2005, p. 286).

By introducing opportunities for the re-use of waste water in alternative treatments, new landscape systems can be created within the city. Urban agriculture and green gutters are potential new landscape conditions that aid in waste water management as mentioned above. Additionally, a compelling argument for the re-introduction of food production within urban settings, aside from the clear benefits in local, healthy food sources with limited distribution miles, is the role that cultivation can play in re-creating nutrient cycles and metabolizing the atmospheric, water, and solid wastes that plague urban settings. As recognized by the United Nations Development Program, reporting on the role of urban agriculture: "In cities choking in their own waste and pollution, an industry that can use urban waste as basic resource is significant" (UNDP, 1995, p. 234).

Several contemporary European precedents for this 'closed loop' system of waste-nutrient cycles are located in the cities of Stockholm, Sweden and Rotterdam, Netherlands. Stockholm utilizes coordinated networks of input/output that capitalize on symbiotic waste and resource needs to create cyclical conditions between different industries. For example, the treatment of sewage produces a sludge that is utilized to fertilize agricultural crops and converted to biogas to provide heat and power for city housing and vehicles. In Rotterdam, the combined heat and power plants of RoCa3 creates a by-product of CO_2, which is then transmitted to nearby greenhouse facilities to increase cultivation yields of local produce (Beatley, 2000). These eco-cycle systems have minimized waste and resource demands and saved local industries and governments substantial amounts of money. Although they do not utilize public landscapes as conditions for re-creating resource cycles, the recognition of symbiosis between multiple industries serves as a powerful precedent in drawing stronger connections between waste and resource in urban settings.

Recognizing landscapes' potential role in the eco-cycle approach, many economic as well as environmental benefits are achieved. Landscape resource systems, or green infrastructure, are typically cheaper than engineered counterparts. New York City's water source provides a compelling example of the economic benefits of landscape solutions over engineered constructions. In protecting the water quality for New York City inhabitants, the city estimated $6 to $8 billion necessary for construction of a new filtration plant. Instead, the City chose to protect the 2,000 square mile (5,180 square kilometer) watershed upstate, costing the City $1.5 billion to purchase the land, construct new sewers and septic systems, and develop programs to limit agricultural pollutions. Long term saving for the project also includes the avoidance of additional costs in the maintenance and repair of the filtration plant (Benedict, 2006, p. 71). Street trees, green gutters, and pervious surfaces in cities such as Chicago, Portland, and New York City, among others, save cities millions of dollars every year in reducing costs for storm-water management and the removal of airborne toxins, including carbon monoxide, sulfur dioxide, and nitrogen dioxide (Ibid).

Finally, productive urban landscape systems provide the additional benefit of reminding city inhabitants

