Adaptation and Migration: Design for the 21st Century Waterfront[1]

DLANDstudio Landscape Architecture + Architecture
Architecture Research Office (ARO)

> We didn't move to New York to be in the wilderness, but we are next to a wilderness.
> Tony Hiss, Waterfront Alliance Conference, May 12, 2021.

It has been just recently that public awareness regarding the ecological importance of our waterways has come to light. Oceans and rivers were considered ideal places to mine resources such as fish, minerals and dump waste. Like many of the world's most popular cities, New York became prosperous because of its location by the water. As the city grew and the port expanded, many of the wetlands that surrounded the city were hardened with bulkheads and then extended with piers and filled land. Times have changed. Climate change, sea-level rise, and the diversification of global supply chains now suggest the need to redesign our urban waterfronts. Design that can blend urban form, ecology, and engineering reveals a productive path to be followed. Prototypes developed over the past two decades for the Bight — the Waterfront of New York and New Jersey — have evolved as important forms of natural infrastructure.

In 1972, the United States President Richard Nixon signed into law two important pieces of legislation: the "Clean Air Act" and the "Clean Water Act". Why this is important for a discussion of climate adaptation, you might ask. In the United States, the legislation promoted action to arrest ongoing pollution and clean up the nation's waterways. The Environmental Protection Agency, which was established simultaneously, was set up to manage and enforce the new green policies. Federal laws are now forcing many municipalities to reduce combined sewer overflows and regulate point source pollution. The actions that cities across the United States are taking help to improve air and water quality. For large coastal cities, laws and their enforcement are also sparking creative redesign of urban infrastructure to create a more symbiotic relationship with the environment.

Projects that include protecting wetlands, increasing urban permeability, restoring marshes, and the addition of ecologically rich sponge park landscapes are all methods of adaptation central to coastal urbanism. Re-establishing the softer edges that existed when European settlers first arrived in the new world presents opportunities not only for increasing biodiversity, but also protection from storm surge and sea-level rise impacts. The transformation of dense cities like New York requires a blending of human-centered urban design (sociology) with an understanding of geomorphology, biology, hydrology (ecology) to create a healthy city where we recognize the true value of nature. Case studies developed by partnering scholars, professionals, and foundations demonstrate paths to be followed in an era of rapid planetary transformation.

MOMA Rising Currents 2010[2]: Lower Manhattan — A New Urban Ground

In 2009, the Museum of Modern Art, with the support from the Rockefeller Foundation, selected five design teams to envision how to transform different parts of New York Harbor to address climate change. ARO and DLANDstudio were invited to consider the following question: What will happen to Lower Manhattan over the next century when global temperatures rise and ice caps melt?

Our team developed a plan to prepare the city for climate change impacts that include sea-level rise and storm surges that could reach 28 feet above current mean sea level. The speculative project explored how altering the currently binary relationship between ecology and infrastructure could transform both experience and function of the city. The canvas for "New Urban Ground" was the land created by humans over 400 years of western occupation of Manhattan. As the water line moved outward with successive hardened bulkheads and piers, the coastal ecosystem was progressively segregated from urban life. We proposed a re-integration of land and water. The interchange would not only manage increasingly heavy rains but also buffer coastal storm impacts to fundamentally transform the experience in the city. The approach harnesses the power of man-made and natural systems to create a hybrid nature-based infrastructure of the future.

New York Now: The Challenges

Global awareness about the perils of global warming has grown tremendously since 2010, when we exhibited our work at the Museum of Modern Art. The public has experienced first-hand the increasing frequency and damage caused by severe storms. The consistent rise in the world's ocean levels makes low-lying coastal areas increasingly vulnerable to inundation and flooding. Local considerations that include upland watershed permeability, ground settling/glacial rebound, and ocean currents create variations. Still, science predicts that rapid ice cap melt would lead to six feet of sea-level rise by 2100. Looking back in time at historical maps can help us to predict future flooding.

PREVIOUS PAGE Proposal Waterfront view.

The proposal "A New Urban Ground" for MoMA's "Rising Currents: Projects for New York's Waterfront" exhibition is an integrated and reciprocal organization of natural and hard infrastructure systems.

Proposal of inundation levels.

In many cases, engineered landscapes of constructed ground are the most vulnerable to disaster. Our team calculated that, if scientists' projections become reality, 21% of Lower Manhattan would be inundated at high tide. Analysis of topography also suggested that a Category 2 hurricane would create surges 24 feet above the future sea level and would flood up 61% of the area. Just two years after the show, New York and the metropolitan region experienced one of the most disastrous environmental catastrophes in its history when Superstorm Sandy devastated the city with flooding and high winds. When Sandy struck the city, our predictions about storm surge became a reality as floodwaters reached the 1624 waterline covering the human landscape.

In waterfront cities, a great deal of attention is paid to extreme tides and coastal storms. How rainwater and sewage are managed is equally important. Hundreds of cities in the United States, including New York, have combined sewer systems. Combined sewers allow sanitary sewage and storm water to overflow into neighboring waterways so that sanitary sewage treatment plants do not get overwhelmed.

The technology was invented to manage the additional effluent stemming from the popularization of flush toilets in the second half of the nineteenth century. Now rainstorms are frequently overloading the system releasing per week into the Upper New York Bay an average of 500 million gallons of polluted effluent from 460 combined sewer outfalls (csos).

The landscape of New York 2100: The Possibilities

Lower Manhattan has a tremendous real estate monetary value and is symbolically the world's financial center. With the increased likelihood of flooding over the next century, our team understood the necessity for protecting the existing assets. Instead of fortifying the island with large walls which would further separate the metropolis from the surrounding natural environment, we proposed integrating ecology into the city's infrastructure. Edges would rise to protect upland assets but then taper down to the water in floodable open spaces and tidal marshes. We also understood the challenge of adapting hundreds of private ownership properties. Public streets became our canvas. In-street infrastructure would be reorganized to become more efficient. The combined engineered system would be more flexible in response to climate change. Four hundred years of development would not be erased but instead redirected to new technology and new functional requirements. The interconnected system of porous green streets and graduated edges will improve the carrying capacity of the urban landscape while also enhancing its connection to nature.

