Land Lines

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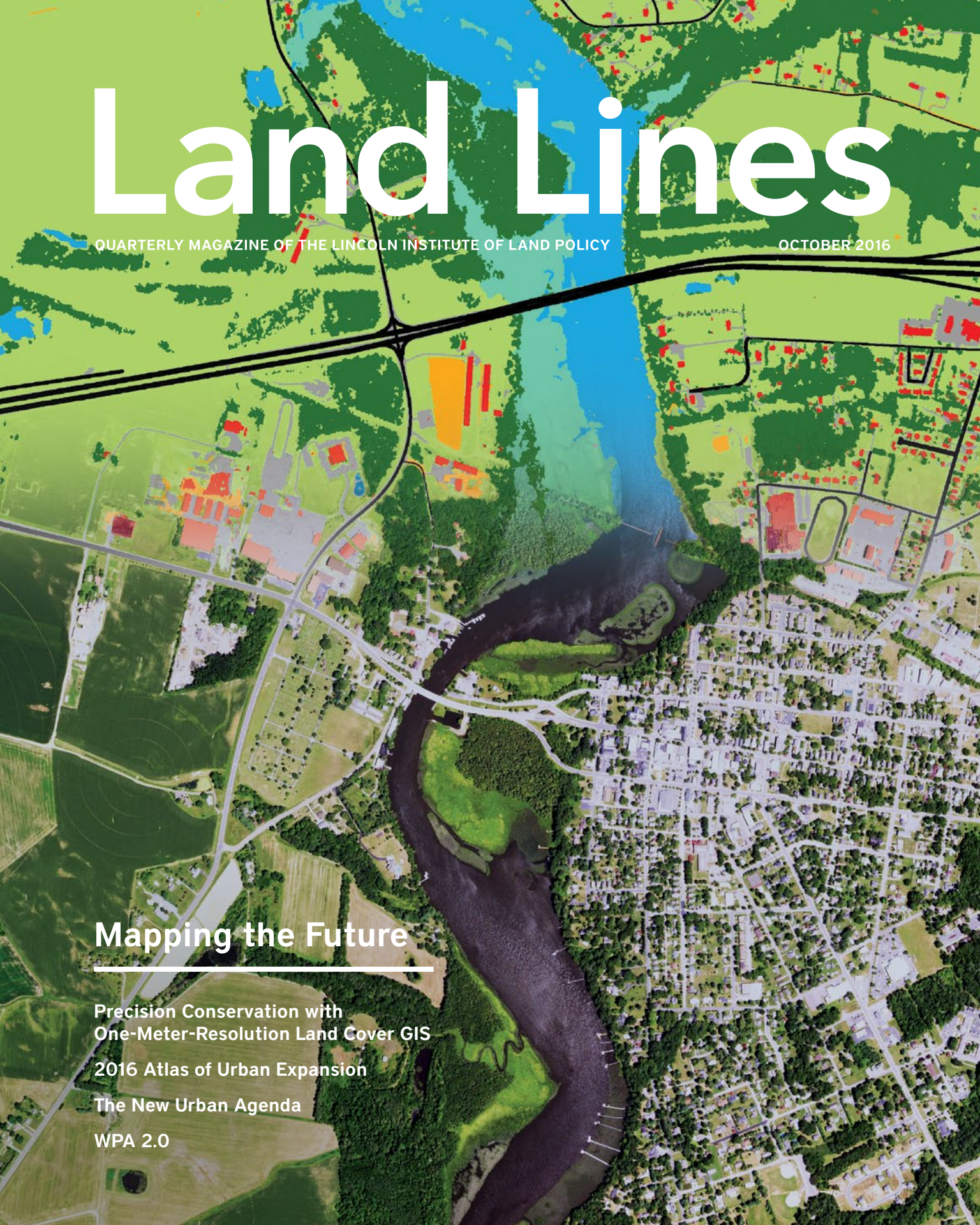

Mapping the Future

Precision Conservation with One-Meter-Resolution Land Cover GIS

2016 Atlas of Urban Expansion

The New Urban Agenda

WPA 2.0

Land Lines

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THE LINCOLN INSTITUTE OF LAND POLICY
is an independent, nonpartisan organization whose mission is to help solve global economic, social, and environmental challenges to improve the quality of life through creative approaches to the use, taxation, and stewardship of land. As a private operating foundation whose origins date to 1946, the Lincoln Institute seeks to inform public dialogue and decisions about land policy through research, training, and effective communication. By bringing together scholars, practitioners, public officials, policy makers, journalists, and involved citizens, the Lincoln Institute integrates theory and practice and provides a forum for multidisciplinary perspectives on public policy concerning land, both in the United States and internationally.

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LINCOLN INSTITUTE OF LAND POLICY

Contents

FEATURES

DEPARTMENTS

Cover illustration: The Chesapeake Conservancy transforms aerial photographs to one-meter-resolution land cover data that classify and quantify landscape features for use in planning, prioritizing, and goal tracking (see p. 8). Credit: The Chesapeake Conservancy

The Road to El Dorado

THIS MONTH, LIKE CONQUISTADORS OF CENTURIES PAST, TENS OF THOUSANDS OF US WILL ASCEND THE ANDES TO QUITO, ECUADOR, IN SEARCH OF EL DORADO. But, unlike our brutal and greedy predecessors, we are not pursuing metallic wealth beyond our wildest dreams. The golden city we seek promises a sustainable urban future. Our map—the New Urban Agenda, which will be announced and adopted during Habitat III, the United Nations Conference on Housing and Sustainable Urban Development in October 2016—tells us where we are going, but it does not tell us how we will get there.

The golden city we seek promises a sustainable urban future. Our map—the New Urban Agenda—tells us where we are going, but it does not tell us how we will get there.

We know that we will encounter monumental challenges as we navigate this path to welcome some 2.5 billion people to the world's cities over the next three decades. We will be tasked with providing jobs and housing for both these newcomers and current urban residents who are inadequately housed or underemployed. And we will have to make unprecedented investments in infrastructure to provide basic services for these new city dwellers. Our local governments will need to step up, as never before, to implement and finance measures to handle extraordinary growth. But while the bulk of responsibility for managing this last epoch of urbanization will fall on local governments, the rest of us are not off the hook. In fact, it is safe to say that the actions of other institutions—particularly national and subnational governments and certain NGOs—will determine whether urbanization succeeds. We will all need to pull together to find our way to larger, more inclusive, equitable, and sustainable El Dorados.

And here is how these golden cities will function. Local, provincial, and national governments will align and coordinate their actions to manage urban growth successfully. This sounds easy enough, but what will it mean in practical terms? It means that different levels of government will commit to getting urbanization right and adopt some new modus operandi. It means that higher levels of government will stop devolving expenditure responsibilities to lower levels of government without identifying or providing sufficient revenues to cover the expenditures. It means that national governments will provide local governments the statutory authority to raise their own funds to meet many of their own financial obligations. It means that we will ensure local governments have the capacity—both technical and human—to make efficient use of all available resources. And it means that national governments will commit to adapt and adjust their policies to match the changing needs of local governments and the contexts in which they work.

Powers conveyed and responsibilities mandated from higher levels of government to lower levels through constitutions and legislation will reflect strategic alignment. Resources transferred from higher government levels to lower levels through agencies or ministries will be less encumbered by earmarks or overbearing compliance rules. Local governments' powers and responsibilities will be codified in constitutional and legislative "rules of the game" that define a better-groomed playing field. Rules that enable localities to manage their affairs—granting them the power to levy certain taxes and fees or the legal authority to enforce tax collection—will displace regulations that constrain the ability of localities to attend to their own needs, such as property tax rate limitations.

Playing by national rules will no longer be difficult or impossible for cities. Other municipal governments will follow Detroit's lead and find ways to avoid leaving tens of millions of already-allocated federal dollars on the table as Detroit did in the years preceding its bankruptcy. They will seek assistance to overcome the staff deficits and technical limitations that led to Detroit's failure to adequately manage federal funding, as noted in the 2015 Government Accounting Office (GAO) report. And they will not fault themselves for their inability to use that money; they will recognize that defects in the design of funding programs are to blame, given that many thriving cities are likewise unable to utilize all of their national funding. And they will know that their problems are not exceptions but rules, as hundreds of cities across the world acknowledge that efficient use, or under-use, of intergovernmental transfers is an almost insurmountable challenge. This is something that we will fix on our way to El Dorado.

But how will we detect and correct defects in the design of intergovernmental transfer

Habitat III—the United Nations Conference on Housing and Sustainable Urban Development—takes place in Quito, Ecuador, from October 17 to 20, 2016. Credit: pxhidalgo / iStockPhoto

programs? Where is the forum where rules of these games are reviewed and refined? It is not surprising that the GAO would conclude that the failure of federal funds to reach the ground is a problem of local capacity. How would the national government get enough objective distance to consider the idea that its programs and policies are ineffective because of bad design? National governments will create programs crafted to fulfill policy goals, not to frustrate local governments' attempts to meet citizens' needs. But how? To know whether their programs are working, they will talk about them with their local counterparts. Although these discussions rarely occur now, they will become commonplace. Productive feedback through honestly brokered conversations will ensure that the troops on the ground are on the same page as the legislature and its ministries. And vice versa.

At 9,350 feet (2,850 meters) above sea level, Quito, Ecuador, is the world's second-highest capital city and a UNESCO World Heritage site. Credit: Sean Randall / iStockPhoto

While the bulk of responsibility for managing this last epoch of urbanization will fall on local governments, the rest of us are not off the hook. We will all need to pull together to find our way to larger, more inclusive, equitable, and sustainable El Dorados.

And this is where other key institutions will play a role. Specifically, NGOs and quasi-governmental organizations will connect the work of policy implementers with policy makers. Some institutions are familiar with the work of local governments and trusted by them as partners, but they also have access to and credibility with national leaders and policy makers. These organizations can serve as honest brokers and conveners to bridge the communication gap between policy conception and implementation and help to improve both. Hundreds of these mediators, or "conversation conduits"—including multilateral funders and social-change philanthropists, think tanks and practice-oriented departments of universities, membership organizations of public officials and development lenders, and the Lincoln Institute of Land Policy—will work together to complete a "virtuous circle" that leads to better policies and aligns the efforts of multiple levels of government to achieve the goals of sustainable urbanization. And they will develop and deliver training and technical assistance to build the capacity of local governments.

It is a bold vision of the future. But without efforts like these, it is hard to imagine how we will achieve the goals of the New Urban Agenda. A significant share of the approximately 4,300 cities in the world with populations greater than 100,000 can use some help to grow their skills and systems, and to communicate better with higher levels of government. And many of them are hungry for the help.

We started on this path with the launch of our global campaign for municipal fiscal health two years ago at a congressional briefing where we were invited to talk about the challenges that perpetuate weak economic performance of older industrial American cities. We will follow next spring with a roundtable co-convened with the Pew Charitable Trusts (a fellow mediator) to present findings from a study of unspent federal grants that we have underway with planning students from Northeastern University (another mediator). We will invite representatives from federal agencies to explore the implications of the findings for reforming formula-funding programs. In addition, we have begun to design and offer training modules to build capacity and technical assistance for cities. But we need help—a lot of it.

Let's take advantage of the Habitat III meeting to network the institutions that want to help cities make efficient use of intergovernmental transfers and other resources—through policy dialogues convened with national governments, or through capacity building programs for local governments, or both. This effort requires more resources and skills than any of us can mobilize individually. We need to tackle this challenge together. The Lincoln Institute is ready to participate in a global effort to empower cities to solve their own problems, and we will identify others to begin the process of mobilizing and coordinating a new global practice. Please seek us out in Quito if you want to learn more about what we are doing and how we might work together.

We will not get another chance to get urbanization right. By the middle of this century, 70 percent of humanity will reside in cities. We must ensure that they are the cities we need.

We will not get another chance to get urbanization right. By the middle of this century, 70 percent of humanity will reside in cities. We must ensure that they are the cities we need. Habitat III is a rare occasion when national governments focus on their urban centers and the outsized role they play in their nations' futures. Let's use this moment to focus our collective efforts to implement the New Urban Agenda in the next two decades, and travel together on the road to a new El Dorado.

Open Reblock Land Readjustment App

LAND READJUSTMENT IS A VITAL BUT DIFFICULT AND TIME-CONSUMING PROCESS: formulating a sort of retroactive version of planning in neighborhoods that developed informally, with unsanctioned dwellings chaotically built in ways that leave some with no access to streets and paths. According to UN-Habitat, 863 million people around the world lived in such settings as of 2014, and the number could rise to 3 billion by 2050. The agreed draft of the New Urban Agenda for the Habitat III conference in Quito, Ecuador, notes that the "rising number of slum and informal settlement dwellers" contributes to intense challenges that exacerbate global poverty and its risks, from a lack of municipal services to increased health threats.

Open Reblock deploys a custom algorithm to read a digital map of an informal settlement and propose what it sees as the optimal strategy for reblocking it. (The algorithm is written to prioritize existing roadways and structures, echoing the traditional goal of minimizing displacement.) This process takes just minutes.

But evolving technology may facilitate revision of these organic layouts in ways that lead to minimal displacement and speed the absorption of such neighborhoods into a city's formal structure, thus providing residents basic services—from sanitation and drainage systems to access for fire and medical emergencies. One of the more promising tools is Open Reblock, a platform currently in a pilot phase in areas around Cape Town, South Africa, and Mumbai, India. The project stems from a collaboration among Shack/Slum Dwellers International (SDI, is a network of urban-poor communities in 33 countries), the Santa Fe Institute (SFI, a nonprofit research and education organization), and Arizona State University.

SDI has long been involved in grassroots "reblocking"—essentially another way of characterizing the land-readjustment process. Luís Bettencourt, a professor of complex systems at the Santa Fe Institute, explains that his group, which focuses on "cities as systems," began working with SDI a few years ago. There was a useful convergence in the high-level, statistics-and-data thinking of the SFI group with the on-the-ground "census" efforts SDI used in its work with informal-settlement communities.

SDI's reblocking efforts could be painstaking. Residents led the process of mapping a neighborhood—on paper. Then they gathered at community meetings, arranged cutouts representing every local structure over that map, and began shifting them around to devise new paths and roadways. While this active collaboration was profoundly beneficial, the analog methodology wasn't exactly speedy.

