Forests and sustainable cities

Inspiring stories from around the world

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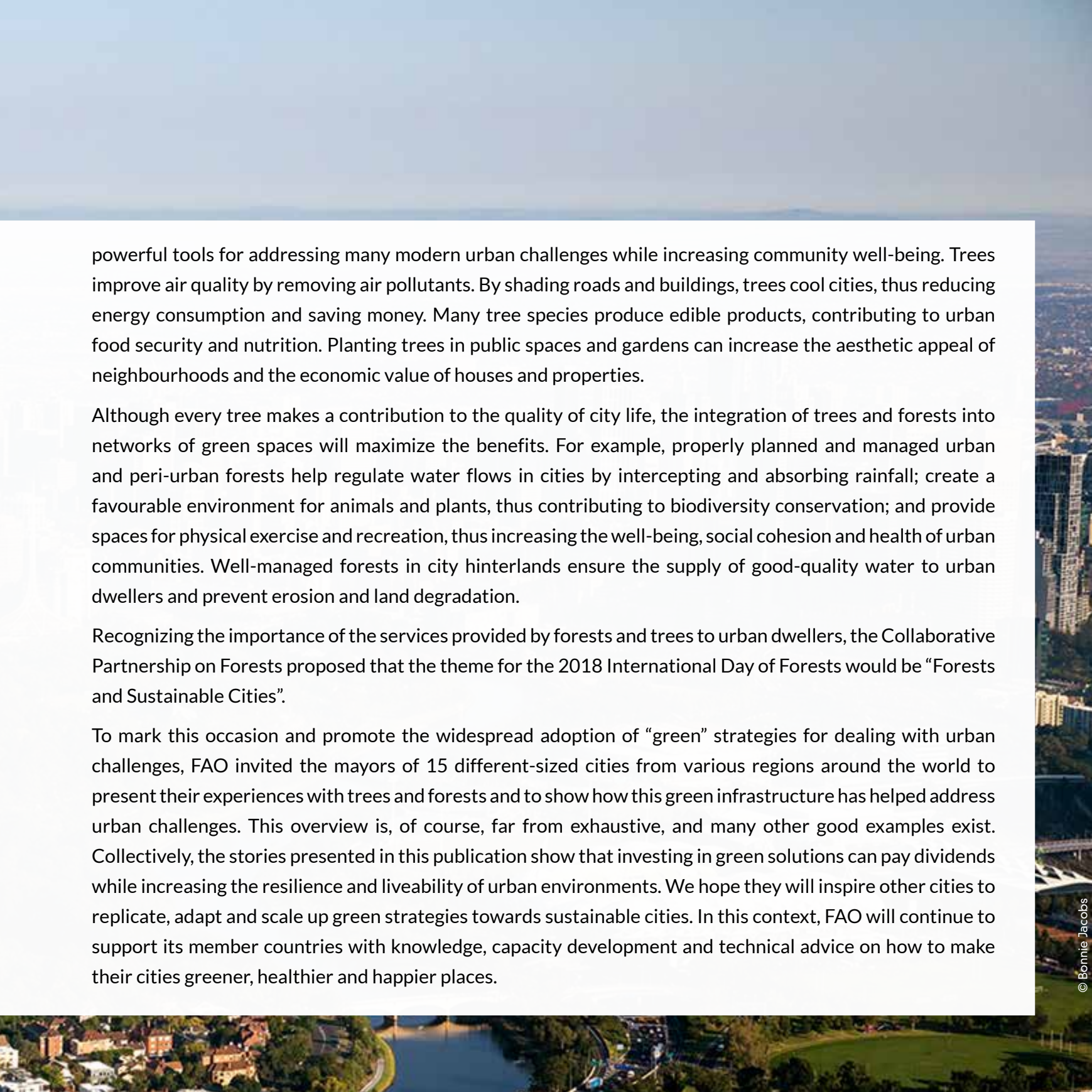Inspiring stories from around the world

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Introduction

Cities can be great hubs for ideas, culture, science, productivity, commerce and social development, offering citizens diverse opportunities for employment, education and lifestyle. The potential of cities is under threat, however, from unprecedented urban growth and an exponential increase in the global urban population. In many cities worldwide, the well-being of communities is at risk to escalating pollution, environmental degradation, demand for water, food and energy, and unemployment, and there is a lack of high-quality public spaces for socializing and recreation.

Many city administrations are struggling to respond to the demands of their rapidly growing populations, especially in lower- and middle-income countries, where urban population growth has often not gone hand in hand with socio-economic development. A lack of capacity to deal with the challenges posed by uncontrolled urban population growth is leading to poverty and hunger, exacerbating social exclusion, and increasing the gap between poor and rich. This challenge was also recognized by the United Nations General Assembly, which, in Sustainable Development Goal 11, calls for "making cities and human settlements inclusive, safe, resilient and sustainable". Indeed, urban planners and city administrators face daily challenges in maintaining sufficient healthy and safe food, clean water, clean air, energy, housing and green spaces and addressing conflicts of interest related to land use.

Solutions are at hand, however. In recent decades, some cities have started to change towards a greener, more sustainable and more resilient model of urban development. They are investing in forests, wetlands and other green spaces – "green infrastructure" – to tackle urban issues previously addressed with engineered solutions that often involve concrete, asphalt and steel. Properly planned, green infrastructure can be cheaper to establish and maintain than engineered solutions while performing similar functions, generating income and employment and increasing the quality of the urban environment. When fully integrated into local urban planning and management, trees and forests can help transform cities into more sustainable, resilient, healthy, equitable and pleasant places to live.

As the stories in this publication show, the results can be stunning. Often underestimated, trees can be

powerful tools for addressing many modern urban challenges while increasing community well-being. Trees improve air quality by removing air pollutants. By shading roads and buildings, trees cool cities, thus reducing energy consumption and saving money. Many tree species produce edible products, contributing to urban food security and nutrition. Planting trees in public spaces and gardens can increase the aesthetic appeal of neighbourhoods and the economic value of houses and properties.

Although every tree makes a contribution to the quality of city life, the integration of trees and forests into networks of green spaces will maximize the benefits. For example, properly planned and managed urban and peri-urban forests help regulate water flows in cities by intercepting and absorbing rainfall; create a favourable environment for animals and plants, thus contributing to biodiversity conservation; and provide spaces for physical exercise and recreation, thus increasing the well-being, social cohesion and health of urban communities. Well-managed forests in city hinterlands ensure the supply of good-quality water to urban dwellers and prevent erosion and land degradation.

Recognizing the importance of the services provided by forests and trees to urban dwellers, the Collaborative Partnership on Forests proposed that the theme for the 2018 International Day of Forests would be "Forests and Sustainable Cities".

To mark this occasion and promote the widespread adoption of "green" strategies for dealing with urban challenges, FAO invited the mayors of 15 different-sized cities from various regions around the world to present their experiences with trees and forests and to show how this green infrastructure has helped address urban challenges. This overview is, of course, far from exhaustive, and many other good examples exist. Collectively, the stories presented in this publication show that investing in green solutions can pay dividends while increasing the resilience and liveability of urban environments. We hope they will inspire other cities to replicate, adapt and scale up green strategies towards sustainable cities. In this context, FAO will continue to support its member countries with knowledge, capacity development and technical advice on how to make their cities greener, healthier and happier places.

