Reducing Runoff:
The Role of Urban Natural Areas in Stormwater Management

Natural Areas Conservancy

Report summary

Urban stormwater management is a growing challenge in the face of climate change, especially in cities like New York with aging gray infrastructure and increasing impervious surfaces. This report, "*Reducing Runoff: The Role of Urban Natural Areas in Stormwater Management,*" presents a comprehensive analysis of how urban natural areas, including forests, wetlands, and meadows, play a critical yet often overlooked role in mitigating stormwater impacts.

Using the InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) model and high-resolution spatial data, this report quantifies stormwater retention across land cover types in New York City, Baltimore, and New Haven while highlighting the need for high-quality data on the presence and condition of urban natural areas. Natural areas in NYC alone absorb an estimated 17% of all urban stormwater, a contribution valued at up to $760 million annually in avoided treatment costs.

The findings show that natural areas consistently outperform other green infrastructure in stormwater capture when normalized by land area, and that forest health significantly enhances this capacity, as healthy forests can absorb up to 10% more stormwater than degraded ones.

Yet, natural areas remain underrepresented in urban stormwater planning, in part due to the lack of high-quality spatial data. This report demonstrates how mapping natural areas, even using parkland as a proxy, can greatly improve our understanding of their ecological and economic value.

This work supports the mission of the Natural Areas Conservancy by highlighting the essential role that urban natural areas play in building climate-resilient cities. By preserving, restoring, and integrating these ecosystems into stormwater infrastructure planning, we can protect both human communities and natural habitats while advancing equitable, cost-effective environmental solutions.

Supported by:

The New York Community Trust, The Eppley Foundation for Research, and The Green Horizons Fund at The Chicago Community Foundation.

Additionally, thank you to our Forest in Cities partners from New York City, Baltimore, New Haven, and Atlanta for your input on this work.

Please cite the following work as:

Clark, Jeffrey A. G., Clara Pregitzer, and Crystal A. Crown. Reducing Runoff: The Role of Urban Natural Areas in Stormwater Management. New York: The Natural Areas Conservancy, 2025.

The importance of healthy natural areas for stormwater management

One of the key benefits of natural areas is their ability to absorb and filter stormwater. Wetlands and forests, for example, capture rainwater through vegetation and soil, reducing the amount of runoff that enters storm drains and flows onto other property. By capturing stormwater, natural areas help prevent flooding and erosion by slowing water flow, allowing for better infiltration into the ground, and reducing the burden on the urban stormwater systems. To maximize the benefits of our urban natural areas, management practices must promote forest health.

1. **Urban natural areas absorb ~2 times the amount of stormwater on a per unit basis when compared to other forms of green infrastructure. In New York City, urban natural areas absorb as much as 17% of all urban stormwater[1].**

2. **The additional cost of treating all stormwater captured by natural areas in New York City is as high as $760 million[2].**

3. **Urban wetlands may face up to an additional 2 billion gallons of stormwater runoff a year if urban forest health declines, increasing the risk of wetland degradation from erosion and increased pollutant load.**

4. **Healthy forested areas absorb almost 10% more stormwater than degraded forests. This difference translates to approximately 4 billion gallons of water annually across New York City[3].**

[1] Based on an annual rainfall of 49.9 inches.
[2] Given a treatment cost of $0.0169 per gallon.
[3] The difference of 4 billion gallons is a comparison between a scenario where all forests are healthy and a scenario where all forests are degraded.

Introduction

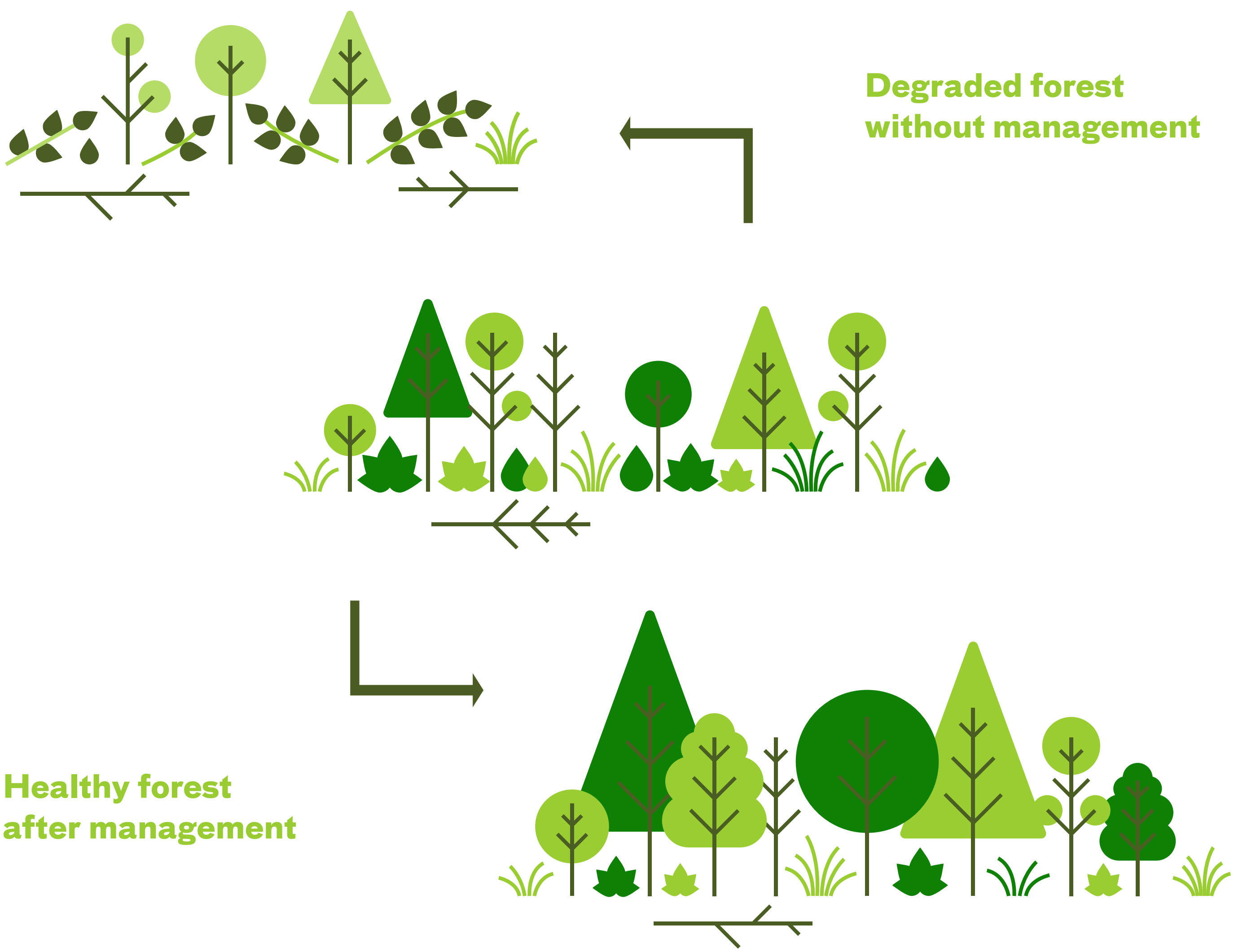
In the face of climate change, cities are encountering multiple challenges. One of the most prominent is the increase of stormwater associated with more frequent and more intense rainfall events (Moore et al., 2021). Large amounts of impervious surfaces and aging stormwater management infrastructure cannot handle the increased precipitation and stormwater events, which can cause significant economic damage and threaten human life (Kessler, 2011; Jiang et al., 2018). Cities are seeking both gray and green infrastructure solutions to mitigate these events.

Current management practices in New York City and many other cities focus on using or modifying traditional gray infrastructure, such as sewers, storm drains, and retention basins. But there is a growing push to implement green infrastructure to increase stormwater capture (Zahmatkesh et al., 2014; Li et al., 2019). This green infrastructure includes managing, expanding, or modifying a wide range of structures such as rain gardens and green roofs as well as street trees and parks (Li et al., 2019). Many organizations and governmental agencies, such as the New York Department of Environmental Protection (DEP), are shifting from traditional gray infrastructure toward green and blue infrastructure, including retention ponds and interconnected built ponds and floodplains (Wilbers et al., 2022; McFarland et al., 2019). Despite the growing interest in using green and blue infrastructure, urban natural areas are often overlooked in stormwater management planning.

Variation in the amount of urban natural areas, type, and quality significantly influences the amount of stormwater absorbed across the city (McPhillips and Matsler, 2018). For example, the amount of stormwater absorbed differs between grasslands and forests; on a finer scale, even the quality of the natural area can impact the amount of stormwater absorbed. Healthy forests with intact canopies and understories can absorb more stormwater than degraded forests (Kuehler et al., 2016). Understanding this variation across cities can be challenging to quantify, and as a consequence, these subtleties are often overlooked when focusing on green infrastructure solutions.

Previous work exploring the role of urban greenspaces tends to treat all greenspaces the same, which may significantly underestimate the role of natural areas in managing urban stormwater. In this report, we utilize a stormwater modeling framework paired with high-resolution spatial data to understand the role of protecting and managing urban natural