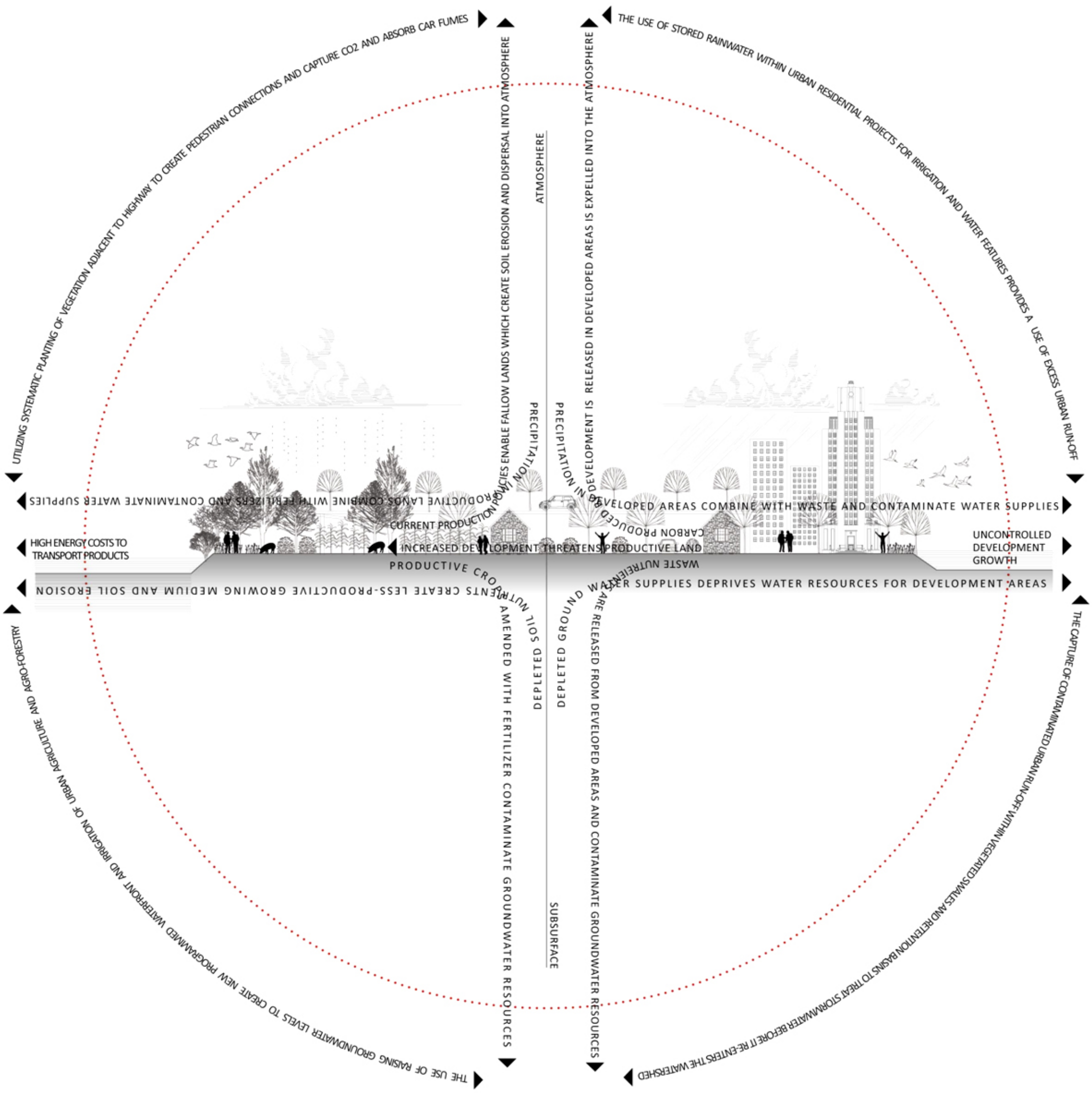

Figure 3:
Diagram of the sustainable city loop, employing multi-productive landscapes to recreate resource cycles

of the waste-nutrient cycles that exist within cities. Too frequently the systems of infrastructure which provide our drinking water, food, and energy as well as cart off our waste, mask the complex processes required to handle these overly engineered solutions. By utilizing landscape conditions to recreate resource cycles, there is an opportunity to expose city dwellers to the important links between natural processes and resources, cities and landscapes.

2. NEW YORK CITY CASE STUDY

In applying the theory of landscapes as the infrastructural opportunity to re-create resource cycles in urban settings, it is useful to consider a specific case study. New York City, with a population of over 8 million inhabitants, and a projected 1 million in growth by 2030 makes a compelling opportunity for consideration of sustainability in a dynamic city. Considering New York City's Mayor Bloomberg's endeavors within his PlaNYC 2030 initiatives, the potential for landscapes to play critical roles in achieving these goals is clear. The plan's goals include: create homes for almost a million more New Yorkers while making housing more affordable and sustainable; ensure that all New Yorkers live within a 10-minute walk of a park; clean up all contaminated land in New York; open 90% of waterways for recreation by reducing water pollution and preserving our natural areas; develop critical back-up systems for aging water network to ensure long-term reliability; improve travel times by adding transit capacity for millions more residents; reach a full 'state of good repair' on New York City's roads, subways, and rail for the first time in history; provide cleaner, more reliable power for every New Yorker by upgrading energy infrastructure; achieve the cleanest air of any big city in America; reduce global warming emissions by more than 30% (New York City Office of the Mayor, 2007). These initiatives include goals for both improving existing infrastructural systems and for the creation of new, environmentally-sound green spaces and waterways. The engagement of multi-productive landscapes that recreate resource cycles provides clear opportunities for layering multiple PlaNYC goals into singular design solutions.

At 8.2 million residents within 304.8 square miles (789.4 square kilometers), New York City is one of the densest cities in the world. However, using the methodology developed by Herbert Giardet to determine the calculation of London's resource use and ecological footprint, as defined by economist William Rees, including surface areas required to feed city inhabitants, supply them with forest product, and reabsorb waste (Girardet, 2005), the total land area required to support New York City is equal to an estimated 56.8 million acres (23 million hectares), or nearly 300 times the existing footprint of 195,000 acres (78,914 hectares).

This breaks down to necessitating 24.6 million acres (10 million hectares) for food production, 2.2 million acres (890 thousand hectares) for forest products, and 30 million acres (12 million hectares) for waste absorption, particularly CO_2 absorption. This calculation includes only domestic resource consumption and waste removal and does not include industrial processes within the city. This calculation also does not factor the 5,100 square miles (13,209 square kilometers) of watershed that currently provide the 80-100 gallons (303-379 liters) of water-utilized daily by New Yorkers (NYC DEP, 2009). The footprint required to provide clean water alone totals nearly 6.5 times the footprint of New York City. What the 56.8 million acres does include is the land area required to process or contain the 4.39 pounds (1.99 kilograms) of solid waste created by New Yorkers daily (Clean Air Council, n.d.) and the over 1 million acres (405 thousand hectares) necessary to treat the storm-water that falls on the average 166,000 acres (67,178 hectares) of 65% impervious urban surface.

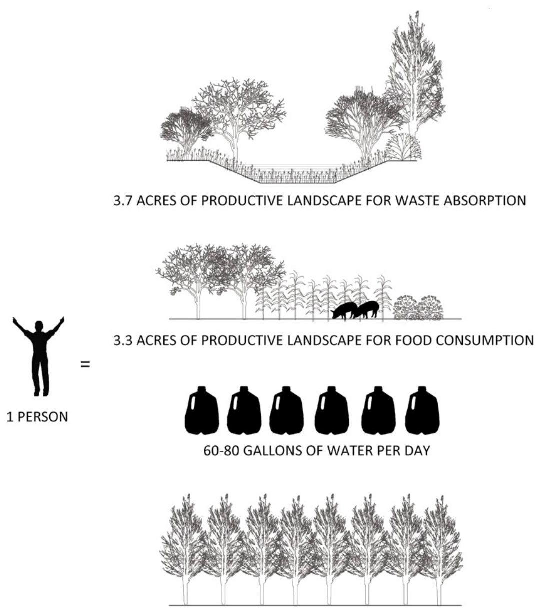

Figure 4:
The average resource needs of a western urban dweller.