People power is bringing green and blue back to Bangkok

8.3 million
Population

156 890 hectares
Land area

5 312 hectares
Public green space

6.4 m^2
Green space per person
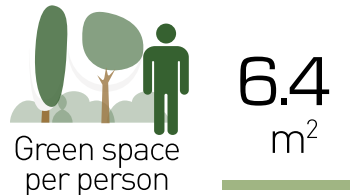
Once upon a time, not so long ago, Bangkok was full of natural green infrastructure – canals, rice fields, mangroves and fruit orchards. People used to travel by boat; every household had a pond for storing rainwater, and people enjoyed the fresh rice and fruits grown in their backyards. They built their houses on stilts, and groceries, noodles and even mail were brought by boat to the doorstep.

Bangkok got its name from a fruit, a Thai version of the olive. Many areas in the city are also named after native plants, such as Bang Kruay, Bang Bon, Bang Sai, Bang Taboon, Bang Na and Bang Kae.

Partnerships are emerging among institutions, companies and communities to protect and create urban forests and restore waterways

Prepared by Oraya Sutabutr and Chantima Soipetch
Big Trees Project, Bangkok

Volunteer tree-carers receive training at historic Thammasat University

Urban nightmare

Older folk can still remember swimming in clean Bangkok canals, but this would be unthinkable today: Bangkok is now an urban nightmare, notorious for its traffic, tangled electrical wires and tiny green spaces.

Looking back on this idyllic past, one cannot help wonder why people have turned away from the practical livelihoods of yesteryear, which were so well suited to the natural environment.

Sirintra Vanno at Chulalongkorn University writes that, "… Our canals have been replaced by roads … resulting in the replacement of trees and green spaces where formerly water could be … absorbed. Agricultural areas of many square kilometres were suburbanized and affected by the development of new homes and private housing communities".

According to Chatchai Ngern-saengruay at Kasetsart University, an area of large grown trees covering 1 600 square metres can provide enough oxygen for ten people. With more than 8 million people, Bangkok would need 16 000 hectares of grown trees, but it has only 3 056 hectares.

Bringing back green and blue

Little by little, however, the tide may be turning.

The Bangkok Metropolitan Administration had plans to increase public green spaces by 8 square kilometres by 2016, with a budget of USD 13.7 million. According to Arom Wongmaha (Head of the public parks section of the Bangkok Metropolitan Administration's Environment Office) the budget was spent to create new parks in outlying areas of Bangkok. As a result, the green public spaces of the city increased by 1.92 square kilometres, with a consequent increase of green space per capita from 6.17 square metres/person in 2016 to 6.41 square metres/person in 2017. According to Prof. Decha Boonkham, designer of many public parks in Bangkok and founder of

A community park in Bang Kachao, across the Chao Phraya River from Bangkok

the Thai Association of Landscape Architecture, much more could be done if the many currently vacant areas of the city were converted into urban parks and if the Bangkok Metropolitan Administration invested in increasing its expertise in urban forest practices by employing qualified arborists to properly look after the trees of the city.

Some outlying parks, such as Beung Nong Bon and Beung Makhamtes, have been cleverly designed as water catchment areas while preserving original landscapes such as rice fields and fruit orchards. According to Prof. Boonkham, however, increasing green spaces more effectively requires the Bangkok Metropolitan Administration to work closely with professionals, civic groups and the private sector. In addition to increasing public participation to the management of the urban forest of the city, this would complement the existing expertise of the Bangkok Metropolitan Administration in green space design, tree planting and tree care, among other things.

Public, private and people power

One collaborative project is the "60 Parks for Princess Sirindhorn Project", which was initiated in 2014 by the Big Trees Project with funding from the PTT Group, the Siam Commercial Bank and the Thai Health Promotion Foundation. The aim of the project was to provide local administrations with volunteer landscape architects to help in establishing public parks around the country. Ten parks have been created in Bangkok with a focus on the original or native vegetation – such as the mangrove forest parks in Bang Kachao and Bang Khuntien to help protect coastal areas and communities.

The private sector has also contributed. Notably, the PTT Group's landfill-turned-ecopark, "Metro Forest", showcases native plants for ecological and educational purposes. Chulalongkorn University, one of the key players in professional arboricultural training and green space conservation efforts, has created a magnificent public park on its own land in the middle of the city. The Chulalongkorn University Centenary Park covers 40 hectares and has a wetland, a rain garden, and an underground water drainage system.

Another promising development is the establishment, in 2016, of the Thailand Urban Tree Network, which brings together public and private entities, professionals and civic groups to advance urban forestry in Bangkok. The network is a product of much greater public awareness about urban

forestry in recent years, and citizens' groups are now taking matters into their own hands, urging parties to work together on green space protection and improvement.

Joint projects executed by the network include the inspection and rehabilitation of historic trees, the recruitment and training of tree-care volunteers, a volunteer "tree watch" programme, and collaboration with authorities to improve public tree care. Among the network's partners are the Royal Forestry Department and the Fine Arts Department. The Royal Forestry Department increasingly welcomes collaboration with non-government sectors in the inspection and rehabilitation of historic trees in urban areas – such as Bangkok's tamarind trees and Ayuthaya's famous Bodhi trees.

The Thailand Urban Tree Network co-hosted the country's first international arboriculture certificate training course in November 2017 in conjunction with the Singapore Arboriculture Society and the New Zealand Arboricultural Association. Training programmes in basic arboriculture have given rise to volunteer tree groups, such as the "Community Arborist Club", which is answering calls to inspect and rehabilitate trees in public places, thereby shouldering some of the responsibilities of authorities.

Also on the rise are urban farms – especially in outer Bangkok areas – initiated by citizens' groups, which feature shady trees and ponds and illustrate the desire among urban residents for more greenery. The Thai Marine Department is tasked with cleaning up Bangkok's canals, reintroducing natural water plants, and improving boat services.