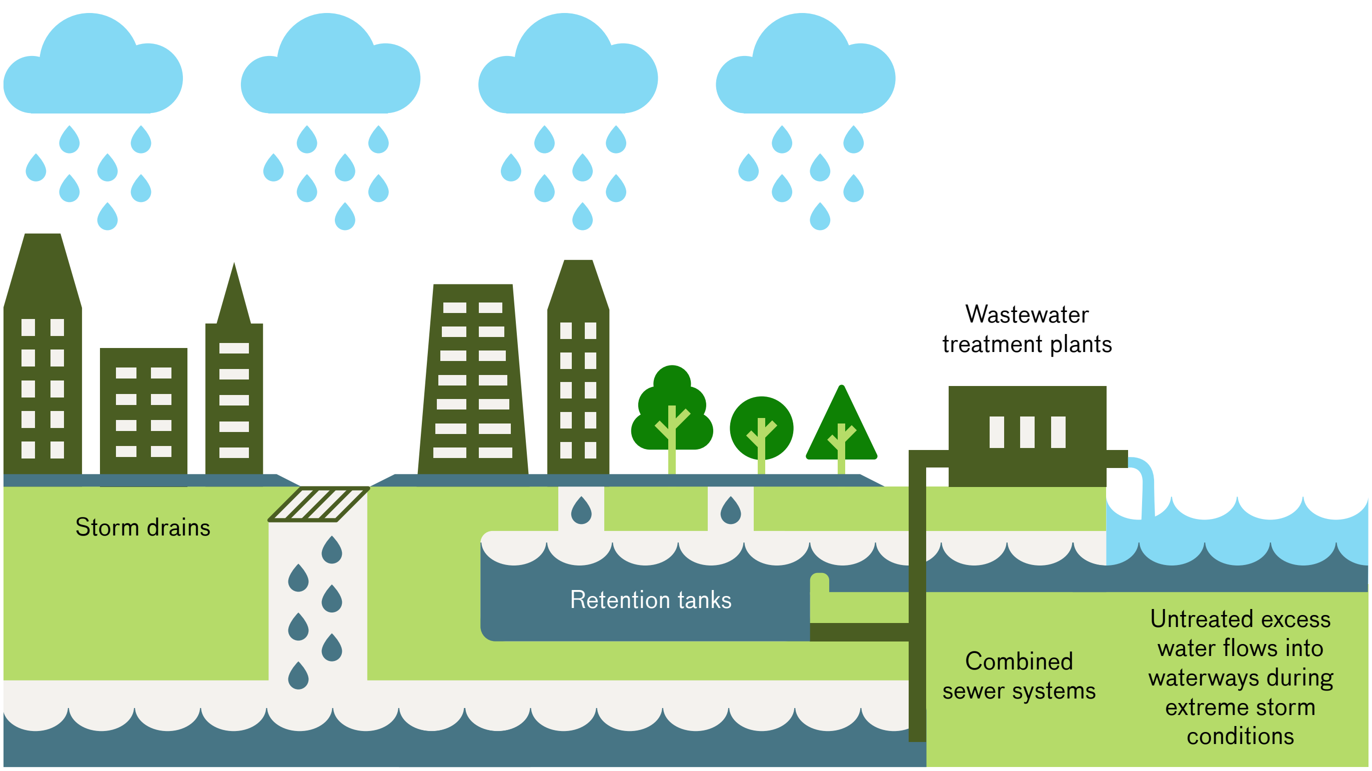
areas in capturing stormwater in cities. Further, by modeling across different scales using different levels of data, we emphasize the need to accurately map the location and quantity of urban natural areas as well as assess the health of these areas to accurately assess the state of urban stormwater management in cities. Specifically, in New York City, New York and Baltimore, Maryland, we highlight how urban natural areas function in comparison to other greenspaces such as lawns and street trees. In these two cities we also model how changing the health of urban natural areas impacts stormwater capture across the entire city. In New Haven, Connecticut, we emphasize the importance of high-resolution and high-quality data. Since natural area maps are not available for New Haven, models can not differentiate natural area canopy from other tree canopy, limiting model interpretation. Further, we highlight the large difference in the estimated role of urban canopy in capturing stormwater that may occur depending on what data is used in model creation.



Current stormwater management approaches

Gray infrastructure: sewer systems in New York City

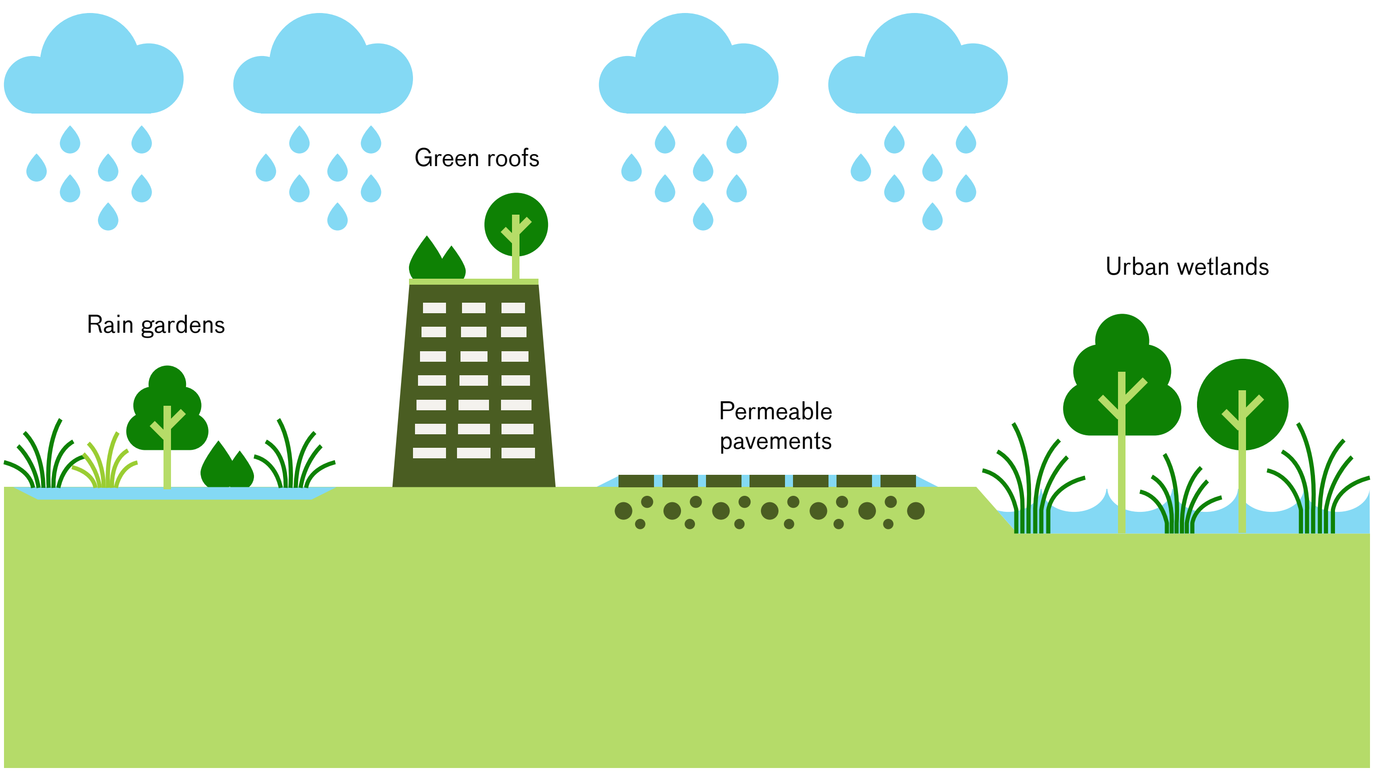
At the core of most cities' stormwater management infrastructure are the traditional gray infrastructure systems which include sewers, drainage pipes, and catch basins. In New York City, the sewer system spans over 7,500 miles of pipes, making it one of the largest in the world (NYC DEP - Sewer Systems)*. These systems are typically built to handle rainstorms that happen once every five years ("five-year storms") or about 1.75 inches of rain in one hour, which occur more frequently than every five years given climate change (Hirabayashi et al., 2013; Wasko et al., 2021). Despite the vast network of sewer pipes, much of this infrastructure is aging with some sections of the sewer dating back to 1855 (Rossi, 1995). Many of these pipes are also part of a combined sewer overflow system (approximately 60%), which allows untreated sewer water to flow directly into natural waterways in the case of extreme rainfall events*. Rainfall captured by these systems that is not sent directly into natural waterways is captured and transported to treatment plants before discharge. As of 2024, maintaining the sewer system costs the city approximately $1.4 billion, with individual metered households paying a minimum of $1.27 a day in sewer and water fees or $0.01 per gallon (NYC DEP 2024 Fiscal Report, NYC 311 Portal).



*See New York City's DEP Citywide/Open Water Plan

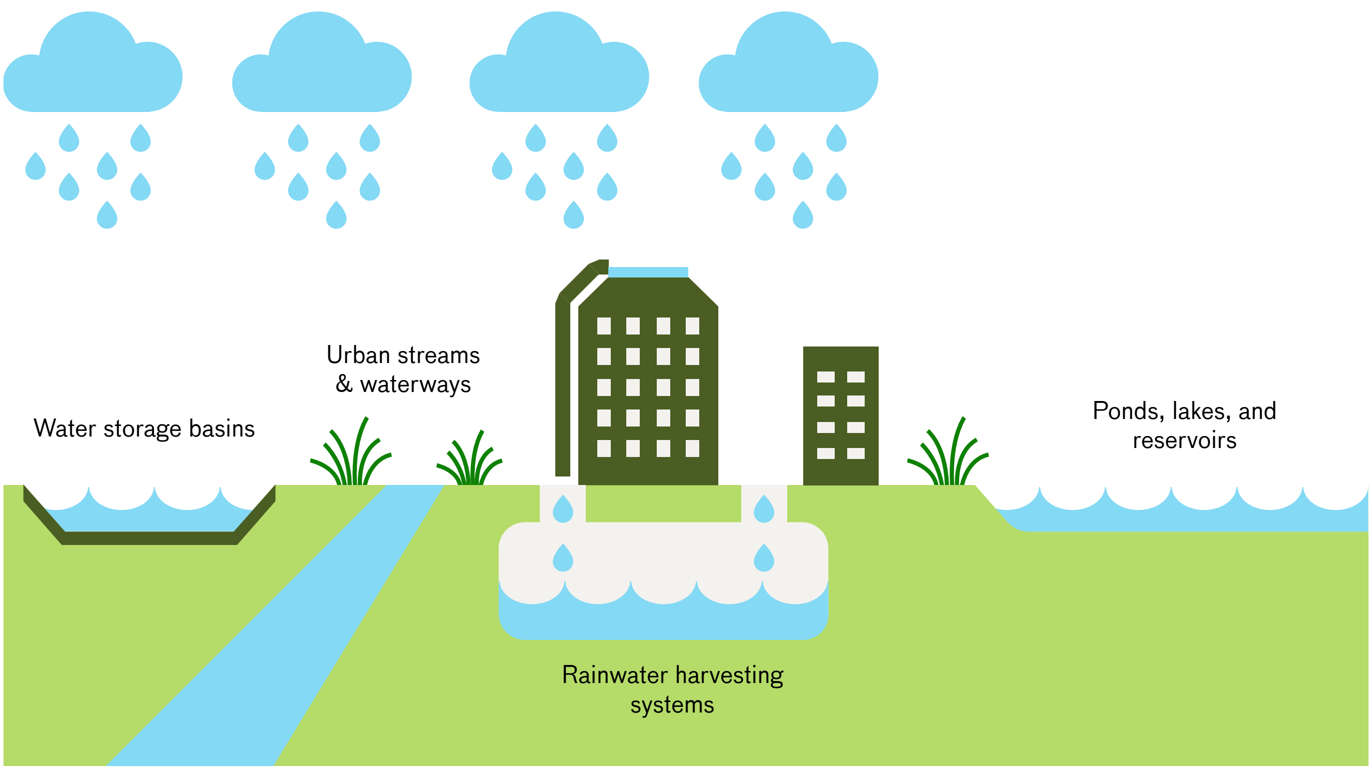
Green infrastructure: nature-based solutions for stormwater management