In comparison, Girardet calculates London's ecological footprint at 48.9 million acres (19.8 million hectares) or nearly 125 times its actual land area. This amounts to 21 million acres for food production (8.5 million hectares), 1.9 million acres (770,000 hectares) for wood-based products, and 26 million (10.5 million hectares) for waste absorption (Girardet, 2005).

2.1 Opportunities for Productive Landscapes to Complete Resource Cycles: 2 Case Studies

In recognizing New York City's ecological footprint and resource demands, opportunities for mitigating these concerns through the layering of economic, social, and environmental conditions to create multi-productive landscapes which re-create resource cycles can begin to shrink the city's footprint and provide a more sustainable and dynamic city.

2.1.1 The Productive Urban Farm A site characterized by the concentration of food and waste industries contained within a limited footprint, Hunts Point provides a compelling opportunity to consider the role in which cyclical resource management might play within New York City. The neighborhood, located on a peninsula within the South Bronx, is frequently described as an island, with the Bruckner Expressway forming an impasse to the north of the site and the confluences of the Bronx River and East River bordering the east, west, and south edges. Within the 690 acres (279 hectares) of the peninsula, nearly half of the area is taken by the Hunts Point Food Distribution Center, one of the largest food distribution centers in the world (Ascher, 2005). Along with the distribution center, other food-related industries within the area include the New York City Terminal Market, Hunts Point Terminal Market, and New Fulton Fish Market. Hunts Point is also home to over two dozen waste transfer stations, a water pollution treatment center, and a sewage pelletization plant along its waterfront. It is estimated that 3,000 trucks drive through Hunts Point daily as a result of the food and waste industries present, contributing diesel fumes to an already heavily polluted site (Zimmerman, 2002).

Amidst this concentration of industrial uses, an existing residential community with a population over 46,000 continues to struggle to retain ground. Over half of the inhabitants receive public assistance in this low-income neighborhood (NYC DCP, n.d.). Alongside the growth of the food industry, the city has recognized a need to preserve the existing community within Hunts Point. In 2005, a Hunts

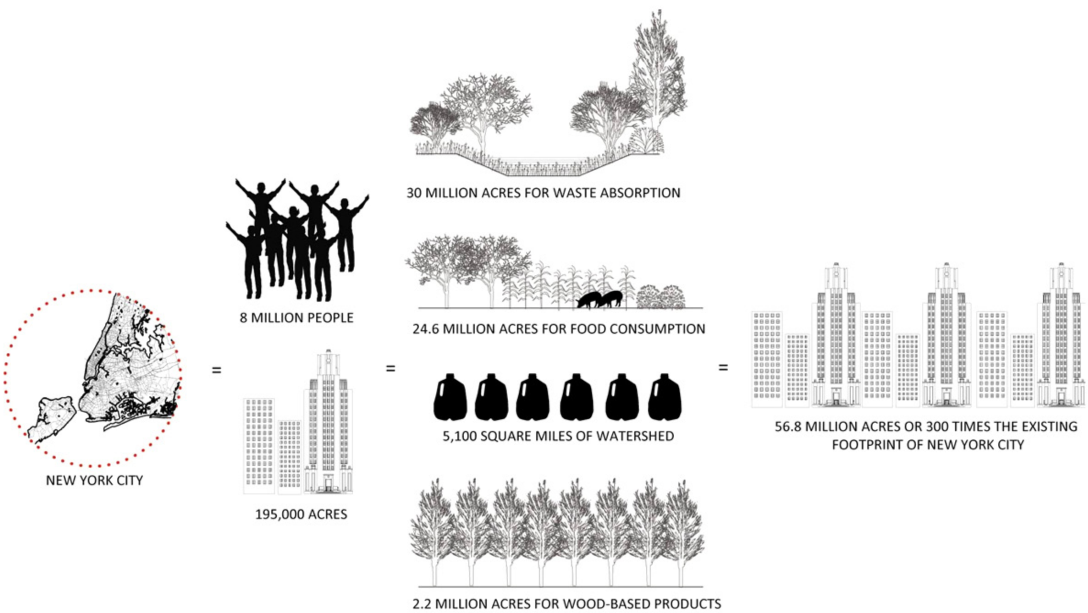

Figure 5:
New York City's average inputs and outputs require nearly 300 times its existing land area.

Point Vision Plan was adopted by the city to create a Special Hunts Point District with goals such as: preserving the existing residential community, creating a zone which would buffer the community from surrounding industrial uses, reducing waste-related industrial growth, and promoting food-related industrial growth (NYC EDC, 2010). Recent investments, including the creation of the Hunts Point Riverside Park and the preservation of historic American Bank Note building to house non-profit, art organization, design firms, and retail food market, exemplify beginning efforts to improve the conditions of residents within the Hunts Point neighborhood while stimulating economic growth (NYCIF, 2008). These efforts, however, stem from a fundamental misconception regarding the separation of functions that including living, eating, and waste production. The city's desire to create buffers and privilege one industry's presence over another belies a missed opportunity to begin integrating land uses and creating an exemplary neighborhood for the cyclical and sustainable ways in which resources might be managed through landscapes.

