



Building Urban Resilience with Nature

A PRACTITIONER'S GUIDE TO ACTION

NOVEMBER, 2018

EARTH
ECONOMICS 

PIONEERED BY THE
ROCKEFELLER FOUNDATION

100 RESILIENT CITIES



MELBOURNE

Cover photo: City of Melbourne: a field of flowers was planted in the City of Melbourne to bring pollinators back into the city and increase the wonder of nature as well as reduce the need to mow lawn.

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EXECUTIVE SUMMARY

100 Resilient Cities—Pioneered by The Rockefeller Foundation (100RC) is dedicated to helping cities around the world become more resilient to the physical, social and economic challenges that are a growing part of the 21st century. This document provides a consistent framework, examples, and actions that local leaders, resilience practitioners, and partners around the world can take to accelerate the uptake of nature and natural infrastructure as key drivers of resilience in their cities.

Nature is fundamental to the functioning of cities – through its delivery of a wide range of goods and services including food, water, air quality, climate regulation, protection from natural hazards, measurable health and economic benefits. Similarly, **natural infrastructure is real infrastructure that can be used by cities to meet specific goals and service targets** like gallons of storm water filtered, storm surge reduction, or heat island mitigation. While meeting specific service targets, natural infrastructure provides valuable co-benefits to the community and economy that grey projects do not. These additional benefits further enhance community resilience and well-being and increase the return-on-investment to the community.

As such, **nature and natural infrastructure are critical assets in strengthening cities’ resilience to a broad range of resilience shocks and stresses** – and failure to protect or enhance them is a missed opportunity to unlock the economic, health, and social dividends that strengthen our cities’ ability to thrive no matter what happens.

Even if governments and businesses alike are starting to recognize nature as a critical component of thriving, resilient cities, **these considerations are all too often absent from the decisions that planners and policymakers are taking** that will ultimately shape the urban landscapes of our cities in the years to come. The fact that 60% of the area projected to be urban by 2050 has yet to be built, presents both a challenge and an opportunity to change direction.

Through our work at 100 Resilient Cities, we have begun to see successful approaches that do just that – programs and projects that leverage nature and natural infrastructure to build city resilience. From advancing Australia’s first metropolitan urban forest strategy in Melbourne, to valuating the ecosystem services of mangroves and other nature-based solutions in Panama City, cities are committing to defend the global commons as a natural way to build resilience.



At the forefront of this movement are the Chief Resilience Officers¹ and 100RC partners who have recognized early on that the value and role of nature in building urban resilience was missing from mainstream planning and decision-making processes, and **committed to bridging the gap between the need to value nature, and political and financial will in policy and capital investments.**

Through a number of 100RC Network convenings and engagements with partners on nature-based resilience initiatives, this collective, led by Earth Economics and Resilient Melbourne, took up the challenge of creating **a practitioner resource for planners, municipal leaders and others that helps support the uptake of nature-based solutions in cities.**

¹ A Chief Resilience Officer (CRO) is a top-level advisor that reports directly to the city mayor. Their task is to establish a compelling resilience vision for his or her city, working across departments and with the local community to maximize innovation and minimize the impact of unforeseen events.



This page and previous page: 100RC Network Exchange Program: Urban Biodiversity and City Resilience (Melbourne, February 2017).
Participants – Chief Resilience Officers and experts from five member cities (Semarang, Boulder, New Orleans, Durban, Melbourne) with Network partner organizations The Nature Conservancy and Earth Economics.

This document is intended for the growing community of Chief Resilience Officers and 100RC partners from the private, public and NGO sectors who have recognized the key role that nature and natural infrastructure play in resilience building and are determined to take concrete steps to influence decision-making and mainstream nature-based solutions in their cities. **It provides simple, consistent vocabulary and messaging** to help practitioners better communicate the value of natural infrastructure to skeptics, but also to help them share important data and build alliances with champions. **It includes case studies from cities at the forefront** of this movement. **It provides recommendations for greater collaboration** among Chief Resilience Officers and 100RC partners, and a call to action to spread knowledge, innovate together, and promote change on the ground.

Ultimately, the goal is to position nature as an asset in strategy development and implementation for all cities, and effect tangible change on the ground. Our hope is that the steps outlined in this document will promote collection and sharing of standardized data between cities and 100RC partners and staff, key to identify opportunities and measure impact. Ideally, this cycle of data collection and sharing will further accelerate the reintroduction of nature in our cities, valued in itself and for the services it can provide, in a sustained and fundamental way.



100 Resilient Cities Urban Resilience Summit Session: Improving City Resilience with Urban Biodiversity (New York City, July 2017).
Participants – Chief Resilience Officers and experts from 9 member cities (Accra, Durban, Melbourne, Mexico City, New Orleans, Pittsburgh, Quito, Semarang, Toronto), with partner organizations AECOM, AGU, Earth Economics, Climate Central.

COMPONENTS and HOW TO USE

What does this guide contain?

1

Tools and vocabulary to make the case for investing in natural infrastructure, by being able to clearly communicate the benefits of nature and how it contributes to urban resilience

2

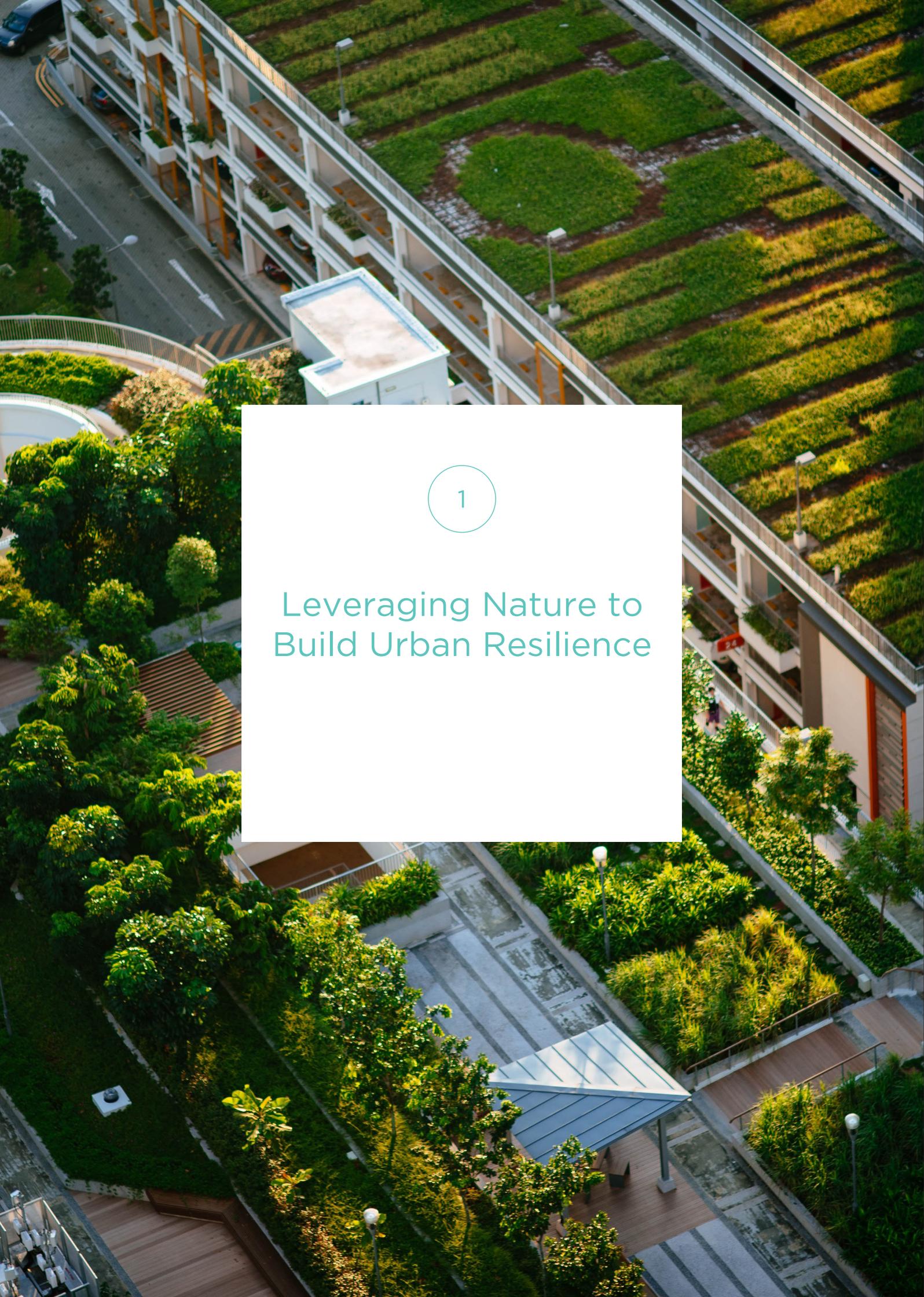
Examples from cities in the Network that have taken steps to introduce and expand the role of nature and natural infrastructure to meet their resilience goals