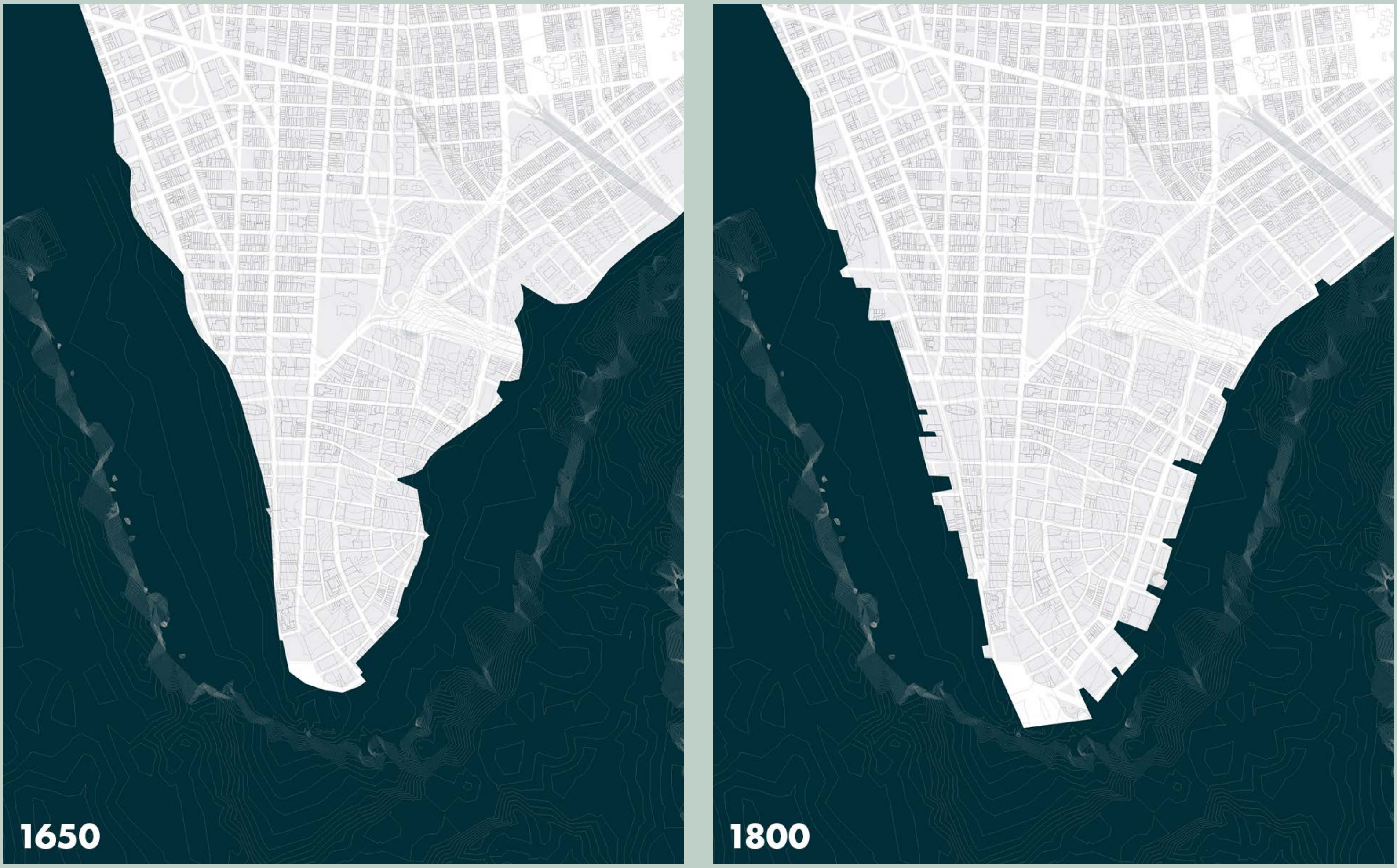
A New Street Ecology

New York has had many waterfronts before it grew to become the city that we all know today. Names such as Water Street and Front Street are clues to past water lines. Each incremental addition to Manhattan Island was made possible by technological advances and economic needs. The landscape constructed from 1625 to the present that we call the "New Urban Ground" is served by a rat's nest of tangled wires, pipes, and conduits underground, some of which are obsolescent. New York City's millions of visitors, workers, and residents are unaware of what lies underground and its possible threats to their livelihood posed by climate change. It is in the democratic public streets that major transformations can happen rather than in private development blocks. A new ecological, humanistic infrastructure can emerge.