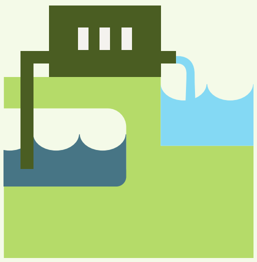
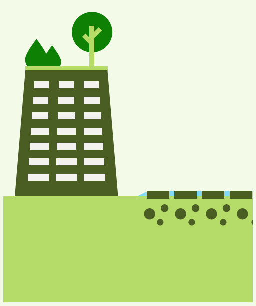
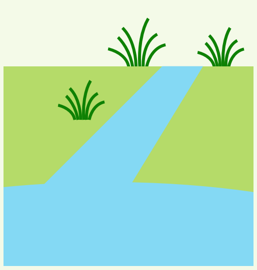
Green stormwater management infrastructure — which includes systems like rain gardens, permeable pavements, green roofs, bioswales, and urban wetlands — offers innovative alternatives to traditional gray infrastructure. These natural systems are designed to absorb and manage rainfall where it falls, reducing runoff and improving water quality (Richter et al., 2023; Chin, 2017). Green infrastructure also often provides benefits beyond stormwater management, such as local cooling and providing habitat for biodiversity (Herath and Bai, 2024; Rainey et al., 2022). In cities like New York, green infrastructure has gained attention for its ability to complement the existing sewer system by capturing and filtering stormwater before it enters the drainage network. For example, the city's initiative to install green roofs on public buildings, create permeable walkways in parks, and develop bioswales along streetscapes has helped absorb rainfall, decreased the urban heat island effect, and reduced pressure on the aging sewer system.



Blue infrastructure: waterways and wetlands

Blue infrastructure, which includes features like wetlands, ponds, water storage basins, and waterways, plays a crucial role in managing stormwater and enhancing urban resilience. Constructed wetland systems are designed to capture and store excess rainwater, slowing its flow and reducing the risk of flooding (Veerkamp et al., 2021; Natural wetlands and streams can be themselves be degraded by excessive and contaminated stormwater runoff. In cities like New York, blue infrastructure works alongside green and gray systems to mitigate the effects of heavy rainfall and rising sea levels. For example, the creation of urban ponds and retention basins helps to manage stormwater runoff, while the restoration of tidal wetlands along shorelines provides natural flood control and improves water quality. By integrating blue infrastructure into urban landscapes, cities can better adapt to climate change and create more sustainable water management systems.



Infrastructure	Definition	Examples	In NYC
Gray 	Engineered systems designed to convey, store, or treat stormwater and wastewater through built, non-natural materials. These systems are often large-scale and centralized.	• Combined sewer systems • Storm drains • Underground storage tanks • Wastewater treatment plants	Newtown Creek Wastewater Treatment Plant in Brooklyn: the largest treatment facility in NYC, managing wastewater and stormwater from northern Brooklyn and western Queens.
Green 	Nature-based solutions that manage stormwater by mimicking natural processes, increasing infiltration, evapotranspiration, and reuse. Typically decentralized and integrated into the urban landscape.	• Green roofs • Bioswales • Rain gardens • Permeable pavements	Bioswale installations in Queens: over 4,000 bioswales have been constructed across NYC, especially in areas like Ridgewood and Glendale to manage runoff and reduce CSO events.
Blue 	Surface water systems that store, convey, or treat stormwater. This includes natural, restored, and constructed aquatic ecosystems that provide both stormwater and ecological benefits.	• Rivers and streams • Wetlands • Ponds and retention basins • Bluebelts	Staten Island Bluebelt: a system that preserves natural drainage corridors like streams and wetlands to manage stormwater and reduce flooding in low-lying areas.

Bringing urban natural areas into the conversation

Despite growing interest in green and blue stormwater infrastructure, urban natural areas are often overlooked in the conversation. These spaces, including forests, wetlands, meadows, and other natural landscapes, are frequently overlooked simply because they already exist and are often taken for granted. Unlike newly constructed green roofs or bioswales, protecting and improving the quality of urban natural areas are not typically seen as part of the modern solution to stormwater management.

However, these areas offer significant potential for capturing and managing stormwater. By improving the health of urban natural areas through habitat restoration, invasive species control, and reforestation, we can enhance their ability to absorb rainfall, reduce runoff, and provide critical flood mitigation services. Rather than solely focusing on building new infrastructure, investing in the preservation and restoration of existing natural spaces can be an effective and cost-efficient approach to managing stormwater, while also enhancing biodiversity and overall urban resilience.

Understudied and underappreciated

Despite their importance, natural areas often receive limited attention in stormwater management strategies. Often, these areas are overlooked simply because the amount of natural area within a city is not quantified, and thus, calculating their impact is not possible. Instead, much of the focus in urban planning historically placed gray infrastructure (e.g., pipes, gutters, and drains) as the solution to stormwater management (Liu et al., 2014; Liu et al., 2021). Recently, green infrastructure, like green roofs and bioswales, has also gained attention. While these engineered systems are vital for managing stormwater, natural areas offer unique advantages that are harder to replicate with built solutions.

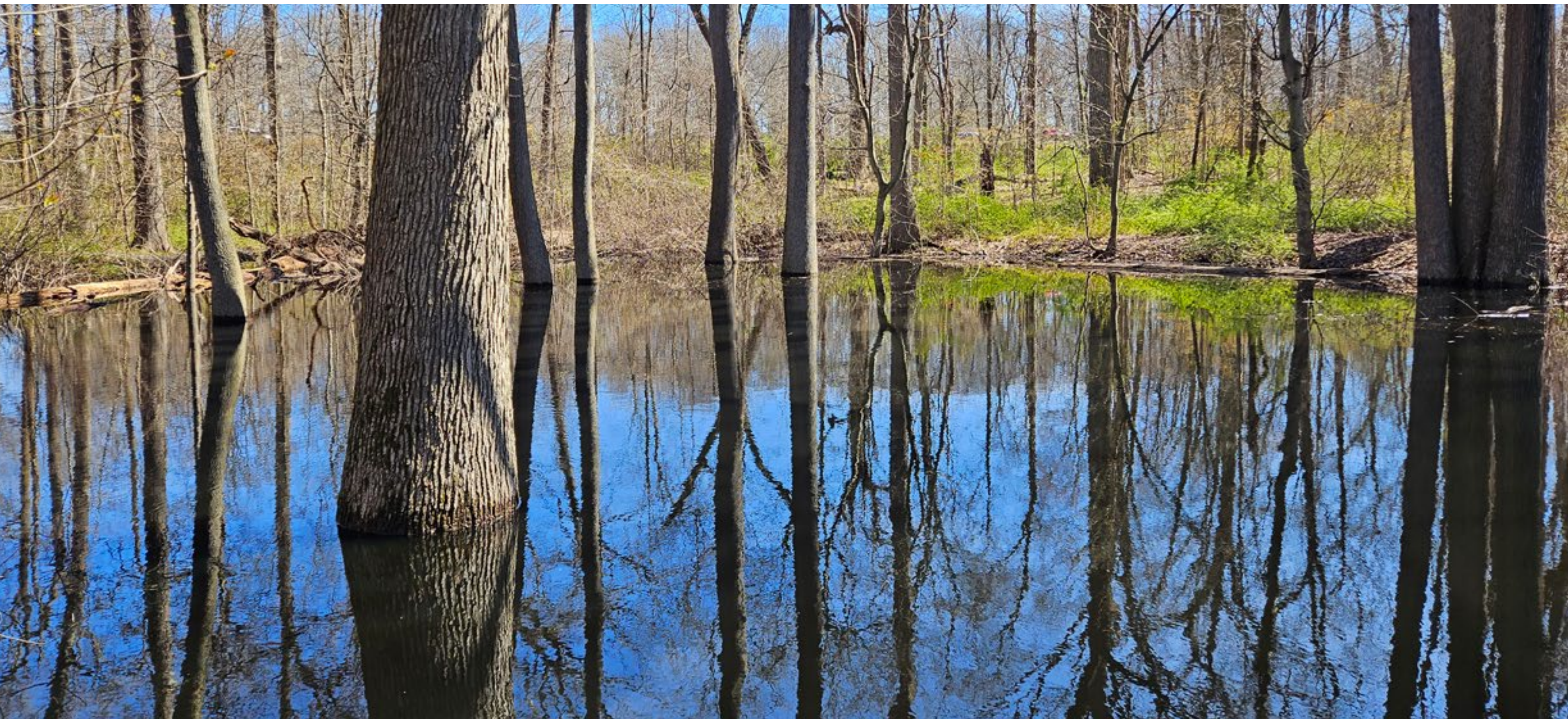
Research on the hydrological functions of natural areas remains limited, particularly in understanding their role in large-scale urban stormwater management. More studies are needed to understand the full potential of these areas in flood mitigation, water quality improvement, and overall ecosystem health. This knowledge gap means that many urban planners overlook the potential of these areas to contribute to sustainable water management.

A critical component for climate resilience

As climate change continues to increase the intensity of storms and the frequency of extreme weather events, the preservation and restoration of natural areas will be more important than ever. These areas not only provide valuable stormwater management services but also contribute to broader ecological health, improve biodiversity, and offer recreational spaces for communities.

Integrating natural areas into urban stormwater management systems can help cities become more resilient to climate change by reducing flood risks, improving water quality, and providing critical ecosystem services (Palemo et al., 2023).

Incorporating natural areas into stormwater management strategies can create a more balanced and sustainable approach, combining the benefits of both nature and engineered infrastructure to mitigate the growing risks posed by climate change.



Understanding the role of urban natural areas with the InVEST Model

The InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) model, developed by Stanford University's Natural Capital Project, is a tool used to assess and map ecosystem services. The toolkit provides a wide range of models, but in this work, we focus on the urban stormwater retention model, which shows how different land cover types, such as roadways, bare soil, forests, and meadows, contribute to managing stormwater. The model provides a spatially explicit overview of where stormwater is captured and where it runs off in urban landscapes while also accounting for gray infrastructure like sewer systems. For full details on the model and data used in this report, see Appendix A.