3

Practical steps that cities can take to introduce and advocate for nature-based solutions

Appendix - Natural infrastructure Matrix

The natural infrastructure matrix has been developed with input from Chief Resilience Officers and teams who attended the 100RC Network Exchange on Urban Biodiversity (Melbourne, February 2017) to provide a suite of examples where nature has been utilized to build resilience in cities. It is also a living resource that can be added to and used for tangible examples. A live version of the matrix is available for viewing and updating on the 100 Resilient Cities Online Community.

An aerial photograph of a modern building with a green roof. The building has a white facade and a series of balconies with glass railings. The roof is covered in a dense layer of green plants, and there are several trees and shrubs around the building. A paved walkway with a blue canopy is visible in the foreground. The overall scene is a blend of urban architecture and nature.

1

Leveraging Nature to Build Urban Resilience



Nature and nature-based infrastructure are becoming recognized as an alternative for many cities. They not only meet specific service targets for water supply or flood management, but also provide a broad array of co-benefits, such as creating new parks and advancing equity and health for underserved neighborhoods.

The reintroduction of nature into our rapidly growing cities is necessary to strengthen urban resilience and promote long-term human well-being. Even in our most densely populated urban centers, nature provides clean drinking water, serves as a much-needed buffer against the devastation from severe storms, and provides respite from rising temperatures and stifling heat waves. Beyond delivering these critical services, nature provides our communities and economy with valuable co-benefits that build community resilience and support individual well-being. From improved health outcomes to lowered crime rates, the integration of natural spaces in the urban environment helps solve important problems and improves the daily lives of a diverse and growing urban population.^{i ii}

Though nature has always supported our cities, the full value of nature's benefits has rarely been calculated or included in decision making or scenario analysis. Most often, planners have chosen to meet their needs with larger and more complex "grey" infrastructure such as large, reticulated water distribution systems and highly engineered, armored coastlines. Nature has long been taken for granted or entirely ignored as an asset or resource to meet challenges brought by urbanization, globalization, and climate change. As a result, massive and often expensive grey infrastructure projects have been built as the preferred solutions to most of our urban needs, even when equally or more effective natural infrastructure solutions exist.

Today, as the global challenges of sea level rise, warming, and urban development intensify, city leaders are seeking cost-effective projects that offer predictable performance and long-term resilience. Nature and nature-based infrastructure are becoming recognized as an alternative for many cities. They not only meet specific service targets for water supply or flood management, but also provide a broad array of co-benefits, such as creating new parks and advancing equity and health for underserved neighborhoods. Interest in and support for natural infrastructure are increasing, but uptake is slow. Many cities simply lack the required data, technical expertise, business cases, or procedural know-how to implement these alternatives to traditionally engineered responses.



2

A Glossary to
Communicate Key
Concepts with
Confidence and
Understanding

The first hurdle to overcome in the broad adoption of nature-based solutions is the lack of simple, sharp definitions and messaging in sharing data and dialogue between cities and with partners. Just like in any newly emerging field, well-intentioned advocates and early adopters around the world have created and distributed numerous overlapping frameworks and definitions. While this helped get many of these ideas into the mainstream, the various frameworks can create confusion and competition, which can hinder implementation.

Terms including green infrastructure, natural capital, biodiversity, biophilic design, sustainability, and many others vie for attention and offer related but not identical perspectives and solutions.

Each of these concepts comes with its own language, practitioners, and professional community. As concern about climate and resource constraints grows, the frameworks and solutions are multiplying. All of this work has value and addresses the simple fact that nature has been largely eliminated from many of our cities and needs to be brought back, for many reasons.

Here is our attempt at summarizing key concepts in the hope that this will be the foundation of a common language:

A COMMON LANGUAGE

Chief Resilience Officers, city leaders, partners, and their communities will benefit from a simple vocabulary and approach that meet the following criteria:

- 1 Easy to remember and discuss
- 2 Consistent terminology for widespread use in urban planning and decision making
- 3 Emphasizes the fact that nature-based solutions are real solutions
- 4 Flexible enough to be adapted to local needs

A) URBAN RESILIENCE

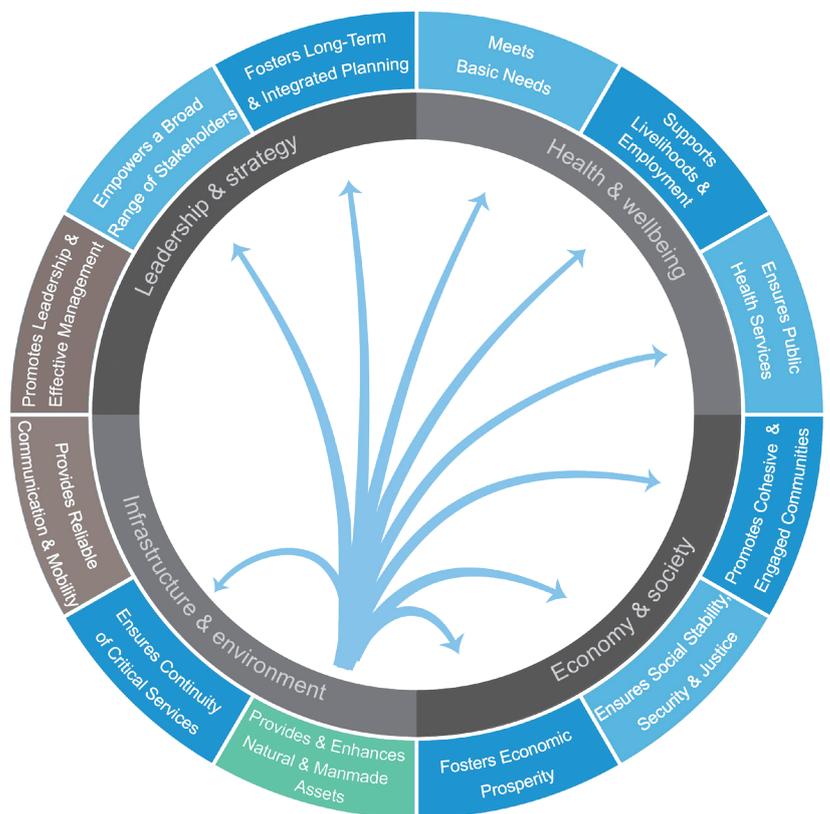


Cities face a growing range of adversities and challenges in the 21st century. From the effects of climate change to growing migrant populations to inadequate infrastructure to pandemics to cyber-attacks. Resilience is what helps cities adapt and transform in the face of these challenges, helping them to prepare for both the expected and the unexpected.