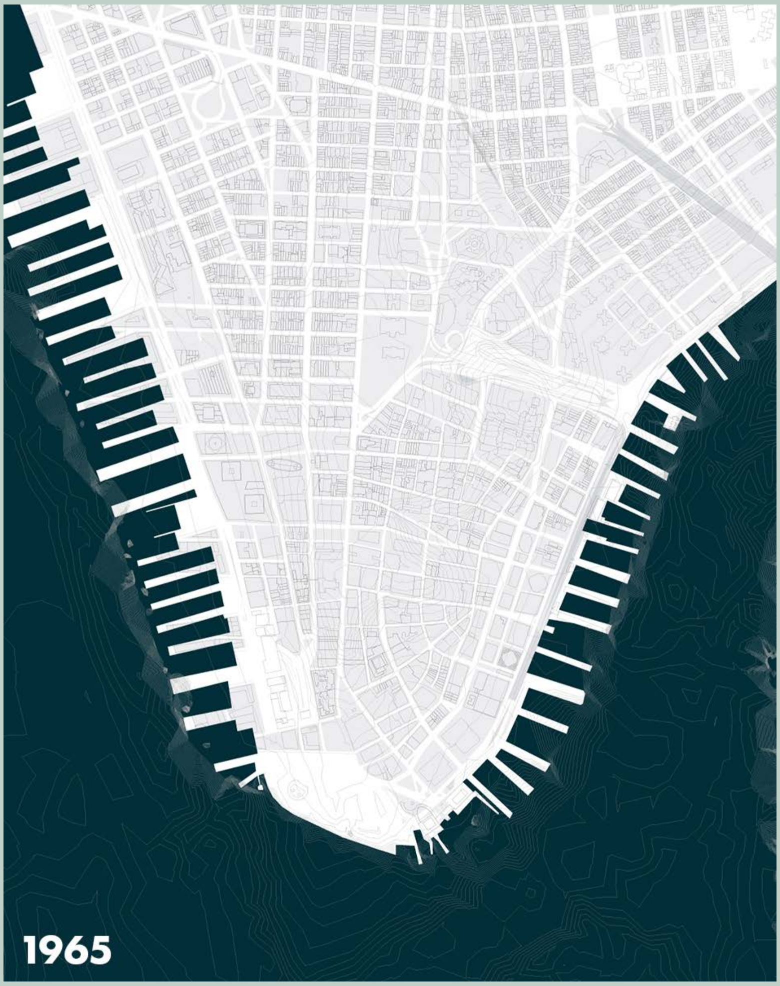
When rain falls on hardened impervious surfaces it currently flows into mechanical storm drains sized for storm intensities based on statistical frequency over time. This data is translated into State and City building codes designed to protect people. History is not a reliable predictor of future storm events as it was in the past. Climate change is making storms more intense, and the result is that many of the engineered systems are overwhelmed, causing damages and increasing water pollution. Freshwater is essential to the function of the estuary, but not if it is contaminated with biological and chemical toxins.

In New York City, streets account for 27% of the urban landscape. Our team saw this as an opportunity to help restore natural hydrologic cycles and natural ecology. First, we measured the street area in lower Manhattan. Then, we calculated the amount of impermeable ground needed to absorb, filter, and clean the stormwater using the City and the State of New York metric of 90% (1.2") storm. This metric means that 90% of all hurricanes that happen in a year are less than 1.2" per occurrence. Regulations are set to manage these storms with piped drains. Our proposal adds capacity to the existing system by enabling the streets to capture stormwater. The idea is to keep water from entering the city's combined sewer system. Our analysis suggested that 80 acres of permeable


2100 CATEGORY THREE
STORM SURGE + 24'
2100 SEA LEVEL +12'
2010 SEA LEVEL + 0'
INUNDATION LEVELS



Lower Manhattan waterfront time evolution.


1965


2009

ground and freshwater wetlands would capture Lower Manhattan's excess runoff.

Streets that serve the area up to the reach of Category 2 storm flooding act like arteries and veins calibrated to capture different flows. In these new green spaces, plants were selected to phyto-remediate the toxins that accumulate from urban runoff and tidal waters. Unlike mono-functional piped infrastructure, the new system adds cooling from evapotranspiration, cleaning from filtration, and beauty to the streetscape. The new porous streets did not impede vehicular circulation. Parking was, however, reduced in anticipation of fewer automobiles in Manhattan, enabling increased urban green space. These streets would change the urban experience, expressing the importance of ecological sustainability.

Existing services (water, sewer, gas, and electric) in this new system will be relocated into waterproof vaults beneath the sidewalk. The vaults are divided into two parts: private utilities (dry systems), such as electric and telecommunications, and public utilities (wet systems), such as water, gas, and sewers. Three types of green streets are designed to manage different amounts of stormwater capture for absorption, retention, and water distribution. Level 1 Streets, located in the area potentially impacted by Category 2 storms, have the lowest capacity and manage water locally, acting like a sponge with permeable paving and plantings in the street bed. Level 2 streets have conduits that would carry water to freshwater wetlands at the perimeter of the island. The island's center is Broadway; this historic street acts as the system's spine connecting Level 2 streets to small collect ponds (embedded in existing city fabric) that store water for redistribution during dry periods. At the city's perimeter, parallel to the shoreline, Level 3 streets are designed to hold storm surge volume and drain back to the harbor. Because of their capacity to withstand higher salinity levels due to inundation from both stormwater and storm surges, Level 3 was selected to be planted in and around. Native plants in the coastal estuary are adapted to the specific microclimate created by this highly efficient and integrated nature-based infrastructure.

A Graduated Edge: From Line to Zone

The network of streets connects into a broader zone of different landscapes. From woody upland planting to reeds and grasses of the shore, different zones of high-performance landscapes are constructed to manage higher sea levels and mitigate storm surge forces and flooding. Traditional programmed parkland, freshwater wetlands, and tidal salt marshes will transform the appearance and function of the urban landscape. The system attenuates waves, manages the urban watershed, filters interior surface runoff, enhances biodiversity, and introduces a new system of public green space. The morphology of the edge depends upon its location. There are varied opportunities on the east and west sides of Lower Manhattan.