Ever-more-accessible digital technology has in recent years eased the process, says SDI Programme Officer: Data Management Anni Beukes. The group now uses a geographic information system (GIS) tool to map settlement boundaries and services available, and then relies on a separate tool for detailed household-level surveys and precise measurements of every structure. Given the wide availability of mobile devices, the process is open to—and indeed dependent on—direct resident participation.

Enrique R. Silva, research fellow and senior research associate at the Lincoln Institute, notes that similar tech-mapping tools are impacting such efforts around the world. "You can map something almost immediately," he says, and involve community members in that process. He points to efforts, backed by the Lincoln Institute and others, that rely on "cheap and universal" devices and crowd-sourcing tools to reach similar goals across Latin America.

A master map that is available in digital form also creates new possibilities. Open Reblock is an example. It deploys a custom algorithm to read a digital map of an informal settlement and propose what it sees as the optimal strategy for reblocking it. (The algorithm is written to prioritize existing roadways and structures, echoing the traditional goal of minimizing displacement.) This process takes just minutes, at most.

"When I first showed it to our communities, they said, 'You're taking our paper cutouts away'!" Beukes says with a laugh. They weren't wrong—and they weren't actually protesting. ("At least the younger ones weren't; some older participants," she adds, "can be hesitant in their uptake of new technology.")

But what Open Reblock produces is not meant to be a strict directive or an end point—community members can still tweak the results based on their direct knowledge and concerns. Indeed, Open Reblock depends on such participation—"creating a shared reality where people can play and create this future reality," Bettencourt says. "It's basically a town-planning tool, at the level of a neighborhood." And by offering "a proof of principle and a starting point" for negotiations, he adds, it radically speeds up one of the toughest steps in the process.

Beukes says participants in the pilot programs have reacted with enthusiasm toward the new possibilities of this system. It means that a final plan will exist in a form that city officials can respond to more easily, and it ensures that all parties are considering the same geospatial data and planning scheme. "It's a template for discussion," Bettencourt adds, one that "puts everyone literally on the same map."

With a grant from Open Ideo, Bettencourt's team and SDI are working to improve the design of Open Reblock's interface, with feedback from community participants in Cape Town and Mumbai. The entire project is being created in open-source code (available on Github), both to encourage improvements from anyone who wants to be involved and to make it easier to scale up future versions for widespread use anywhere.

In this Open Reblock map of an informal neighborhood on the outskirts of Harare, Zimbabwe, the dotted lines illustrate how new street segments would connect the seven interior parcels outlined in orange with the existing street network in black. Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbo

The project is, of course, not a magic solution. Land readjustment can be contentious, and Silva points out that important issues around the value of any given settlement dweller's property must still be worked out on a more individual, human level. Bettencourt and Beukes agree that Open Reblock is a supplement to, not a substitute for, existing processes.

Still, Bettencourt points to UN-Habitat numbers to speculate that there may be a million neighborhoods around the world in need of reblocking. "That's a scary number," he says. And it adds to the sense among some observers that there's just something impossible about the effort—particularly when, on a case-by-case basis, the process gets bogged down over time.

But all this may be less intimidating from a technologist perspective. Think of the mapping and data-collection tools that have emerged in recent years as an early step that builds on the long-existing work of SDI and others. Open Reblock is just one more iteration of that trajectory. "I think we have all the ingredients, but we have to start doing," Bettencourt says. "If there's a system to capture the data and run proposals on top of it, that's a big step. It doesn't create the change, but it helps."

Rob Walker (robwalker.net) is a contributor to Design Observer and *The New York Times*.

The Chesapeake Conservancy transforms aerial photographs to one-meter-resolution land cover data that classify and quantify landscape features to aid conservation efforts: grass, fields, and other low-lying vegetation are light green; the tree canopy is dark green; bare earth is orange; roads are black; sidewalks, parking lots, and other impervious surfaces that are not roads are grey; structures are red; water is blue; and emerging wetlands are turquoise. Credit: The Chesapeake Conservancy

PRECISION

CONSERVATION

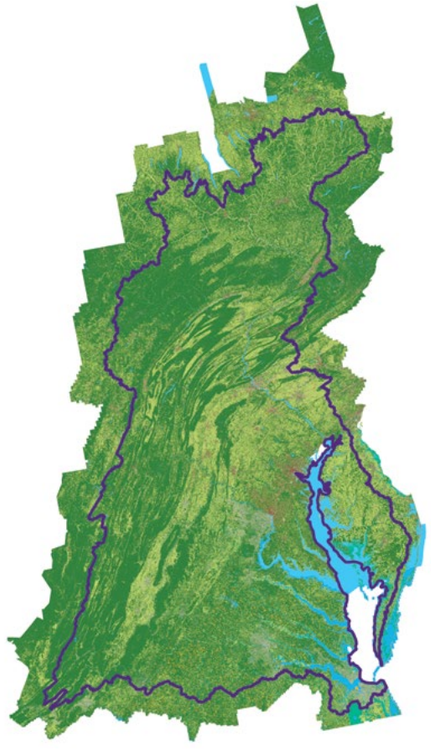
Pinpointing Pollution in the Chesapeake Bay with One-Meter-Resolution GIS

By Kathleen McCormick

THE CHESAPEAKE BAY IS A CULTURAL ICON, A NATIONAL TREASURE, AND A NATURAL RESOURCE protected by hundreds of agencies, nonprofit organizations, and institutions. Now with unprecedented accuracy, a new ultra-high-resolution digital mapping technology, developed by the Chesapeake Conservancy and supported by the Lincoln Institute of Land Policy, is pinpointing pollution and other threats to the ecosystem health of the bay and its watershed, which spans 64,000 square miles, 10,000 miles of shoreline, and 150 major rivers and streams. At one-meter-by-one-meter resolution, the "precision conservation" mapping technology is gaining the attention of a wide range of agencies and institutions that see potential applications for a variety of planning purposes, for use throughout the United States and the world. This new land cover dataset, created by the Conservancy's Conservation Innovation Center (CIC), has 900 times more information than previous datasets, and provides vastly greater detail about the watershed's natural systems and environmental threats—the most persistent and pressing of which is pollution of the bay's waters, which impacts everything from the health of people, plants, and wildlife to the fishing industry to tourism and recreation.

The three-dimensional land classification datasets have 900 times more information and close to a 90 percent accuracy level.

"The U.S. government is putting more than $70 million a year into cleaning up the Chesapeake but doesn't know which interventions are making a difference," says George W. McCarthy, president and CEO of the Lincoln Institute. "With this technology, we can determine whether interventions can interrupt a surface flow of nutrients that is causing algae blooms in the bay. We can see where the flows enter the Chesapeake. We'll see what we're getting for our money, and we can start to redirect the Environmental Protection Agency (EPA), the Department of Agriculture, and multiple agencies that might plan strategically but not talk to each other."



The Chesapeake Conservancy's ultra-high-resolution land cover dataset covers nearly 100,000 square miles and can pinpoint pollution and other threats to the ecosystem health of the Chesapeake Bay and transfer diffuse sources of pollution into identifiable point sources on the landscape. Credit: Chesapeake Conservancy/ UVM/ WorldView Solutions

"We're able to translate raw imagery to a classified landscape, and we're training the computer to look at what humans see at eye level—and even to identify individual plants."

The nonprofit Chesapeake Conservancy is putting finishing touches on a high-resolution map of the entire watershed for the Chesapeake Bay Program. Both organizations are located in Annapolis, Maryland, the epicenter of bay conservation efforts. The program serves the Chesapeake Bay Partnership, the EPA, the Chesapeake Bay Commission, and the six watershed states of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia—along with 90 other partners including nonprofit organizations, academic institutions, and government agencies such as the National Oceanic and Atmospheric Administration, the U.S. Fish and Wildlife Service, the U.S. Geologic Survey (USGS), and the U.S. Department of Defense.

On behalf of this partnership, EPA in 2016 invested $1.3 million in state and federal funding in the Conservancy's high-resolution land cover project, which is being developed with the University of Vermont. Information gleaned from several precision mapping pilot programs is already helping local governments and river partners make more efficient and cost-effective land-management decisions.

"There are a lot of actors in the Chesapeake Bay watershed," says Joel Dunn, president and CEO of the Chesapeake Conservancy. "We've been working on a very complicated conservation problem as a community over the last 40 years, and the result has been layers and layers and many institutions built to solve this problem."

"Now it's not a collective will problem but an action problem, and the whole community needs to be partnering in more innovative ways to take restoration of the watershed's natural resources to the next level," he adds.

"Conservation technology is evolving quickly and may be cresting now," Dunn says, "and we want to ride that wave." The project is an example of the Conservancy's efforts to take its work to new heights. By bringing "big data" into the world of environmental planning, he says, the Conservancy is poised to further innovate as "conservation entrepreneurs."

What Is Precision Mapping Technology?

Land use and land cover (LULC) data from images taken by satellites or airplanes is critical to environmental management. It is used for everything from ecological habitat mapping to tracking development trends. The industry standard is the USGS's 30-by-30-meter-resolution National Land Cover Database (NLCD), which provides images encompassing 900 square meters, or almost one-quarter acre. This scale works well for large swaths of land. It is not accurate, however, at a small-project scale, because everything at one-quarter acre or less is lumped together into one type of land classification. A parcel might be classified as a forest, for example, when that quarter-acre might contain a stream and wetlands as well. To maximize improvements to water quality and critical habitats, higher resolution imaging is needed to inform field-scale decisions about where to concentrate efforts.

Using publicly available aerial imagery from the National Agriculture Imagery Program (NAIP), combined with LIDAR (or Light Detection and Ranging) land elevation data, the Conservancy has created three-dimensional land classification datasets with 900 times more information and close to a 90 percent accuracy level, compared to a 78 percent accuracy level for the NLCD. This new tool provides a much more detailed picture of what's happening on the ground by showing points where pollution is entering streams and rivers, the height of slopes, and the effectiveness of best management practices (BMPs) such as bioswales, rain gardens, and forested buffers.

"We're able to translate raw imagery to a classified landscape, and we're training the computer to look at what humans see at eye level," and even to identify individual plants, says Jeff Allenby, director of conservation technology, who was hired in 2012 to leverage technology to study, conserve, and restore the watershed. In 2013, a $25,000 grant from the Information Technology Industry Council (ITIC) allowed Allenby to buy two powerful computers and begin working on the digital map. With support from the Chesapeake Bay Program, his geographic information system (GIS)-savvy team of eight has created a classification system for the Chesapeake watershed with 12 categories of land cover, including impervious surfaces, wetlands, low vegetation, and water. It is also incorporating zoning information about land uses from the Chesapeake Bay Program.

The Technology's Potential

Precision mapping "has the potential to transform the way we look at and analyze land and water systems in the United States," says James N. Levitt, manager of land conservation programs for the department of planning and urban form at

Development encroaches on agricultural landscapes throughout the Chesapeake Bay watershed leading to a degradation of both traditional ways of life as well as water quality. Credit: Emily Myron/ Chesapeake Conservancy

Unbuffered landscapes, such as this shoreline along the Chesapeake Bay, offer no protection from waves, leading to increased erosion, and can be a significant source of sediment and nutrient pollution. Credit: Jeff Allenby/ Chesapeake Conservancy

The Conservancy team is also working to overlay land cover data with parcel-level county data to provide more information on how land is being used. Combining high-resolution satellite imagery and county land-use parcel data is unprecedented.

the Lincoln Institute, which is supporting the Conservancy's development of the technology with $50,000. "It will help us maintain water quality and critical habitats, and locate the areas where restoration activities will have the greatest impact on improving water quality." Levitt says the technology enables transferring "nonpoint," or diffuse and undetermined, sources of pollution into specific identifiable "point" sources on the landscape. And it offers great potential for use in other watersheds, such as the Ohio and Mississippi river systems, which, like the Chesapeake watershed, also have large loads of polluted stormwater runoff from agriculture.

It's a propitious time to be ramping up conservation technology in the Chesapeake region. In February 2016, the U.S. Supreme Court decided not to consider a challenge to the Chesapeake Bay Partnership's plan to fully restore the bay and its tidal rivers as swimmable and fishable waterways by 2025. The high court's action let stand a ruling by the 3rd U.S. Circuit Court of Appeals that upheld the clean water plan and reinforced restrictions on the total maximum daily load, or the permissible limit of pollution from substances like nitrogen and phosphorus. These nutrients, found in agricultural fertilizers, are the two major pollutants of the bay, and are addressed under federal water quality standards established by the Clean Water Act. The ruling also allows EPA and state agencies to fine polluters for violating regulations.

The Chesapeake Bay's water quality has improved from its most polluted phase in the 1980s. Upgrades and more efficient operations at wastewater treatment plants have reduced nitrogen going into the bay by 57 percent and phosphorus by 75 percent. But the watershed states are still in violation of clean water regulations, and increasing urban development calls for constant assessment and pollution reduction in water and critical habitats.

Pilot Project No. 1: Chester River

Backed by funding from ITIC's Digital Energy and Sustainability Solutions Campaigns, the Conservancy completed a high-resolution land classification and stormwater runoff flow analysis for the entire Chester River watershed on Maryland's eastern shore. Isabel Hardesty is the river keeper for the 60-mile-long Chester River and works with the Chester River Association, based in Chestertown, Maryland. ("River keeper" is an official title for 250 individuals worldwide who serve as the "eyes, ears, and voice" for a body of water.) The Conservancy's analysis helped Hardesty and her staff understand where water flows across the land, where BMPs would be most effective, and which degraded streams would be best to restore.

Two-thirds of the Chester River watershed's land cover is row crops. Row-crop farmers often apply fertilizer uniformly to a field, and the fertilizer runs off with stormwater from all over the site. This is considered nonpoint pollution, which makes it harder to pinpoint the exact source of contaminants flowing into a river—compared to, say, a pile of manure. The Conservancy's team mapped the entire Chester watershed, noting where rain fell on the landscape and then where it flowed.

"With the naked eye, you can look at a field and see where the water is flowing, but their analysis is much more scientific," says Hardesty. The map showed flow paths across the whole watershed, in red, yellow, and green. Red indicates higher potential for carrying pollutants, such as flow paths over impervious surfaces. Green means water is filtered, such as when it flows through a wetlands or a forested buffer, making it less likely to carry pollution. Yellow is intermediary, meaning it could go either way. The analysis has to be "ground-truthed," says Hardesty, meaning the team uses the GIS analysis and drills down to an individual farm level to confirm what's happening on a specific field.