100RC defines urban resilience as “the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience.”

100RC supports the adoption and incorporation of a view of resilience that includes not just the shocks—earthquakes, fires, floods, etc.—but also the stresses that weaken the fabric of a city on a day to day or cyclical basis. Examples of these stresses include high unemployment; an overtaxed or inefficient public transportation system; endemic violence; or chronic food and water shortages. By addressing both the shocks and the stresses, a city becomes more able to respond to adverse events and is overall better able to deliver basic functions in both good times and bad, to all populations. Building urban resilience requires looking at a city holistically: understanding the systems that make up the city and the interdependencies and risks they may face. By strengthening the underlying fabric of a city and better understanding the potential shocks and stresses it may face, a city can improve its development trajectory and the well-being of its citizens.

Nature-based solutions can contribute to multiple drivers of resilience as defined by the City Resilience Framework.



B) NATURE AND NATURAL INFRASTRUCTURE



Infrastructure is defined as “the basic physical and organizational structures and facilities needed for the operation of a society or enterprise.”ⁱⁱⁱ Historically, this term has been used to describe roads, water systems, and power grids. The time has come to ensure that nature and natural infrastructure are viewed as assets equally necessary for the successful operation of a society.

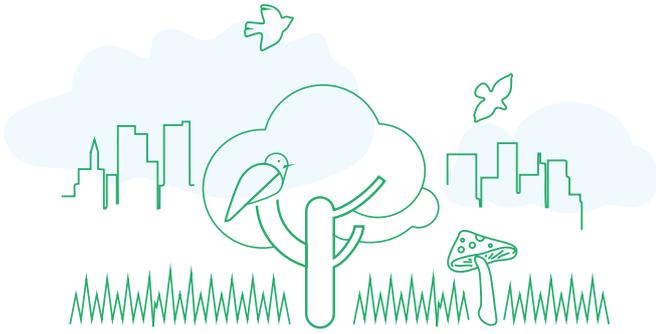
In fact, cities that have included trees on asset registers report that trees are more likely to be considered an essential city service. The City of Melbourne includes trees on its asset register which accounts for the value of a tree if it is destroyed or has to be removed.

Together, nature and natural infrastructure describe both healthy, natural systems at scale (e.g. watersheds, forests, and natural shorelines) as well as distributed, engineered infrastructure like green roofs, storm water capture basins, and urban forests. The intent is not to introduce new terms but to simplify the conversation under the shared focus on nature. The key concept is that **nature and natural infrastructure are real infrastructure** - infrastructure that needs to be strategically planned and managed to provide ecosystem services to humans. The term natural infrastructure also fits comfortably alongside other city planning standards including transportation, water, power, and wastewater infrastructure and ultimately should be melded into those disciplines to ensure that natural infrastructure alternatives are fully considered in all planning and decision making.



Wetland buffers, Thurston County, WA

C) BIODIVERSITY



The state of a city or region's biodiversity serves as both a lag indicator (has biodiversity improved or declined?) as well as a lead indicator (what is the likely future state of a city?)

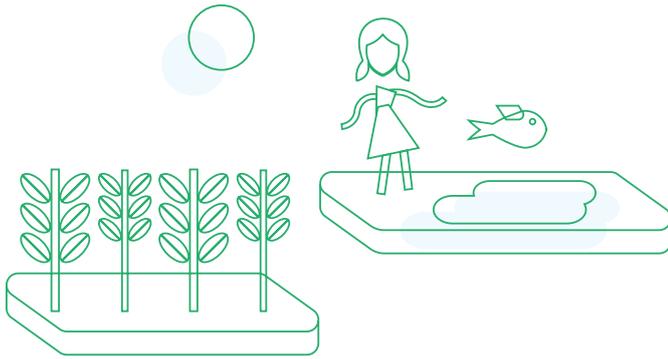
Though often used interchangeably with ecosystem services and natural capital, biodiversity refers specifically to biological diversity – the variety of living organisms within a given area.^{iv} It encompasses all components of the living world: the number and variety of plants, animals and other living things (including fungi and micro-organisms) across our land, rivers, coasts, and oceans, as well as their diverse genetic information, their habitats and ecosystems, and their connections with other life forms and the natural world. ([Biodiversity 2037](#))

Biodiversity is often used as a measure of (or proxy for) ecosystem health and stability. The state of a city or region's biodiversity serves as both a lag indicator (has biodiversity improved or declined?) as well as a lead indicator (what is the likely future state of a city? e.g. loss of pollinators such as bees may indicate future challenges for urban greening, as well as an inability to grow crops locally).



Superb Blue Fairy Wren spotted during Bioblitz (citizen science) in Melbourne.
Photo courtesy City of Melbourne.

D) ECOSYSTEM SERVICES



Ecosystem services describe the benefits people receive from nature. Nature and natural infrastructure, whether pristine or engineered to meet specific service targets, provide many ecosystem service benefits to people.

The [Millennium Ecosystem Assessment \(MEA\)](#) offers a comprehensive and accessible framework to define and categorize benefits offered by large- and small-scale natural infrastructure.^v The MEA Framework organizes more than 20 ecosystem services into the following categories:

Provisioning Services: The products obtained from ecosystems (e.g. genetic resources, food and fiber, and fresh water)

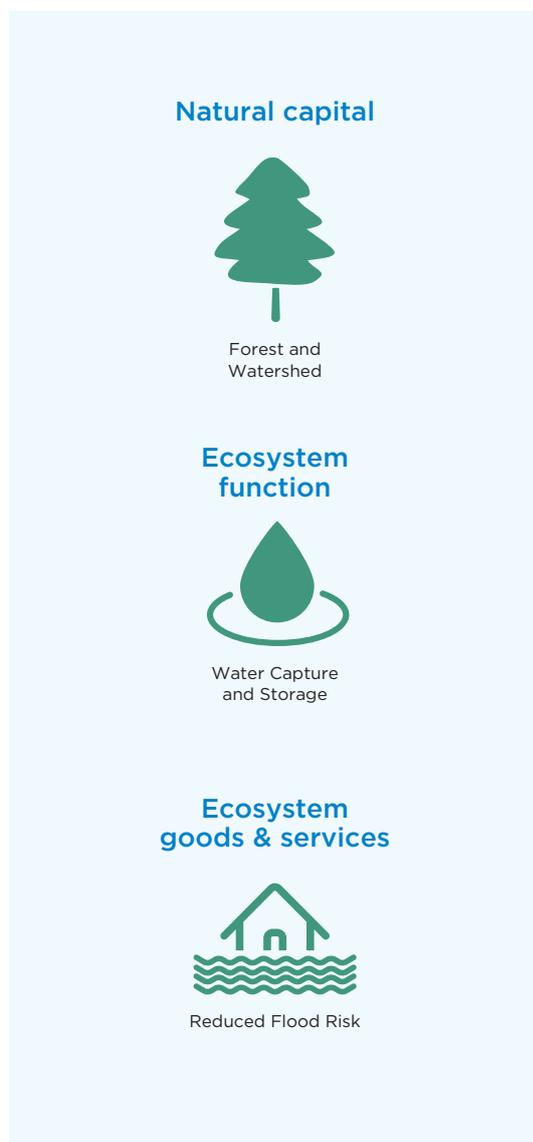
Regulating Services: The benefits obtained from the regulation of ecosystem processes (e.g. the regulation of climate, water, and some human diseases)