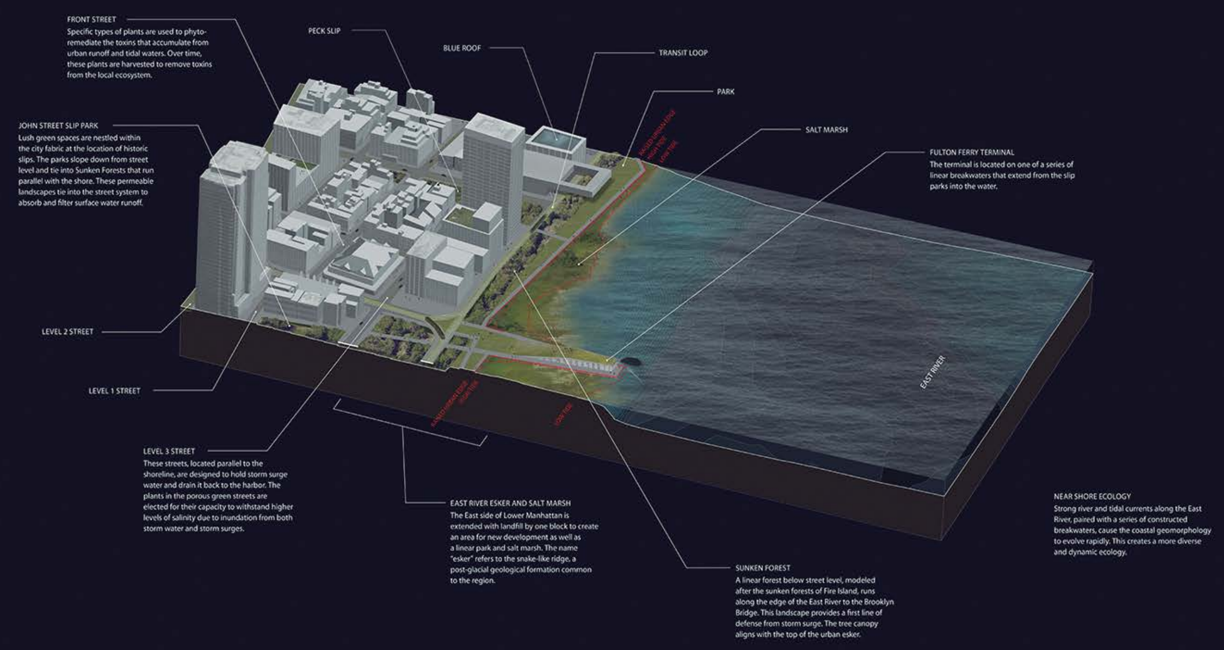
West Side Urban Estuaries

The Upper Bay of the New York-New Jersey Coastal Estuary is characterized by waters with lower salinity than the Atlantic Ocean. Flows from the Hudson River watershed mix with the tidal waters, and a brackish ecosystem is created. Sediment and freshwater enrich the ecology, contributing to a more diverse ecosystem. Along the west side of Manhattan, the landscape is reshaped in a crenelated pattern that creates protected urban marshlands within the urban fabric. When Battery Park City was created, the fill line extended all the way to the scrubbing channel of the Hudson River. At the line between fill and drain, the grade drops off dramatically. Due to the steep bathymetry of the harbor adjacent to Battery Park City, we proposed crenulations cut into the island.

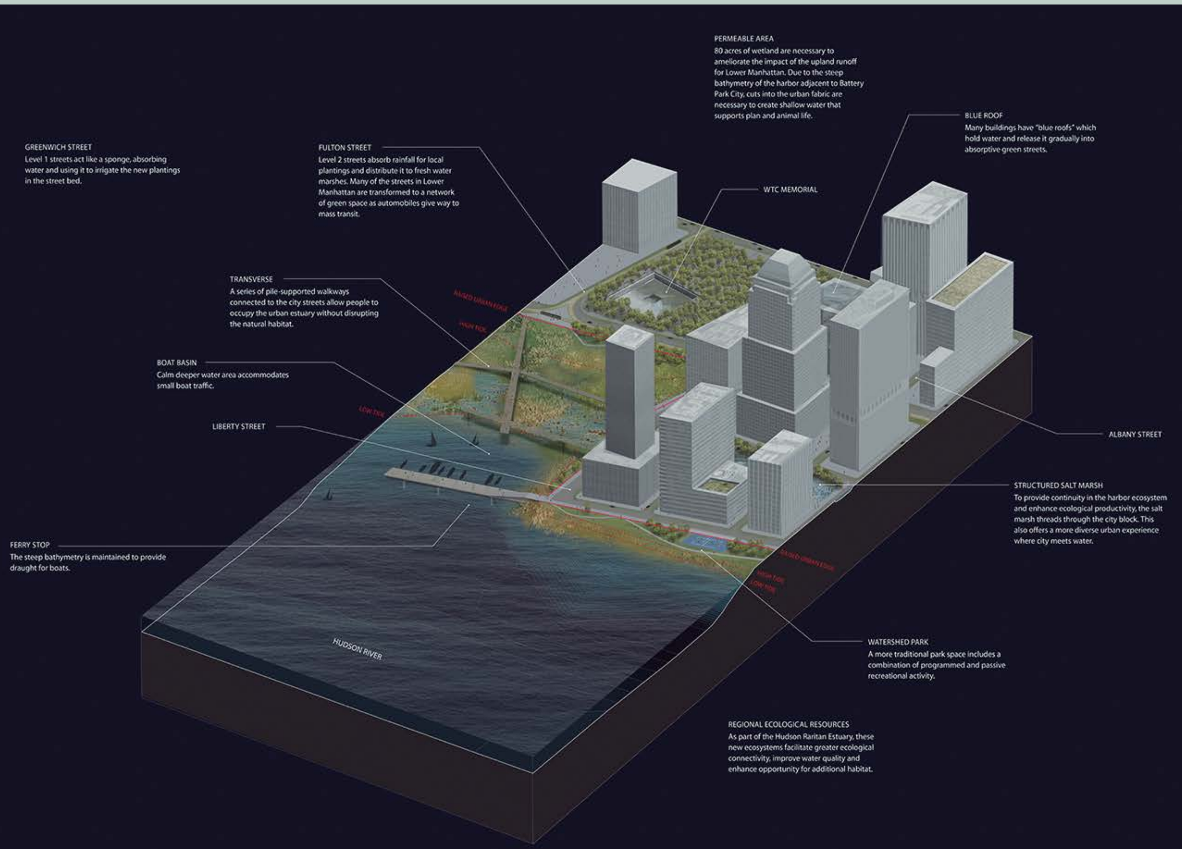
Further north, new filled areas are created to balance the cut. The new protected shallow waters create protected shallow waters that support the addition of a biologically rich ecosystem to the city, creating a balance between ecological and economic sustainability. Dramatic tidal variation in the harbor means that much of this intertidal zone is submerged twice daily. The temporal relationship between human and natural circulation patterns adds interest to this new softened edge. Water movement will provide the most dramatic visual effects, but migrating birds and fish add an extra layer of interest.