Annual Water Balance:

Precipitation (P) = Retention (V_{RE}) + Surface Runoff (V_{RU})

Retention (V_{RE}) = Interception (INT) + Infiltration (I) + Evaporation (E) + Transpiration (T)

Surface Runoff (V_{RU}) = Precipitation (P) – Retention (V_{RE})

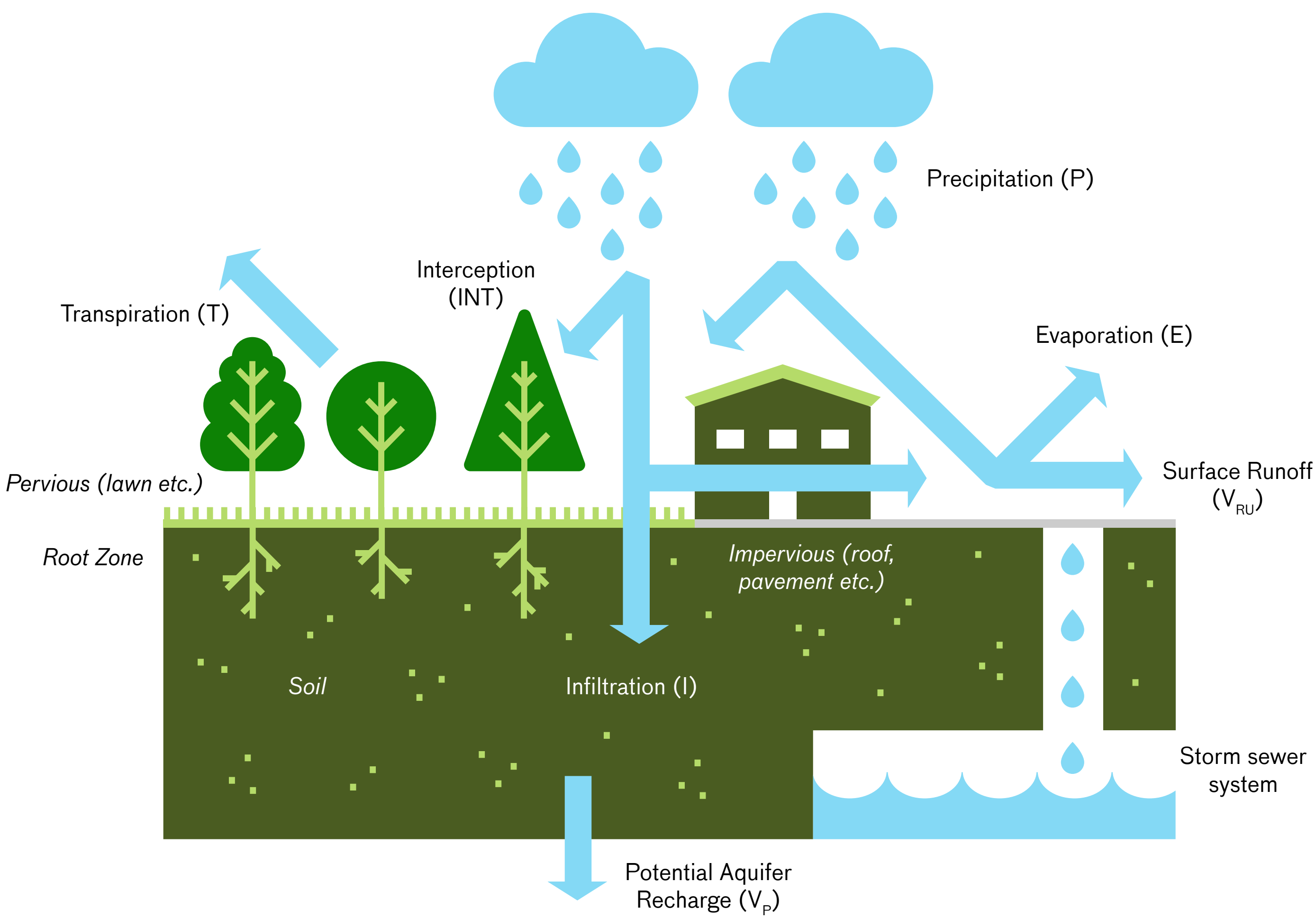
Runoff Coefficient (RC) = V_{RU} / P

Retention Coefficient (RE) = V_{RE} / P = 1 – RC

Potential Aquifer Recharge (V_P) = Infiltration (I) – Transpiration (T)

Percolation Ratio (PE) = V_P / P

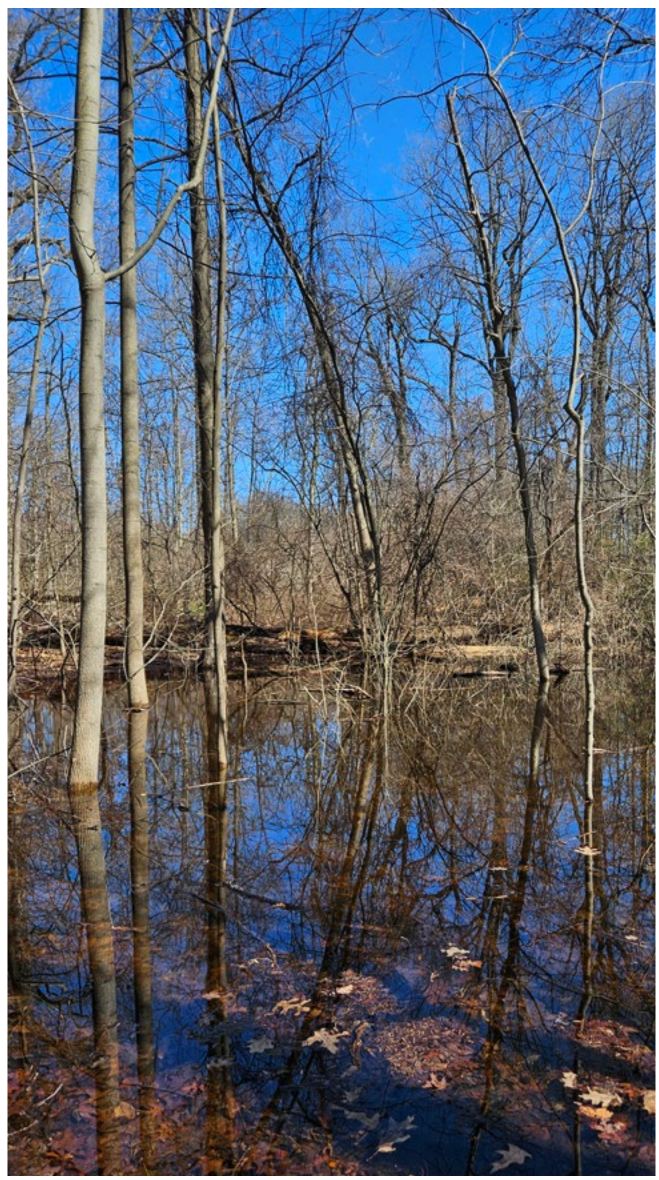
Journey of the Raindrop



The role of urban natural areas in stormwater management: three case studies across scales

Accurate stormwater modeling depends heavily on the resolution and quality of input data, especially when evaluating the performance of natural areas in capturing runoff. High-resolution maps of natural areas are essential because they allow researchers and planners to distinguish between different types of vegetation and land cover, such as wetlands, upland forests, and maintained lawns. Models like the InVEST Urban Stormwater Retention Model require detailed information on land cover and surface characteristics to estimate the amount of water absorbed versus the amount that becomes runoff. Without precise data on the extent, type, and distribution of natural areas, model outputs may underestimate or misrepresent the stormwater benefits these spaces provide. This has direct implications for planning and investment, as it affects how cities prioritize green infrastructure and natural habitat protection.

This project was conducted across three different scales to illustrate how data resolution influences stormwater modeling outcomes. In New York City, we were able to use LiDAR-derived elevation and canopy data along with detailed land cover classifications, allowing us to evaluate the stormwater retention potential of distinct habitat types with a high degree of accuracy. In Baltimore, the focus was on forest patches, using high-resolution urban tree canopy data that distinguishes forests from other tree-covered areas; this enabled us to assess the specific value of urban forests for managing runoff. In contrast, for New Haven and Atlanta, only national-scale public datasets were available. These lower-resolution datasets limited our ability to assess fine-scale variation in natural areas, so we categorized canopy as either "protected" or "non-protected" (e.g., inside or outside of park boundaries). While this approach still allowed us to conduct useful comparisons, it underscored that in cities like Atlanta, where much of the canopy is not formally protected, the long-term stormwater benefits of urban trees may be at risk from future development.



New York City

New York City's stormwater model benefits from having the highest-resolution data available out of all the cities assessed in this report. Not only is there high resolution imagery derived from LiDAR but this imagery is also classified to include natural areas. The inclusion of natural areas in the landcover classification schema is rare for most cities and allows for finer scale distinctions in how different land covers capture stormwater. This is especially beneficial when trying to assess the role of urban canopy in stormwater management since canopy in urban forested areas tends to absorb more stormwater than stand alone street trees or landscaped canopy.

New York City's land cover at a glance

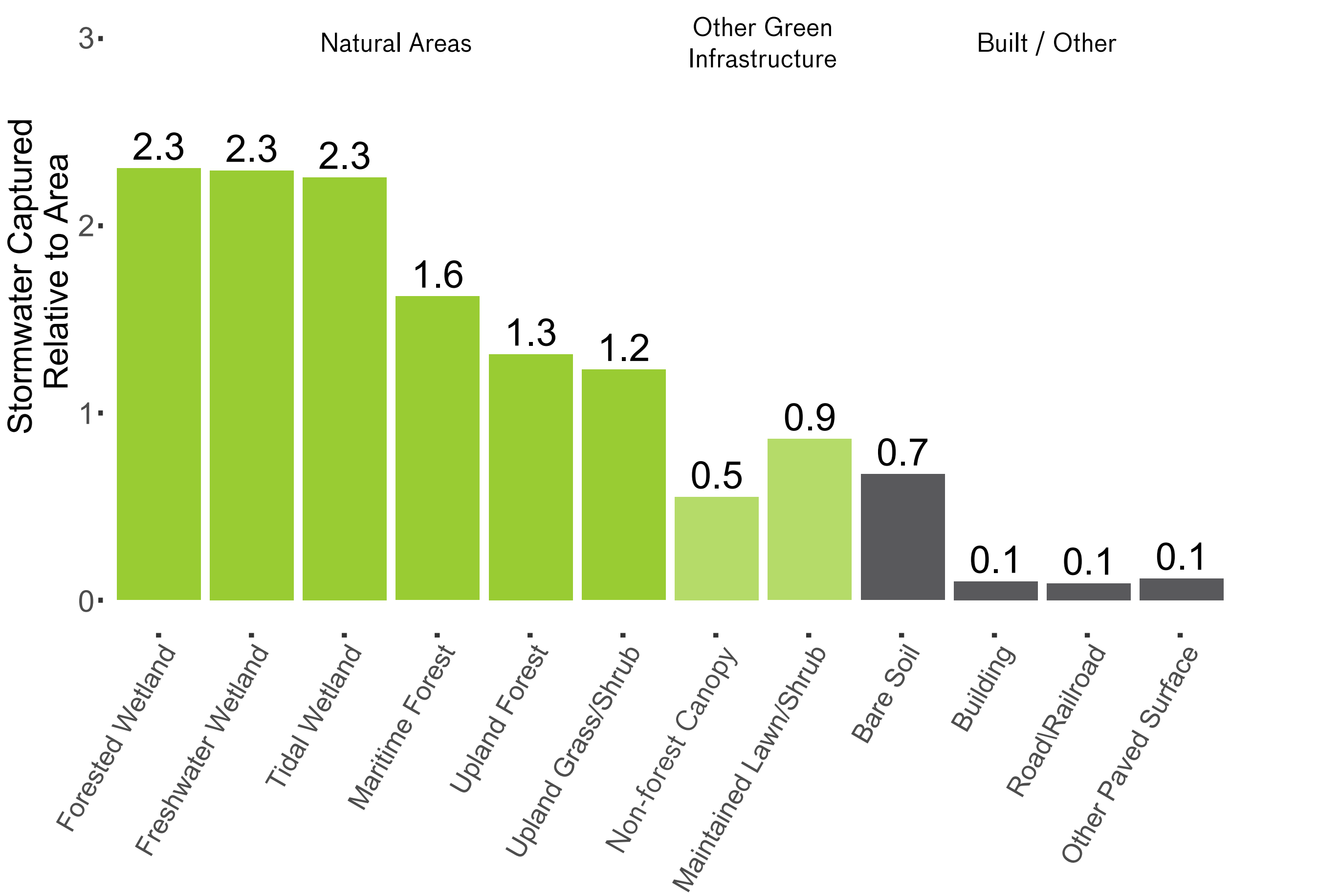
While many may think of New York City as a concrete jungle, approximately 40% of the city is green. Below is a breakdown of land cover in New York City as defined by the Natural Area Conservancy's Ecological Cover Map (2014).