By re-conceptualizing resources into cyclical conditions, the limited footprint in which these major industries occupy can become an advantage to managing the concentration of waste and food on Hunts Point. Opportunities for open spaces that create buffers between food, waste, and people can express the relationship between resources instead of masking them. A component of this integrated resource scenario includes the creation of streetscape amenities such as pervious sidewalks, water-collecting street gutters, and large-canopy street trees throughout the residential and industrial zones of the peninsula. The streetscape would work productively to collect storm-water for re-use in irrigation and industrial processes, while street trees would provide shade and filter air pollutants. Creation

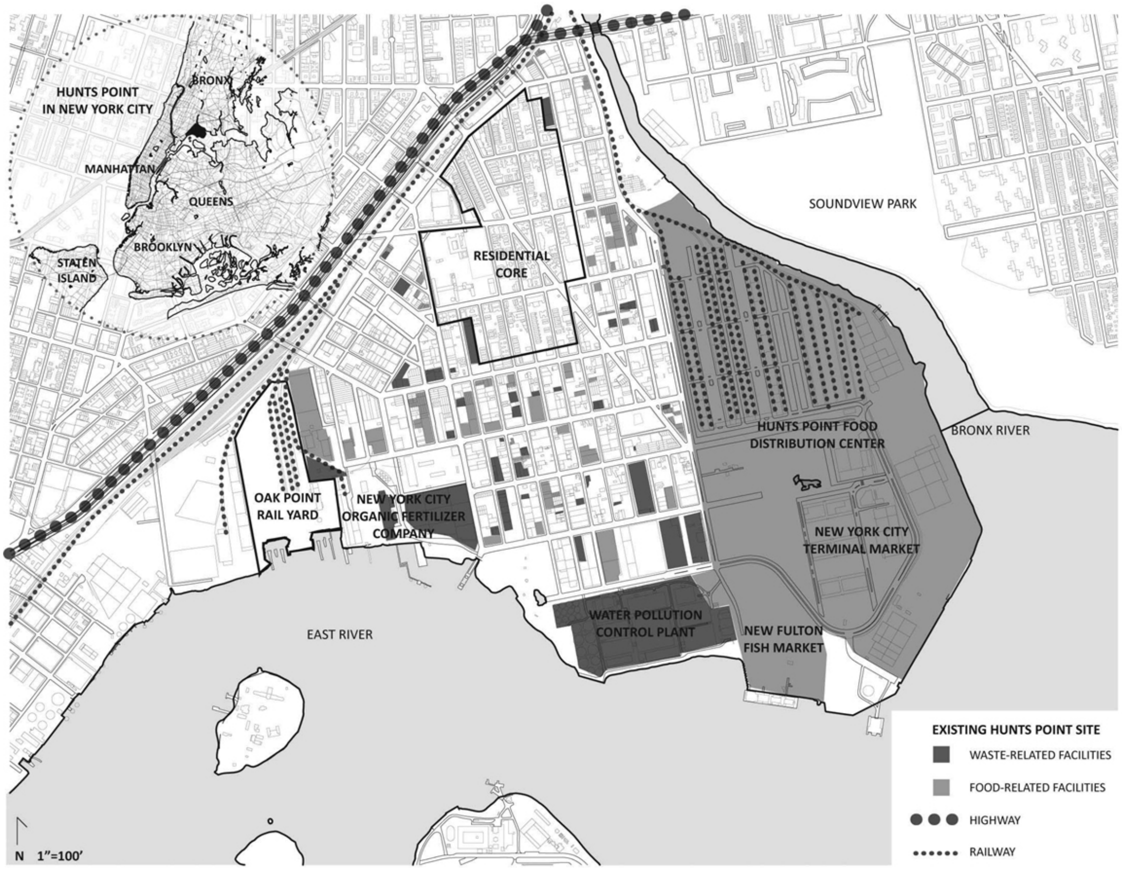

Figure 6:
Hunts Point peninsula, a constrained site of conflicting residential and food and waste industrial uses.