The sheltered marshes are comprised of salt marches supported by tidal flows and freshwater wetlands fed by the porous green street system. Within these wet city-scapes are navigable streams and ferry stops, small craft recreations areas, and boardwalks that provide a rich juxtaposition between the intensity of the city and the tranquility of the wetland. Throughout the marshlands, a series of pile-supported walkways connect city

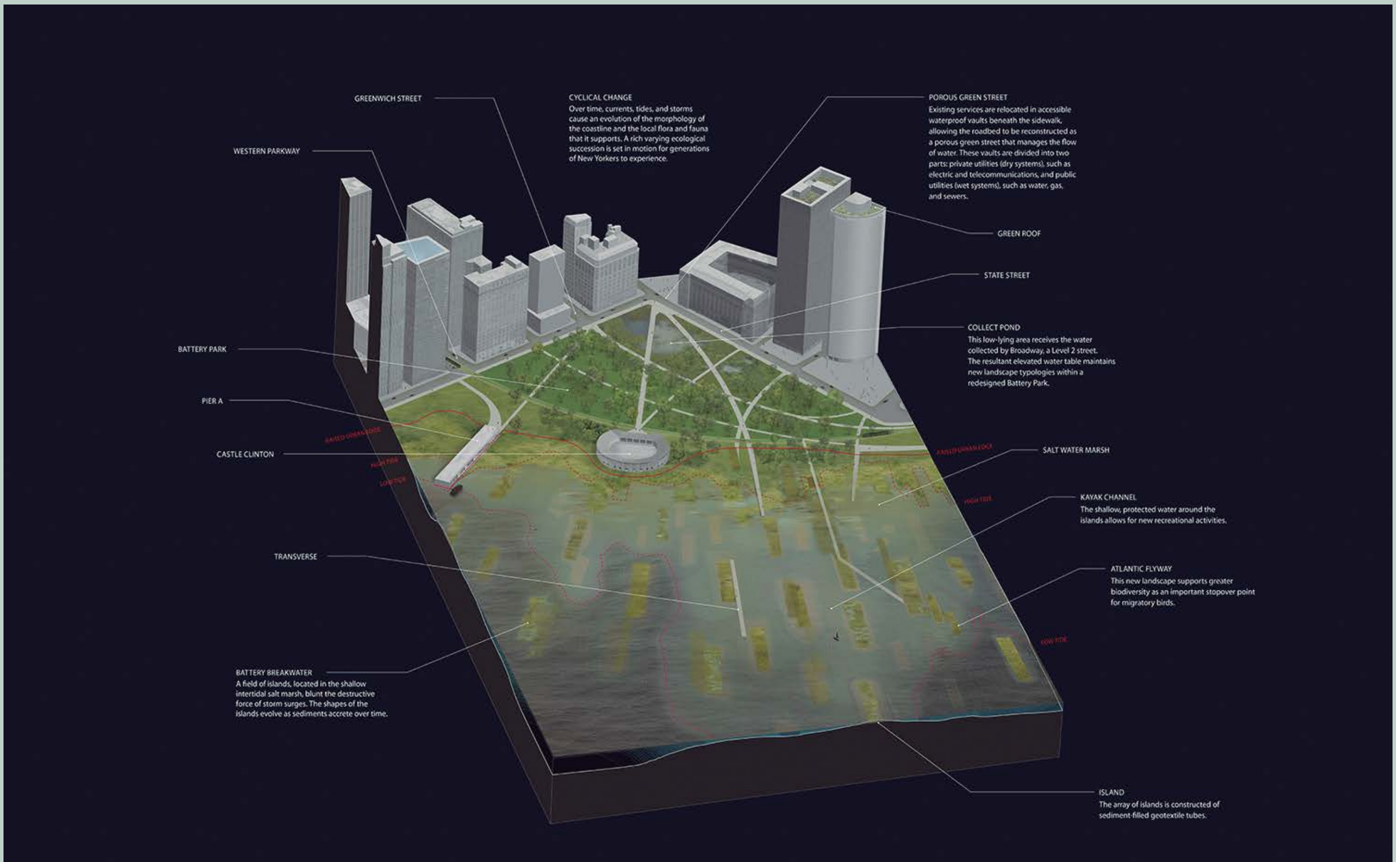
General plans of the three types of green streets of "A New Urban Ground" proposal.