Classification	Land Cover %	Land Cover Class	Land Cover %
Natural Areas	11	Forested Wetland	1
		Freshwater Wetland	1.7
		Tidal Wetland	4.6
		Maritime Forest	1.2
		Upland Forest	6.3
		Upland Grassland	3.5
Other Green Infrastructure	29	Non-forest Canopy	15
		Maintained Lawn	13.7
Built / Other	59	Bare Soil	0.6
		Building	23.4
		Roads / Railroads	15.3
		Other Paved Surfaces	19.7

New York City's natural areas and stormwater capture

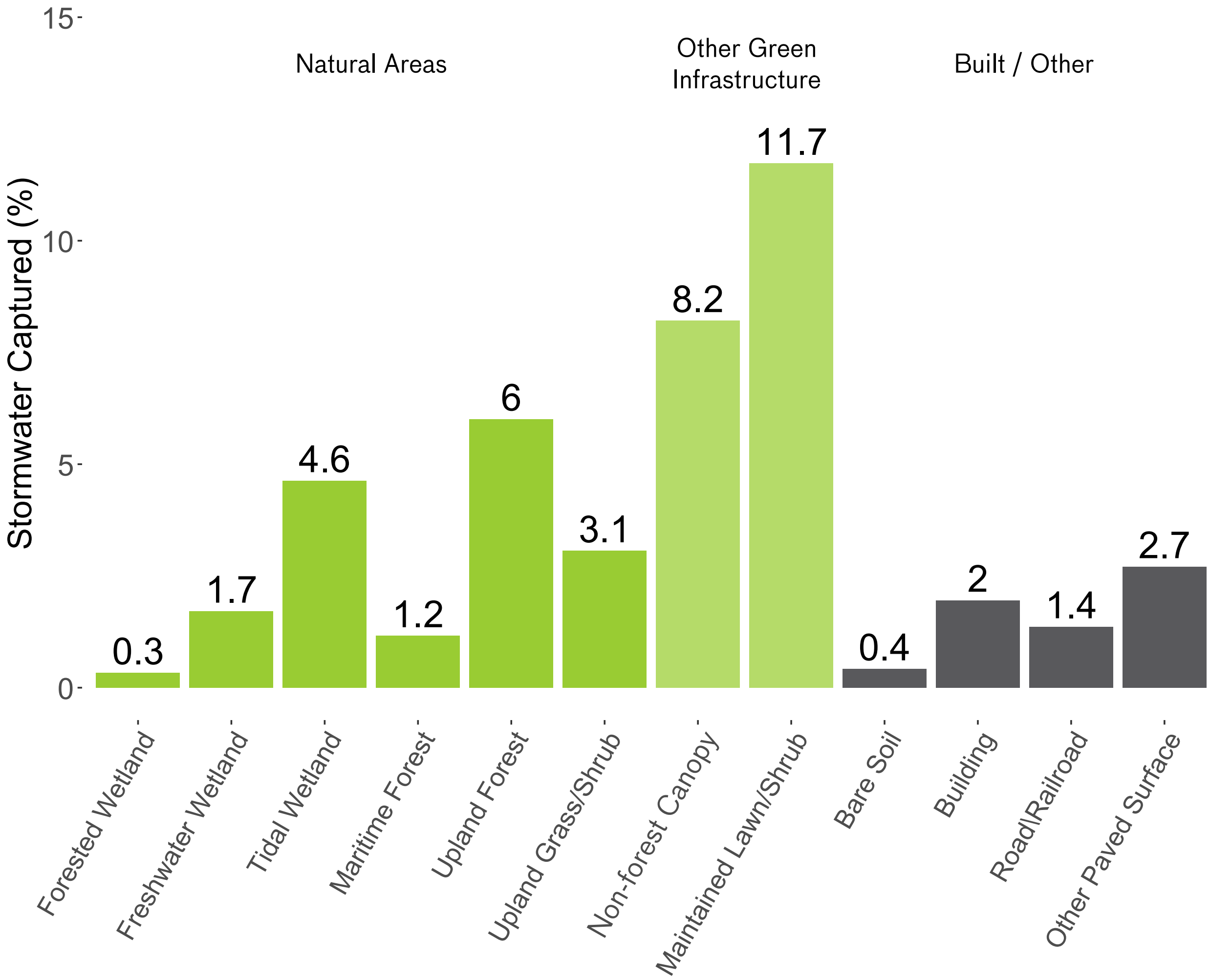
Overall, most natural areas capture twice as much stormwater as what directly lands on them. This is because, in many cases, stormwater is running off impervious surfaces and into natural areas where it is absorbed. In total, New York City's natural areas currently absorb ~17% of all stormwater within the city. The upland forest in New York City contributes the most to this capture, accounting for 6% of all of the stormwater capture. Overall, green infrastructure accounts for the most stormwater absorption with ~ 20% of all stormwater captured by maintained lawns and other canopy such as street and landscaped trees. However, this large volume of stormwater captured is in part due to the fact that nearly 30% of New York City is composed of lawns and non-natural area canopy. When you account for the amount of stormwater capture compared to total landcover, natural areas strongly outperform all other land cover.

NYC Relative Capture Figure



The figure shows how much stormwater is captured by each type of land cover compared to how much area that land type occupies. A value greater than one means that the land type captures more stormwater than expected for its size. A value less than one means it captures less stormwater than expected based on its area.

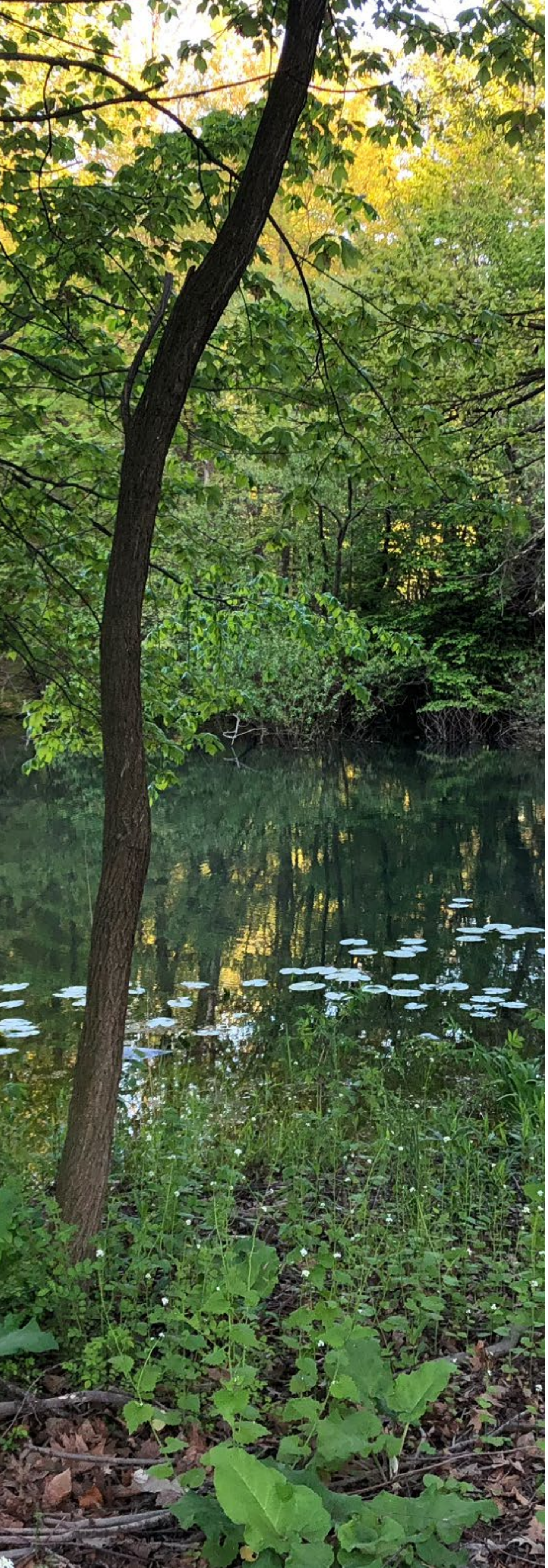
NYC Percent Capture Figure



The figure shows the total percentage of stormwater captured by each type of land cover. The total value across all types of land cover is less than one because large amounts of stormwater runoff into rivers and the ocean as well as into the sewer system.