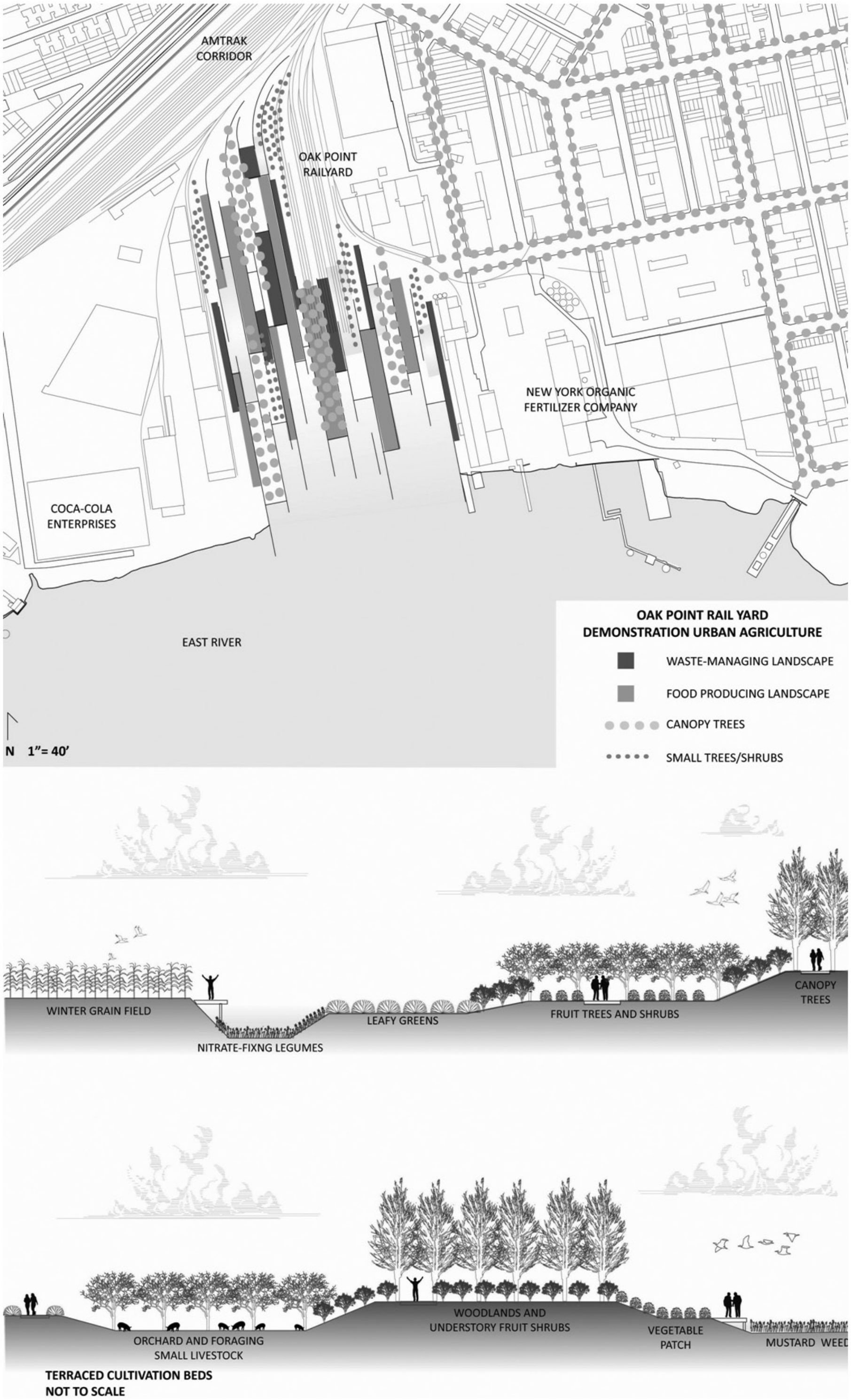

Figure 7:
Hunts Point as model neighborhood for cyclical resource use, with productive streetscapes and demonstration urban agriculture field.

of community garden plots for local residents presents an opportunity for utilizing storm-water for irrigation and cultivation of nutritious food for an impoverished neighborhood.

Ultimately, development of the vacant parcel of the former Oak Point rail yard would provide almost 30 acres (12 hectares) of urban agriculture demonstration, utilizing similar methods employed at Berlin and Gennevilliers to treat waste and provide an alternative source of local food to compete with the food distributed currently at Hunts Point.

Additionally, these cultivation fields would empower local Hunts Point residents to participate and take pride in their local environment, provide a demonstration of resource re-use methods in waste management and food production that could be employed throughout the neighborhood and city. It could add iconic value, as an example of organic landscape solutions which empower cities to limit their ecological footprints by treating waste and producing food locally.

This scenario requires reconsideration of sorting processes at both the sewage treatment facility and waste transfer stations, so that organic wastes could be reused in compost and fertilization. Adoption of city-wide compost collection, alongside trash and recycling collection, would aid in the separation process of organic wastes for re-use and educate city inhabitants of the differences between wastes. Diversion of sewage from the pelletization plant and into demonstration cultivation fields would alleviate pressures on the sanitary sewage treatment while providing necessary nutrients to plant growth, and use of diverted storm-water as irrigation would reduce overflow conditions that result in untreated effluents dumped into local water bodies.

Although the acreage at Hunts Point rail yard, or even within the entire Hunts Point neighborhood, is not sufficient to treat all of New York City's waste production or produce all of the city's food needs, the site can begin to test and develop methods for other neighborhood interventions within the city. The complexity required to manage resources, as evidenced by Del Porto's study of city waste-water systems, and the scale at which these landscape systems operate efficiently, as employed in 19th century Paris and Berlin, requires consideration of neighborhood-scaled interventions to treat the growing infrastructural needs of New York City. The advantage of recognizing landscapes on a neighborhood scale as opportunities to mitigate waste and product needs lies in the localized exposure of city residents to these related processes. As a neighborhood inundated with the city-wide waste and product pressures, Hunts Point can exemplify an alternative model of waste-resource management to better improve the current short-term conflicts on site, and help alleviate city-wide pressures on the site in the long-term, through educating other neighborhoods to the local benefits of such an approach.