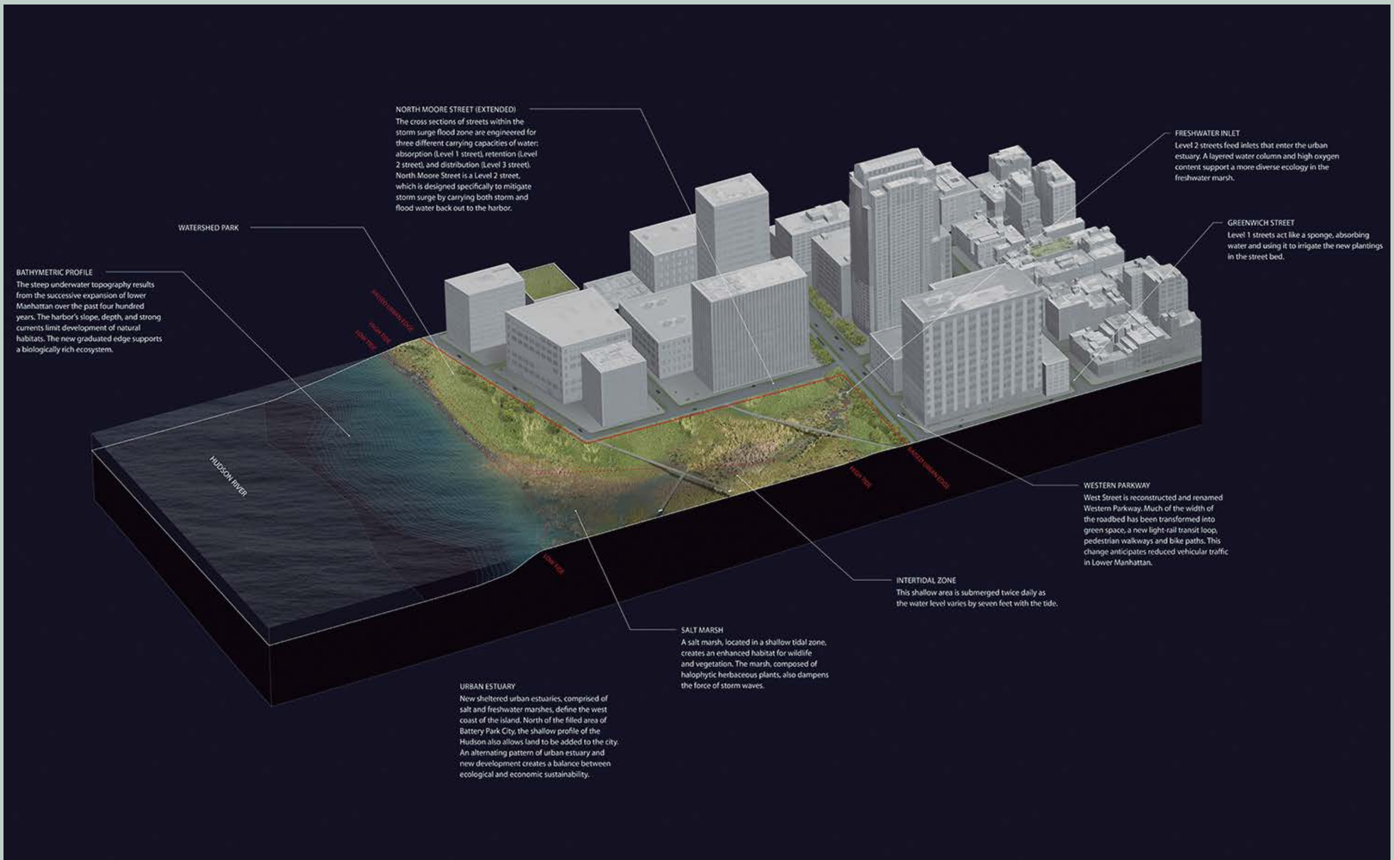
EAST RIVER ESKER AT FULTON STREET



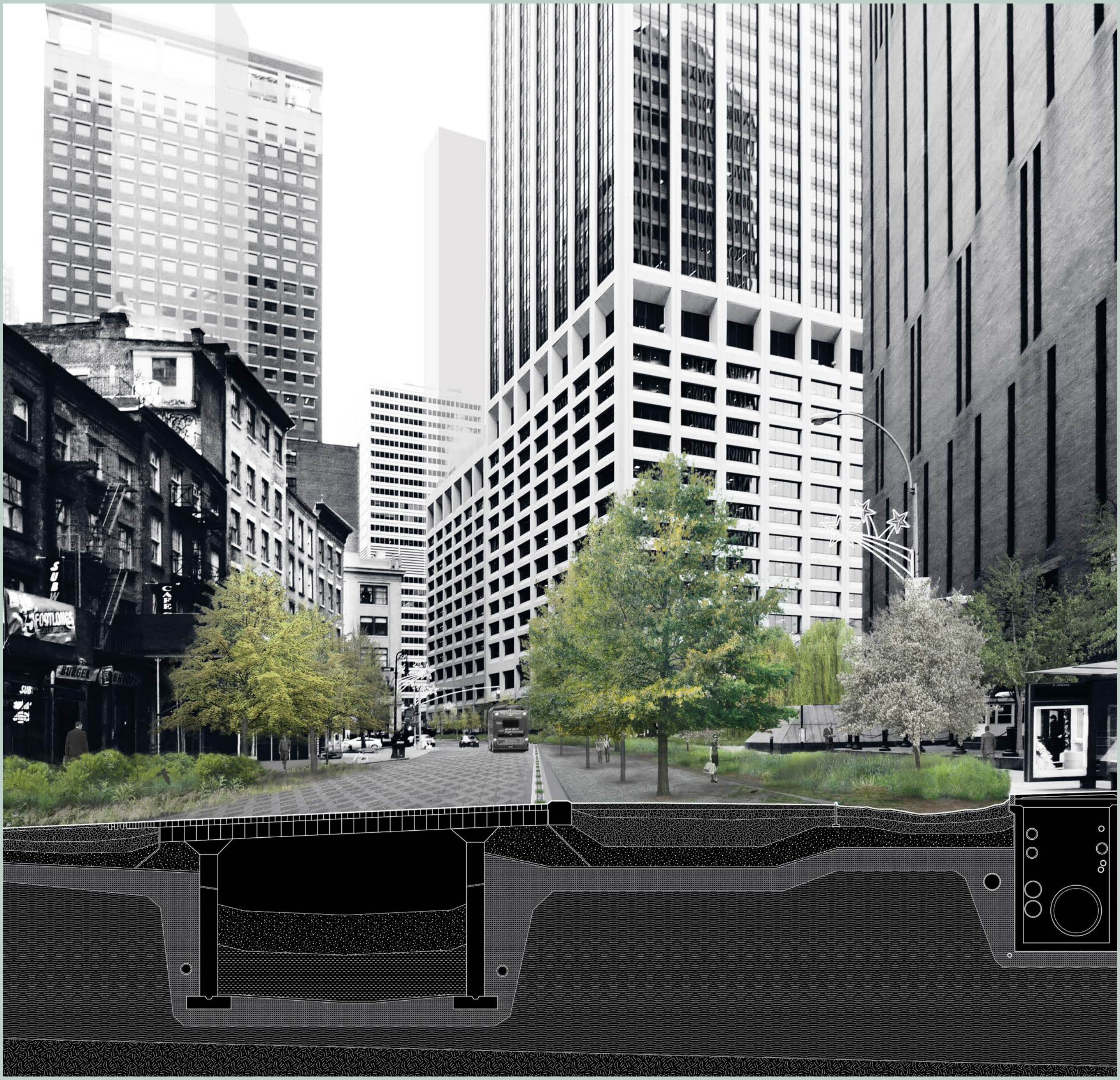
URBAN ESTUARY AT LIBERTY STREET



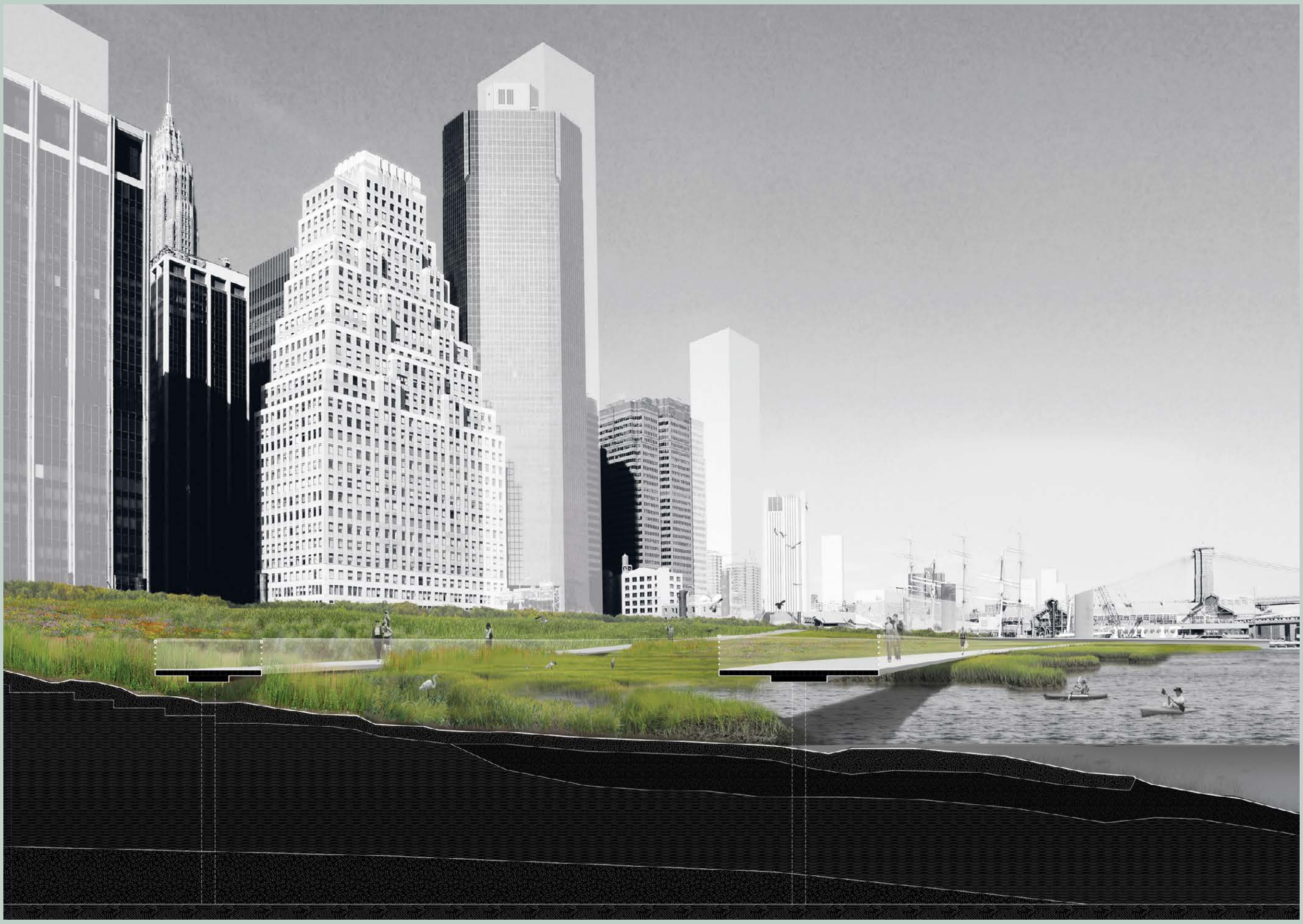