Supporting Services: Ecosystem services that are necessary for the maintenance of all other ecosystem services (e.g. habitat and genetic diversity)

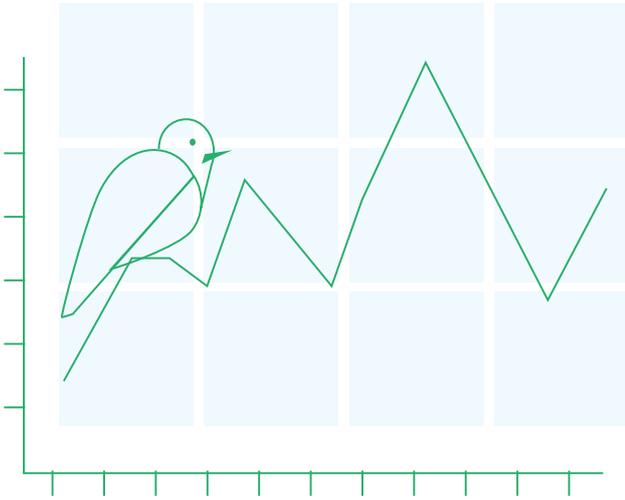
Cultural Services: The non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience (e.g. knowledge systems, social relations, and aesthetic values)

Ecosystem services can be understood and calculated as a consistent flow of economic value provided by nature year after year. Most natural infrastructure will provide a broad range of benefits of varying magnitude depending on ecosystem type (wetland vs. beach), climate zone (tropical vs. temperate), and ecosystem health (pristine or impaired).

Natural capital functions



E) MARKET VS NON-MARKET BENEFITS



When considering ecosystem services, values will often include both market and non-market components. A market benefit is literally the value at which a resource could be sold at market. For example, timber and fish have specific market values determined by location, type, demand, quality, and scarcity, among other factors. The value of a stand of timber or a school of fish could be calculated directly based on these characteristics and the going market rates. However, many ecosystem services such as pollination, recreation, mental health, and air quality are not and could not be easily traded in markets.

For non-market benefits, economists have developed a set of methods and tools to calculate their economic value to the community. For example, a portion of a hiking trail's recreation value is revealed by the expense that visitors are willing to incur to take a hike. The hiker's willingness to pay for travel, equipment, and lodging will be far higher for a national park than a community walking trail.

Replacement cost is another method that can be used to estimate the cost of replacing the service using man-made infrastructure, if the service were no longer provided. For example, if a city wanted to estimate the water capture, filtration, and storage value of a pristine watershed, it could assume that the value of these services is at least as great as the cost of replacing them with constructed reservoirs and filtration plants in the event that the natural watershed is damaged.

The point is that both market and non-market benefits represent real value to the community and economy and should be fully considered in decision making. Omitting non-market values because they are more difficult to calculate is shortsighted and perpetuates the long-standing bias towards grey infrastructure as the only viable solution to our problems.



CASE STUDY: MELBOURNE

While there is currently no total valuation for Melbourne's metropolitan trees, several local councils (e.g. City of Melbourne, Moreland and Banyule) have used iTree Eco to value aspects of their urban trees. A Melbourne University Masters study^{vi} attempted to value the benefits of Melbourne's total metropolitan street trees using i-Tree Eco. Incomplete data sets meant that the value of the street trees could be calculated in only 13 of the 32 local government areas. For these 13 local government areas, the structural street tree value was calculated to be A\$2.5 billion, based on replacement cost of individual trees with a similar tree based on size, species, health and location. Annual ecosystem service savings were estimated at A\$6.2 million including included air pollution removal, carbon storage and sequestration, and avoided runoff.

F) ECOSYSTEM HEALTH



Compared to impaired ecosystems, pristine and fully productive ecosystems provide significantly higher value in terms of the number and quantity of ecosystem services. The difference in ecosystem service levels will vary depending on the nature of the impairment. For example, a forest damaged in a hurricane may provide less habitat initially, but its ability to capture storm water may remain intact. Considering ecosystem health is important when assessing natural assets within urban areas

where “natural areas” are often highly impaired. A concrete-lined, polluted creek with no surrounding vegetation will provide few ecosystem services. Though the economic methods for equating the quantity and value of ecosystem services with ecosystem health are just now emerging, incorporating ecosystem health metrics into value estimates is important. The most basic approach is to simply scale down all the anticipated benefits based on a subjective assessment of ecosystem health compared to pristine conditions. If the wetland supports only half the historical population of the birds, plants and fish, then a rough value would be that ecosystem services are provisioned at 1/2 of the historic rate. With support from ecologists and site-specific data, much more granular estimates can be made for the impairment’s effect on individual ecosystem services, such as carbon sequestration and water management capacity, to derive a more granular understanding of how the value of benefits will be reduced.



Watershed restoration



3

Building a Business Case

A. NATURAL INFRASTRUCTURE IS REAL INFRASTRUCTURE

Natural infrastructure is real infrastructure that can be used by cities to meet specific goals and service targets like gallons of storm water filtered, storm surge reduction, or heat island mitigation. Until this is fully mainstreamed in urban planning and decision making, we will not see the level of funding and implementation required to effectively address critical urban challenges. Often, natural infrastructure can compete successfully with its grey infrastructure analogs on the basis of lifecycle cost, resilience value, and public support. Natural infrastructure can also be paired with grey solutions to reduce overall program cost and boost long-term performance of the combined facilities. While meeting specific service targets, natural infrastructure provides valuable co-benefits to the community and economy that grey projects do not. These additional benefits further enhance community resilience and well-being and increase the return-on-investment to the community.

Co-benefits describe the value of a natural capital asset beyond meeting a particular goal or service target. Co-benefits can be obvious, like providing a new recreation opportunity or a community gathering space, or subtler, such as improving soil stability or providing habitat for pollinators.

Failure to recognize and value these important co-benefits to communities and the economy has propelled many cities to make choices that degrade or eliminate nature, at a great cost to resilience, equity, and well-being, that is now being more fully realized.

There is a substantial body of literature that recognizes the benefits of a nature in the city. Nature and biodiversity in the city can provide:

Physical health benefits by encouraging physical activity - lowering obesity levels, reducing the incidence of some diseases, e.g. chronic heart disease. It is also beneficial for healing and pain relief. There are mixed results from studies about mortality and birth outcomes.

Mental health and well-being by reducing stress - stress reduction benefits across a range of outcomes including concentration and memory, impulse inhibition, aggression, stress relief, mood, self-esteem, childhood developmental behaviors, assisting people suffering depression, cancer and children with ADHD behaviors. Recent studies have also identified that there may be an indirect role for biodiversity in mental health.

Social cohesion by providing a welcoming shared space - increasing community and neighborhood connection, and reduced levels of fear and crime.

Preference for green spaces - people prefer vegetated urban areas to non-vegetated urban landscapes and that their choices bring about the resultant health and wellbeing values.