"We are a small organization and have relationships with most of the farmers in the area," says Hardesty. "We can look at a parcel of land, and we know the practices that farmers use. We've reached out to our landowners and worked with them on their sites and know where pollution may be entering streams. When we know a particular farmer wants to put a wetland on his farm, this land use and water flow analysis helps us determine what kind of BMP we should use and where it should be located." The value of precision mapping for the Chester River Association, says Hardesty, has been "realizing that the best place to put a water intercept solution is where it's best for the farmer. This is usually a fairly unproductive part of the farm." She says farmers generally are happy to work with them to solve the problem.

The Chester River Association is also deploying the technology to use resources more strategically. The organization has a water monitoring program with years of watershed data, which the Conservancy team analyzed to rank streams according to water quality. The association now has GIS analysis that shows the flow paths for all stream subwatersheds, and is creating a strategic plan to guide future efforts for streams with the worst water quality.

The limitations of 30-meter data (A) for identifying small scale features, such as riparian buffers or low intensity development, on the landscape is evident when compared to the Conservancy's new one-meter land cover data (B). Credit: Chesapeake Conservancy

Pilot Project No. 2: York County Stormwater Consortium BMP Reporting Tool

In 2013, the Conservancy and other core partners launched Envision the Susquehanna to improve the ecological and cultural integrity of the landscape and the quality of life along the Susquehanna River, from its headwaters in Cooperstown, New York, to where it merges with the Chesapeake Bay in Havre de Grace, Maryland. In 2015, the Conservancy selected the program to pilot its data project in York County, Pennsylvania.

Pennsylvania has struggled to demonstrate progress in reducing nitrogen and sediment runoff, especially in places where urban stormwater enters rivers and streams. In 2015, EPA announced that it would withhold $2.9 million in federal funding until the state could articulate a plan to meet its targets. In response, the Pennsylvania Department of Environmental Protection released the Chesapeake Bay Restoration Strategy to increase funding for local stormwater projects, verify the impacts and benefits of local BMPs, and improve accounting and data collection to monitor their effectiveness.

York County created the York County-Chesapeake Bay Pollution Reduction Program to coordinate reporting on clean-up projects. The Conservancy's precision mapping technology offered a perfect pilot opportunity: In spring 2015, the York County Planning Commission and the Conservancy began working together to improve the process for selecting BMP projects for urban stormwater runoff, which, combined with increased development, is the fastest growing threat to the Chesapeake Bay.

The planning commission targeted the annual BMP proposal process for the 49 of 72 municipalities that are regulated as "municipal separate storm sewer systems," or MS4s. These are stormwater systems required by the federal Clean Water Act that collect polluted runoff that would otherwise make its way into local waterways. The commission's goal was to standardize the project submittal and review processes. The county had found that calculated load reductions often were inconsistent among municipalities because many lacked the staff to collect and analyze the data or used a variety of different data sources. This made it difficult for the commission to identify, compare, and develop priorities for the most effective and cost-efficient projects to achieve water-quality goals.

HOW TO USE THE YORK COUNTY STORMWATER CONSORTIUM BMP REPORTING TOOL

To use the online tool, users select a proposed project area, and the tool automatically generates a high-resolution land cover analysis for all of the land area draining through the project footprint. High-resolution data is integrated into the tool, allowing users to assess how their project would interact with the landscape. Users also can compare potential projects quickly and easily, and then review and submit proposals for projects with the best potential to improve water quality. Users then input their project information into a nutrient/sediment load reduction model called the Bay Facility Assessment Scenario Tool, or BayFAST. Users enter additional project information, and the tool fills in the geographic data. The result is a simple, one-page pdf report that outlines the estimated project costs per pound of nitrogen, phosphorus, and sediment reduction. See the tool at: http://chesapeakeconservancy.org/apps/yorkdrainage/.

Runoff from landscapes throughout the Susquehanna River watershed is leading to water-quality issues such as sediment and nutrient pollution. New tools developed by the Chesapeake Conservancy aim to maximize the benefits of restoration projects while minimizing cost and impacts to land owners. Credit: Emily Myron/Chesapeake Conservancy

The Conservancy and planning commission collaborated to develop the user-friendly, web-based York County Stormwater Consortium BMP Reporting Tool (box, p. 14), which allows different land use changes and restoration approaches to be compared and analyzed before being put into place. The Conservancy, commission, and municipal staff members collaborated on a uniform template for the proposals and data collection, and they streamlined the process with the same data sets. The Conservancy then trained a few of the local GIS professionals to provide technical assistance to other municipalities.

"It's easy and quick to use," explains Gary Milbrand, CFM, York Township's GIS engineer and chief information officer, who is a project technical assistant for other municipalities. In the past, he says, municipalities typically spent between $500 and $1,000 on consultants to analyze their data and create proposals and reports. The reporting tool, he says, "saves us time and money."

The commission required all regulated municipalities to submit BMP proposals using the new technology by July 1, 2016, and proposals will be selected for funding by late fall. Partners say the municipalities are more involved in the process of describing how their projects are working in the environment, and they hope to see more competitive projects in the future.

"For the first time, we can compare projects 'apples to apples,'" says Carly Dean, Envision the Susquehanna project manager. "Just being able to visualize the data helps municipal staffs analyze how their projects interact with the landscape, and why their work is so important." Dean adds, "We're only just beginning to scratch the surface. It will take a while before we grasp all of the potential applications."

Integrating Land Cover and Land Use Parcel Data

The Conservancy team is also working to overlay land cover data with parcel-level county data to provide more information on how land is being used. Combining high-resolution satellite imagery and county land use parcel data is unprecedented. Counties throughout the United States collect and maintain parcel-level databases with information such as tax records and property ownership. About 3,000 out of 3,200 counties have digitized these public records. But even in many of these counties, records haven't been organized and standardized for public use, says McCarthy.

EPA and a USGS team in Annapolis have been combining the one-meter-resolution land cover data with land use data for the six Chesapeake

Riparian buffers, or trees planted along waterways, can help reduce erosion of shorelines, prevent sediment from the land getting into the water, and reduce the amount of nutrients in runoff. Credit: Jeff Allenby/ Chesapeake Conservancy

states to provide a broad watershed-wide view that at the same time shows highly detailed information about developed and rural land. This fall, the team will incorporate every city and county's land use and land cover data and determine adjustments to make sure the high-resolution map data matches local-scale data.

The updated land use and cover data then will be loaded into the Chesapeake Bay Watershed Model, a computer model now in its third of four beta versions of production and review. State and municipal partners, conservation districts, and other watershed partners have reviewed each version and suggested changes based on their experience in stormwater mitigation, water treatment upgrades, and other BMPs. Data will detail, for example, mixed-use development; different agricultural land uses for crops, hay, and pasture; and measures such as how much land produces fruit or vegetable crops. That's where the conversion from land cover to land use comes in to help specify the pollution load rates.

"We want a very transparent process," says EPA's Rich Batiuk, associate director for science, analysis, and implementation for the Chesapeake Bay Program, noting that the combined land cover and land use data will be available online, at no cost. "We want thousands of eyes on land use and cover data. We want to help state and local partners with data on how we're dealing with forests, flood plains, streams, and rivers. And we want an improved product that becomes the model for simulations of pollution control policies across the watershed."

Scaling Up and Other Applications

As the technology is refined and used more widely by watershed partners, the Conservancy hopes to provide other data sets, scale up the work to other applications, and conduct annual or biannual updates so the maps reflect current conditions. "This data is important as a baseline, and we'll be looking at the best way to be able to assess change over time," says Allenby.

Watershed partners are discussing additional applications for one-meter-resolution data, from updating Emergency-911 maps, to protecting endangered species, to developing easements and purchasing land for conservation organizations. Beyond the Chesapeake, precision mapping could help conduct continental-scale projects. It offers the conservation parallel to precision agriculture, which helps determine, for example, where a bit of fertilizer in a specific place would do the most good for plants; the two combined could increase food production and reduce agriculture's environmental impact. The technology could also help with more sustainable development practices, sea level rise, and resiliency.

Many people said it wasn't feasible for a small nonprofit to do this kind of analysis, says Allenby, but his team was able to do it for a tenth of the cost of estimates. The bigger picture includes making land use and cover data available to the public for free. But that's an expensive proposition at this point: The data needs backup, security, and a huge amount of storage space. Working with Esri, a Redlands, California-based company that sells GIS mapping tools, as well as Microsoft Research and Hexagon Geospatial, the Conservancy team is transferring the data. The process now runs linearly one square meter at a time. On a cloud-based system, it will run one square kilometer at a time and distribute to 1,000 different servers at once. Allenby says this could allow parcel-level mapping of the entire 8.8 million square kilometers of land in the United States in one month. Without this technology, 100 people would have to work for more than a year, at much greater cost, to produce the same dataset.

Precision mapping could bring greater depth to State of the Nation's Land, an annual online journal of databases on land use and ownership that the Lincoln Institute is producing with PolicyMap. McCarthy suggests the technology might answer questions such as: Who owns America? How are we using land? How does ownership affect how land is used? How is it changing over time? What are the impacts of roads environmentally, economically, and socially? What changes after you build a road? How much prime agricultural land has been buried under suburban development? When does that begin to matter? How much land are we despoiling? What is happening to our water supply?

"Can it solve big social problems?" queries McCarthy. One of biggest outcomes of precision mapping technology would be to develop better ways to inform land use practices, he says, especially at the interface between people and land, and water and land. Land records are needed to use this technology most effectively, which might be challenging in some places because these records don't exist or are inconsistent. But it's a methology and technology that can be used in other countries, he says. "It's a game changer, allowing us to overlay land use data with land cover data, which could be hugely valuable to rapidly urbanizing places like China and Africa, where patterns and changes will be seen over the land and over time. It's hard to exaggerate the impact."

"It's a game changer, allowing us to overlay land use data with land cover data, which could be hugely valuable to rapidly urbanizing places like China and Africa, where patterns and changes will be seen over the land and over time. It's hard to exaggerate the impact."

"Our goal is the world, to use this technology for transparency and accountability," says McCarthy. "The more information planners have access to, the better stewards we can be for the planet." The tool should be shared with "people who want to use it for the right purposes, so we're making the value proposition that this is a public good that we all need to maintain," he says, similar to the way USGS developed GIS.

"We need the right public-private arrangement, something like a regulated public utility with public oversight and support that will maintain it as a public good."

Kathleen McCormick, principal of Fountainhead Communications, LLC, lives and works in Boulder, Colorado, and writes frequently about sustainable, healthy, and resilient communities.

BOUNDARY ISSUES

The 2016 Atlas of Urban Expansion Indicates Global De-Densification

Cities around the world seem to be stretching out physically and consuming land at a rate that exceeds population growth. As populations double, land use triples.

By John Wihbey

WHEN CITY GROWTH COMES UP IN PUBLIC DISCOURSE, THE CONVERSATION ALMOST INVARIABLY FOCUSES ON POPULATION. We speak of "booming" cities that have grown from, say, 2 to 5 million in just a few decades or declining cities that are hollowing out and losing residents at a rapid rate.

The common unit of understanding and measurement, in other words, is almost always the number of people. Measures of land use are often missing from the picture, despite the fact that cities grew much more in land use than in population between 1990 and 2015, according to data from the UN-Habitat Global Urban Observatory. In developed countries, urban population grew 12 percent, while urban land use increased by 80 percent. And in developing countries, population expanded by 100 percent while urban land use rose 350 percent.

Land use issues will become more critical as the world population exceeds 9 billion and 2.5 billion persons migrate to cities by 2050, according to the United Nations' projections. Configuring urban areas and their available resources to support this massive inflow will be critical to sustaining human life on the planet, says George W. "Mac" McCarthy, president and CEO of the Lincoln Institute.

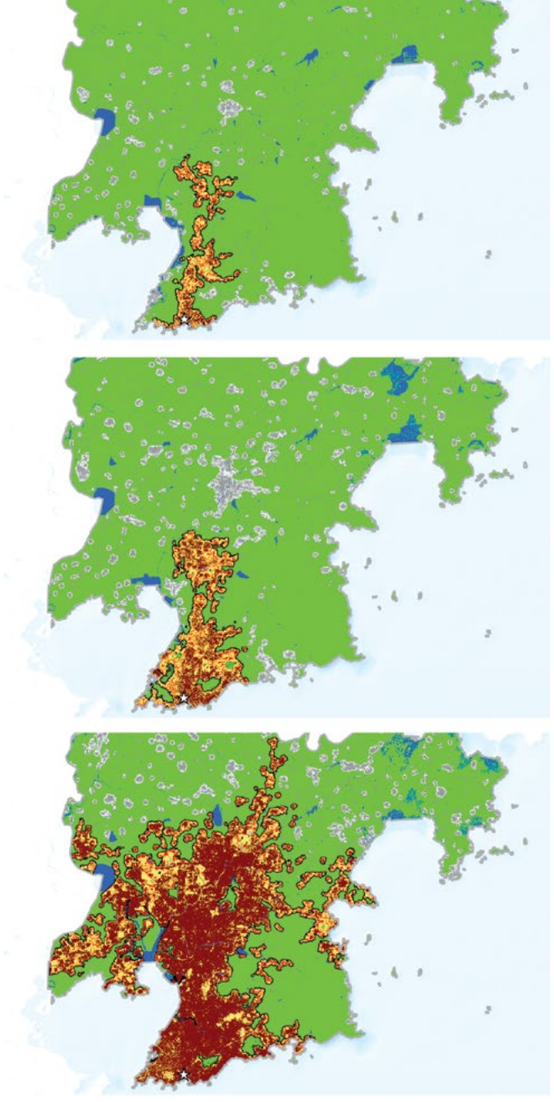
Between 1991 and 2014, Kozhikode, India, had among the fastest rates of population growth and outward urban expansion in the Atlas's global sample of cities: population grew at an average annual rate of 7.6 percent per year, rising from 203,000 to 1.17 million, and the built-up area associated with Kozhikode's urban extent grew even faster, at 17.2 percent per year. An in-depth analysis of Kozhikode's expansion areas revealed almost entirely unplanned extension by accretion. (The maps on p. 18 show the city in 1991, 2001, and 2014. The brown sections are built-up urban areas, red are built-up suburban areas, black are built-up rural areas, light green are urbanized open space, and green are rural open space. Credit: New York University Urban Expansion Program

It's a profound area of concern: How exactly are these rising urban populations changing global maps? Further, can we observe regular, even predictable, patterns? And are these trend lines, such as they are, sustainable over time?