BATTERY BREAKWATER



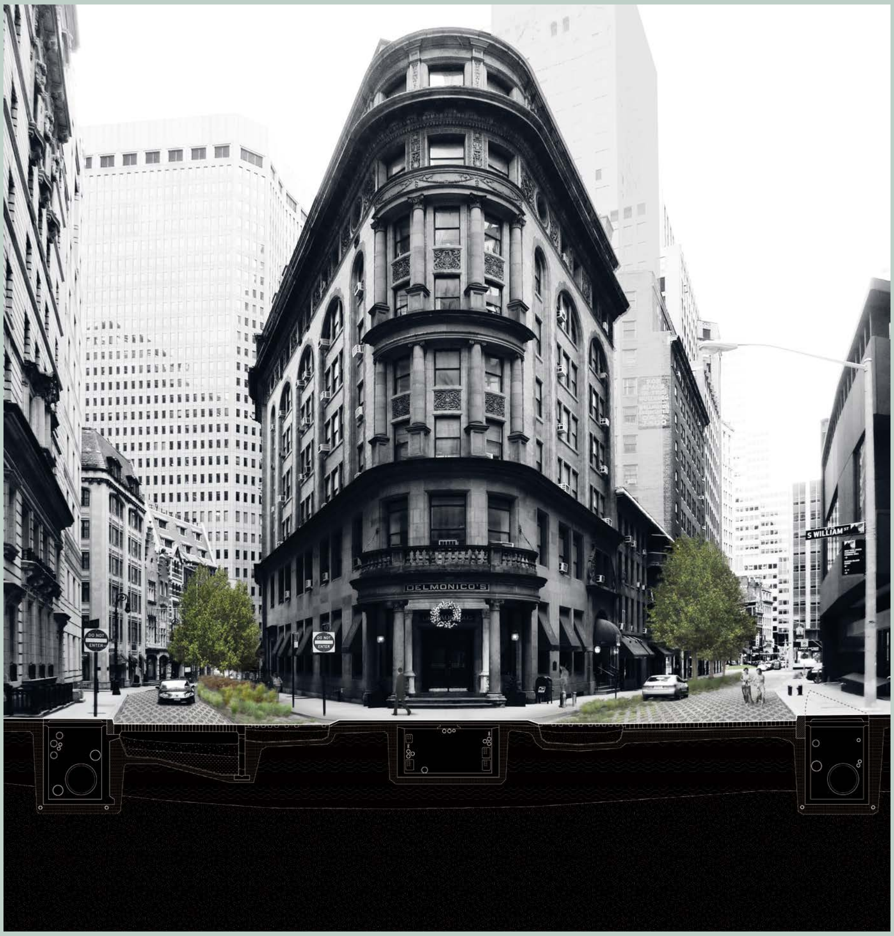
URBAN ESTUARY AT NORTH MOORE STREET



Details of
the proposal
in sections
of the city
in clockwise:
East River,
Hudson River
and Water St.