Learning from the past

Sometimes the situation in Bangkok seems bleak, but efforts are underway to correct the mistakes of the past. The public is becoming more vigilant, organized and mobilized, and they will not keep quiet. Authorities and private companies, therefore, are becoming increasingly aware of the need to conserve and increase urban trees and green spaces. If the government sector, commercial entities, arborists, landscape architects and civil-society groups work together for long enough through formalized partnerships and with the public interest in mind, Bangkok has the potential to become a greener city.
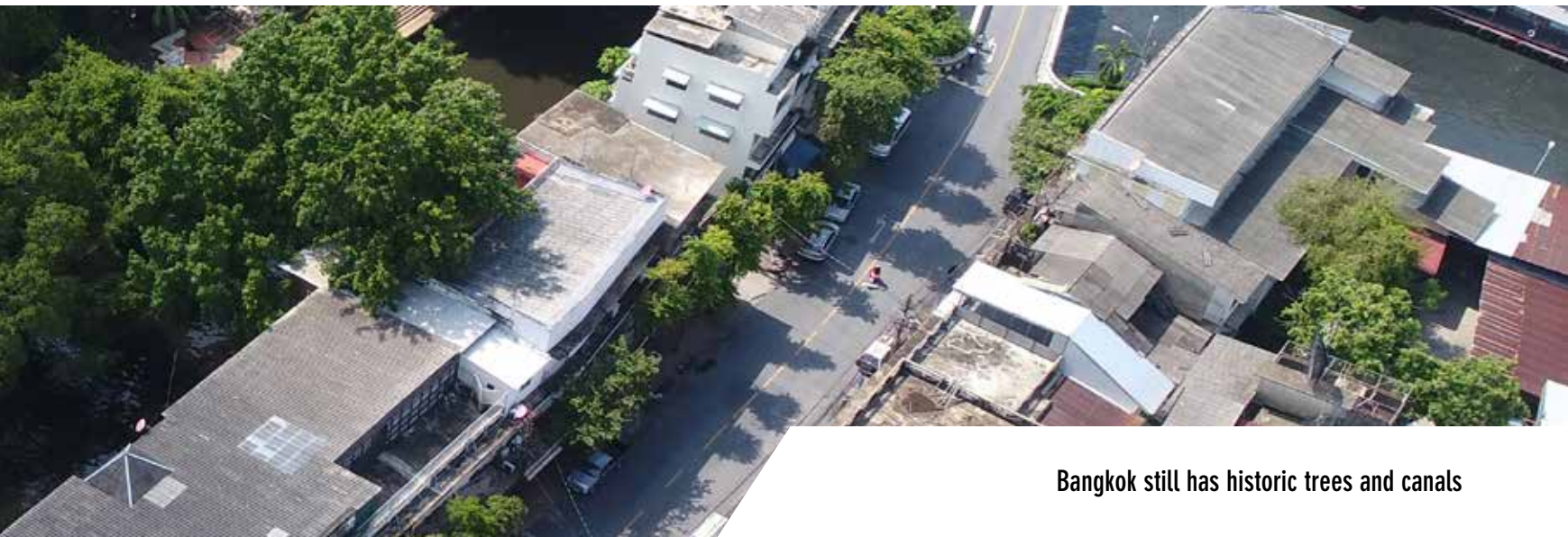
Bangkok still has historic trees and canals

Trees: the cool approach to city cooling in Phoenix, Arizona

1.6 million
Population

134 420 hectares
Land area

16 252 hectares
Public green space

100.0 m^2
Green space per person
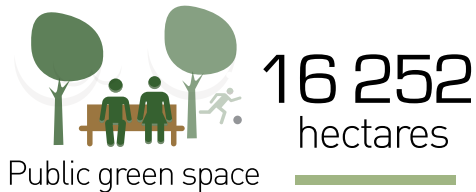
Phoenix – the capital city of Arizona in the United States of America – is a hot place: on average, the temperature reaches 100 °F (37.8 °C) or higher on 109 days per year. In the early 1900s, Phoenix was known as the "City of Gardens and Trees". But the city's shift from a small agrarian-based community in the Sonoran Desert to one of the country's largest cities has come with growing pains.

Rapid urbanization since 1950 has led to a decline in community green spaces and tree canopy, creating significant issues with urban heat. Climate researchers have charted daytime temperature increases of 5.5 °F (3 °C) between 1948 and 2000 and night-time increases of 9 °F (5 °C). This change is due in part to urban sprawl – replacing the desert and agricultural lands with buildings, concrete and pavements. Urban growth has meant increases in power consumption, vehicle emissions and urban heat.

This American city is turning back to trees to cool its overheated urban environment

Prepared by Richard Adkins
City of Phoenix Parks and Recreation

Young trees provide residents with welcome shade on a hot afternoon. Trees are making a comeback in Phoenix

© City of Phoenix

Bringing back trees

To tackle its problem of overheating, city management is partnering with the business community, non-profit organizations and citizens to bring back trees, shade and green spaces as a significant component of the development process in Phoenix.

The Mayor and the City Council adopted the Tree and Shade Master Plan in 2010, which focuses on increasing the tree and shade canopy. It is "an investment strategy of creating a healthier, more liveable and prosperous Phoenix", said Mayor Phil Gordon when he introduced the plan.

Addressing the problem of urban heat and growing the tree canopy is also a major component of the city's sustainability plan, according to chief sustainability officer Mark Hartman. "I view trees as an amazing technology which provides numerous benefits to support both the built and natural environments", he says.

Valley of the Sun

Phoenix is Arizona's largest city and centre of the "Valley of the Sun" metropolitan area, which covers 14 600 square miles (about 38 000 square kilometres), includes 26 cities and towns, and is home to more than 4.5 million people. Partnering with neighbouring communities to share ideas and plan for the future is a significant component of the effort to grow the tree canopy and reduce urban heat.

In 2010, Phoenix was the first city in the Valley of the Sun to establish a tree-canopy goal. The existing canopy is approximately 12 percent of the land area, and the target is to grow this to 25 percent by 2030. Such an aggressive increase requires public and private cooperation, and Phoenix is set to provide the example, not only for other nearby cities and towns but also for businesses and private landowners.

"Increasing the tree canopy has to be a public and private partnership", says Richard Adkins, the city's forestry supervisor.

Growing the tree canopy to address the problem of urban heat is a major component of the Phoenix sustainability plan

© City of Phoenix

Signs, banners, information sheets and community workshops are used to inform both residents and policymakers of urban forest value and benefit.

Public support

Referred to as a low-risk, high-yielding investment, trees are making a comeback. Voters have supported the city's efforts by passing the Phoenix Parks and Preserve Initiative twice to provide a modest percentage of sales taxes for habitat restoration, new park construction, the purchase of preserve land, and tree planting.

The city has developed an online community tree map, MyTreeKeeper, on which interested citizens can look up the estimated value and benefit provided by any of the 93 000 trees maintained by the city and even by an entire park. These trees provide the city with benefits worth an estimated USD 7.8 million annually – and they are only a portion of the estimated 3.16 million trees in the city, providing overall annual benefits estimated at more than USD 40 million.

Since the acceptance of the Tree and Shade Master Plan, city departments have made a concerted effort to include tree and shade language in new policy and project initiatives, including the Plan PHX General Plan, the Walkable Urban Code and the Complete Street Policy. Additional funding is also being allocated to plant new trees and replace damaged or dead trees in parks and along streets.

"We are even working with local utilities to correct past design issues and help to provide a healthier, more diverse urban forest", says Adkins. "It's all about planting the right tree in the right place to provide value and benefit, to increase the quality of life for citizens and economic vitality for the city".

A recent study found that, for a typical Phoenix

neighbourhood, increasing the tree canopy to 25 percent of the land area could reduce air temperatures by 4.3 °F (2.4 °C). For a vacant lot, obtaining the goal of 25 percent canopy cover could have a cooling effect of 7.9 °F (4.4 °C). This kind of canopy increase would provide welcome relief in neighbourhoods with heat-related concerns.

"By partnering with neighbourhood volunteers and community groups, a community forester programme and a community tree guide have been developed to help engage citizens", Hartman says. The "Love Your Block PHX" and "Resilient PHX" initiatives provide small grants to support local planting and shade efforts. The city is also working with researchers in two pilot neighbourhoods to monitor surface temperature changes, increase heat safety awareness, and plant more trees.