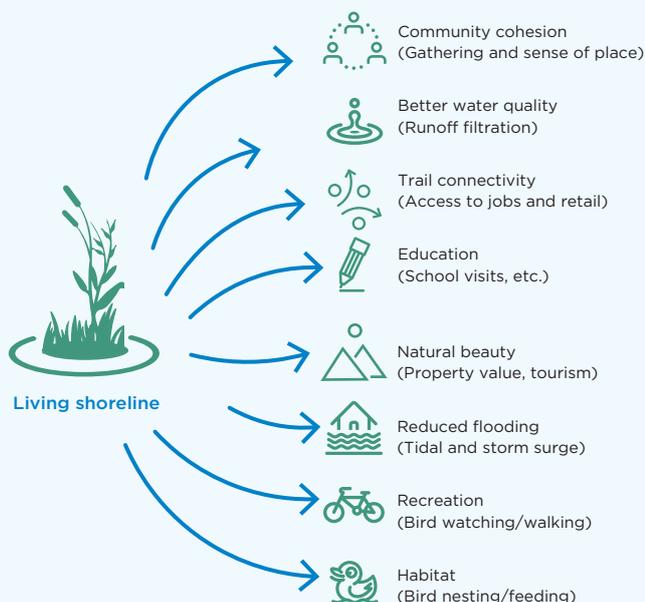
Biodiversity and the conservation of native species - benefits for species richness, habitat for native species and habitat for threatened species.

Ecosystem services: Cooling and air quality - vegetation generally, and large trees specifically, reduce urban heat both on the street and at a neighborhood level. Urban vegetation and especially trees, capture and filter multiple air pollutants, including ground-level ozone, sulphur dioxide, nitrogen oxides and particulate matter. ^{viii}

Natural infrastructure benefits

An example of natural infrastructure that offers co-benefits is living shorelines, which are more broadly beneficial than the more commonly deployed, single-purpose, armored shoreline protection.

An important characteristic of living shorelines and of much natural infrastructure is that they become more robust over time as they mature. This long-term stability and resilience of many natural infrastructure solutions contrasts starkly with grey infrastructure that degrades in performance over time as maintenance costs grow, and eventually the grey asset must be demolished and replaced entirely. Though not immune to damage, a living shoreline is more likely to recover fully and more quickly after a shock than a grey solution that may suffer costly damage or may even fail catastrophically. ^{vii}



B. EXAMPLES – CITIES ARE LEADING THE WAY

A number of cities have taken bold steps to expand nature in urban areas and deploy natural infrastructure to meet specific goals and enhance quality of life and resilience for their residents. The following are a few examples of how 100RC cities are putting these natural infrastructure concepts into action. For a longer list of examples refer to the accompanying matrix on the 100 Resilient Cities Online Community.



The global epidemic of urban tree canopy loss directly correlates with an overall decline in urban resilience and livability of our cities. In small and large cities alike, dwindling tree canopy and associated biodiversity loss contribute to worsening air pollution, urban flooding, sense of community and deadly urban heat islands. In the United States alone, the US Forest Service estimates that 36 million urban trees are lost each year.^{ix} Though architects are more likely than ever to design trees and greenspace into new buildings plans, the scale of planting is a fraction of the overall loss.

Melbourne's Urban Forest Initiative is a flagship action of the Resilient Melbourne strategy. Its primary objective is to ensure that strong natural assets and ecosystems exist alongside a growing population. It is linking existing urban greening, reforestation, and nature conservation initiatives across metropolitan Melbourne to improve wellbeing and reduce exposure to hazards such as heatwaves and flooding.

Population projections for metropolitan Melbourne anticipate close to a doubling of its current 5 million people by 2050. With such growth comes pressure to further expand the city's urban footprint. The urban growth boundary for Melbourne is around

3,000sq km although the metropolitan Melbourne geographical size is 10,000 sq km. Like many other cities, a strong correlation has been found between areas of socioeconomic and health disadvantage with a lack of green cover and a high incidence of heat.

Retaining canopy cover at existing levels, let alone increasing it, will be a challenge for Melbourne without concerted effort. Until about 1990, traditional residential development in Melbourne took the form of a detached house that occupied only about a third of a standard residential lot, with the remaining two-thirds of the lot used as a yard (i.e. green space). Since then, the physical form of new suburban development has changed dramatically. The current trajectory is for dwellings to cover over 40% and up to 65% of the lot, resulting in a significant loss of backyards, trees, biodiversity, and permeable surface.^x

Natural infrastructure also has a direct impact on property value and resulting tax revenue for the city. A literature review by the Victoria Institute of Strategic Studies^{xi} noted that the presence of trees increases the selling price of residential units from approximately two to nine percent, and that the proximity of open green space also correlates with an increase in property sales prices. Engineering

firm AECOM's Brilliant Cities Report^{xii} on green infrastructure estimated that an increase of 10% in the leaf canopy of street trees alone could increase the value of Sydney properties by an average of \$50,000 per unit (based on three suburbs).

By collaborating broadly across levels of government and sectors, the metropolitan urban forest strategy aims to scale successful approaches to increase canopy cover and vegetation, including green walls and roofs, and open spaces to protect and enhance biodiversity and collectively benefit

the city. It will help employ strategic decisions to value the benefits of an urban forest consistently across Melbourne's 32 municipalities. Using "the whole is greater than the sum of its parts" philosophy, the metropolitan urban forest strategy will drive innovative and progressive action using mapping, a compelling business case, and implementation funding incentives to encourage buy in for an urban forest that is future-focused and unified. The metropolitan urban forest strategy is due for delivery by mid-2019.

Singapore Garden City Building a Green Corridor^{xii}



After the Keretapi Tanah Melayu (KTM) Berhad (Malaysian Railways Limited) station was relocated from Tanjong Pagar to Woodlands on 1 July 2011, the Urban Redevelopment Authority (URA) embarked on one of its most extensive public engagement exercises to explore ways to develop the disused railway and its surrounding land, which became known as the Rail Corridor.

Various interest groups, residents, students, the general public and professionals were consulted via multiple means. To foster a stronger collaboration between public sector agencies and interest groups, a working group (Rail Corridor Consultant Group—RCCG, which was later renamed the Rail Corridor Partnership) comprising officers from the URA and the National Parks Board (NParks) as well as representatives from interest groups was created to programme and promote community activities and events along the Rail Corridor.

Design workshops and competitions were also held to generate interest among students and design professionals. More than 2,000 secondary and polytechnic students participated in workshops to reimagine how the Rail Corridor could foster a

sense of place and memory for youths in urbanised Singapore. These proposals then travelled around the nearby constituencies to gather feedback from the residents.

These residents—including seniors, children, and the physically challenged—also got to become 'planners' for a day when they were invited to draw up master plans to illustrate how stretches of the Rail Corridor near where they lived could be relevant to their needs.

The output of these consultations were distilled into planning and design goals to guide the conceptualisation and design of the Rail Corridor. As part of the request for proposal, "Rail Corridor—An Inspired and Extraordinary Community Space", a competition was held for design professionals to develop a Concept Master Plan and Concept Proposals for the Corridor. These proposals, informed by the extensive public consultation, produced designs that were better attuned to the needs of the communities living along the Rail Corridor.