To date, there has been little scientific understanding of broad global patterns related to how city borders, systems, and land-use patterns are changing. But the newly revised, second edition of the online Atlas of Urban Expansion, first published in 2012, aims to fill this crucial gap in knowledge. Produced through a partnership among UN-Habitat, the New York University Urban Expansion Program, and the Lincoln Institute, the new Atlas performs very precise analysis of satellite imagery, coupled with population figures and other data, to study the changing nature of cities observed from 1990 to the present. The full report and data are set to be unveiled this October at the Habitat III global cities summit in Quito, Ecuador, as part of the implementation of the UN's New Urban Agenda.

The new Atlas analyzes 200 cities (up from 120 in the 2012 sample), rigorously selected from among the 4,231 cities in the world with populations greater than 100,000 (as of 2010) that constitute a representative sample of large urban areas. The 200 cities in question make up about 70 percent of the world's urban population.

The United Nations statistics division has now accepted and adopted this "UN Sample of Cities" as a way to conduct ongoing analysis of urbanization trends. "Cities, how they form, and the effects of urbanization on the quality of human life must now be treated as a science," says Joan Clos, executive director of UN-Habitat, during the launch at UN headquarters in New



Like Kozhikode, Qingdao, China, also had among the fastest rates of population growth and outward urban expansion in the global sample of cities: population grew at an average annual rate of 7.2 percent per year between 1990 and 2013, rising from 853,000 to 4.5 million, and the built-up area associated Qingdao's urban extents grew even faster, at 11.6 percent per year. Unlike Kozhikode, Qingdao's expansion areas revealed mostly planned, orderly extensions. The maps on this page show the city in 1990, 2000, and 2013. The brown sections are built-up urban areas, red are built-up suburban areas, black are built-up rural areas, light green are urbanized open space, and green are rural open space. Credit: New York University Urban Expansion Program

York in June 2016: "The unprecedented confluence of climate change, population boom, and the rush to live in cities means that our critical human development will take place in cities."

With unplanned settlement fluidly redefining many urban boundaries, it is crucial, experts and planners say, to produce a consistent method for studying cities as contiguous spatial units, not just administrative jurisdictions. The UN Sample of Cities also enables transition from an urban agenda based on country-level data to one predicated on city-based data collection and analysis.

Studying such a sample allows us to infer some generalizable rules about large urban areas, notes Atlas coauthor Shlomo "Solly" Angel, a professor and senior research scholar at New York University. "The sample accurately represents that universe," he says of cities with populations of 100,000 persons or more, "so you can actually make statements about that universe given information about the sample. That's the more scientific contribution of this Atlas."

Land Consumption and "De-densification"

What, then, can be said of the world's large cities, now that such representative data have finally been collected and crunched?

One reliably observed pattern is that cities around the world seem to be stretching out physically and consuming land at a rate that exceeds population growth. This tendency corroborates the findings of the first-edition Atlas, which indicates "falling density." In the past, this was termed "sprawl," and some refer to it now as "de-densification." In any case, for a planet increasingly concerned with sustainability, energy efficiency, climate change, and resource scarcity, this is not a good trend: Density generally allows for greener and more sustainable living patterns.

Angel notes that there is a kind of rough statistical rule that emerges from the new Atlas work: As populations double, land use triples. "Even though people would like to see densification increase or at least stay the same, it doesn't," he adds.

Many policy makers have been unable, or unwilling, to see this reality unfolding in recent decades. Don Chen, director of Equitable Development at The Ford Foundation, says that the issue of sustainable growth is "very uneven in terms of planning officials' awareness." In many countries, he adds, "various orthodoxies are battling it out," and frequently the "cards are stacked against us" in terms of changing norms and official attitudes: "For many, many decades, and in some countries for centuries, there have been incentives [for] building on virgin land."

And even where there is political will for change, there are "multiple dimensions of capability to build upward, such as in-ground infrastructure," Chen notes. Wider complex systems must be coordinated from a policy perspective in order to achieve greater density and land conservation.

In any case, the data analysis effort undertaken in the Atlas—which at root is intended to help define a new "science of cities"—may serve as a wake-up call. Angel says the Atlas can be a "tool for convincing policy makers that the expansion they must prepare for is considerably larger than their own little back-of-the-envelope calculations, or what their planners have in their master plans."

Increasing density again will necessitate sacrifice and modification of existing norms for living standards in many places: It will require people to live in smaller apartments and homes, in multifamily housing, and in higher buildings. It also will frequently require redevelopment of low-density areas in cities.

McCarthy acknowledges that the data are "a little bit chilling," as they reveal a pervasive pattern that signals huge trouble ahead. "It's something that we have to stop—whether we call it 'sprawl' or 'de-densification' or something else," he says. "We can't continue to consume all of our best land with urban development. We still have to feed ourselves. We still need to collect water."

He also notes many ill-fated attempts to build large housing units far outside denser urban areas, leaving millions of units across the world largely empty. This has happened in many countries, from Mexico and Brazil to South Africa and China. "Why is it that we continue to build these developments in the middle of nowhere and expect people to live there?" McCarthy says, noting that it is vital to link jobs and industrial activity with housing.

Clearly, smarter, more proactive planning is required for growth across the world, the project's researchers say. That means finding the right ways to channel city growth spatially and to create the infrastructure—transportation, water, sewer, and other necessities—so the new settlements and housing units are serviced appropriately.

With unplanned settlement fluidly redefining many urban boundaries, it is crucial to produce a consistent method for studying cities as contiguous spatial units, as opposed to just administrative jurisdictions.

Moreover, it is also necessary, Atlas researchers say, for many of the big cities around the world—from Lagos, Nigeria, to Mexico City to Zhengzhou, China—to adopt more next-generation thinking about so-called "polycentric" cities. That will require moving beyond the traditional paradigm of hulking, monocentric cities with a huge urban core and instead creating polycentric networked hubs, whereby a metropolitan area will have many interlinked urban centers.

Signatures of Unplanned Settlement

The satellite imagery analyzed in the Atlas also highlights other key patterns that are both drivers and/or symbols of the overall de-densification trend worldwide.

One very granular mark is the lack of four-way intersections, a clear sign that roads are being laid out haphazardly, in a largely unplanned way. Such informality and unplanned development have been increasing over time across the world. The pattern, however, is strongly correlated with lower GDP per capita, and therefore is more pronounced in the developing world and global South. Linked to this observed pattern is an increase in urban block size, as shantytowns and unplanned settlements of many kinds grow without regard to transportation needs.

Indeed, the Atlas also suggests a pervasive lack of orderly connections to arterial roads, which are key to facilitating transportation to employment and economic networks. Built-up areas within walking distance of wide arterial roads are less frequent than they were in the 1990s, according to data from that decade. And more generally, there is simply not enough land being allocated for roads.

In addition, low-density tracts and small dwellings are unnecessarily consuming precious urban open space—parks and green spaces that can make dense urban areas more livable.

Angel says planners need to get ahead of the coming wave of urban migration and secure land for transportation, affordable housing, arterial roads, and open space. That needs to be done before settlement happens, when land prices subsequently soar and the logistics of moving populations become trickier. "This can be done at a relatively small cost," Angel notes. He suggests that planners begin to "make some minimal preparations for it."

Even in countries where there is a high degree of central planning, the data contained in the Atlas may prove helpful for diverse land management challenges.

"Compared to most cities in the developing world, Chinese cities are better managed," says Zhi Liu, director of the Lincoln Institute's China program. "The Atlas is still useful for China, as it provides accurate, visual urban expansion data and analytics to planners that could strengthen their understanding of the scale and patterns of urban expansion in their cities."

The Atlas Data Challenge

Behind the new analytical insights produced by the Atlas, an intriguing and important backstory of data collection and analysis highlights future challenges for urban theory and monitoring of global cities, especially in developing nations.

Alejandro "Alex" Blei, a research scholar in the urban expansion program of New York University's Marron Institute for Urban Management, said that assembling the 200 cities for the representative sample was no easy task, as there is no universally accepted definition for a metropolitan area. Researchers had to account for variables such as regional location, growth rate, and population size in order to ensure the sample was representative, and they had to create a careful and defensible methodology.

An ancient spice trading center on the coast of the Arabian Sea in Kerala, Kozhikode (also known as Calicut) is one of the most rapidly growing cities in the sample but has negligible urban planning. Credit: Tuul and Bruno Morandi / Alamy

Another booming coastal town, on the Yellow Sea in Shandong Province, Qingdao is known for Tsingtao beer, the world's longest sea bridge, and planned, orderly, albeit rapid development. Credit: Gang Liu / Alamy

NASA's Landsat database, a satellite imagery program running since the 1970s, was the basis for the spatial analysis. While that methodical, scientific dataset is of exceedingly high quality, the underlying population data, which was key for establishing migration- and settlement-related patterns, was frequently less than perfect.

"Some countries have very well-established data programs," Blei said. But in other cases the data are very "coarse," and large cities, particularly in the developing world, have only broad census zones. It is therefore difficult, at times, to make fine-grained insights about population changes in connection with land use shifts, as the researchers had to assume equal density over large tracts of the metropolitan area in question.

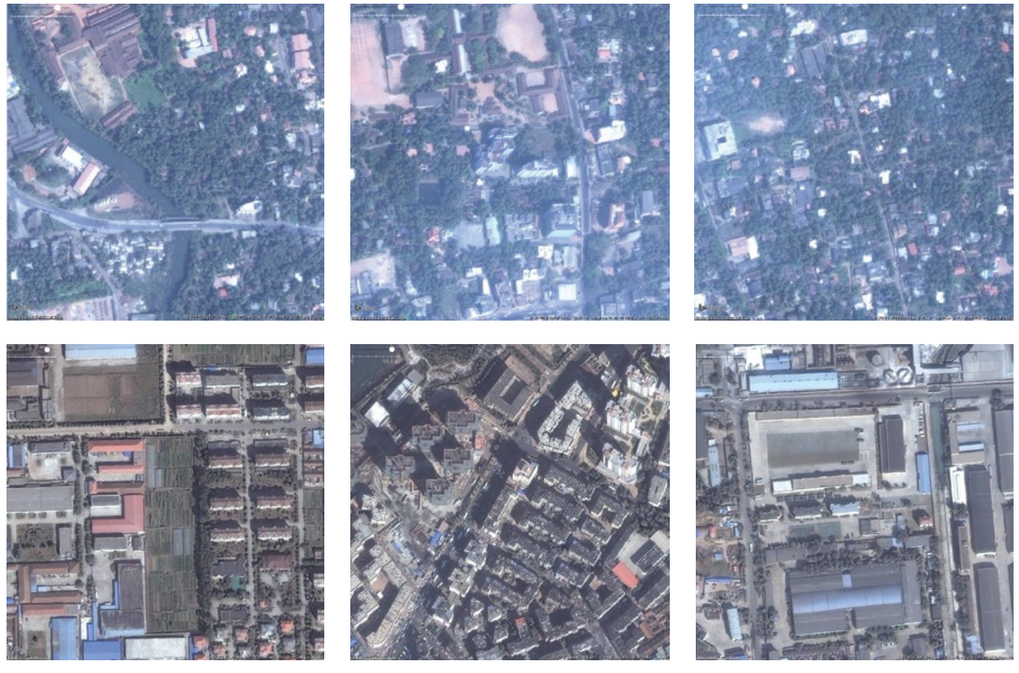
Scanning the NASA pictures, the researchers had to analyze pixels to assess whether there was impervious coverage surface or soils. They performed this task with powerful software according to well-established methods, but correlating it with population data was not always smooth. "Unfortunately, there's not very much we can do if the data are not very good, but we did the best we could under the circumstances," Blei says.

Evidence suggests the need for less variation in population data collection and synthesis across countries, in order to derive more actionable insights for policy makers in every country. And more global consensus is needed around the definition of cities. The U.S. Census Bureau defines them very precisely as "urbanized areas," or "metropolitan statistical areas," but they are frequently defined in more scattered ways by other countries' data collection agencies. Asia and Africa—home of many of the fastest-growing cities, both in terms of population and geographic extent—suffer from a lack of granular city population data that speak to neighborhood-level change.

Global Nuances and Uncertain Futures

The publication of the new Atlas will, of course, join a long debate in policy and academic circles about how to measure sprawl, both high- and low-density, and the best models for addressing related issues. The new Atlas also speaks to a long research literature on the consumption of resources and quality of life in urban contexts.

Enrique R. Silva, a senior research associate at the Lincoln Institute who has specialized in Latin American planning and governance issues, notes that the Atlas research will continue to help advance understanding of government planning and rule-making, as well as residential pricing. The 2016 Atlas project includes surveys conducted with various stakeholders in cities that might yield insights on planning policies and markets, among other issues.



This image shows clear qualitative differences in the layouts of streets and blocks in the expansion areas of Kozhikode (top), which were mostly unplanned, and Qingdao (bottom), which were mostly planned. From 1990 to 2014, 28 percent of Qingdao's built-up area was in roads and streets compared to 8 percent in Kozhikode; four-way intersection and average block size were 51 square kilometers and 4.7 hectares respectively in Qingdao compared to 10 square kilometers and 7.5 hectares in Kozhikode; and the amount of residential development in formal land subdivisions or housing projects accounted for 76 percent of Qingdao's expansion area compared to 1 percent in Kozhikode. Credit: Bing

"It's definitely an effort that is needed," Silva says. "It's a first-mover type of project. The measure of success will be the extent to which other researchers, whether through critique or support of the initial idea, can improve upon it and contribute to our understanding of how cities are growing, or even contracting."

It will also help ground-level understanding for those studying or making policy in particular cities. Silva points to a place like Buenos Aires, which he calls a "classic case" where the expansion of territory is occurring faster than the population growth—and where many people are being displaced outward from the denser city core. Silva says that research by his Lincoln Institute colleague Cynthia Goytia has shown how lax land use regulation affects settlement patterns. Land markets and their regulations affect affordability, and this can result in unplanned settlements, her research suggests.

Neema Kudva, an associate professor at Cornell University who is an expert in growth patterns in India and South Asia, also praises the "very careful work" performed in the Atlas effort. But she worries that smaller cities—those under 100,000 and therefore excluded from the analysis—may see different dynamics that are subject to more variable patterns and experiences.