The importance of natural area health

The health of natural areas directly impacts the ecosystem services they provide. In the case of stormwater, healthier natural areas often contain more vegetation, which allows for greater stormwater absorption. In addition to directly absorbing the stormwater, additional vegetation, especially in the understory, slows the runoff of stormwater, which can be particularly impactful in areas with steeper elevation changes. In our model, we ran three different scenarios to account for "current" forest health conditions as informed by the Natural Areas Conservancy Ecological Assessment and "healthy" and "degraded" scenarios based on stormwater retention coefficients and forest characteristics proposed in the United States Department of Agriculture Urban Hydrology for Small Watersheds resource (TR-55). In our forest management scenarios, if all our forested natural areas were managed to be high-health, they could capture 10% more stormwater (1.6% of total stormwater) than natural areas in our degraded model. There are many co-benefits to ensuring healthy and resilient forests (social and ecological) and this would be a relatively low-cost and high-return on investment solution to reducing stormwater runoff in New York City.

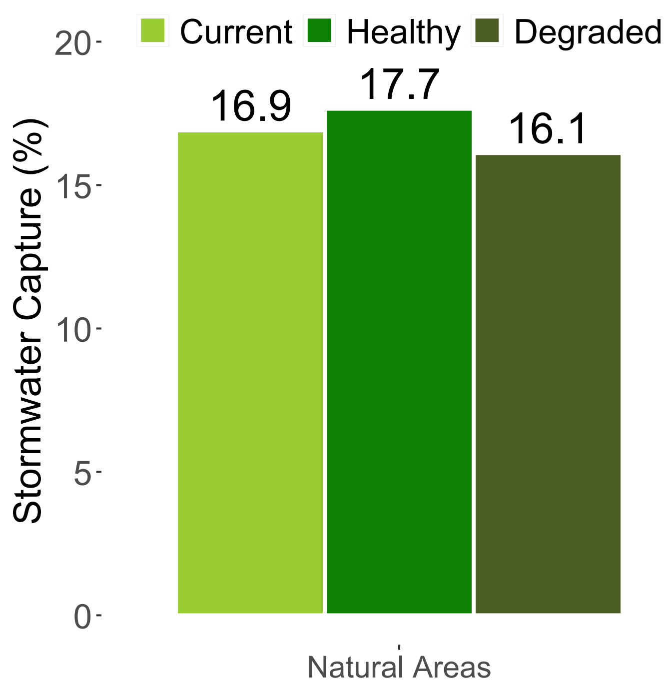


A note on wetlands

When the overall health of forests declines, more stormwater runs off into both the sewer systems and the wetlands. The increase in stormwater entering wetlands in our degraded model was 2 billion gallons compared to the "current scenario" and 4 billion gallons compared to the "healthy" scenario.

This increase in stormwater threatens wetlands by both eroding sediment within the wetlands and increasing the amount of pollutants that enter them.

NYC Stormwater Capture % Change by Health



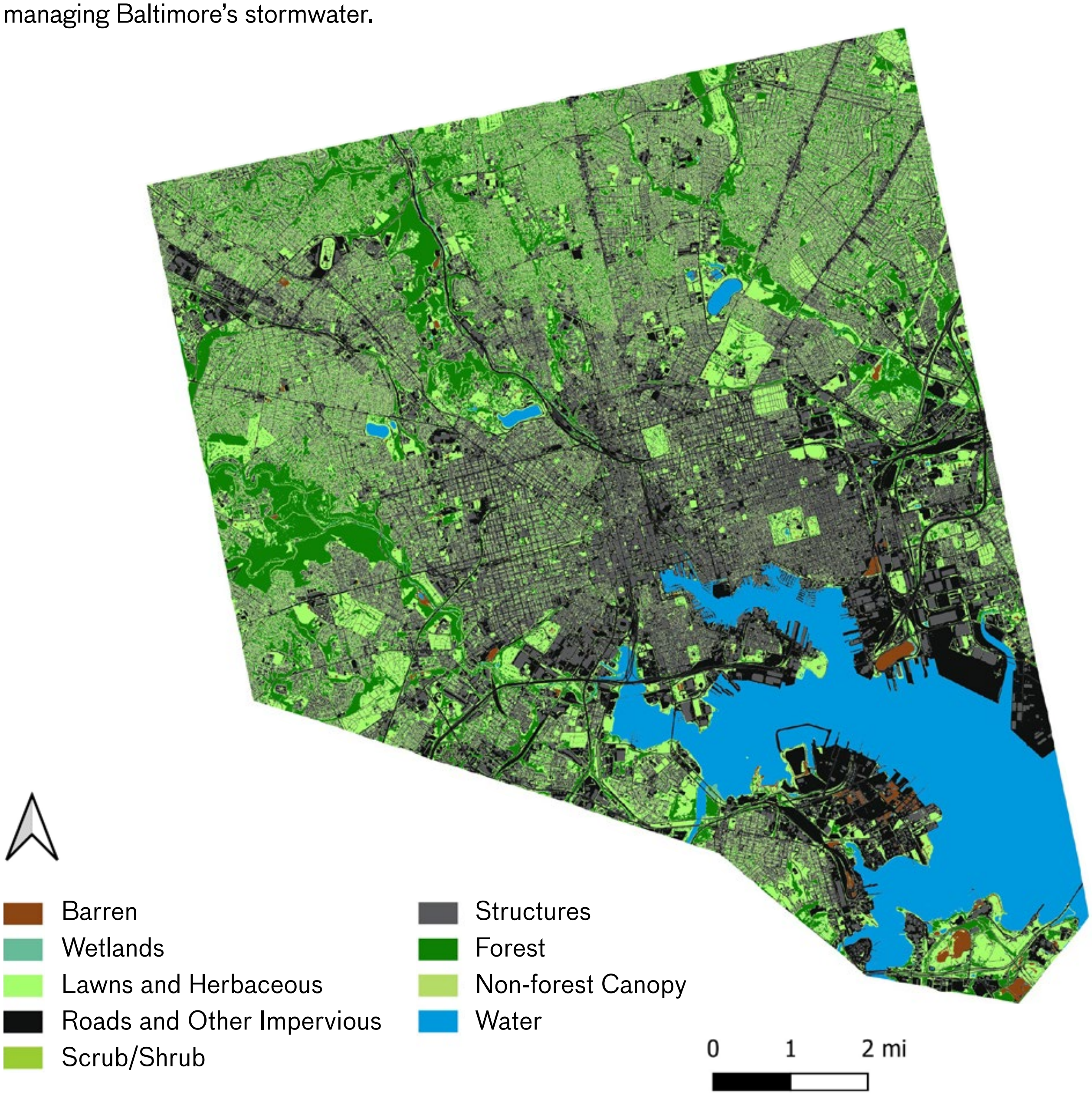
The figure highlights the total amount of stormwater captured by natural areas under three different scenarios. Current represents the current state of natural forested areas in New York City. Degraded represents a scenario in which all forests in New York City become degraded, and healthy represents a scenario in which all forests in New York City become healthy.

Baltimore

The focus of the Baltimore, Maryland, model is assessing the role of urban forest patches in stormwater management. Baltimore has 1-meter resolution data from the Chesapeake Bay Conservancy project, which distinguishes between forest and other canopy layers (e.g., canopy over roads, canopy over structure). While the resolution of this information and classification of land cover is not as detailed as New York City's data, the ability to distinguish between forested areas and other canopy provides a key feature for determining the role urban natural areas play in managing Baltimore's stormwater.

Baltimore's land cover at a glance

Landcover data in this assessment can be found at the Chesapeake Bay Conservancy's Land Use/ Land Cover Data Project Portal. This data provides 50 distinct classifications. Although the model was run using each land classification, for the purpose of reporting, we have aggregated several of these classifications for ease of understanding. Hayfields, pasture, and extractive land covers were not included in the table below.

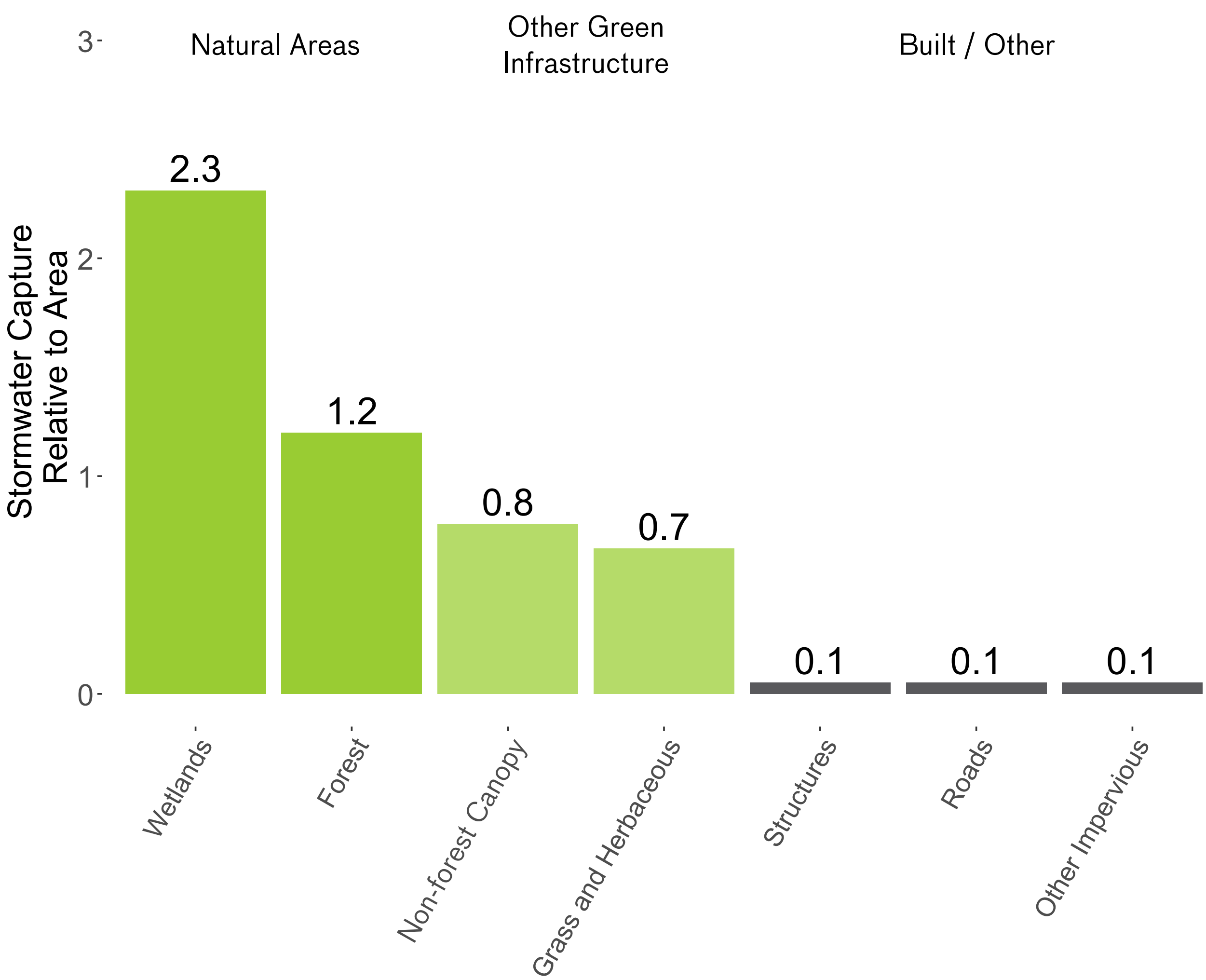


Classification	Land Cover %	Land Cover Class	Land Cover %
Natural Areas	6.71	Wetland	0.14
		Forest	6.57
Other Green Infrastructure	40.7	Non-forest Canopy	22.16
		Maintained Lawn (Grass and Herbaceous)	17.8
Built / Other	52.5	Developed Pervious	2.9
		Building	14.9
		Other Impervious Surfaces	34.7