The city has constructed canopy maps that can be used to identify vulnerable neighbourhoods and areas in need of shade. Working with neighbourhood specialists and city planners, these areas can be focal points for creating green corridors and other shade amenity projects.

Another new project seeks to plant trees on city property and exchange carbon credits for maintenance dollars. By planting both food- and shade-producing trees as well as generating funds for tree care, this project has great potential for expanding the tree canopy and educating citizens on the value of shade resources.

In addition to trees, the community is finding other ways to incorporate shade. According to Edward Lebow, the city's public art programme director, "shade has been designed into a wide range of city public art projects. Artists have created new forms for shade structures at transit centres, parks and public gathering areas. By combining beauty and function, these works help to alleviate the desert heat and have become distinct landmarks throughout the city".

Creating forest parks to protect Independencia (Lima) from landslides

225 thousand
Population

1456 hectares
Land area

38.6 hectares
Public green space

1.7 m²
Green space per person

From her precarious home made of plywood and calamine, Barbarita Gonzales has an excellent view of Peru's capital city, Lima, the world's second most-populated desert city after Cairo. For a year now, she has been living with her family on the steep slope of a hill in the district of Independencia in Lima's north.

Barbarita will soon give birth to her second child, but she worries she could be evicted. She and her husband bought the land from land traffickers using all their savings from years of hard work at a Lima restaurant. Her worry is understandable – their fragile home is in an area declared at high risk to earthquakes and heavy rains and could be destroyed at any moment.

At least 1 million people on the periphery of Lima are living in houses built on hillsides, all of which are vulnerable to natural disasters. In Independencia alone, 18 000 vulnerable properties are home to nearly 100 000 people – almost half the population of the district.

The aim of a programme to afforest mountainsides in the Peruvian capital is to reduce risk for vulnerable communities

**Prepared by José Sato, Felipe Parado and Hector Chambi
Independencia Programme, Center for Studies and Disaster Prevention**

An afforestation pilot zone in the district of Independencia in northern Lima

© Héctor Chambi/PREDES

Afforestation project

One way to reduce the threat of landslide is afforestation. Faced with high population growth in areas at risk, the municipality of Independencia took action in 2015 to reduce the potential for disaster in vulnerable areas. Implemented by the Center for Studies and Disaster Prevention (PREDES) with support from the United States Agency for International Development and the Office of Foreign Disaster Assistance, the risk-reduction programme includes a hillside afforestation project.

In the El Volante II and El Volante III settlements in the south of the district, for example, where 94 families live, 300 native seedlings have been planted (molle serrano, tara, palo verde, mimosa and other species). Techniques such as the application of hydrogel (to help retain water), composting and drip irrigation are being used to ensure high rates of seedling survival and growth.

Why should people participate in the afforestation of arid hills? This was the question many villagers asked when they were told of the afforestation effort and the need for their support to ensure its success. Little by little, however, the local people have come to understand that afforestation will help reduce the risk of disasters because it stabilizes slopes, controls or prevents rock falls, retains mud and sediments created in heavy rains, restricts informal settlement, and improves the environment.

Two years after the first steps were taken towards afforestation, the Ecological Forest Park project, known as Boca de Sapo ("Toad Mouth"), is gaining strength and fame. An area of 14 hectares (the size of five football fields) has been designated for the park, which includes trails, viewing points and family recreation spaces. By the end of 2017, 3 000 native trees had been planted and a drip irrigation system installed using treated wastewater.

Seven forest parks

In implementing the afforestation project in the district, the municipality of Independencia, through its Office of Environmental Management, is planning to create seven new forest parks with similar characteristics to those of Boca de Sapo. These parks will involve 86 settlements that lack property titles.

The projects will be carried out over the next few years if they receive sufficient political commitment from authorities. Implementing the ambitious programme to create forest parks requires the cooperation and coordination of various institutions, such as the district municipality, the agency for the formalization of informal properties, and the National Superintendence of State Property.

The implementation of forest parks will contribute to the development and entrepreneurship of the population and the city as part of sustainable urban management. It will also help safeguard the future of Barbarita Gonzales and her young family by reducing the risk to their home, thereby enabling them to stay in their hillside location.

© Héctor Chambi/PREDES

Residents participate in tree-planting in the "Boca de Sapo" forest park upslope of houses, Independencia, Lima

Beijing's afforestation miracle

21.7 million
Population

1.7 million hectares
Land area

87 450 hectares
Public green space

40.3 m^2
Green space per person
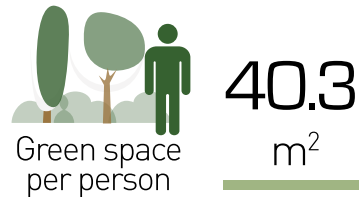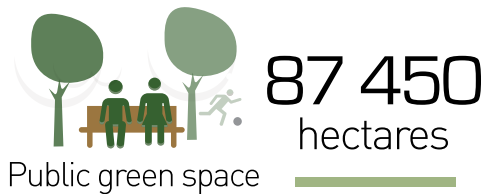
Beijing, the capital city of China, sits in the northwest of the North China Plain, which covers a vast 1.64 million hectares. With a population of nearly 22 million permanent residents, Beijing is one of the world's most populous cities, as well as one of the most affected by air pollution, the heat island effect and other environmental problems.

The uneven distribution of ecosystems is a feature of "big-city syndrome". Without large forests and other green areas, cities risk becoming concrete jungles with increasingly serious effects on the health and well-being of urban dwellers.

In fact, most of Beijing's forests are in the mountainous areas in the northwest; forests are rare in the southeastern part. Some Beijing residents must drive 40–50 km if they want to visit a forest.

One of the world's largest cities is being transformed by the establishment of large areas of urban and peri-urban forests

Prepared by the Beijing Gardening and Greening Bureau

The original landscape along Yongding river in the Fengtai district of Beijing

© Beijing Gardening & Greening Bureau

Beijing's largest afforestation programme

In 2004, the Government of China launched the "Forest City Programme", a national initiative to increase tree cover in and around urban areas with the aim of improving the liveability of cities for urban dwellers. In this framework, in 2012, Beijing initiated the largest afforestation programme in its history. With a vision of "two rings, three belts, nine wedges and multiple corridors", more than 54 million trees were planted in four years on an area of 1 050 000 mu (70 000 hectares, with 1 mu equating to 1/15 of a hectare).

By the end of the afforestation programme, there were 23 forest patches with areas exceeding 667 hectares and another 210 patches with areas greater than 67 hectares. Forests now cover 25.6 percent of the city plain, an increase of 42 percent.

A unique feature of the afforestation is that these large new forests are on the periphery of urban areas. Between the city's central districts and the new city centres, and between the various new city centres, high-quality afforestation has produced an endless and spectacular sea of trees. An urban forest ecosystem, featuring large areas of forest, large ecological corridors, nine "wedges of green" and multiple green belts, has been created. The distribution of forests in the megacity has been significantly improved.

In many places, afforestation and park construction have been accomplished simultaneously to provide shade, flower fragrances and birdsong as well as green corridors and squares for walking and recreation. Eighteen large special parks, such as the Locust Tree Park and the Qinglonghu Forest Park, and 500 recreational forests and green lands, have also been established. The finished section of the Dongjiao Forest Park (the city's largest park) is ten times the size of New York's Central Park.