In trying to create "one science of cities," she says, we may miss significant differences between small and big metropolitan areas, limiting our ability to imagine creative interventions. "The difference between small and big can be the ability to influence political processes, the ability to garner funds, to organize, to intervene," Kudva says. "For a person like me who is interested in smaller places, things like the Atlas provide important suggestions, important points of reference, important counterpoints, but they are not always useful."

Kudva also wonders if large-scale, emerging changes related to energy systems, global warming, sea-level rise, and political upheaval may alter worldwide land use patterns, compared to those observed in the past. The issue of falling density is potentially reversible, she believes. "That trend could change," she says. "We need to play a more interventionist role."

Still, better data and a more detailed picture of settlement patterns can substantially help address challenges common to cities of many different sizes. Chen, of the Ford Foundation, notes that research like the Atlas is necessary to combat issues such as unequal access to opportunity. "We need baseline data, and we need to understand the relationship between how we use land and other things."

The issue of global inequality, which McCarthy calls the biggest "unassailable challenge" of cities, looms in all of the data. Beyond the layers of the Atlas's global maps are stubborn facts and dilemmas that researchers and policy makers are only beginning to understand and address. "The biggest one is the absolute concentration of poverty and geographic isolation of large segments of the population," McCarthy says, noting that sometimes 30 to 50 percent of residents in many large cities live in "deplorable conditions."

Decent affordable housing that is meaningfully integrated into the economic network and flow of cities has to be a priority. Yet many national efforts to date have failed to achieve that goal. "That's the thing that I find most vexing," McCarthy says.

As the new Atlas is rolled out in October at the UN-Habitat III conference in Quito, that issue—and many others affecting the world's fast-growing cities—is sure to be framed even more precisely and powerfully by the new, comprehensive data.

John Wihbey is an assistant professor of journalism and new media at Northeastern University. His writing and research focus on issues of technology, climate change, and sustainability.

Here we see the digitization of road features in a single locale in Kozhikode (top) and Qingdao (bottom). In many unplanned, rapidly growing cities such as Kozhikode, poor road network connectivity and the low share of land in streets compromises mobility and poses serious economic challenges for residents. Obtaining city-level estimates for urban layout metrics required analyzing dozens of quasi-randomly located 10-hectare study areas, or locales, distributed throughout a city's entire expansion area. Credit: Google

WPA 2.0

Beauty, Economics, Politics, and the Creation of New Public Infrastructure

A rendered view of DLANDstudio's proposal for BQGreen. With this proposal, the Brooklyn-Queens Expressway (BQE) is reconceived as an environmentally and socially productive spine comprising new recreational spaces, ecological strategies, and infrastructural improvements that radically enhance the performance of the urban trench. The design for BQGreen ameliorates many of the compounding environmental, economic, and social byproducts of the highway artery, including noise pollution, increased asthma rates among children, and an absence of greenery. Drawing courtesy of DLANDstudio Architecture + Landscape Architecture, PLLC.

By Susannah Drake

DURING THE PAST 400 YEARS, the land known as the United States of America has been transformed by massive public and private works projects and technological innovations intended to facilitate commerce, improve public health, and foster economic development. While these projects generated tremendous wealth for the nation, the gains were often to the detriment of the environment. The global realities of climate change—in combination with growing urbanization and associated poverty—have raised awareness of the ecological impact of such infrastructure. Americans are now at a unique moment in history when politics, economics, ecology, and culture (design) can all be part of a new movement. We need a WPA 2.0.

The WPA is the Works Progress Administration (1935–1943)—the largest and most ambitious program of U.S. President Franklin D. Roosevelt's New Deal during the Great Depression. Much of the present-day infrastructure in the United States was built by either the WPA or the similarly named PWA (Public Works Administration). Almost every city, town, and community in America benefited from a new WPA- or PWA-built airport, bridge, dam, park, road, school, or other public building.[1]

Let me now reflect, albeit briefly, on the history of public works projects in the United States to discern where the world's richest nation is, today, in terms of its urban infrastructure. This will allow a glimpse into how landscape architects, architects, and planners are addressing the needs and opportunities that face not only American cities, but communities and cities throughout the world as they confront the pressing realities of global climate change.

This feature is adapted from Nature and Cities: The Ecological Imperative in Urban Design and Planning, *edited by Frederick R. Steiner, George F. Thompson, and Armando Carbonell (Lincoln Institute of Land Policy, November 2016).*

CANALS AND HARBORS

Early settlement in the United States showed patterns of towns and cities directly related to water resources. Navigable waterways, safe harbors, and access to fresh water for fire prevention, sanitation, power production, farming, and drinking were central to the development of major commercial centers. Construction of the Erie Canal (1817–1825), for example, made New York the financial capital of the world during the nineteenth century by opening up critical supply lines for timber, furs, minerals, and agricultural products that helped the North win the American Civil War (1861–1865). Since then, we have seen the gradual decoupling of urban transportation systems from the physical environment in the United States.

THE GRID

Looking back to nineteenth-century America, ideals of Manifest Destiny and the agrarian myth fueled a need to organize and cultivate the nation's western frontiers. The Land Ordinance Act of 1785 was a resolution written by Thomas Jefferson (1743–1826), then a delegate from Virginia, to create a federal system for the survey and sale of federally owned land west of the Appalachian Mountains, intended to fund the federal government at a time when the government could not raise fiscal resources through taxation.[2] It was then that an uncoupling of environmental and development systems started to take place on a large scale: The public land survey system parceled land into gridded territories, townships, and sections without regard to the geomorphology or carrying capacity of the property. Territories (24 x 24 miles; 38.624 x 38.624 kilometers), townships (6 x 6 miles; 9.656 x 9.656 kilometers), and sections (1 x 1 mile; 1.609 x 1.069 kilometers) were numbered and organized boustrophedonically, an alternating pattern from the top right to the bottom left quadrant of a square, similar to the path a farmer might follow when plowing a field.[3]

AGRICULTURE, RAILROADS, AND THE GRID

When Horace Greeley (1811–1872), the famous editor of *The New York Herald Tribune*, purportedly declared in an editorial (13 July, 1865), "Go West, young man, go West and grow up with the country," he rallied the nation.[4] Greeley was responding, in part, to the Homestead Act of 1862, which enabled veterans, freed slaves, and even women to file a claim to a half-section of land (640 acres; 260 hectares) if they agreed to live on it and improve it for five years, further promoting agrarian values that were part of an American nationalism, which developed during a time of rapid industrialization. Manifest Destiny and agrarian culture, as characterized decades earlier by de Crèvecoeur (1735–1813) in numerous books, mythologized farming, espousing rural life as the foundation of character.[5] However, the gridding of America and subsequent development of national rail lines—enabled by government grants of more than 300 million acres (121,405,693 hectares) to rail companies—were not reliant on natural systems for their development; instead, both worked in opposition to the waterways and topography they encountered, some of them extreme.

This illustrated map of infrastructure projects implemented by the Public Works Administration from 1935 reveals the scope and ambition of the New Deal to reach every corner of the United States "for the public good." Map by C. H. W. The David Rumsey Map Collection www.davidrumsey.com

Supremacy over the landscape had its limits. While rail lines could be drawn to previously inaccessible corners of the country, facilitating commerce, they required long, gradual grade change and abundant clean water to function, limiting universal access. Farms and towns located themselves on and near new rail lines, but land in more arid climates west of the 100th meridian did not have the carrying capacity characteristic of Thomas Jefferson's Virginia.[6] Parcels of half-sections needed to be combined and annexed to enable productive use for timber or cattle grazing, uses that have their own heavy impacts on indigenous landscapes. The scale of operations moved toward a more standardized practice, away from the ideals of the rural farm. Western settlers and transcendentalists alike thought nothing of the consequences of introducing nonnative plant communities to the detriment of the indigenous environment.

A hallmark of the Industrial Revolution in the United States was the first transcontinental linking of rail lines—the Union and Central Pacific Railroads at Promontory Summit in Utah Territory near present-day Brigham City—on 10 May, 1869. Infrastructure tied to natural systems for the first two and a half centuries of the nation's development could now follow a much more flexible path. By 1910, there was a network of more than 250,000 miles (402,336 kilometers) of rail covering the United States. Coeval with this infrastructural growth, the nation's waterways transitioned from being critical economic lifelines to convenient disposal sites. As Carolyn Merchant has observed, "In the United States, industrial chemicals and wastes, including sulfuric acid, soda ash, muriatic acid, limes, dyes, wood pulp, and animal byproducts from industrial mills contaminated waters in the Northeast."[7] Ongoing pollution of rivers, canals, and ports still leaves neighboring communities managing the consequences of years of environmental abuses, despite the benefits of the 1972 Clean Water Act.

As natural systems became less important for access, they remained critical for raw materials. The relationship between water rights and rail lines, for instance, was critical not only because clean water was necessary to power steam engines, but also because the relationship between agriculture and rail transport systems opened up new areas of the country for the development and trade of commodities such as corn and wheat, legacy crops to this day.

COMBINED SEWERS

When English plumber Thomas Crapper (1836–1910) popularized the use of the flush toilet during the 1860s, he surely had no idea of the potential future impact upon municipal water-management systems. His work triggered a cascade of events leading to the degradation of global waterways 150 years later. Rapid urbanization in the United States during the nineteenth century created the need for collective management of sanitary waste. In search of innovation, the United States looked to Europe, where a new form of infrastructure—the combined sewer—was developed to manage increased sanitary waste coming from more flush toilets. Combined sewer overflows (CSOs) release a witch's brew of surface-water runoff and sanitary sewage into neighboring waterways when there is too much effluent for treatment plants to manage. Today, New York City, like 772 U.S. cities, has a combined sewer system where—in even a light rain—sanitary and storm wastes combine, releasing excrement, prophylactics, oil, pesticides, and heavy metals into New York's harbor and rivers.

Around the world the combined sewers that unite sewage and stormwater in a common pipe—once a transformative infrastructure

solution—have reached their limit. Growing urban populations and increased impermeable surfaces perpetually overload the sewage-treatment systems in cities globally. With sewage ever more frequently overflowing into waterways and a rise in sea level further compromising the outfall systems, policy makers and even private funders need to empower designers to rethink the design and management of urban stormwater and sanitary water systems. More severe and frequent storms resulting from global climate change will increasingly affect the hardened, postindustrial waterfront. Innovative urban design that can dissipate the forces of storm surge, manage flooding, reduce surface-water runoff, and reduce a heat-island effect need to be worked into an adaptation plan for waterfront cities. Without major changes to technology, the natural and human resource management of global health and productivity will be compromised.

THE NEW DEAL

Beginning in 1933, during the depths of the Great Depression, political leaders in the United States put forward programs under the New Deal that offered targeted relief for the massive number of unemployed and poor Americans, gradual recovery in the economic sector, and reform of the financial system. Significantly, New Deal programs also transformed the nation's critical infrastructure. Roads, water-management structures, and pathways for electrification provided access, sanitation, and power to formerly undeveloped areas of the country. Parks, public buildings, bridges, airports, and other civic projects followed. Under President Franklin D. Roosevelt, the WPA employed millions of unemployed people, including women and minorities, constructing a renewed cultural identity for the nation.

A hallmark of the New Deal programs—valued at $20 billion (more than $347 billion at current value)—was the work of artists, writers, landscape architects, architects, and other creative professionals who helped shape the look and cultural literacy of the country during the twentieth century. Legions of laborers guided by designers and bureaucrats worked locally with a regional palette of materials to create extraordinarily beautiful yet practical work that reflected national pride and civic awareness. The work was modern and aspirational and showcased indigenous character and material. President Roosevelt understood the need for large-scale government action to help get the country back on its feet and headed in a new direction.

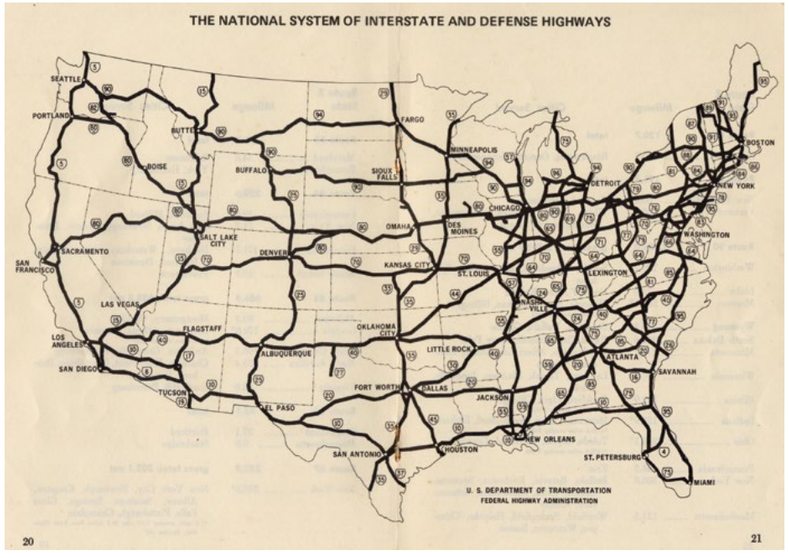
THE FEDERAL HIGHWAY SYSTEM

Two decades later, in the aftermath of World War II and the Korean War, President Dwight D. Eisenhower signed the Federal-Aid Highway Act of 1956 into law. Also known as the National Interstate Defense Highways Act, the transcontinental highway system was presented to the public as essential to national defense systems and was funded at a cost of $25 billion through a tax on gasoline and diesel fuel. The term "infrastructure," which developed during World War II to describe military logistical operations, became one of the president's most visible and longlasting initiatives in the form of the U.S. interstate highway system. Eisenhower, the five-star general and supreme commander of Allied forces in Europe during the war, admired the efficiency of the German autobahns and sought to create a similar system in the United States. The unified design standards for the nation, consistent with the tenets of modernism, suggested the potential of technology to overcome geophysical obstacles in the landscape with hard engineering. The project catalyzed the development of sprawling new mega-regions of the late twentieth century.

UNCOUPLING

The sociologist and philosopher Jürgen Habermas (b. 1929), in his 1999 essay "The Uncoupling of System and Lifeworld," suggested that the processes of differentiation and specialization inherent to modernism are undemocratic and that a democratic system of leadership in advanced capitalistic societies such as the United States enables decision making that is unreflective of society's broader voice:

> But political domination has socially integrating power insofar as disposition over means of sanction does not rest on naked repression, but on the authority of an office anchored in turn to legal order. For this reason, laws need to be inter-subjectively recognized by citizens; they have to be legitimated as right and proper. This leaves culture with the task of supplying the reasons why an existing political order deserves to be recognized.[8]



This map, dated October 1, 1970, shows the routes of the U.S. interstate highway system, officially called the Dwight D. Eisenhower National System of Interstate and Defense Highways. Begun in 1956, construction of the original interstate system took 35 years to complete and has since expanded to more than 47,856 miles (77,017 kilometers). Map courtesy of the U.S. Department of Transportation and Federal Highway Administration.