2.1.2 The Multi-Productive Urban Pier An additional site for consideration of integrated resource management occurs at the New York Container Terminal site at Howland Hook, located on the northwestern corner of Staten Island borough of New York City. New York City owes its origins as a commercial and cultural center to its extensive shoreline and advantageous location on maritime trade lines. Today, New York City's water systems are designed to maximize economic activity through the transport of international trade, which requires significant infrastructural management to dredge navigable canals and construct large-scale waterfront ports (Ascher, 2005).

Chinese imports currently account for 20% of all foreign trade in the United States, representing the largest contributor to transport resource use. Prior to the dredging of navigable canals which deepened waterways up to 45 feet (13.7 meters), most Chinese imports traveled intermodally via ports in Los Angeles, California (Lipton, 2004). Recognizing that 28.5% of the total energy consumption in the US is used for transport, which is equivalent to 28.95 quadrillion BTUs and accounts for 97.48% of total petroleum consumption (U.S. Bureau of Transportation Research and Innovative Technology Administration, 2010), consideration of product transport systems becomes critical in dealing with today's global energy and environmental concerns. Due to the economies of scale, lower speeds, less air resistance and friction, and the lack of topography, water-based transport emits 80% less carbon and 35% less nitrogen into the atmosphere than land based transport (World Resources Institute and World Business Council for Sustainable Development, 2004). Additional resources are also needed for construction and maintenance of roadways for land transport. It is therefore critical to understand the important role these navigable waters, including dredged canals and ports suitable to handle the modern container ships, play in efficient and economically competitive international trade. Due to the important role of maritime trade, New York City's hundreds of miles of shoreline resemble little

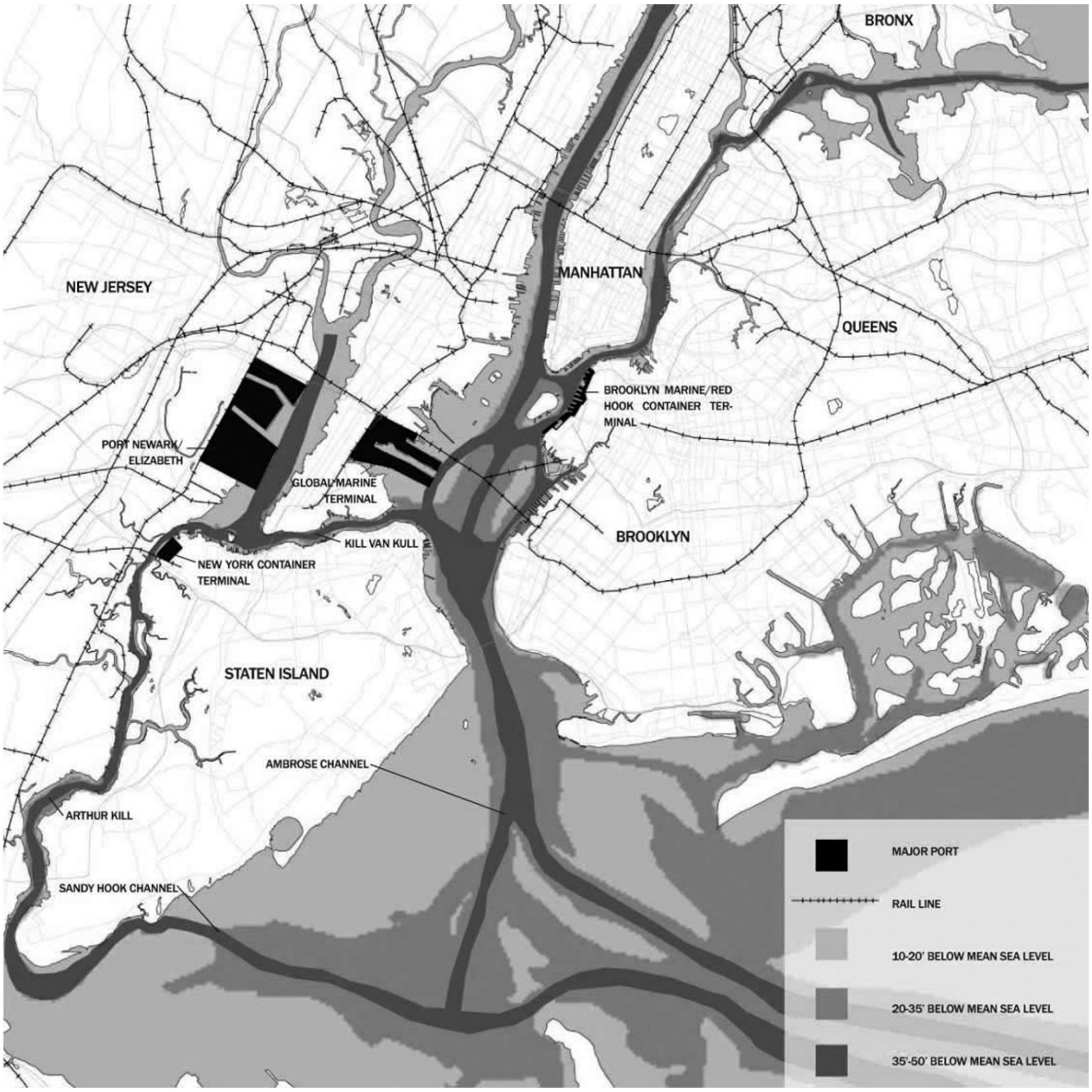

Figure 8:
New York City's shoreline, port locations, and navigable canals.

of the native conditions that existed prior to human settlement of the city; as trade and commerce drive the development of waterfronts, the quality of natural tidal wetland and salt marshes have shrunk, and the design of integrated economic and productive waterfronts is underdeveloped within New York City's shoreline.