The Beijing afforestation programme involved social workers in voluntary tree-planting activities

Restoring sand excavation pits

The interventions implemented in the framework of the afforestation programme included the ecological restoration of sand excavation pits and wastelands. A large sand pit along the Chaobai River in Huairou District in the city's northeast, for example, was more than 70 metres deep in some places. It had been formed by the excavation of sand for construction over decades and was highly vulnerable to sand storms. Using various afforestation techniques, the pit has been turned into a suburban forest park more than 400 hectares in size.

In four years the city has afforested 24 267 hectares of ecologically fragile areas, including sand pits, sandy lands, pit-ponds and polluted lands. Five areas vulnerable to sand storms – the Yongding River, the Chaobai River, the Dasha River, Kangzhuang and Nankou – have been ecologically restored.

Public satisfaction

In suburban and peri-urban areas, most lands were afforested after moving low-end industries. The afforestation has increased the forest extent in those areas and provided neighbourhoods with more space for recreation. In Tangjialing village, outside Beijing's 5th Ring Road, many illegally constructed buildings were demolished after the relocation of the village. Today, this once highly populated place has become a pleasant urban forest park. A survey by the State Forestry Administration's Urban Forest Research Center showed that the Beijing Plain Afforestation project has a very high degree of public recognition: public satisfaction with the project was determined to be 72.3 percent, and public support was at 94 percent.

 Beijing is still striving to increase its urban forests, using every inch of available land. In 20 years, or sooner, those newly planted seedlings and saplings will have grown into big trees, and the benefits for the community will have increased.

© Beijing Gardening & Greening Bureau

Landscape ecological forests in Xiji town, Tongzhou district, Beijing

Opening people's eyes in Nairobi's Karura forest

3.1 million
Population

69 600 hectares
Land area
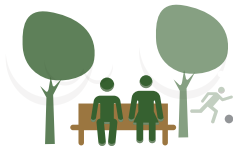
14 553 hectares
Public green space

46.4 m^2
Green space per person

Karura forest – a forest in the central north of Kenya's capital, Nairobi – was once a crime-ridden area. Plans were made to turn it into commercial and residential land uses. But when the local community became involved in its management, its fortunes turned around.

Karura forest covers 1 041 hectares of valuable real estate, bordered by the suburbs of Muthaiga, Gigiri, Runda, Ridgeways, Mathare North, Peponi and New Muthaiga. It was gazetted in 1932 and is managed by the Kenya Forest Service (KFS) in conjunction with the Friends of Karura Forest Community Forest Association. Among other things, it is home to the KFS headquarters.

Karura forest has historical, cultural, social and economic value for the people of Nairobi and Kiambu counties and for Kenya as a whole. Among its historical features are the Mau Mau caves and an old church used by freedom fighters in the colonial period. The forest also boasts a waterfall, a bamboo forest, marshlands, a lily lake, and diverse species of fauna and flora.

The forest's proximity to rapidly growing Nairobi led to plans to reduce the forest area to make way for built development, but these plans have been controversial. Conservationists, led by the late Wangari Maathai, conducted a highly publicized campaign to save the forest.

© Ninaras

This historic urban forest was under threat, but getting communities involved has turned it into a valued asset

Prepared by Paul Opanga and Romanus Opiyo

Participatory approach in Karura forest

In recent years, public participation – as enshrined in Kenya's constitution – has become vital for addressing environmental problems and bringing about sustainable development. The Karura forest has numerous stakeholders, including the KFS, the private sector, community and resident associations, donors and non-governmental organizations, each of which plays a complementary role in the forest's use and conservation.

A partnership between the Friends of Karura Forest Community Forest Association, the KFS and the local community has made substantial changes to the forest through stakeholder involvement. Between 2009 and 2012, for example, the partnership fenced and secured the forest, thus reducing the risk of land-grabbing by illegal private developers and preventing the forest from use as a dumping site by hijackers and murderers. Instead, the forest has become a significant tourist attraction: from zero visitors in 2009, the forest now welcomes, on average, 16 000 visitors per month, 70 percent of whom are Kenyan citizens.

The KFS is working with communities near the forest, who are benefiting from employment associated with tree planting, firewood collection and a forest apiary. The involvement of the community in major decisions on the forest resource is still inadequate, however.

The recent Kenya National Forest Programme 2016–2030 emphasizes the development of urban forests and a participatory approach involving county governments. The KFS Head of Natural Forests, Charity Munyasia, reaffirms that "collaboration with various stakeholders is a key aspect of participatory approaches and did contribute to improved forest management at Karura forest".
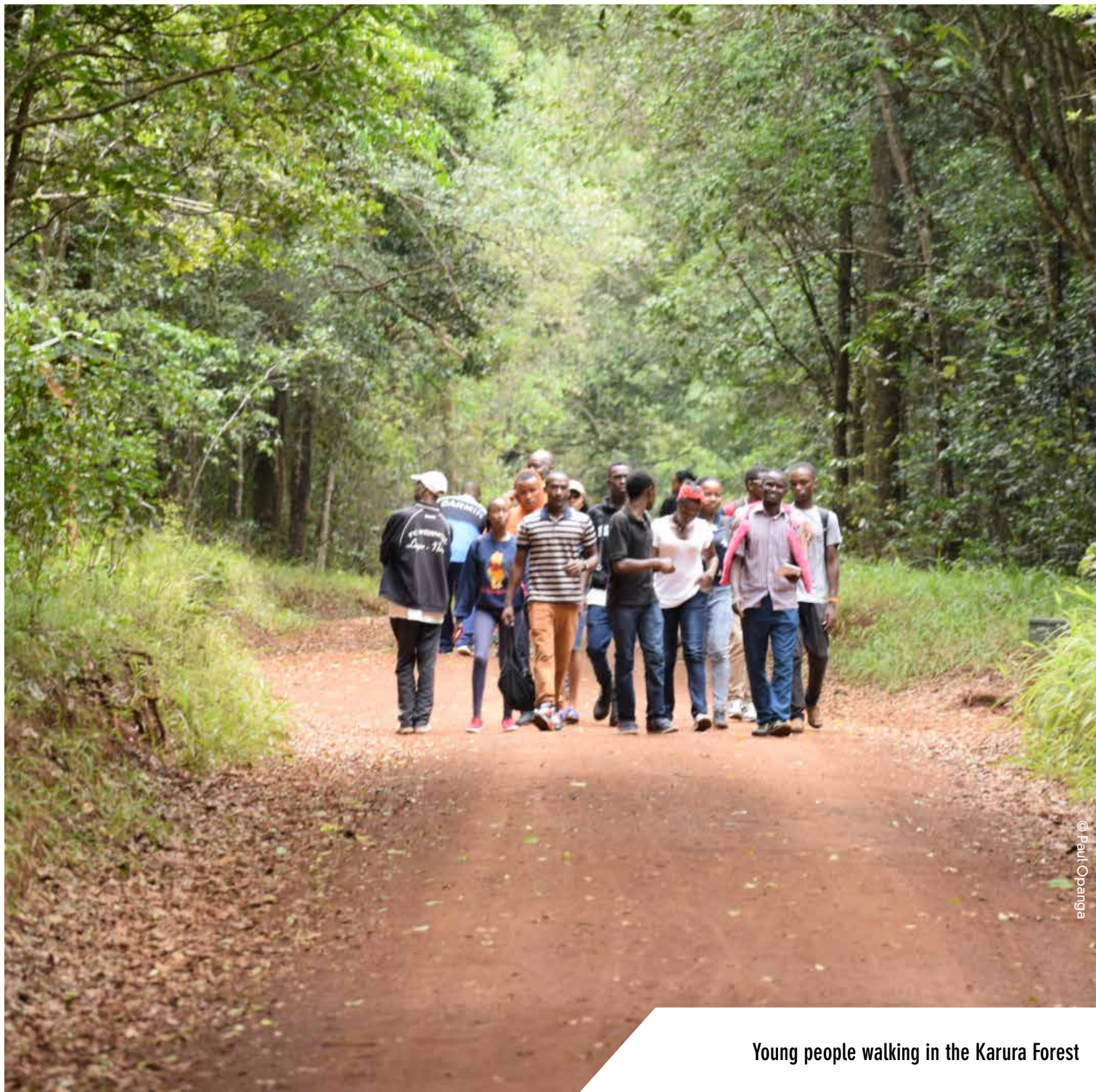
The main challenge in using a participatory approach in the Karura forest is the high-density residential community living near it; people in the community have diverse needs, and it is difficult to please everyone. Expectations are very high and are unlikely to be fully met.