Through a democratic system, leaders are empowered to make massive decisions about the shape of their country with what I might characterize as "blind faith" in paternalistic power, which, when coupled with postwar fear and fatigue, is further enhanced. Technology reigned in the post–World War II period, and American culture was such that an uncoupling of the systems (such as interstate highways) from the life-world (the social and physical environment)—when presented by a war hero turned president—carried the necessary balance of paternalism and idealism to enable political support for the largest public works project in U.S. history.

As repressed groups, stifled by modernism's systems-based approaches, found voice in the later twentieth century, the need for "different voices" (to borrow Carol Gilligan's term) infused culture.[9] The women's movement, civil rights movement, and modern environmental movement each lent local and personal voices against the unsupportable rationality of current power structures. For the environmental movement, this contributed to important legislation such as the Clean Air Act of 1963 and the Clean Water Act of 1972.

THE PROBLEM

Many of the projects completed during the New Deal era are at the end of their lifespan. As James L. Oberstar has concluded:

> Nearly sixty years after much of the interstate highway system was constructed in the 1950s and 1960s, we are now seeing many facilities become stretched to the limit of their design life and beyond. The world-class surface transportation system passed on by previous generations of Americans has reached the age of obsolescence and now needs to be rebuilt.[10]

Many canals and harbors are no longer used for commerce with the same intensity they once were, and they are, in many cases, decayed, underutilized, polluted, and subject to rising sea level and storm surge. Less than half of the

original 300,000 miles (482,803 kilometers) of rail corridors across the United States are still in use for rail.[11] America's 772 cities have combined sewers that still dump significant amounts of sewage effluent into waterways. Highways and bridges are in similarly poor condition. The repair and replacement of these monumental infrastructure systems in their current configurations do not reflect social, environmental, and technological advances that have occurred during the last half century.

Every four years, the American Society of Civil Engineers issues a report card on America's infrastructure. Here are the grades given in 2013 and 2009:

CATEGORIES	2013	2009
Aviation/Airports	D	D
Bridges	C+	C
Dams	D	D
Drinking Water	D	D-
Energy	D+	D+
Hazardous Waste	D	D
Inland Waterways	D-	D-
Levees	D	D-
Ports	C	(N.A.)
Public Parks and Recreation	C-	C-
Rail	C+	C-
Roads	D	D-
Schools	D	D
Solid Waste	B-	C+
Transit	D	D
Wastewater	D	D-
Overall Grade	D+	D

D = Poor; **C** = Mediocre; **B** = Good.[12]

An unprecedented combination of deeply troubling environmental problems, political evolution, and new design and technology now present an unparalleled opportunity to improve America's infrastructure. Given the realities of global climate change and increased urbanization and population growth, interdisciplinary teams of thinkers must develop models of urban design that work with the hydrologic, transportation, ecologic, economic, and cultural systems that will make cities better-performing and more compelling places to work, live, and raise families. It is unclear whether this work will be driven primarily by the federal government, as it is in France or the Netherlands, or through the public-private partnership models common in the United States. The crucial role of design in the public realm is undervalued and attitudes need to change.

Understanding how physical geography, ecology, and climate function is critical to the development of new types of infrastructure that are more responsive to the forces of nature. The idea of using natural systems to provide public amenities and health benefits is not new. Frederick Law Olmsted (1822–1903), for example, used tidal flows to reduce pestilence and pollution in his design and plan for the Back Bay Fens of Boston during the late 1880s. With advances in technology in the aftermath of the Industrial Revolution, engineered solutions were seen as superior to historical precedent. Viewing infrastructure as a machine was the answer. As we observed in the aftermath of Hurricanes Katrina (2005), Irene (2011), and Sandy (2012), engineered systems are inflexible and can fail with catastrophic consequences as the severity, frequency, and intensity of storm events increase.

It is time to rethink the nineteenth- and twentieth-century engineering model and consider options that can again work in concert with the natural environment. Roads were traditionally aligned with rivers in many rural areas because they were cheaper to build, but roads and bridges in Vermont were destroyed in minutes by the flood-swollen rivers during Hurricane Irene. In metropolitan New York, highways, train yards, tunnels, and public housing located in floodplains along the postindustrial waterfront, where the land was cheap, were severely flooded during Hurricane Sandy in 2012. Replacement of New Jersey's PATH trains and rebuilding of flooded tunnels and other public and private property in areas subject to more frequent inundation is costing taxpayers hundreds of millions of dollars a year when states of emergency are declared so frequently. Miami sits on a permeable bed of limestone at the interface of saltwater and freshwater and faces frequent hurricanes and flooding from upland and coastal sources that threaten not only its major industry—tourism—but also the ecological health of the Everglades.[13]

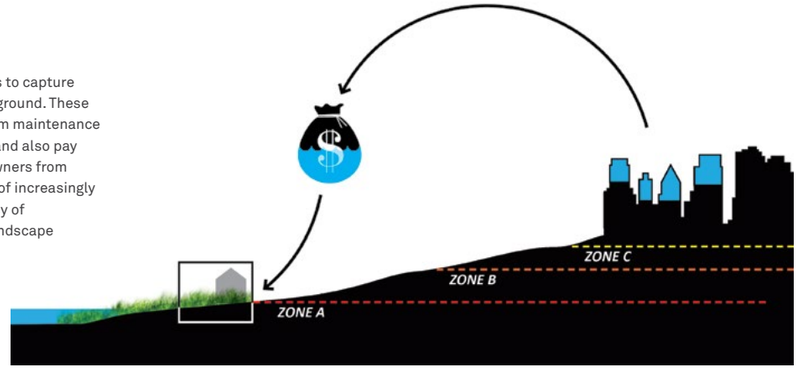
In many cities across the United States, combined sewer systems were an economical solution to sanitary engineering until climate change and population growth changed the balance sheet. Today, designers and public officials often look to Europe for water-management technology. American municipalities first looked at examples of combined sewers in France and Germany, and they now look to the Dutch for flood control. The Netherlands translates literally to "low lands," and its strategy of planning includes 200 years into the future (long term), while constantly reconstructing dikes, dams, and polders (short term) is seen as necessary to protect not only the built environment, but also the agricultural economy dependent on sweet water (the Dutch term for fresh nonsaline water). In the United States, municipalities need to look further to the future and realize there are real opportunities to develop new innovations based on the nation's geographic diversity. The prominent American geographer Gilbert F. White (1911–2006), in addressing the 1934 national flood-control policy, suggested that the multi-billion-dollar program to build reservoirs, canals, levees, and deeper river channels did not reduce flood losses decades later. In his words:

> By assuming that only engineering works were needed to curb the cost of unruly streams, other possibly effective means were neglected. Little or no attention was paid to such alternatives as land use regulation or flood-proofing of buildings. By assuming the engineering works would do what the benefit-cost calculations had solemnly estimated they would do, without attempting to verify the practical results in land use, the public reaped quite different effects.[14]

America's reliance on water-management structures thus provides a false sense of security in relation to availability, cost, and protection from catastrophic flooding. White suggested further that the "single purpose levee may set a confident scene for later catastrophe; a single-purpose reservoir may appropriate a unique dam site without assuring complete reduction in flood losses."[15] In many of White's essays—written over a period of 60 years as a professor of geography and esteemed government advisor on natural hazards and flooding—he advocated a more holistic approach to design and planning and a testing of applied technology to gauge effectiveness.

Solutions

We know that gradual, buffered waterfront edges and barrier islands can dissipate wave energy, contain saltwater inundation, and make habitat that also helps to sequester carbon. The function of barrier reefs, salt marshes, and cypress swamps can thus inspire new models for an ecosystem's management. Planning and designing for the periodic swells of rivers and streams may well necessitate an incentivized plan such as Zone (A)ir to relocate homes, towns, roads, communities, and businesses. It is critical that we adapt the architecture (buildings) and landscape architecture (infrastructure and outdoor space) by rethinking the porosity of the landscape, the materials of construction, the relocation of mechanical systems, and access. To the point: Our roads can soak up water, our highway trenches can be covered with parks that clean the air and provide recreational space, our waters' edges can have an alternating combination of hard edges to facilitate commerce and



Zone (A)ir uses zoning increases to capture the value of property on higher ground. These funds then finance the long-term maintenance of protective coastal wetlands and also pay for the relocation of property owners from sites vulnerable to the impacts of increasingly violent storms. Diagram courtesy of DLANDstudio Architecture + Landscape Architecture, PLLC.

softer edges to protect valuable upland real estate. Key to all of this thinking is the interface between human occupation and the environment.

The beginnings of this work in ecological design and planning are already apparent in Chicago, Philadelphia, and Portland, Oregon, where sidewalk swales and porous paving are becoming part of the standard streetscape. New York City is also taking on pilot projects to test the effectiveness of new materials and ideas, but testing takes time when action is needed. In floodplains along the Mississippi River, communities with low populations are being relocated and spillways opened to flood farmlands so that population centers downstream are safer. We cannot contain the force of water, as we once believed. Long-term, large-scale planning and actions that reduce our impact on the land, work in concert with natural systems, and enable new systems of exchange are necessary if we are to lessen the impacts of nature's force.

Gilbert White long ago suggested a holistic and integrated regional approach to sound water management, but his voice fell on deaf ears, as single-purpose engineering solutions to local problems were constructed without consideration of watersheds and "sewersheds." As towns and cities now work to manage aging infrastructure that is unable to handle impacts of more frequent storms and a rising sea, they have a huge opportunity to embrace new thinking and technology that, more than four decades after the federal Clean Water Act became law, will ameliorate day-to-day and storm-related wastewater loads with new and holistic gray/green engineered approaches.[16] The costs of new infrastructure are real: Presently, approximately $95 billion will be needed to mitigate combined sewer overflows to bring cities in compliance with the 1972 law. Simultaneously, hundreds of billions will be needed to protect communities and cities against future flooding. Resources to address these issues should be combined for cost-effectiveness and efficiency.

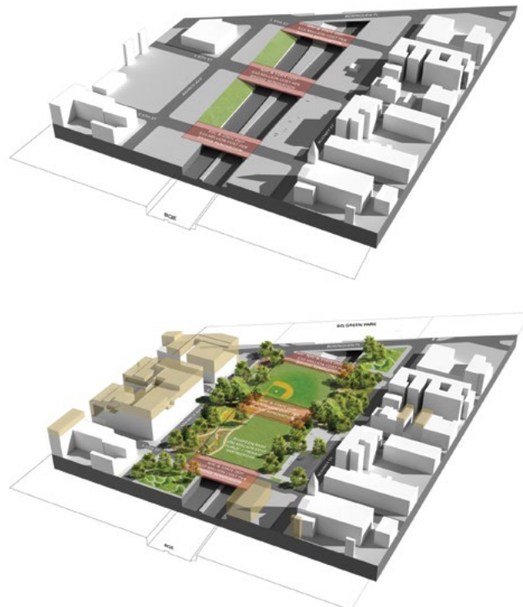
Expansion of new green infrastructure networks—where hard surfaces are removed, utilities are protected, and stormwater is channeled for the irrigation of public parks, gardens, and wetlands—can also help mitigate and absorb floodwaters. Green (nature-based) infrastructure systems allow us to rethink not only the overarching functions of infrastructure, but also our experience of nature in the city. Municipalities have an opportunity to design and plan in the most comprehensive and cost-effective manner. The survival of towns and cities that currently exist at or just above sea level depends on aggressive, widespread rethinking of infrastructure for resilience to climate change and destructive storms. As we know, even if all 196 nations honor the commitments each made in Paris, in December 2015, to mitigate the effects of climate change, the global sea levels will rise at least 3 to 4 feet (0.914 to 1.219 meters) within a century, and all areas along the world's coasts with elevations under 15 feet (4.572 meters) are extremely vulnerable to high tides and storm surge.[17]

WPA 2.0: A NEW NATURAL INFRASTRUCTURE SYSTEM

In response to the 285 deaths and widespread devastation (more than $50 billion in damage) caused by Hurricane Sandy (2012), three levels of U.S. government—federal, state, and local—established commissions, task forces, special initiatives, white papers, 12-point plans, plenary panels, and waterfront revitalization programs, all with vaguely military overtones that would convey action and strength. But will anything come of their recommendations? How can their ambitious designs and plans for modifications and improvements to make our city, state, and national infrastructure resilient to regular and extreme weather impacts be financed? To mitigate and counter the effects of an aging and ill-equipped infrastructure, to prepare now for global climate change, and to finance a new resilient defense network, I propose WPA 2.0 as a timely and much-needed solution.

The new infrastructure needed to adapt the nation's cities, communities, and rural countryside to the realities of flooding and global climate change will require reconstruction on a massive scale of both gray and green infrastructure systems. Traditional, inflexible "gray" engineering approaches—which require waterproofing of transit systems, tunnels, and utilities or redirecting water with levees, dikes, and barriers—will work better in tandem with more resilient, ecological "green" approaches, including using currents and wind to distribute sediment for new barrier islands, reusing dredge materials to create shallows for wetlands, redesigning streets to absorb and filter stormwater, propagating a range of aquatic plants to make an ecologically rich buffer to storm surge, expanding natural flood zones (and buying out the people and businesses in them) that also function as parks most of the time, taking stormwater from highways and capturing sheet runoff in sponge parks, among other stormwater-capture systems.

As noted earlier, during the Great Depression, President Franklin D. Roosevelt's New Deal programs brought sturdy, high-quality, and beautiful designs to public infrastructure with a national expenditure of $20 billion at a time when the gross domestic product was only $73 billion. The programs created millions of jobs, helped to restore economic stability, and offered financial reform to a flawed banking system. The Tennessee Valley Authority (TVA) was the largest New Deal enterprise. It was formed to harness and manage waterways of the Tennessee River watershed in seven states, create a public utility, and direct numerous resources to an impoverished region of the nation. Along with water management to prevent annual flooding and to manage navigation, President Roosevelt's signing of the TVA Act created dams for the production and delivery of lower-cost electricity in an era when private utility companies were seen to be exploiting already financially stressed customers. And while the TVA was an electric utility that harnessed the power of water to deliver power, by the 1950s it added coal-burning power plants and, by the 1970s,



This diagram depicts DLANDstudio's transformation of three BQE bridges in need of renovation. Each bridge costs approximately $10 million to replace—substantial expenditures that the city cannot avoid. The proposal for BQGreen creates an enabled economy by filling the space between the bridges with new park space and activating underused passive spaces. Diagram courtesy of DLANDstudio Architecture + Landscape Architecture, PLLC.

nuclear power plants to deliver more power to meet growing demands. Energy production is at the root of global warming.