Baltimore's natural areas and stormwater capture

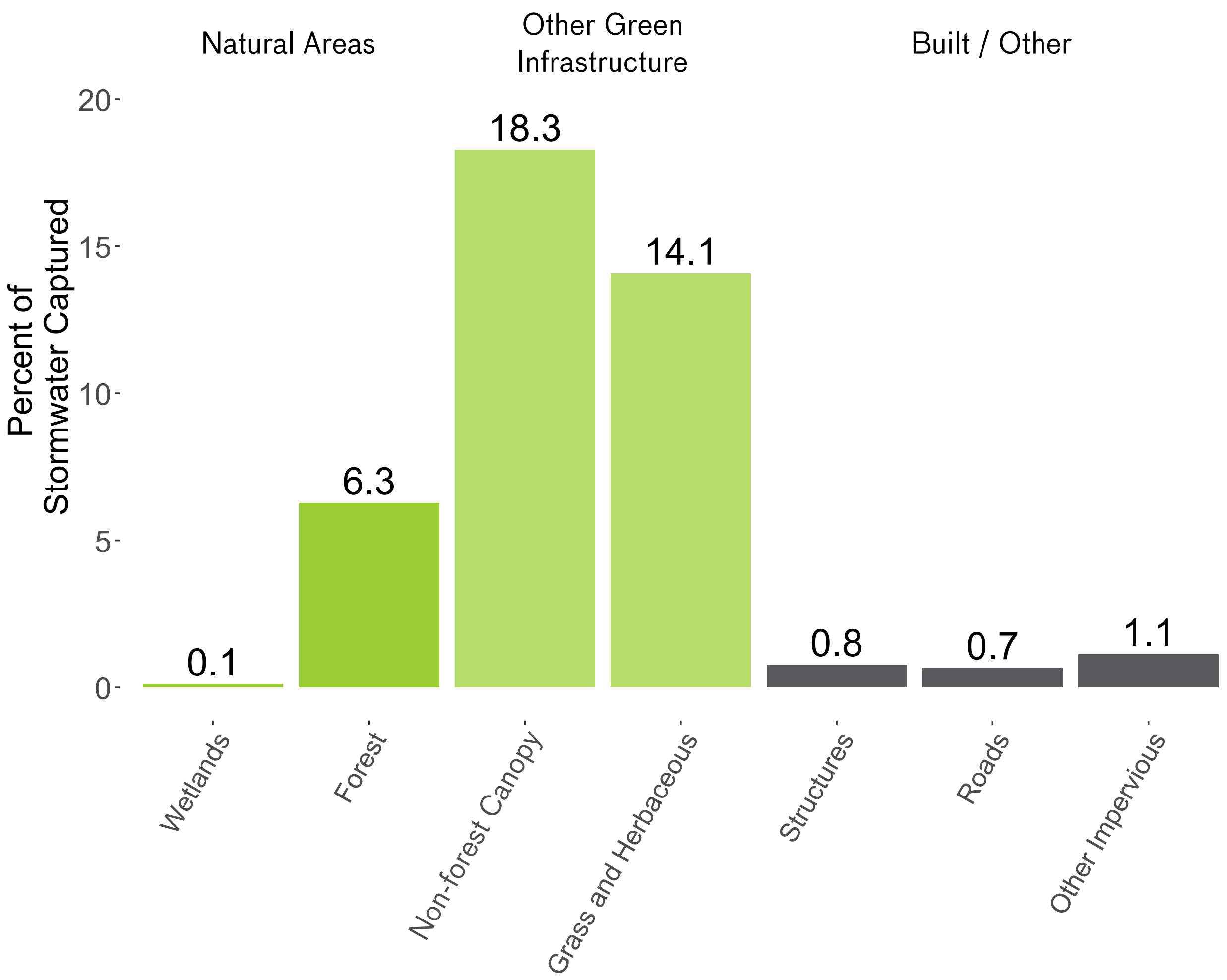
Baltimore's forest captured 6.3% of all total stormwater in the "current" scenario, which assumes the health of all of Baltimore's forests to be in average condition. Similar to New York City, the majority of stormwater captured in Baltimore (~33%) was captured by maintained lawn and non-forest canopy. However, also like New York City, proportionally, forests captured more stormwater than other tree canopy, although this impact was not as pronounced. The difference between healthy and degraded forests was more extreme in Baltimore with forests in the healthy scenario absorbing nearly 40% more stormwater than forests in the degraded scenario (a total difference of 2.1% of all stormwater). This significant difference illustrates the importance of maintaining healthy forests to maximize stormwater capture.

Baltimore Relative Capture Figure



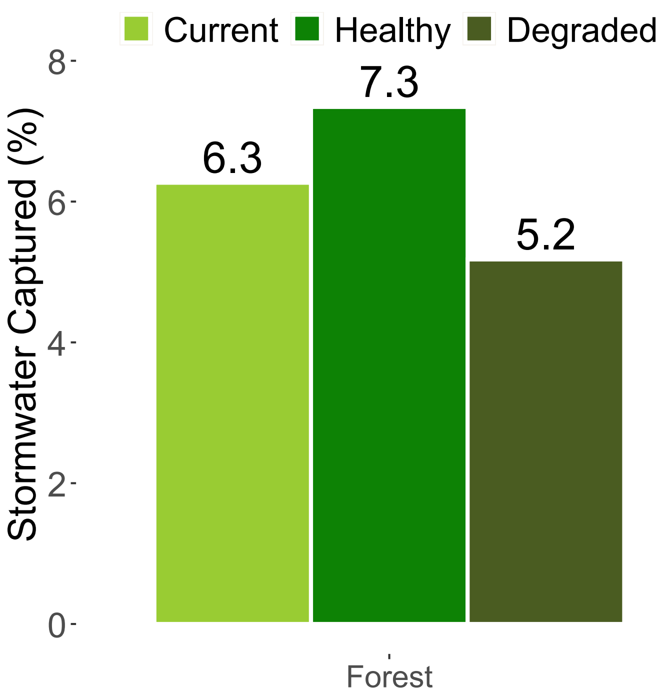
The figure shows how much stormwater is captured by each type of land cover compared to how much area that land type occupies. Unlike in New York City, the figure focuses on only wetlands and forests as natural area classes since other natural areas are not identified. A value greater than one means that the land type captures more stormwater than expected for its size. A value less than one means it captures less stormwater than expected based on its area.

Baltimore Percent Capture Figure



The figure shows the total percentage of stormwater captured by each type of land cover. The total value across all types of land cover is less than one because large amounts of stormwater runs off into rivers and the ocean as well as into the sewer system.

Baltimore Stormwater Capture % Change by Health



The figure highlights the total amount of stormwater captured by natural areas under three different scenarios. Current represents the current state of natural forested areas in Baltimore. Degraded represents a scenario in which all forests in Baltimore become degraded, and healthy represents a scenario in which all forests in Baltimore become healthy.

How to assess urban natural areas without natural area maps: parks as a proxy for urban natural areas

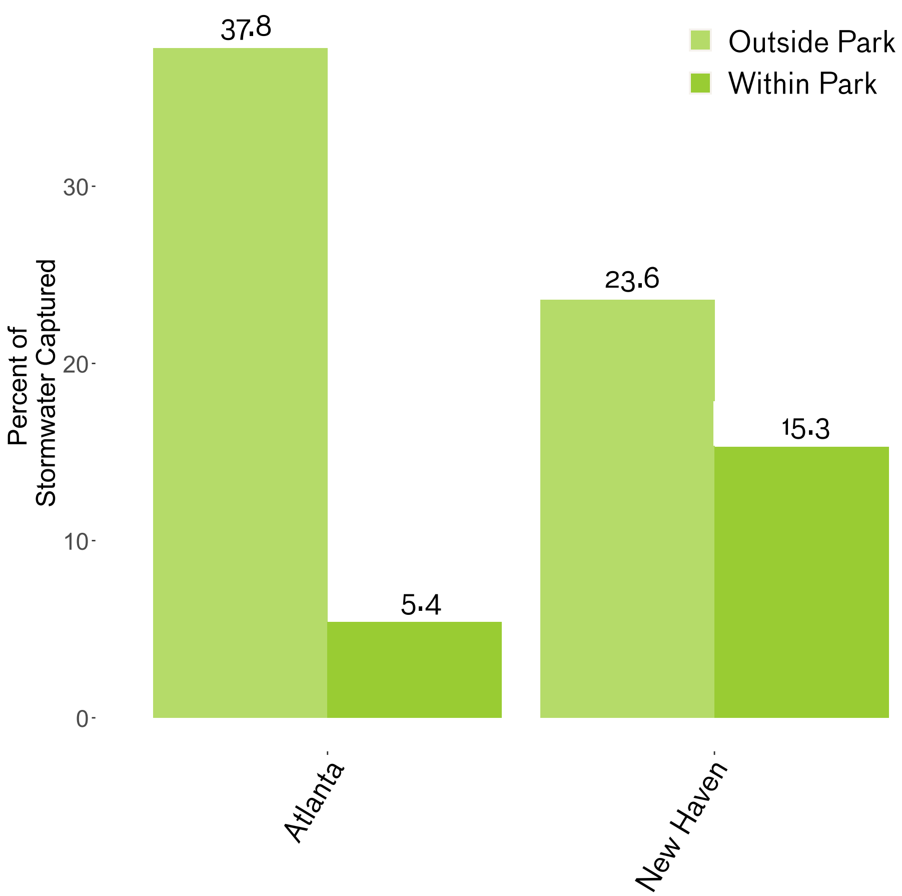
Most cities in the United States do not have maps of urban natural areas. This severely limits the ability of planners and managers to fully understand how stormwater is managed within their cities. When natural area maps are not available, we must instead rely on other resources to try and assess the potential stormwater capture capacity of natural areas. Fortunately, there are national datasets, including the National Land Cover Dataset maintained by the United States Geological Survey which provides 30 meter resolution data. While these datasets provide high coverage allowing for people across the United States to map land cover, the 30-meter resolution creates a challenge when trying to understand the distribution of urban natural areas as well as other green features, since many of these features get lumped into the "developed land" category. To address this issue, we also utilized the National Oceanic and Atmospheric Administration's Coastal Change Analysis Program's (C-CAP) 1 meter resolution canopy data. Unfortunately, while this data provides high-resolution information on canopy, it does not distinguish between types of canopy (i.e., natural vs. landscaped) and is only available in coastal states in the United States. However, with these two datasets, we are able to run the InVEST model on any city that falls within a coastal state. We can then pair our model output with the Trust for Public Land's parkserve database to understand what urban canopy falls inside or outside parkland. Although parkland is not a perfect proxy, our natural areas are most likely to be found within parkland. Additionally, this comparison allows us to assess how much stormwater is captured by urban canopy that is protected, highlighting scenarios where non-protected canopy is lost.