Local perceptions of Karura forest

Nevertheless, local people have benefited considerably from the participatory approach now employed in the Karura forest. The forest is no longer a place of danger for them but, rather, a source of opportunities. The forest employs 46 permanent workers, 36 of whom are from surrounding communities. As part of the process of rejuvenating the forest, the management started charging an entrance fee. Locals resisted this at first, but over time they have come to accept it because the many benefits of forest conservation are becoming clear.

John Kamau, a local resident and tree carer, says, "Not only does our involvement in management on Karura forest offer increased job and enterprise development in areas of nursery development, but also recreation moments in biking, picnicking where our children can explore further opportunities to create income for themselves ... Interaction with various people from corporate companies involved in the management or recreational activity in the forest has opened my eyes to many ways in which companies, neighbours and community-based institutions can be integrated in urban forest management. More businesses and opportunities could be availed if the city authority prioritizes green space and work closely with relevant stakeholders".

© Paul Opanga

Young people walking in the Karura Forest

Growing together in Halifax

310 thousand
Population

23 500 hectares
Land area

1 800 hectares
Public green space

14.0 m²
Green space per person
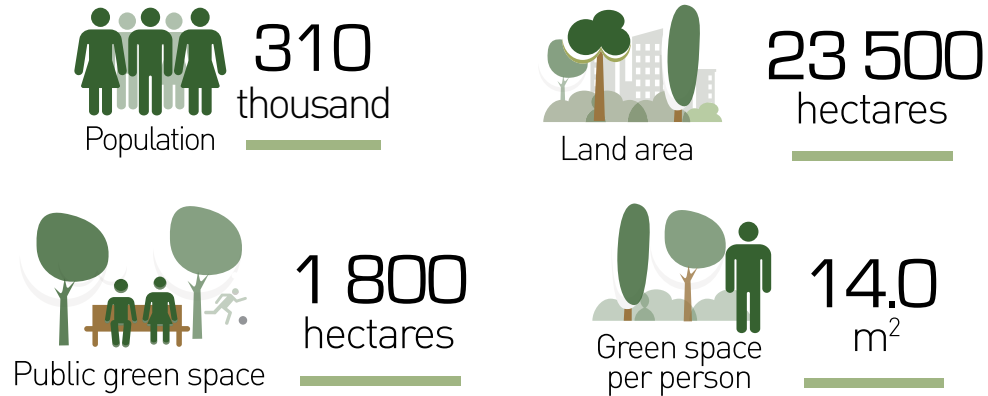
This is a story about the power of partnership to achieve the lofty aim of a sustainable city.

The signs were evident, even at the turn of the millennium, that Halifax – the capital of the province of Nova Scotia in eastern Canada – should have an urban forest master plan. The idea was introduced in August 2001 with a motion at the Regional Council to "investigate strategies intended to foster the retention of urban canopy and develop a management plan for urban forests". This was a profound departure from usual practice: it is one thing for a council to maintain street-tree planting and pruning in response to the demands of its citizens; it is quite another to ramp up an urban forestry programme to set and meet strong goals for an increase in the urban tree canopy.

The need for an urban forest master plan increased in urgency due to a series of destructive events over more than a decade. A beetle infestation, a hurricane, and a succession of severe storms destroyed tens of thousands of trees in the urban forest and damaged and compromised many surviving trees. Halifax residents, therefore, have experienced directly the impacts of a major loss of urban trees.

"The urban forest programme really needed the guidance that only an urban forest master plan can give", says John Simmons, the city's Urban Forester.

A productive partnership helped create a strong master plan for forests in this city in Nova Scotia, Canada

Prepared by Peter Duinker and John Charles

A new grove of sugar maple trees graces a busy highway intersection in Halifax

© Peter Duinker

Implementing the master plan

The Regional Council unanimously adopted the city's first urban forest master plan in September 2012. Plan implementation commenced in the next month, and much has happened since. City crews and landscaping contractors have planted many thousands of trees along streets, and volunteer groups have planted thousands more trees in green spaces and parks. Urban orchards have been established in community gardens across the city, and new regulations are being developed to protect trees. The maintenance of the city's existing street trees has improved, too, with a new pruning programme designed to put into effect a proactive pruning cycle. Citizens are being informed about the city's trees through urban forest "walkabouts" and educational events targeted at people who want to learn more about their urban forests. The master plan won a national award for planning excellence from the Canadian Institute of Planners.

A research partnership

How did this happen, and what ingredients drove the development of the urban forest master plan? We believe that the key ingredient was an urban forest research

partnership between the Halifax Regional Municipality and Dalhousie University.

To kickstart the planning process, inventories were made in 2008 of the city's trees, and the collected data were used to evaluate the environmental benefits of urban trees, such as air-quality improvement, carbon-dioxide reduction, and stormwater control. The findings were instrumental in securing an ongoing commitment from the Regional Council to provide funds for the preparation and implementation of the master plan.

Spatial data on the city's urban forest were collected using advanced remote-sensing techniques, enabling detailed spatial planning in a geographic information system. The data were also used to calculate a suite of 111 neighbourhood-level subplans to be combined to form the master plan – the first time, to our knowledge, this approach has been used anywhere.

The urban forest master plan was developed through a partnership that involved Municipality staff and researchers at Dalhousie University. Starting in 2010, a research team made up mainly of graduate students conducted studies on issues ranging from best urban forest management practices to the potential impacts of climate change. The partners jointly undertook public consultations, prepared a forest inventory, mapped the resource, analysed the data and wrote the master plan.

The overall goal of the plan is to ensure a sustainable future for Halifax's urban forests. Trees, after all, are a key part of sustainable cities.