The need for greater urban climate resilience is a consequence of global warming, and emissions from combustion are a primary source. According to the U.S. Environmental Protection Agency (EPA), created in 1970 by executive order of President Richard M. Nixon, power plants, refineries, and chemical manufacturing accounted for almost 84 percent of total reported emissions of carbon dioxide, methane, nitrous oxide, and fluorinated gases in 2013.[18] A modest tax on the companies that are responsible for the majority of climate-affecting pollution, including electric utilities, auto companies, oil companies, and other industrial polluters, could yield revenues necessary to create a Natural Defense Fund and finance a plan for climate change–resilient infrastructure for the next century. The idea of taxing carbon is not new. A tax on the largest carbon emitters and water polluters could bankroll a fund dedicated to urban and rural climate resilience. And the corporations can afford it: Even with energy prices at historic lows, the 10 largest power utility companies, for example, reported sales of more than $17 billion in 2014, and in the Fortune 500 list the top 10 oil refining companies alone had profits of nearly $67 billion in 2015.

In 2014, the U.S. government authorized nearly $50 billion to repair the damages from Hurricane Sandy. Although no monies were created for new defense systems, President Barack Obama included $1 billion in his 2015 budget for a climate-resilience fund. This was a good start. In fiscal year 2015, the Federal Highway Budget included $48.6 billion for repairs of an infrastructure system nearing the end of its designed lifespan. In the next two decades, cities across the country will need to spend at least $100 billion to clean up stormwater runoff and to reduce combined sewer overflows (CSOs) to comply with the Clean Water Act of 1972. It is unlikely that either local communities or the federal government will come up with the funds needed from taxpayers. Thus, by applying a minor tax on the industries whose practices have led to global climate change, a Natural Defense Fund can be created. If a related Natural Infrastructure System had the funding equivalent to the WPA of the New Deal, there would be a level of funding for resilient public works for the next century and beyond that would actually make a difference. As with the efforts to fight wars or help the nation recover from the Great Depression, a major program of renewal and development of the nation's infrastructure will ensure the survival of cities, towns, and rural areas and lead to tens of thousands of permanent jobs in the public and private sectors, in the design, building, and maintenance of a new infrastructure for stormwater alone.

In 2005, I founded DLANDstudio, an interdisciplinary design firm based in Brooklyn, New York, where we have been developing systematic interventions and adaptations of urban infrastructure that address many of the issues described above. The work, funded with a combination of grants and public funding, involves pilot projects that are relatively small in relation to the enormity of the problem. The idea behind them is to find small pilots that, when applied on a broad scale, can have a large impact. Our projects are mostly in New York, but our planning stretches around the world. One of our most important projects is the Gowanus Canal Sponge Park, which operates to absorb, hold, clean, and filter surface water in one of the most polluted bodies of water in the United States.

GOWANUS CANAL SPONGE PARK

The Gowanus neighborhood of Brooklyn, New York, has a rich history. Originally a large marshy wetland, the area was the site of early Dutch settlement, important Revolutionary War battles, and industry, including the energy and construction sectors. In recent decades, the canal has been better known for the lingering effects of industrial pollution and municipal waste.[19]

Planners today envision the area as a new site for large residential development, a controversial proposal in the face of projections of a rising sea level from climate change. In this context, working closely with local community organizations, government agencies, and elected officials, DLANDstudio initiated and designed a new kind of public open space called Sponge Park™.[20]

In New York City, 0.10 inch (2.54 millimeters) of precipitation (especially rain) triggers a combined sewer overflow. The Hudson and East rivers, New Town Creek, Long Island Sound, Jamaica Bay, and Gowanus Canal are some of the key bodies of water impacted by these spills. Sponge Park™ redirects, holds, and treats stormwater runoff to minimize the volume of overflows that occur within the Gowanus Canal, and it serves as a model for similar street-ends that sheet-drain into canals, rivers, and other bodies of water in cities everywhere.

The Sponge Park™ design equally values the aesthetic, programmatic, and productive importance of treating contaminated water flowing into the Gowanus Canal, an EPA Superfund site. The park is designed as a working landscape that improves the environment of the canal over time. This innovative plan proposes modular strategies to divert stormwater runoff for use in the public park along the canal, thereby reducing the input of stormwater into the sewer system. The plants and engineered soils included in our design draw heavy metals and toxins out of contaminated water.

While most urban infrastructure projects have their challenges, the Sponge Park project had to confront not only geomorphic layers, but also layers of bureaucracy. We had to work with no fewer than nine different federal, state, and city agencies, each with overlapping ownership and regulatory oversight. As part of our creative response to those challenges,DLANDstudio raised all of the design and construction funding for the project from the New York State Council on the Arts, U.S. Congress, New York City Council, New England Water Pollution Control Commission, New York State Department of Environmental Conservation, and New York State Environmental Facilities Corporation. Through the use of grant funding, we were able to innovate in a way that would be impossible through normal procurement procedures. Because the project was seen as a pilot and was led by an outside entity but with the cooperation of government, we were able to create an innovative and replicable system. The first street-end absorbs 2 million gallons of stormwater per year. If Sponge Parks were built on every street-end in New York's five boroughs, upward of 270 million gallons of water would be absorbed and cleaned before entering New York Harbor.

HOLD SYSTEM

Highway Overpass Landscape Detention Systems, or HOLD Systems, collect and filter stormwater from highway downspouts. HOLD Systems are planted, modular, green infrastructure systems that absorb and filter pollutants such as oil, heavy metals, and grease out of contaminated outfalls, rendering runoff much cleaner as it is released into drains and waterways. The system's ability to retain water during heavy rain also improves the water quality of adjacent bodies of water. Plant palettes selected for each site help to break down or absorb copper, lead, cadmium, hydrocarbons, zinc, and iron commonly found in runoff. Specially calibrated soils maximize plant productivity and create the ideal level of drainage for citywide stormwater management needs.

HOLD Systems are designed for easy transport and deployment, and they can be quickly

A Highway Overpass Landscape Detention (HOLD) System is a modular bioswale that can be deployed under elevated infrastructure to filter and retain excess stormwater. Photograph courtesy of DLANDstudio Architecture + Landscape Architecture, PLLC.

and easily installed in hard-to-reach, hard-to-drain areas along interstate highways. HOLD Systems can remediate the impact that a highway infrastructure makes on the hydrologic cycle of neighboring areas. Three modular systems—two in the ground and one above ground—have already been developed by DLANDstudio to adapt to water-table height, permeability, site toxicity, and the availability of sun. These systems are currently being deployed in three locations in New York City—two in Flushing Meadows–Corona Park under the Van Wyck Expressway and one in the Bronx under the Major Deegan Expressway—with funding and other support from the New York City Department of Environmental Protection, Long Island Sound Futures Fund, and the National Oceanic and Atmospheric Administration.

MOMA: "A NEW URBAN GROUND"

"A New Urban Ground" was developed by DLANDstudio with ARO (Architecture Research Office) of New York City, as part of the Museum of Modern Art's (MoMA) "Rising Currents" exhibition in 2010. In the proposal, we offered an integrated and reciprocal organization of natural and hard-infrastructure systems. A combination of strategies—including wetlands on the perimeter, a raised edge, and sponge slips (water-management landscapes in old boat slips)—were paired with new street infrastructure systems away from the water's edge in order to protect Lower Manhattan from flooding in the event of another large storm such as Hurricane Sandy, which was but a Category One hurricane when it hit the New Jersey, New York, and Connecticut shores.

The proposal consists of two components that form an interconnected system: porous green streets and a graduated edge. Porous streets will absorb typical rain events and help keep surface water out of the city's combined sewer system. In larger storms, the streets filter and carry water to new perimeter wetlands to enrich coastal ecologies.

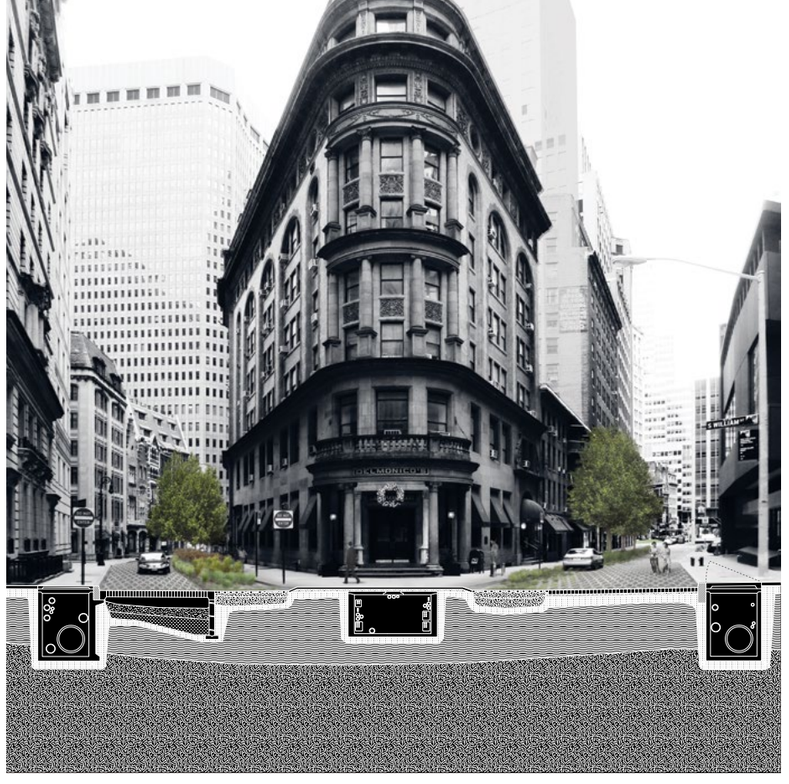
Three interrelated, high-performance systems are constructed on the Atlantic Coast to mitigate the expected rise in sea level and the force of a storm surge: a park network, freshwater wetlands, and brackish marshes. "A New Urban Ground" offers a new way for urban design and planning that brings together natural ecologies with engineered infrastructure systems to transform the city in both performance and experience. This plan, which was proposed almost two years before Hurricane Sandy flooded Lower Manhattan, Staten Island, Red Hook, and the Rockaways, has been cited internationally as a viable model for new civic approaches in resilience to storm surge and sea level rise.[21]

BQGREEN

Highway infrastructure systems across the United States are designed for one primary purpose: to move people and goods quickly from one place to another. But, as a society, it is time to rethink this singular, limited view and consider how infrastructure systems can also become productive corridors of beauty, culture, ecology, and recreation. The BQGreen project considers one such corridor—the Brooklyn-Queens Expressway (BQE)—and examines in depth two sites along its 11.7-mile (18.829-kilometer) length.

The BQE was originally proposed by the Regional Plan Association during the mid-1930s to relieve traffic congestion, facilitate industrial development, and strengthen the connection between the boroughs of New York City. The BQE differed from the city's other parkways by accommodating both commercial and noncommercial traffic. City planner Robert Moses (1888–1981), as the chairman of the Triborough Bridge and Tunnel Authority, charted its path from the Brooklyn Battery Tunnel near Red Hook to Grand Central Parkway in Queens. Construction of the BQE left a trail of divided neighborhoods in its wake.

We know from examples such as Riverside Park (1875 and 1937) in Manhattan, a hybrid Olmsted- and Moses-era park constructed on a concrete box over a major rail corridor, that it is possible to layer transportation with extraordinary public parks. Density is an urban concept that is tied to economics. As the land that infrastructure systems occupy becomes more valuable, it makes sense to layer. As environmental impacts and benefits begin to be assessed in economic terms, the value of making significant alterations to our roadways becomes more attractive at a time when America's highway infrastructure is near the end of its lifespan and in need of significant repair. As these old systems are replaced, why not reexamine them and consider how they might serve economic, ecological, recreational, public health, and pedestrian-friendly circulation needs in addition to transportation?



This section drawing of Beaver Street in Manhattan shows how public and private utility infrastructure is housed in accessible waterproof vaults beneath the sidewalk. These vaults are divided into two parts: one with private utilities (dry systems such as electricity and telecommunications) and the other with public utilities (wet systems such as water, gas, and sewers). The roadbed of the street, freed of infrastructure, becomes a new permeable landscape. The overall design is calculated to manage all of the upland stormwater on site. Drawing courtesy of DLANDstudio Architecture + Landscape Architecture, PLLC, and Architecture Research Office.

Since 2005, DLANDstudio has examined two sunken sections of the BQE. The project began on a theoretical level with a grant from the New York State Council on the Arts to look at tiny Cobble Hill and Carroll Gardens before expanding to study a very different neighborhood in South Side Williamsburg, with funding from then City Councilwoman Diana Reyna. The latter study went into great detail about the economic, social, and public health consequences of adding a park to the impoverished neighborhood. Extensive community outreach included visits to neighboring playgrounds, church events, and performances to make sure we recognized the voice of the community. Data were developed regarding the financial feasibility of capping costs—including ventilation and structural costs—as well as analysis of job creation, real estate value, and even the bump in retail sales at neighboring bodegas. We studied public health issues and discovered very high asthma and obesity rates as well as a relative dearth of open recreational space for kids in the vulnerable preadolescent stage. We discovered gang territories defined by the trench and imagined blurring the boundaries with new soccer and baseball fields. We helped the community to dream and then engaged the agencies to help fulfill that vision, with formal support for the proposal from New York City's Departments of Transportation, Environmental Protection, and Parks and Recreation. Outreach to Congressional Representative Nydia Velázquez and U.S. Senator Kirsten Gillibrand also yielded positive support. To realize this vision will take the collaboration of city, state, and federal agencies; through the master plan we are making a strong argument for why this is the right project for all to support, as

New linear parks such as the QueensWay can not only reduce heat-island effect, increase nonvehicular connectivity, and manage stormwater, but also can reflect the cultural heritage and natural history of a place to add renewed meaning to the urban environment. Diagram courtesy of DLANDstudio Architecture + Landscape Architecture, PLLC

we work to make our communities and cities more efficient, livable, and environmentally productive.