Proctor Creek Greenway Atlanta

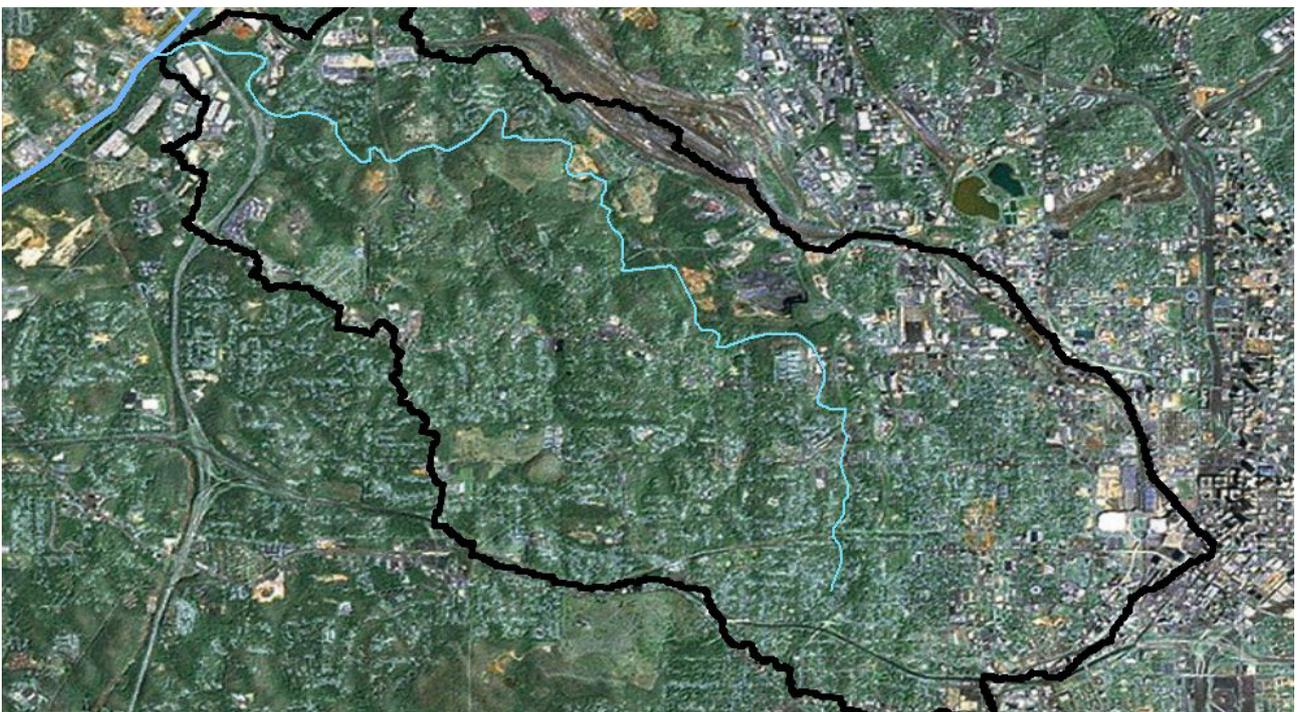


Wholly contained within the city's borders, Proctor Creek, a tributary of the Chattahoochee River, originates in downtown Atlanta and snakes through the economically depressed Westside neighborhoods five miles from city center, where more than 90% of residents are minorities. Within the 16 square miles of the Proctor Creek Watershed, over 50,000 people face poverty-related urban challenges like food deserts, health issues due to frequent flooding of sewage-contaminated water, and a high number of vacant and blighted properties.

The creek and surrounding lands have also been plagued for decades with environmental degradation including erosion, pollution from illegal dumping, and high bacteria levels from storm water runoff and sewer overflows; in 2013, the U.S. Environmental Protection Agency (EPA) designated Proctor Creek one of nineteen priority Urban Waters locations in the country.

To build upon the work being done to improve water and soil quality and shore up sewer infrastructure, one of the initiatives of Atlanta's Resilience Strategy was to construct the first segment of the new Proctor Creek Greenway trail. This will contribute to the Resilience Strategy's wider goals of creating 500 new acres of publicly accessible greenspace across the city by 2022.

Complete with biking and pedestrian trails, the Proctor Creek Greenway offers multiple co-benefits from a single intervention, as it will facilitate exercise and healthy living, enhance Atlanta's natural assets, and foster economic development in an area of the city which faces considerable environmental and economic challenges. The resilient Greenway project will leverage green infrastructure to curb flooding and runoff, provide local residents with increased connectivity to other areas of Atlanta, and foster a sense of an overall more cohesive community.



On May 7, 2018, that first segment of the Greenway—three out of the eventual seven total miles—officially opened to the public. In a ribbon-cutting ceremony, former Chief Resilience Officer (CRO) Stephanie Stuckey said she is “proud to see this project come to fruition and connect an underserved part of Atlanta to areas seeing progressive growth and development.”

The trail was funded through a \$160,000 investment from the Atlanta Department of Watershed Management and a \$3.6 million investment from a transportation-oriented special-purpose sales tax (TSPLOST) endorsed by voters in 2016. This first three miles of the Proctor Creek Greenway are an impressive model of thoughtful, resilient trail infrastructure. It serves as the kickoff segment to a grander inter-connected trail system.

At the inauguration of the new Greenway, Mayor Keisha Lance Bottoms stated that, thanks to this initiative, “a once overwhelmingly polluted waterway has been revitalized to provide

historically isolated neighborhoods greater access to nearby parks, schools, and restaurants.”

The vision for the Proctor Creek Greenway Trail is to expand from three to seven miles. On the southern end, the Greenway will connect the Westside Beltline Trail to Quarry Park (the largest park in the City of Atlanta), and on the northern end, the Trail will continue running alongside Proctor Creek to create a critical access point to the Chattahoochee River. Once complete, the continuous greenway will feature 400 acres of green space and 50 acres of linear park, and it will connect scores of isolated neighborhoods in West and Northwest Atlanta to schools, restaurants, and transit. Moreover, when Cobb County and Fulton County build their respective river walks that traverse the Chattahoochee, the Proctor Creek Greenway will eventually link downtown Atlanta to the Silver Comet Trail that runs all the way out to Alabama.^{xiv}

Panama City's Diverse Watershed and Mangrove Forests



Panama City is a city of almost 801,000 people and is one of the fastest-growing economies in Latin America. As part of its strategy development, Panama City requested an ecosystem service valuation of its substantial natural assets, including its vital mangrove forests, fisheries, and biodiverse watersheds. As development pressure threatens to fragment Panama City's rich natural areas, city leaders realize they need to calculate and communicate nature's value to decision makers and the public. Earth Economics prepared a summary valuation that identified a minimum of \$1.6 billion in critical ecosystem services contributed each year to the city and regional economy.

As part of its recently released strategy, Panama City will seek to conduct more integral benefit-cost analyses to capture a wider range of benefits and understand not only the value provided today but also the repercussions if productive ecosystems are converted to urban development. This type of data will be of particular value to decision makers evaluating a variety of preservation vs. development options.^{xv}

Rotterdam's Climate Proof ZoHo Resilience District



Climate Proof ZoHo shows the implementation of the Rotterdam Climate Adaptation Strategy at the district scale. ZoHo has been established as an urban laboratory in Rotterdam where promising climate measures are combined with the urban transition and its local initiatives. Climate Proof ZoHo aims to make the Zomerhofkwartier a more resilient and vital district at the same time.

The Zomerhofkwartier and Agniesebuurt are among the areas in delta city Rotterdam that are vulnerable to the effects of heavy rainfall, extended periods of drought, and heat stress. With our Benthemplein Watersquare, Rotterdam took the first step toward climate proofing ZoHo. The next step is to enlarge the climate proof area. After years of decline, local entrepreneurs, creative professionals, and neighborhood associations have settled in ZoHo to experiment with re-programming the area with new ways of development. The Climate Proof

Zomerhofkwartier initiative combines this urban transformation with innovative resilience measures based on the Rotterdam Adaptation Strategy. The process included a deep analysis of the district climate conditions and a series of workshops where Zomerhofkwartier inhabitants and professionals were working together to define specific strategies and a shared perspective to follow.