"The urban forest master plan demonstrates our deep commitment to building a healthy, liveable, sustainable city", says Halifax Mayor, Mike Savage. "Besides the obvious environmental benefits, like the improvement in air quality, trees help reduce energy demand by providing shade for cooling in the summer and protection from cold winds in the winter. But perhaps most important is the beautiful legacy they leave for generations to come".

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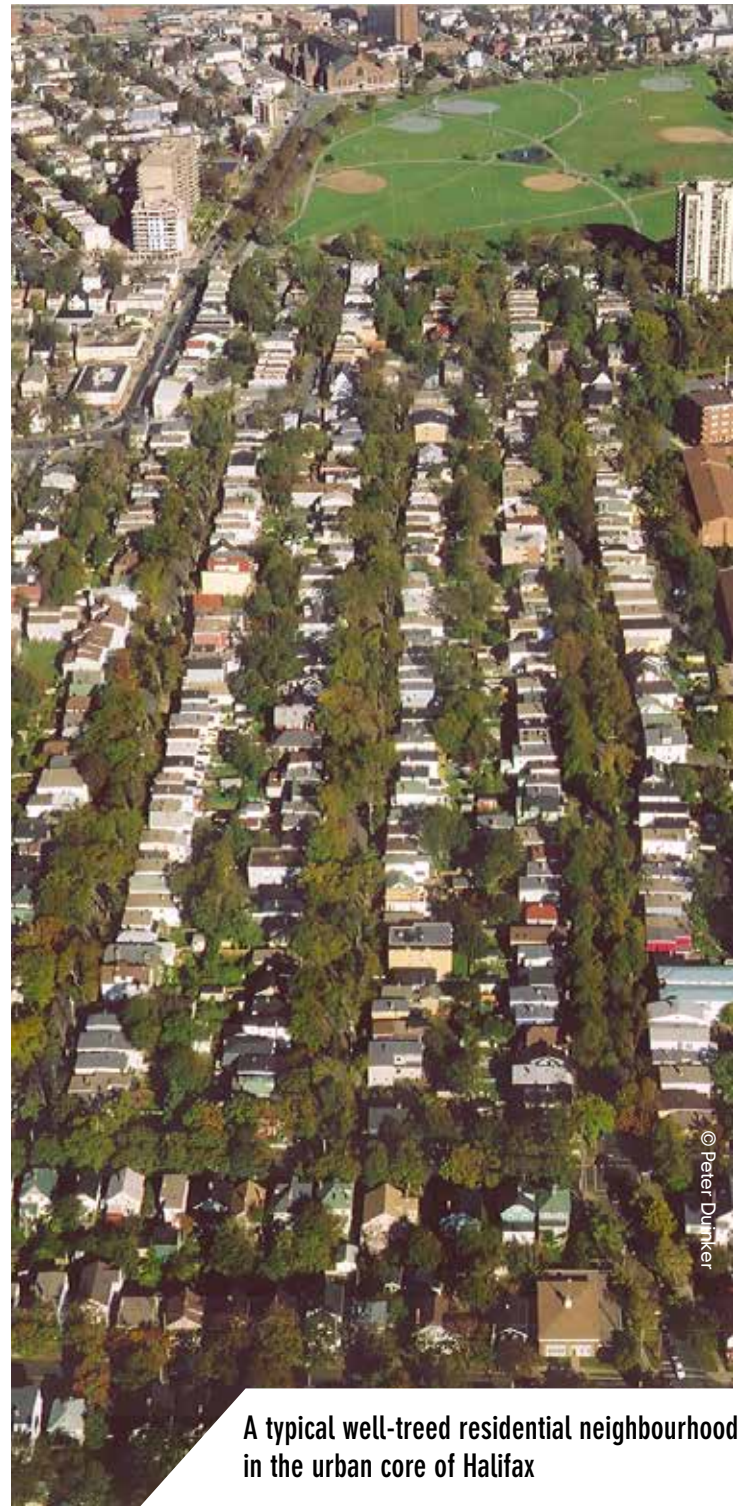
A typical well-treed residential neighbourhood in the urban core of Halifax

Public involvement

Plans are a vital prerequisite, but the transition from planning to implementation needs careful attention. The team conducted four public workshops in the spring of 2012 to obtain community input on prioritizing and implementing the directives of the master plan. Three main themes were discussed: trees in the public realm; trees in the private realm; and land-use policies and by-laws. A wide range of stakeholders attended the workshops, and almost 500 individuals took part in an online survey to document the public's priorities for implementation.
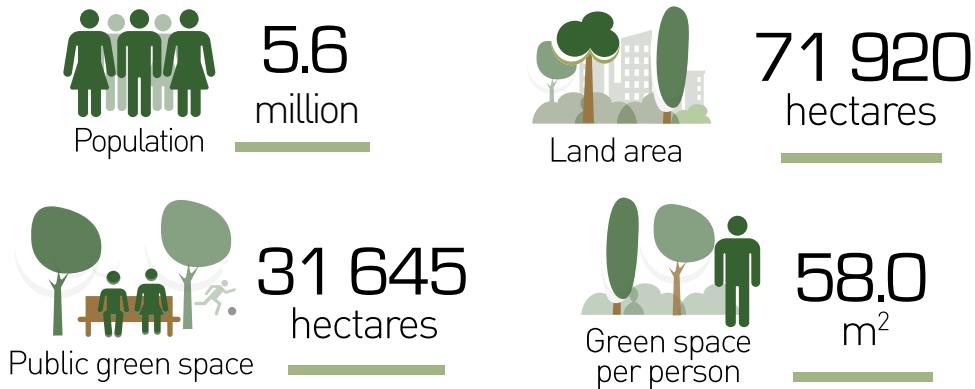
The following priorities for immediate attention were incorporated into the master plan because of the public consultation process:

- increase funding, plant more trees on municipality land, and improve urban forest maintenance;
- adopt new regulations and standards to conserve urban forest canopy cover; and
- promote citizen stewardship of the urban forests and develop educational programmes.

Most of the master plan's directives corresponding to these priorities are now being implemented. Although much more needs to be done to ensure the sustainability of Halifax's urban forests, the master plan clearly articulates implementation priorities based on the views and opinions of the public. The citizens of Halifax were active stakeholders in the development of the plan and remain strongly involved today.

The moral of the story is this: partnership arrangements involving energetic, talented and devoted people, with the support of progressive institutions, enable synergies that can make remarkable progress toward sustainability.

Singapore: the surprisingly green and biodiverse city

5.6 million
Population

71 920 hectares
Land area

31 645 hectares
Public green space

58.0 m²
Green space per person

"As a small country, we are always innovating to make the most of our limited land resources. Even as we intensify our urban land use, we will set aside 9 percent of our land for our nature reserves and parks by 2030. This is a conscious choice – one which is never easy, especially when you consider the competing uses for housing, industry, defence and transport infrastructure. We consciously do so for the benefit of all Singaporeans, because a connection to nature is a must-have, not a good-to-have."

Mr Desmond Lee, then Minister of State for National Development,
at the Launch of the Festival of Biodiversity 2014

Singapore is well known as a green city, attracting names such as "Garden City", "City-in-a-Garden", "Vertical Garden City", "City of Gardens and Waters" and "Biophilic City". Large parts of the city have a verdant ambience.