New Haven, Connecticut, and Atlanta, Georgia

Both New Haven, Connecticut, and Atlanta, Georgia, are cities with high amounts of urban canopy. New Haven has approximately 40% canopy coverage and Atlanta boasts 47% canopy cover. A key difference between the cities lies in where this canopy is located. Almost one fifth of all land in New Haven is parkland managed by either the township or the state of Connecticut and a large majority of this parkland is forested. As a result, canopy in parklands heavily contribute to stormwater capture with nearly 15% of all stormwater being captured by canopy within parklands. While the majority of stormwater capture in New Haven comes from canopy outside of parkland, it is likely that the value of natural areas is underestimated in this scenario as a uniform stormwater capture coefficient was used for all canopy since we could not pre-define which areas were natural vs. landscaped. Even with this potential undervaluing of natural areas, the contribution of canopy in parkland is still significant.

In contrast, while Atlanta has a high amount of urban canopy, the majority of this canopy is found outside of parkland. In fact, only about 6% of all of Atlanta's canopy is found within parks highlighting a high potential loss of canopy, and thus stormwater retention capacity due to lack of protection. In a worst-case scenario, development in Atlanta could result in as much as a 38% drop in stormwater capture capacity.

New Haven and Atlanta Park vs. Non-park Figure



The total amount of stormwater captured by the canopy within parks vs. outside of parks in New Haven and Atlanta. Although Atlanta captures approximately 4% more stormwater than New Haven, the majority of stormwater captured in Atlanta is captured by the canopy without formal protected status. In an extreme scenario in which both cities lost all canopy outside of parks, New Haven would retain three times the stormwater capture capacity of Atlanta. This highlights the importance not only of monitoring the location and health of natural areas but also ensuring these spaces have both protection and funding for long term care.

Conclusion

Urban natural areas, including forests, wetlands, and meadows, are powerful, cost-effective assets for managing stormwater and building climate resilience. This report highlights that natural areas in cities like New York absorb more stormwater per acre than any other green infrastructure, with healthier ecosystems providing even greater benefits. Despite this, natural areas remain undervalued and understudied in urban stormwater planning due to data limitations and a lack of visibility in policy frameworks. By integrating these ecosystems into city infrastructure strategies, we not only alleviate flooding but also support biodiversity, improve air and water quality, and enhance community well-being.

The need for natural area maps

Mapping natural areas is crucial for understanding stormwater management in urban environments. These greenspaces, such as parks, wetlands, and urban forests, play a significant role in absorbing and filtering stormwater, reducing surface runoff, and mitigating the risk of urban flooding. High-resolution mapping allows city planners and environmental scientists to quantify the stormwater retention capacity of these areas, identify key locations for conservation or restoration, and optimize stormwater infrastructure investments. By integrating spatial data with hydrological models, cities can enhance their resilience to extreme weather events, improve water quality, and support urban biodiversity, while also mitigating the heat island effect. Comprehensive mapping, therefore, serves as a foundational tool for sustainable urban planning and climate adaptation strategies.

Call to Action

Urban residents:

Advocate for the protection and restoration of local natural areas. Whether it's supporting community tree planting, volunteering in park stewardship programs, or urging your representatives to fund green initiatives, your voice can help ensure these spaces thrive. Recognize that healthy urban forests and wetlands aren't just scenic backdrops—they are vital infrastructure that protects your neighborhood from flooding and climate impacts.

City planners and agencies:

Make urban natural areas a core component of stormwater and climate adaptation planning. Invest in high-resolution natural area mapping, prioritize forest and wetland health in stormwater management plans, and include natural area protection in infrastructure funding. By leveraging existing ecosystems alongside gray and green infrastructure, cities can create more resilient, equitable, and cost-effective solutions to growing stormwater challenges.

Reference List

Chin, D. A. (2017). Designing Bioretention Areas for Stormwater Management. *Environmental Processes, 4*(1), 1–13. https://doi.org/10.1007/s40710-016-0200-0

Herath, P., & Bai, X. (2024). Benefits and co-benefits of urban green infrastructure for sustainable cities: Six current and emerging themes. *Sustainability Science, 19*(3), 1039–1063. https://doi.org/10.1007/s11625-024-01475-9

Hirabayashi, Y., Mahendran, R., Koirala, S., Konoshima, L., Yamazaki, D., Watanabe, S., Kim, H., & Kanae, S. (2013). Global flood risk under climate change. *Nature Climate Change, 3*(9), 816–821. https://doi.org/10.1038/nclimate1911

Jiang, Y., Zevenbergen, C., & Ma, Y. (2018). Urban pluvial flooding and stormwater management: A contemporary review of China's challenges and "sponge cities" strategy. *Environmental Science & Policy*, 80, 132–143. https://doi.org/10.1016/j.envsci.2017.11.016

Kessler, R. (2011). Stormwater Strategies: Cities Prepare Aging Infrastructure for Climate Change. *Environmental Health Perspectives, 119*(12), a514–a519. https://doi.org/10.1289/ehp.119-a514

Kuehler, E., Hathaway, J., & Tirpak, A. (2017). Quantifying the benefits of urban forest systems as a component of the green infrastructure stormwater treatment network. *Ecohydrology, 10*(3), e1813. https://doi.org/10.1002/eco.1813

Li, C., Peng, C., Chiang, P.-C., Cai, Y., Wang, X., & Yang, Z. (2019). Mechanisms and applications of green infrastructure practices for stormwater control: A review. *Journal of Hydrology*, 568, 626–637. https://doi.org/10.1016/j.jhydrol.2018.10.074

Liu, A., Li, D., Liu, L., & Guan, Y. (2014). Understanding the Role of Urban Road Surface Characteristics in influencing Stormwater Quality. *Water Resources Management, 28*(14), 5217–5229. https://doi.org/10.1007/s11269-014-0788-7

Liu, J., Sample, D. J., Bell, C., & Guan, Y. (2014). Review and Research Needs of Bioretention Used for the Treatment of Urban Stormwater. *Water*, *6*(4), Article 4. https://doi.org/10.3390/w6041069

Liu, Q., Cui, W., Tian, Z., Tang, Y., Tillotson, M., & Liu, J. (2022). Stormwater Management Modeling in "Sponge City" Construction: Current State and Future Directions. *Frontiers in Environmental Science, 9*. https://doi.org/10.3389/fenvs.2021.816093

McFarland, A. R., Larsen, L., Yeshitela, K., Engida, A. N., & Love, N. G. (2019). Guide for using green infrastructure in urban environments for stormwater management. *Environmental Science: Water Research & Technology, 5*(4), 643–659. https://doi.org/10.1039/C8EW00498F

McPhillips, L. E., & Matsler, A. M. (2018). Temporal Evolution of Green Stormwater Infrastructure Strategies in Three US Cities. *Frontiers in Built Environment, 4*. https://doi.org/10.3389/fbuil.2018.00026

Moore, R. A., Martinetti, D., Bigg, E. K., Christner, B. C., & Morris, C. E. (2021). Climatic and landscape changes as drivers of environmental feedback that influence rainfall frequency in the United States. *Global Change Biology, 27*(24), 6381–6393. https://doi.org/10.1111/gcb.15876

Palermo, S. A., Turco, M., Pirouz, B., Presta, L., Falco, S., De Stefano, A., Frega, F., & Piro, P. (2023). Nature-based solutions for urban stormwater management: An overview. *IOP Conference Series: Earth and Environmental Science, 1196*(1), 012027. https://doi.org/10.1088/1755-1315/1196/1/012027

Rainey, W., McHale, M., & Arabi, M. (2022). Characterization of co-benefits of green stormwater infrastructure across ecohydrologic regions in the United States. *Urban Forestry & Urban Greening, 70*, 127514. https://doi.org/10.1016/j.ufug.2022.127514

Richter, M., & Dickhaut, W. (2023). Long-Term Performance of Blue-Green Roof Systems—Results of a Building-Scale Monitoring Study in Hamburg, Germany. *Water, 15*(15), Article 15. https://doi.org/10.3390/w15152806

Rossi, M. C. (1995). The history of sewage treatment in the City of Buffalo, New York. *Middle States Geographer, 28*, 9–19.

Veerkamp, C. J., Schipper, A. M., Hedlund, K., Lazarova, T., Nordin, A., & Hanson, H. I. (2021). A review of studies assessing ecosystem services provided by urban green and blue infrastructure. *Ecosystem Services, 52*, 101367. https://doi.org/10.1016/j.ecoser.2021.101367

Wasko, C., Nathan, R., Stein, L., & O'Shea, D. (2021). Evidence of shorter more extreme rainfalls and increased flood variability under climate change. *Journal of Hydrology, 603*, 126994. https://doi.org/10.1016/j.jhydrol.2021.126994

Wilbers, G.-J., de Bruin, K., Seifert-Dähnn, I., Lekkerkerk, W., Li, H., & Budding-Polo Ballinas, M. (2022). Investing in Urban Blue–Green Infrastructure—Assessing the Costs and Benefits of Stormwater Management in a Peri-Urban Catchment in Oslo, Norway. *Sustainability, 14*(3), Article 3. https://doi.org/10.3390/su14031934

Zahmatkesh, Z., Karamouz, M., Goharian, E., & Burian, S. J. (2015). Analysis of the Effects of Climate Change on Urban Storm Water Runoff Using Statistically Downscaled Precipitation Data and a Change Factor Approach. *Journal of Hydrologic Engineering, 20*(7), 05014022. https://doi.org/10.1061/(ASCE)HE.1943-5584.0001064

Natural Areas Conservancy

naturalareasnyc.org