The insertion of quality open space has the capacity not only to improve the aesthetics of neighborhoods, but also to serve as a catalyst for ecological and economic improvements to the urban environment. This project establishes a vision of the BQE as a place of opportunity where new open space can be created by introducing an environmental and recreational corridor and turning a former eyesore into a public amenity.

QUEENSWAY

Already, 20,000 miles (32,187 kilometers) of abandoned rail corridors have been turned into bicycle and pedestrian greenways across the United States.[22] The QueensWay Vision Plan, commissioned by the Trust for Public Land (TPL), a nonprofit organization founded in 1972, is one of TPL's several current national initiatives to transform former rights-of-way in cities into active and engaging community greenways. The project involves the conversion of a former Long Island Rail Road line into a new open-space corridor for the public.

The history of land development in Queens is largely defined by the numerous rail lines that subdivided open tracts of land during the late nineteenth and early twentieth centuries. The QueensWay appropriates one of these infrastructural lineaments to opposite effect, as a unifying device. Each of the three main segments of the QueensWay—northern, central, and southern—possesses a distinct physical character that creates unique staging opportunities for the interaction of urban and natural space. Along its 3.5-mile (5.633-kilometer) length, the former right-of-way transforms from an elevated embankment to a ravine to an elevated steel viaduct. The adjacencies along the QueensWay also vary, with Little League baseball fields along the northernmost end; big-box-store parking lots, residential neighborhoods, and a public park in the middle; and crossing train lines, commercial corridors, and parking lots to the south. Issues such as safety, security, and the privacy of adjacent properties are directly tied to how the former railway line moves through the urban landscape. A quiet presence in the city, camouflaged by school-bus parking, overgrown vines, light industry, and limited access, the QueensWay has the potential to be a beautiful recreational and ecological amenity for the community.

The Future

John Wesley Powell (1834–1902)—among America's greatest geologists, scientific surveyors, and explorers—in his famous 1878 "Report on the Lands of the Arid Region of the United States," called for a clearer understanding of the climate and carrying capacity of the American Southwest, recognizing that not all landscapes and their capacities for human development are the same:

> To a great extent, the redemption of all these lands will require extensive and comprehensive plans, for the execution of which aggregated capital or cooperative labor will be necessary. . . . It was my purpose not only to consider the character of the lands themselves, but also the engineering problems involved in their redemption, and further to make suggestions for the legislative action necessary to inaugurate the enterprises by which these lands may eventually be rescued from their present worthless state.[24]

Powell wrote at a time when massive changes and their resultant impacts upon the American landscape were only beginning to be understood. We are at a similar stage in history when global climate change and an overall recognition of the impacts of people on the natural environment are yielding potentially catastrophic consequences. Powell, Gilbert White, and Jürgen Habermas, writing in different eras, all called for the integration of disciplinary and social thinking about our interaction with the physical world, beginning with the inherent, natural capacities of an environment to perform. Though they approached issues from different perspectives, they also understood a need for a multivalent, interdisciplinary approach to our occupation of the planet that involves ecological, economic, sociological, and artistic metrics.

The unprecedented and unrepeated investment in the American landscape during the New Deal and post–World War II periods provides replicable models from which to develop new systems of infrastructure that will help ameliorate the impacts of urbanization and climate change. New technologies and approaches to infrastructure that value working with natural systems can help create systems that grow stronger and more resilient over time. Collective will, new financing models—public or private—and strong leadership are needed to make WPA 2.0 a natural infrastructure system that can reduce human impact on the global biota. □

Susannah Drake is the founding principal of DLANDstudio Architecture and Landscape Architecture, whose "Rising Currents New Urban Ground" proposal is in the permanent collection of the Museum of Modern Art and Cooper-Hewitt Design Museum. Since 2005, she has taught at Harvard, IIT, FIU, CCNY, Syracuse, Washington University in St. Louis, and The Cooper Union. Her work and writings have appeared in *National Geographic* and *The New York Times*, and she has contributed to *Infrastructural Urbanism* (DOM Publishers, 2011), *Under the Elevated* (Design Trust for Public Space, 2015), *DEMO:POLIS* (Akademie der Künste, 2016), and *Nature and Cities: The Ecological Imperative in Urban Design and Planning* (Lincoln Institute of Land Policy, 2016).

1. The WPA and the PWA were both New Deal programs during the Great Depression. Despite their similar-sounding names, they have critical distinctions: First, WPA laborers were hired directly by the government, while the PWA contracted much of their work to private entities. Second, the WPA engaged primarily in smaller projects with local governments such as schools, roads, sidewalks, and sewers, while PWA programs included large-scale bridges, tunnels, and dams. See: Leighninger, Robert D. "Cultural Infrastructure: The Legacy of New Deal Public Space." *Journal of Architectural Education*, Volume 49, No. 4 (May, 1996): 226–236.

2. Carstensen, Vernon, "Patterns on the American Land," *Publius: The Journal of Federalism*, Vol. 18, No. 4 (Fall 1988): 31–39.

3. Stilgoe, John R., *Common Landscape of America*, 1580 to 1845 (New Haven, CT: Yale University Press, 1983), 104.

4. The origins of this famous phrase about Manifest Destiny in America are disputed. Fred R. Shapiro, the editor of the *Yale Book of Quotations*, comments on the origins in the *Yale Alumni Magazine* (September/October 2008); see http://www.archives.yaleulumnimagazine.com.

5. See, for example, de Crèvecoeur, J. Hector St. John, *Letters from an American Farmer* (London, UK: T. Davies, 1782).

6. See Hudson, John C., *Plains Country Towns* (Minneapolis: University of Minnesota Press, 1985), which won the first John Brinckerhoff Jackson Book Prize of the Association of American Geographers.

7. Merchant, Carolyn, *The Columbia Guide to American Environmental History* (New York, NY: Columbia University Press, 2002), 112.

8. Habermas, Jürgen, "The Uncoupling of System and Lifeworld," in Elliott, Anthony, ed., *The Blackwell Reader in Contemporary Social Theory* (Oxford, UK: Wiley-Blackwell, 1999), 175.

9. Gilligan, Carol, *In a Different Voice: Psychological Theory and Women's Development* (Cambridge, MA: Harvard University Press, 1982).

10. Oberstar, James L., special comments in LePatner, Barry B., *Too Big to Fall: America's Failing Infrastructure and the Way Forward* (Lebanon, NH: Foster Publishing, in association with the University Press of New England, 2010), xi.

11. Tracy, Tammy, and Hugh Morris, *Rail-Trails and Safe Communities: The Experience on 372 Trails* (Washington, D.C.: Rails-to-Trails Conservancy, 1998); available online at http://www.railsto-trails.org/resources/documents/resource_docs/Safe%20Communities_F_lr.pdf.

12. See http://www.infrastructurereportcard.org.

13. See, for example, Kolbert, Elizabeth, "The Siege of Miami," *The New Yorker* (December 21 and 28, 2015): 42–46 and 49–50.

14. White, Gilbert F., "The Changing Role of Water in Arid Lands," in Kates, Robert W., and Ian Burton, eds., *Geography, Resources, and Environment: Vol. 1, Selected Writings of Gilbert F. White* (Chicago, IL: University of Chicago Press, 1986), 137.

15. Ibid.

16. As defined by the EPA, "gray" infrastructure is "conventional piped drainage and water treatment systems" and "green" infrastructure is "designed to move urban stormwater away from the built environment [and] reduces and treats stormwater at its source while delivering environmental, social, and economic benefits." See EPA, "What is Green Infrastructure"; available at https://www.epa.gov/ green-infrastructure/what-green-infrastructure.

17. See, for example, Ganis, John, with essays by Liz Wells and James E. Hansen, *America's Endangered Coasts: Photographs from Texas to Maine* (Staunton, VA: George F. Thompson Publishing, 2016).

18. See http://www3.epa.gov for an update.

19. See Alexiou, Joseph, *Gowanus: Brooklyn's Curious Canal* (New York, NY: NYU Press, 2015).

20. For an overview of Sponge Park, see Foderaro, Lisa W., "Building a Park in Brooklyn to Sop Up Polluted Waters: Site Will Treat Thousands of Gallons near Canal," *The New York Times* (December 16, 2015): A27 and A29.

21. See, for example, Palazzo, Danilo, and Frederick R. Steiner, *Urban Ecological Design: A Process for Regenerative Place* (Washington, D.C.: Island Press, 2011), 6; and "Rising Currents: Projects for New York's Waterfront to Respond to Climate Change," *Landscape Architecture China*, Vol. 11, No. 3 (June 2010): 70–75.

22. The origins of the rails-to-trails movement was brilliantly presented by Charles E. Little in his now-classic book, *Greenways for America* (Baltimore, MD: The Johns Hopkins University Press, in association with the Center for American Places, 1990).

23. Carbonell, Armando, Mark Pisano, and Robert Yaro. 2005. Global gateway regions. September. New York, NY: Regional Plan Association. http://www.america2050.org/pdf/globalgatewayregions.pdf.

24. Powell, J. W., "Report on the Lands of the Arid Regions of the United States, with a More Detailed Account of the Lands of Utah" (Washington, D.C.: Government Printing Office, April 2, 1878), viii.

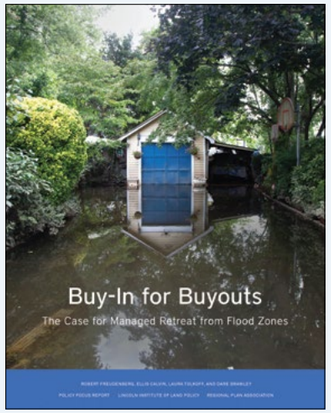
This feature is adapted from Nature and Cities: The Ecological Imperative in Urban Design and Planning, *edited by Frederick R. Steiner, George F. Thompson, and Armando Carbonell (Lincoln Institute of Land Policy, November 2016).*

NEW LINCOLN INSTITUTE POLICY FOCUS REPORT

Buy-In for Buyouts

The Case for Managed Retreat from Flood Zones

By Robert Freudenberg, Ellis Calvin, Laura Tolkoff, and Dare Brawley



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IN THE FACE OF RISING SEA LEVELS, more frequent and severe storms, and other climate change risks, flood-prone communities need to give greater consideration to strategic retreat through buyouts, a policy tool for removing residential development from the most vulnerable areas, according to new research published by the Lincoln Institute of Land Policy in collaboration with the Regional Plan Association.

In *Buy-In for Buyouts: The Case for Managed Retreat from Flood Zones*, authors Robert Freudenberg, Ellis Calvin, Laura Tolkoff, and Dare Brawley demystify the mechanics of buyout programs and how they have been implemented in the United States, with a focus on communities in the New York metropolitan region that suffered damage from hurricanes Irene and Sandy. They provide a roadmap for making programs more effective and more likely to garner the support of local governments and community members.

Managed retreat "allows residents to forge new beginnings on safer ground and helps create public amenities by acquiring homes in flood-prone areas and restoring the land to natural floodplain functions," the authors write.

The fiscal impact of buyout programs is one of the biggest factors weighed by local governments deciding whether to embrace or resist buyout programs, according to the report. Incorporating financial considerations into the reuse of acquired properties and the relocation of residents is critical. For example, well designed parks can make nearby property more desirable, and open space projects can increase water supply and help prevent flooding.

"Restricted land use coupled with new amenities can increase property values and, in turn, increase local revenue," the authors write. "If local governments plan properly, home owners can relocate within the municipality and thereby maintain, and even enhance, the tax rolls."

Buyout programs in the United States date back to the 1970s. They are funded primarily by federal grants from the Federal Emergency Management Agency (FEMA) and the Department of Housing and Urban Development (HUD), but programs are typically managed and overseen locally. The details of programs vary greatly, but in most cases a public agency acquires properties from home owners and converts them to a less risky use—usually open space or parkland, although in some cases structures may be rebuilt to meet strict building code and elevation requirements.

Buyout programs can help break a cycle in which home owners are incentivized to live in disaster-prone areas by federally subsidized flood insurance, which effectively shifts financial risks to the public. Under the 2012 Biggert-Waters Flood Insurance Reform Act, many of these subsidies will be phased out, which is expected to raise premiums sharply for some residents and increase the need for alternative solutions such as buyouts. *Buy-In for Buyouts* examines the use of buyouts in five communities in New York, New Jersey, and Connecticut, and analyzes the implementation of programs at the state, county, and municipal levels. The report includes a detailed fiscal impact analysis of each community that untangles the costs and benefits of removing properties from the floodplain and from property tax rolls, as well as an analysis of local demographic factors such as income, ethnicity, and home ownership rates, which are critical for understanding how well programs serve socially vulnerable populations. The local communities include Oakwood Beach, Staten Island, New York; Mastic Beach, Long Island, New York; Wayne Township, New Jersey; Sayreville, New Jersey; and Milford, Connecticut.

Buyout programs played out very differently in each community. For example, the Oakwood Beach neighborhood benefited from being part of New York City, which made the loss of property tax revenue negligible and helped achieve 99 percent participation. In Mastic Beach, by contrast, buyout efforts were hamstrung by opposition from some municipal officials, and "conflicting programs and messages from different agencies and levels of government led to confusion among residents over their options."

In reviewing the cases studies and analyzing buyout programs across all levels of government, the authors make the following recommendations for designing and improving programs:

- Rethink the purpose and timeline of buyout programs as a long-term adaptation strategy, not merely for short-term recovery.
- Standardize buyout program requirements at the federal level and increase capacity at the state and local level.
- Consider alternative funding models, such as land trusts or community preservation taxes.
- Provide incentives for property owners—including the opportunity for entire blocks to relocate together.

Asking residents or entire neighborhoods to uproot themselves and their families "is laden with social and political difficulties," the authors write, and thus many communities have dismissed managed retreat as a strategy. The unavoidable impacts of climate change, however, will require adding retreat to the adaptation toolbox. This report will help communities craft the most effective and equitable programs before the next storm hits.

Managed retreat "allows residents to forge new beginnings on safer ground and helps create public amenities by acquiring homes in flood-prone areas and restoring the land to natural floodplain functions."

Days after Hurricane Irene hit, Fayette Park in Wayne, New Jersey, remained impassable. Credit: Tim Pioppo/FEMA (2011)

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