The New York Container Terminal site at Howland Hook on the northwest shore of Staten Island provides an opportunity to layer economic and ecologic approaches to creating a productive waterfront. Formerly owned by U.S. Lines, this 187-acre port sat inactive for 10 years after bankruptcy in 1986. It was reactivated in 1996 by the Port Authority of New York, with over $350 million invested in upgrading facilities (Ascher, 2005). In 2001, the Port Authority acquired Port Ivory, an additional 124 acres, from Proctor & Gamble. This included portions of the Arlington Marsh, one of the few remaining tidal wetlands in New York City's shoreline. In an attempt to protect a portion of this march, 70 acres of Port Ivory's salt marshes were transferred from the Port Authority to New York

City Department of Parks and Recreation in 2007 (Newman, 2007). Remaining portions of Port Ivory are still slated for development, as the New York Container Terminal continues to thrive as an active port site. Conflicting adjacent ownership and layered resource needs of this waterfront site is typical of many cities throughout the United States and other western, industrial countries. The competing need for both economically productive and ecologically productive shorelines exists simultaneously, and is currently acting as an impasse in pursuing an approach to the site.

Currently, maritime container ships as large as 1,043 feet long (318 meters) and 141 feet wide (43 meters), dock at the port. The piers are over 2,500 feet long (762 meters) with over 200 acres (81 hectares) of impervious surfaces to provide room for the necessary equipment for loading, unloading, and storing containers (United States Army of Engineers, 2002). As a result, the New York Container Port at Howland Hook is a highly constructed and massively scaled waterfront with immense bulk-head edges and great swaths of impervious hardscapes upland. With over 2 million containers handled on site within a year, the New York Container Terminal at Howland Hook is a formidable footprint on Staten Island's shore.

Providing a productive functioning tidal marsh is also crucial to the long-term sustainability of the region. Although Howland Hook has been the site of

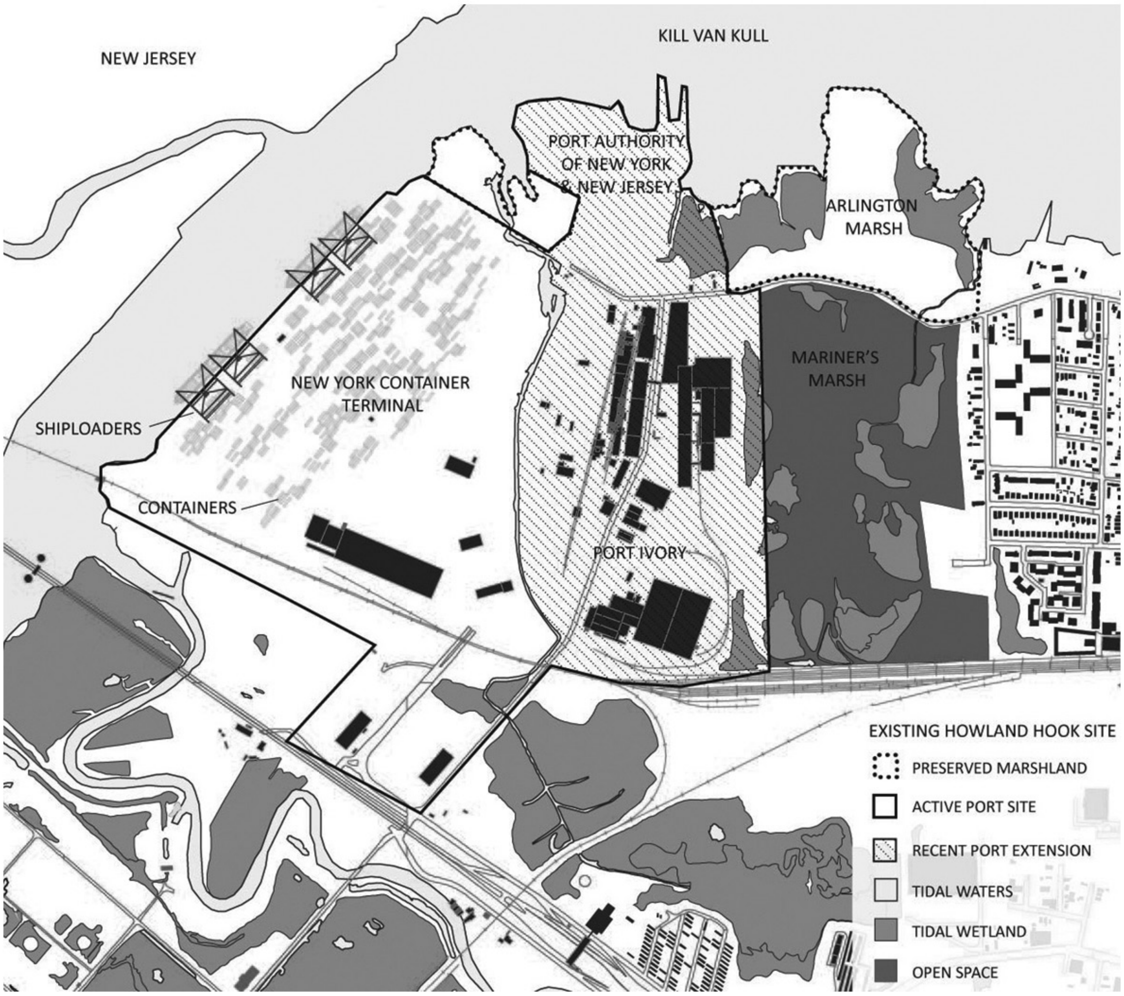

Figure 9:
Staten Island's Howland Hook, site of conflicting economic and environmental needs.