Details of
the proposal
in sections
of the city
in clockwise:
Old Slip,
Delmonico's
Restaurant
and West St.



streets and allow people to occupy the landscape without disrupting the natural habitat. The structured salt marsh threads through city blocks to provide continuity of the harbor ecosystem at unique points. Rather than waterfront parks, we call them watershed parks to characterize the increased connection to broader hydrologic systems. Upland areas will include programmed spaces such as sports fields and passive recreational areas with a rougher natural landscape. The park spaces thread back into the city's fabric along the green streets, including reconstructed West Street (renamed Western Parkway). Much of the width of the roadbed of Western Parkway has been converted into green space, with a new light-rail transit loop, pedestrian walkways, and bike paths.

The Battery Breakwater

Battery Park lies at the tip of Lower Manhattan. Anchored by a historic Castle Clinton, the park is the gateway for visitors of Ellis Island and the Statue of Liberty. The shallows just off-shore support salt and freshwater marshes that weave through a series of artificial breakwater islands and integrate back into the shore. The islands, made from geotextile tubes filled with dredged sediments, are covered with soil and ECOncrete® to support marine life. The islands are strategically placed to dull the force of storm surge by interrupting the period of the waves. Together this new island marsh landscape creates a stop-over along the Atlantic flyway for migratory birds. It also provides an opportunity for kayaks and canoes to explore the wetland habitat.

East Side Esker and Salt Marsh

The bathymetry off-shore of the east side of Lower Manhattan is relatively gradual. We propose extending the island's edge with new fill to elevate the edge, add new development, a new park, and new salt marsh areas. A linear forest 18 feet below the new street-level runs parallel to a new development corridor from the Battery to the Brooklyn Bridge. The microclimate that is created with this move is modeled after the underwater forests of Fire Island. Like the barrier island and dune-scape of Long Island, this landscape provides the first line of defense against storm surge. The barrier also references eskers, the long snake-like glacial mounds formed under the ice during the last ice age common to the region. The new tree canopy aligns with the top of the urban esker creating a linear park spanning between the underwater forest, the marsh, and the East River. The historic slips that once allowed boats to bring goods deeper into the island have long been filled. These landscapes will be renewed as a place of exchange, but this iteration adds ecological value to the landscape. The slip parks slope down from street level and connect to the linear sunken forest. The sponge slip landscapes extend the permeable street network to filter surface water runoff further. The slip parks are paired with a series of constructed breakwaters and new ferry docks along a new Lower Manhattan water transportation route.

A Continually Evolving New Urban Ground

In the landscape constructed by a man wishing only to conquer natural systems, we propose a less binary construction that balances biological and human-made systems. With a proposal that unites harbor ecologies and urban infrastructure, the design preserves important buildings, monuments, and urban form, while demonstrating a more flexible, resilient, and adaptive future for Lower Manhattan. This new urban model improved the performance and experience of urban life. The proposal is catalytic. It will, over time — by design — mature in sometimes unpredictable ways. As currents, tides, and storms transform the coastline, the local flora and fauna will help build urban climate resilience. Climate change and increasing population are now challenging us to be an active part of this morphology. A rich varying ecological succession is set in motion for generations of New Yorkers to experience. In essence, Manhattan will re-invent itself yet again by developing in tandem with natural systems.

AUTHOR

DLANDstudio is an interdisciplinary design firm founded in 2005 by Susannah C. Drake, FASLA, AIA. Born from her vision of making cities more ecologically productive, the firm develops methods to layer environmental, engineering, and political structures to make real change in the built environment. The firm has won numerous awards and competitions, and our work is in the permanent collections of the Museum of Modern Art and the Cooper Hewitt, Smithsonian Design Museum. Susannah C. Drake is the principal and founder of DLANDstudio. Susannah's research has been at the forefront of innovation on urban ecological infrastructure. Susannah has led design studios at Harvard University, Washington University in St. Louis, the Illinois Institute of Technology, Cooper Union, and City College of New York. She served as President and Trustee of the New York ASLA and as a Trustee of the Van Alen Institute. She was a contributor to Nature and Cities, published in 2016 by the Lincoln Land Institute. Her work has received numerous national and international awards and is in the permanent collections of the Museum of Modern Art and the Cooper Hewitt, Smithsonian Design Museum.

COLLABORATOR

Architecture Research Office (ARO) is led by Stephen Cassell, Kim Yao, and Adam Yarinsky. Since 1993, the firm's diverse project portfolio — spanning strategic planning, architecture, and urban design — is united by a principled and engaged approach to design, collaborative process, and technical precision, always in an effort to achieve the greatest aesthetic impact with the fewest natural and financial resources. This philosophy has earned the firm over one hundred design awards, including the 2020 AIA Architecture Firm Award, the AIA New York State Firm of the Year Award, and the Smithsonian Cooper-Hewitt National Design Award for Architecture.

NOTES

1. This essay is an expansion and editing of a text originally created as part of the MOMA Rising Currents Exhibition in Collaboration with Adam Yarinsky and Stephen Cassell of ARO.
2. Exhibition website: www.moma.org/calendar/exhibitions/1028>. Blog on website: <www.moma.org/explore/inside_out/category/rising-currents/#description.

CREDIT

Exhibition photos: © 2010 The Museum of Modern Art, New York. Photo: Thomas Griesel.

MOMA Rising Currents 2010: A New Urban Ground, Manhattan, New York, 2010.