In this perspective, impervious surfaces like pavement and concrete are replaced with permeable pavement and green public spaces that improve water infiltration and storage, which helps make the network of streets and public spaces more attractive. Several pilot projects are slated for the district; some of them can already be enjoyed, and others will be realized soon. Climate proofing ZOHO is a process and a work in progress, but the city is committed to making it a reality.^{xvi}

A vibrant park scene featuring a large pond in the foreground with a single duck swimming. The background is filled with lush green trees and people walking on a path. A white rectangular box is overlaid on the center of the image, containing text.

4

Take action!

4 Basic steps to introducing
nature in cities

Though there is much interest in expanding nature and natural infrastructure in cities, progress toward implementation has been slow and fragmented. Decades spent designing and deploying heavily engineered solutions have institutionalized a deep culture and expertise around grey infrastructure that is difficult to shift. But without seriously considering natural infrastructure, all cities may be missing cost-effective, highly resilient solutions to their challenges. The good news is that basic steps can be relatively easy to undertake.

Every city starts from a different place in terms of challenges and assets. Some cities, like Boulder, have abundant, healthy natural assets paired with serious threats from flood, wildfire, climate change, and water insecurity. Other cities, like Jakarta, face critical issues of lowland, coastal flooding and poor surface water quality due to millions of people using the city's rivers for washing, cooking, and sanitation. Though they are starting from different places, each city can take the same specific steps to assess their natural assets and consider opportunities to implement natural infrastructure solutions to mitigate and adapt to shocks and stresses.

The following specific activities can be incorporated by Chief Resilience Officers into their Resilience Strategy development and implementation process. Each is presented with an overview, problem statement, and an example or two. Each activity can be customized for individual city needs and goals.

A) BUILD AWARENESS AND COLLABORATE

While each city may have a small number of advocates who are knowledgeable about nature and natural infrastructure, city-wide awareness of the concepts and a shared vocabulary for discussing them are frequently missing. This lack of a shared understanding may be the most important barrier that cities face in mainstreaming natural infrastructure. When done well, awareness building can bring together city departments with shared goals to design and implement innovative, multi-benefit projects. Awareness building about the benefits of natural infrastructure can also help to rebrand nature, which, for many urban residents, is

associated with polluted, trash-filled streams and dark, threatening parks.

The goal of awareness building is to empower local stakeholders to convey natural infrastructure and ecosystem service concepts in a way most relevant to their own context and challenges. With this shared information and perspective, residents will advocate for natural infrastructure and the city can have more productive discussions and identify new partnerships and funding mechanisms. The following activities are example starting points for many cities.

Host a Natural Infrastructure Workshop with Local Stakeholders

Host a full day workshop with leaders and technical staff from multiple departments to provide basic concepts, followed by hands-on work in cross-disciplinary teams to design a real or conceptual natural infrastructure project for the city. The activity should identify and estimate benefits from existing or planned implementations, identify potential project stakeholders, and consider innovative financing mechanisms that link benefit providers and beneficiaries.



CROs exchanging ideas at the 100 Resilient Cities' Urban Resilience Summit, New York, 2018.

Connect with Peers and Partners

A growing number of cities and organizations are planning and deploying creative, multi-benefit, natural infrastructure projects. It can be incredibly valuable to invite leaders to your workshop or to at least connect informally to gather lessons learned. Review the natural infrastructure project matrix (available for viewing on the 100 Resilient Cities online community) and become familiar with approaches taken by other cities around the world. Use the 100RC online community tool and connect with other CRO's on what has worked, what hasn't, and how you might leverage such knowledge to demonstrate success and plan for your own implementation.

Get the community involved

Citizen Science involves public participation and collaboration in scientific research with the aim to increase scientific knowledge^{xvii} Citizen science calls on citizens to observe, interact with and monitor what exists in the world around them inspiring experiential learning and stewardship. Citizen science nature programs, such as Australia's [Aussie Backyard Bird Count](#) and the City of Melbourne's [Citizen Forester](#) program, raise the profile and value of nature within the community in a place based manner. It's a great way to harness community skills and passion to fuel the capacity of science to answer our questions about the world and how it works.



Bioblitz (citizen science program) in Melbourne. City of Melbourne.

B)



IMPLEMENT SMALL, PILOT PROJECTS AND QUANTIFY THE BENEFITS

Real progress cannot be made until city leaders and technicians gain firsthand experience with nature-based projects and witness performance, cost effectiveness, and durability for themselves. Chief Resilience Officers can define projects during strategy development to inform the larger vision or weave projects into implementation. Either way, until stakeholders get their hands dirty, uncertainty and misinformation can slow or stop progress. This pilot-scale work should be conducted by core technical and planning staff that also manage traditional capital assets and projects. Implementation by special “green” project teams reinforces that these solutions are “different” and require special handling. Remember, the more natural infrastructure projects are able to follow the standard procedures, the more likely they will become core to long-term planning.

In some cases, it may be most practical to conduct a holistic benefit-cost analysis (BCA) of an existing project that involves natural infrastructure. Most likely, analysis of the original project did not include the full suite of benefits. This type of retrospective analysis can be illuminating, because the team can literally see the benefits. A holistic BCA seeks to calculate all benefits of a project in economic values, not only the direct service goals. For example, a flood control project that includes a waterfront walking path would capture benefits of recreation and exercise, improved connectivity between neighborhoods, and the boost to local real estate value, among others. When necessary data is not available to complete detailed estimates, then directional (positive and negative) indicators can



Native wildflowers for biodiversity and storm water treatment. City of Melbourne.

be applied instead. Similarly, for a holistic analysis of grey infrastructure, projects should include the related costs such as loss of ecosystem services when developing open space.

Cities might also choose to conduct a small-scale demonstration project that meets a service need, e.g. storm water control, but also provides broad co-benefits and conducts a holistic BCA. Again, this will provide stakeholders with a real-life example they can carry forward when advocating for larger, more complex initiatives. Of course, some cities may have a need and capability to launch directly into full-scale projects. Whether the project is large or small, the seven qualities of resilience promoted by 100RC may be valuable for helping to consider intervention and infrastructure goals, as well as defining co-benefits: Reflectiveness, Resourcefulness, Robustness, Redundancy, Flexibility, Integration, and Inclusiveness.

C) CONDUCT A POLICY AND PROCEDURE REVIEW

Long-term change at scale requires supporting policy mechanisms and procedures that build institutional memory and practice to make the management of natural infrastructure assets routine and efficient. This is the same support that is already in place for other types of urban infrastructure. While each city's challenges and opportunities will be different with regard to defining and implementing natural capital solutions, there are several steps that will likely be beneficial for all.

Formally Adopt a Natural Infrastructure Policy

A formal statement from city leaders (mayor's office, council, etc.) that reinforces the goal that natural infrastructure be considered alongside grey infrastructure to meet core city needs is critical and helps to drive adoption and consistency. Without a formal statement and clear direction from city leadership, natural infrastructure projects are unlikely to gain much traction. Many cities will have a corporate or community vision that includes protecting or improving the natural environment. Use this as a starting point and demonstrate natural infrastructure projects can support this goal while providing many other benefits. Ideally, the statement is simple and allows individual departments to apply the concepts to best meet their own needs and goals. Again, this policy does not pre-suppose that natural infrastructure is the best solution, but only that it should be considered seriously where core infrastructure decisions are made.

Require Inclusion and Evaluation of Natural Infrastructure in Planning

Because natural infrastructure solutions are often not considered as "real" solutions to core challenges, they are not considered in traditional decision-making tools like benefit-cost analysis and return-on-investment calculations. When left out of an analysis, the value of nature is deemed to be zero by default. At a minimum, change in ecosystem service values should be counted as directional indicators, positive or negative. This assures that the benefit providers and beneficiaries at least are aware and engaged in



Community planting. City of Moreland -Melbourne

the process. A city with more valuation experience will want to include detailed economic valuation data for a range of environmental, social, and economic benefits in strategy development and implementation planning. Again, natural infrastructure will not always be the right solution, but if a natural infrastructure project or a blended natural/grey project seems viable to meet project goals, the city should have the tools and capability to complete a robust comparable analysis.