heavy industry both in its past and present, a lull in maritime industries in the mid-20th century allowed wetland grasses, shellfish, and birds to reclaim the Arlington Marsh, located to the northeast of the terminal site. Nearly 100 acres of tidal wetlands, including salt marshes, still currently exist northeast of the Howland Hook site, a remnant of the original shoreline conditions of New York City's native waterfront. Spartina alternifolia, an indicator species for one of the most productive natural habitats, is present in abundance. It provides shelter for juvenile fish and nutritious seed for birds; over 100 species of birds nest and feed in the marshland (Newman, 2007). Other important aquatic life, such as clams, oysters, snails, crabs, sea cucumbers and many more thrive in the shallow tidal water, providing an integral link within the food-chain. Additionally, it is these tidal marshes that serve as sponges which absorb excess water in floods and high tides, filtering nutrients and transpiring water, thus helping to manage watersheds (France, 2003). Currently 70 acres (28 hectares) of the Arlington Marsh are protected, but due to industrial adjacencies that continue to expand, the health of the marsh is in

Figure 10:
A conceptual plan and section of a multi-productive landscape solution to Howland Hook, providing a layered approach to economic, environmental, and social concerns.

conflict with traditional designs for the development of the port.

The design approach to the waterfront at Howland Hook should seek to integrate the infrastructural, economic, and ecologic needs of the site by providing a balanced landscape that allows for a productive port facility and marshland ecologies. One scenario draws from the historical forms of waterfront shipping, balancing re-oriented forms into opportunities for functioning water-based transport and salt-water wetlands. The design requires a reorientation of large-scaled piers perpendicular to the shoreline, similar to historic precedents, in order to maximize waterfront edge, and scaled for the operational needs of large-scale port infrastructure. In this scenario, the constructed piers would utilize the already abundant fill that is produced from the canal dredging efforts. By double-loading piers with a spine of rail and roadway land-transport, which pulls storage of the containers to the interior of the site, ecological waterfront would be maximized and disparate portions of wetland would be re-connected. Transport lines could also bridge over the moments of wetland connection. The extension of the existing peninsula to construct piers would provide protection of marshes from the wake of ship traffic in the channel. Additionally, diversion of storm-water run-off into fresh-water wetlands and the use of pervious paving with the capacity to further infiltrate run-off will protect the more sensitive salt marshes from contamination. Extensions of the publicly accessible Mariner's Marsh as open space adjacent to existing residential neighborhoods would allow the public to enjoy wetlands, shoreline, and harbor views via boardwalk trails.

Conceptually, this scenario might not resolve all conflicting concerns, but it does begin to create hybridized solutions that give multiple resource concerns equal priority in development of a multi-productive landscape. Through this kind of holistic design thinking, landscapes become active contributors to the dynamic and sustainable city of the future.

3. CONCLUSION

Productive landscape systems engaged in the process of resource management provide unique opportunities to limit ecological footprints of urban areas by overlapping economic, social, and environmental needs in cities and recreating resource cycles that have been lost due to post-Industrial growth. These productive landscapes have the additional capacity to expose city inhabitants to the cyclical processes that link waste to product, as well as provide relief from density through recreational and social programs. Two site specific case studies in New York City provide opportunities to understand the latent potential in existing urban landscapes to become productively engaged in the processes of resource management. By utilizing real sites situated within the social, economic, and environmental conditions of current cities, landscape scenarios can begin to address current local issues that have impacts on a global scale.

A change in the perception of waste and its connection to product is necessary, as well as recognition of a broader definition of infrastructure that includes landscapes, or green infrastructure. Projects such as Howland Hook's productive pier and Hunts Point's urban agriculture can expose the relationships that multiple resource have to one another and exemplify how landscapes, operating as infrastructure, can more efficiently and with less cost ameliorate some of the growing pressures of built infrastructure. Waste to resource flows are a natural condition and their relationship has been utilized in western cities prior to the Industrial Revolution. Designing landscapes that reintroduce this condition into cities is possible at locations such as Hunts Point. Other resources, such as water-based distribution systems and ecologically-productive waterfronts, although they might seem mutually exclusive, can also become integrated into single solutions that privilege their productive co-existence within a landscape.

Lastly, a change in our aesthetic for landscape is also necessary. Recognizing that infrastructure and resource management in the landscape can be both productive and expressive of nature's processes, the beauty of an urban landscape, whether flooded with storm-water, dotted with solar panels, or inundated with organic waste, should be measured in its ability to productively provide management of resources as well as express the story of its processes.

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