Inventory Nature and Natural Infrastructure and Quantify Their Ecosystem Services

Most cities spend significant time and effort identifying and managing their built capital assets: buildings, pipes, roads, and bridges. The same cannot be said about natural infrastructure and the valuable services and co-benefits that they provide. For example, the parks department will have an inventory of city parks under management but will almost certainly not have even a qualitative estimate of the amount of storm water captured by these parks and the subsequent reduction in urban flooding.

Though detailed valuation of these assets and benefits may not be feasible, gaining a directional or qualitative understanding of each asset and benefit is an important first step. More advanced cities will work with experts to produce a detailed spatial inventory of assets along with a database of value

per-hectare, per-year values for ecosystem services by different land and asset types. Depending on need, values may be high-level or granular. Finally, the most advanced cities will incorporate the value, maintenance, and lifecycle of natural capital directly in their enterprise asset management software. Any progress documenting and tracking natural assets will foster more effective, long-term planning and management.

As with resilience planning overall, the approach to these tasks will vary based on each city's challenges, capacity, and overall strategy. However, taking these basic steps will ensure that each city is able to apply their full suite of assets to achieving city-level resilience goals.

D) **RESPOND TO COMMON PUSHBACK IN A CLEAR, PROACTIVE MANNER**

Even in cities that prioritize nature and natural infrastructure, there are often many barriers that slow or stop the design and implementation of natural infrastructure projects. Significant energy and focus are required to make the case for nature and natural infrastructure solutions, even when the benefit-cost ratio is positive and there is broad community support. Even the most persuasive data and arguments may receive pushback for reasons described throughout this paper. The following responses to common challenges can help smooth the way.



Pushback 1: We have other priorities as a city - natural infrastructure will need to wait.

Response: The diverse benefits and uses of natural infrastructure serve to simultaneously address many priorities and challenges. Even cities focused on non-environmental shocks and stresses would benefit from a more detailed understanding of their natural assets and the many ways they support the local community and economy. Parks and natural areas can provide gathering spaces for the community, building the valuable social capital that is critical to community resilience. A healthy river can rebuild community pride across ethnic, economic, and social lines. Similarly, communities with rich natural resources may be able to commercialize that through, for example, the growth of an eco-tourism economy that attracts new spending and investment.



Pushback 2: We need the business case for natural infrastructure before we can proceed.

Response: The lack of a business case for natural infrastructure is one of the most common barriers

cited by planners and city leaders. In some cases, this feels like cities are waiting to be handed a neatly packaged solution. This will likely not ever happen. City stakeholders must apply their own expertise and experience to find natural infrastructure opportunities and work through the many barriers to implementation. This is hard, creative work that requires a strong support network and persistence. The steps outlined here provide a good starting place.



Pushback 3: We cannot afford to implement natural infrastructure.

Response: This statement requires a two-part response. First, in most cities, there is a significant sum of money invested in building and maintaining built infrastructure and recovering from shocks and stresses. Hurricane Harvey in the Southern United States caused more than \$150 billion in damages alone.^{xviii} Even smaller, less wealthy cities spend relatively large sums on traditional infrastructure like water systems and transportation. With thoughtful planning and insight, money that is already flowing through every city can be tapped to support natural infrastructure planning and

construction in place of grey infrastructure, as and when appropriate. Tapping these existing budgets may well be easier than creating entirely novel funding sources with new rules and expectations. However, until we discuss, design, and implement natural infrastructure as “real” infrastructure, this likely won’t happen.

Second, in some cases, cities cannot afford to not invest in natural infrastructure. As discussed above, natural infrastructure can provide less expensive, more resilient solutions to many urban challenges while providing substantial co-benefits. This powerful fact helps to rally and unite stakeholders and advocates from different political and economic corners.

Pushback 4: We are not allowed to use ecosystem service values.

Response: Even the most well informed and motivated advocates run into many tactical roadblocks to inclusion of ecosystem services in project and financing decisions. Smoothing the path to widespread adoption of natural infrastructure

requires a focused effort within each city to identify, prioritize, and resolve specific barriers that impede progress. Barriers may include lack of awareness, access to training, data availability, or motivation. This work requires time and can be tedious, but the long-term benefits in terms of improved decision making are substantial.

Pushback 5: We’ve implemented natural infrastructure, but our problems are still here.

Response: This is typically an issue of scale. The problems we face are substantial, but we are still doling out natural infrastructure in bits and pieces. Think of the scale of our water or transportation systems: most cities have invested billions of dollars to make these platforms stable, efficient, and resilient. The same will not be true of natural infrastructure, in terms of geographic and economic scale, until we begin to implement solutions at a municipal scale with requisite, sustainable long-term funding mechanisms.



Thornton Creek, Seattle, WA

The Role of 100RC Partners

Through the 100RC Network and via direct work with cities around the world, partners are critical to the protection of natural assets and advancement of natural infrastructure. Engineers, planners, and financiers help cities understand and address many of their social, economic, and environmental resilience challenges. However, a large percentage of experts, whether in the private or public sector, learned and developed their skills at a time when most problems were addressed with single-purpose, grey infrastructure solutions. Not to fault anyone, but this is simply how problems were solved until very recently. Like city staff and community residents, 100RC partners can grow their natural infrastructure awareness and technical skills and immediately apply these new skills in their work with cities. Through professional associations and networks, partners can spread best practices and implementation tools rapidly to city staff and community members eager for change.

Many of the actions described for Chief Resilience Officers in the pages above can also be applied to partners and their work with cities. For example, engineering and planning firms can host internal natural infrastructure workshops to build vocabulary and awareness across internal technical support and implementation teams. They can also identify internal barriers within their firms that reduce the likelihood that nature-based solutions will be prioritized and submitted to clients. When natural infrastructure projects are designed and constructed, firms can ensure that robust construction and operational cost and technical performance data collection are built into each project and shared widely to advance the field.

Partners with expertise in project financing, insurance, and evaluation can similarly look for opportunities to level the playing field for natural infrastructure projects. Instruments that were developed specifically to implement single-purpose, grey infrastructure tend to be insufficient to address complex, multi-purpose projects that provide a mixture of market and non-market benefits and require input from diverse stakeholders. New approaches and tools are needed to help cities successfully create projects to a scale that address the challenges and are appealing to lenders.



Natural infrastructure projects often provide enhanced resilience and more rapid recovery to shocks

Lenders should also be able to leverage the fact that natural infrastructure projects often provide enhanced resilience and more rapid recovery to shocks, but these values are rarely considered when designing financial instruments and setting rates.

Partners have a unique opportunity to advance the field while providing clients with high-performing, cost-effective solutions to resilience challenges, but success will depend on hard work and broad collaboration within this quickly evolving field.

A Pivotal Opportunity for Cities

The opportunity to build and rebuild resilient and healthy communities by taking advantage of natural infrastructure's many benefits is available to every city.

While there will be many challenges, these solutions will provide some of the most productive and cost-effective options to meet cities' challenges. At the same time, they will provide valuable co-benefits that will make cities better places to live for residents struggling with a broad array of shocks and stresses.

The Chief Resilience Officers, partners, and the overall 100RC community are uniquely positioned to help cities learn and rebuild nature as a core part of their long-term resilience strategies.

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