Such a high level of greenness is unusual in at least two ways. One is that such greenness exists, even though the city is highly built-up. A city's greenery is generally inversely related to its population density, but Singapore's greenery is substantially above those of cities with equivalent population densities. The second unusual aspect relates to how Singapore became such a green city because, within 100 years of its founding as a British colony, it had lost more than 95 percent of its original vegetation cover, which consisted of lowland rainforest, freshwater swamps and mangroves.
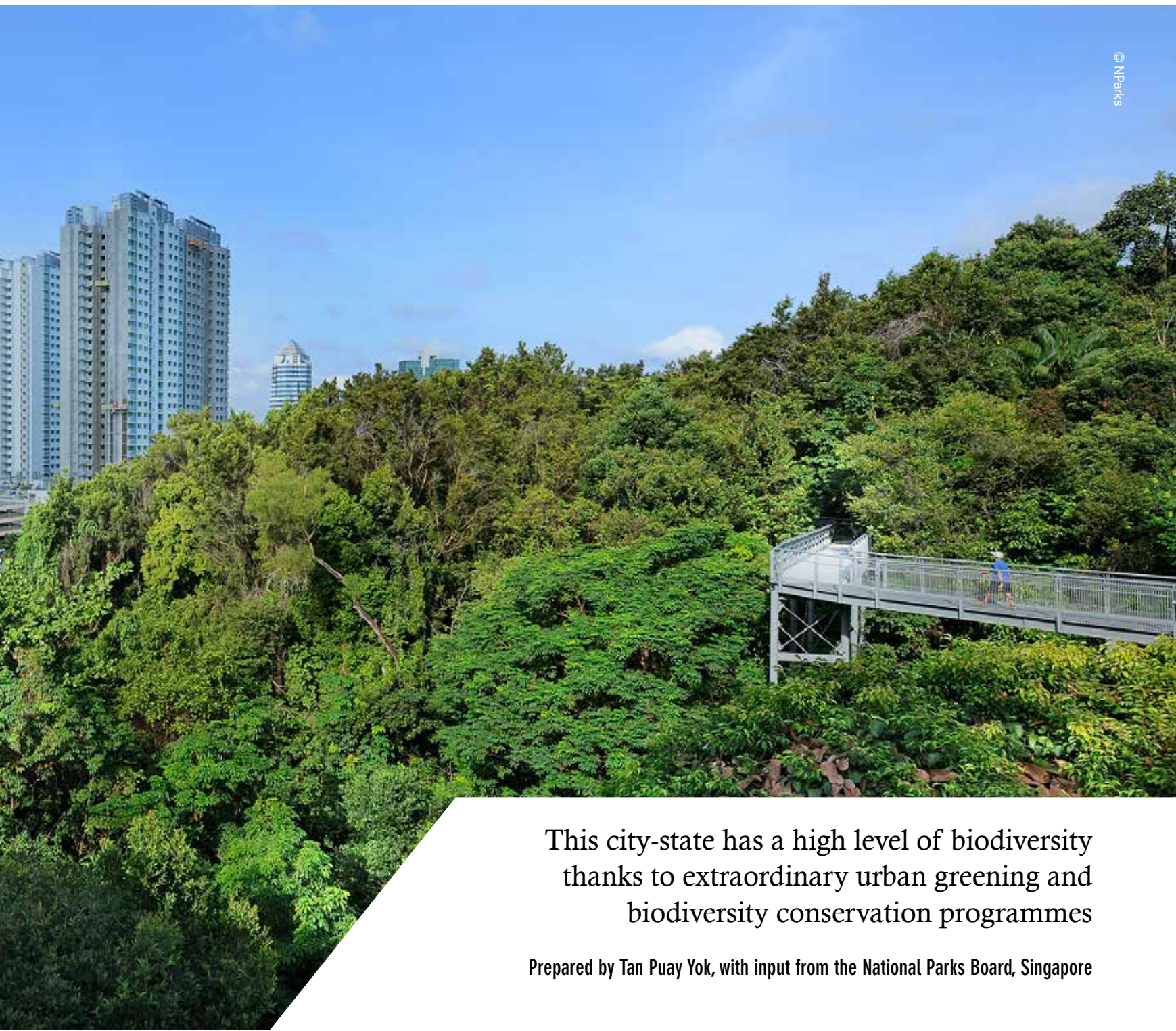
This city-state has a high level of biodiversity thanks to extraordinary urban greening and biodiversity conservation programmes

Prepared by Tan Puay Yok, with input from the National Parks Board, Singapore

Greening and development

Much of Singapore's greenness today can be attributed to its active urban greening programme. But the programme has been unusual itself because it was initiated more than 50 years ago when Singapore was still a young, Third World nation with numerous socio-economic challenges in an era when cities paid far less attention to urban greening than they do now. The fact that urban greening was politically supported and systematically pursued, even as the nation underwent rapid economic development, was uncommon then and has turned out to be remarkably farsighted.

Today, it would be unusual for a major city not to give attention to urban greening. Indeed, over the last two decades or so there has been a surge in advocacy for the greening of cities. The reasons for this are clear: parks, woodlands, green roofs, street planting verges, residential yards, community gardens and other forms of urban green spaces improve microclimates, mitigate stormwater flows, improve the visual quality of urbanscapes, increase human mental and physical well-being, and support biodiversity. The scientific evidence for such benefits is accumulating steadily, and many studies now focus on translating scientific knowledge into policies and practice.

One emerging area of focus in greening cities is urban biodiversity conservation. There is growing consensus that, contrary to earlier misconceptions, cities can play active roles in biodiversity conservation. Conversely, biodiversity in cities is important for the ecological functioning of remnant ecosystems and constructed green areas, and it is increasingly understood to have health benefits for humans, provide opportunities for environmental education and create environmental awareness and care. Singapore has been an early mover in promoting biodiversity, and its experience can provide useful lessons for other cities.

Biodiversity conservation starts with knowing what to conserve

"In the end we will conserve only what we love; we will love only what we understand; and we will understand only what we are taught."

Baba Dioum, 1968

This quote underscores the role of biodiversity surveys as a key step in urban biodiversity programmes. Biodiversity surveys are crucial for knowing which species are present where and thereby beginning the process of understanding and appreciating them.

Having lost much of its natural vegetation, it might be expected that Singapore would be impoverished in biodiversity. Yet biodiversity surveys continue to bring surprises. In addition to significant marine biodiversity, new species and records are also regularly reported in the country's terrestrial ecosystems, largely through the efforts of ongoing biodiversity monitoring by public-sector organizations such as the National Biodiversity Centre, as well as by conservation scientists, civil-society organizations and interested members of the public.

Biodiversity surveys have also proved crucial for identifying sites that require protection or impact assessment and mitigation measures, and to identify population trends. Such efforts underpin the recognition that Singapore is very rich in native species for such a highly urbanized country. The experience gained in Singapore has also led to the development of the Singapore Index, or City Biodiversity Index, which was developed under the auspices of the Convention on Biological Diversity and is now used by about 30 cities for biodiversity monitoring.

A drone shot of primary rainforest in Singapore's Bukit Timah Nature Reserve. Singapore is one of only a few cities in the world with primary forest within its city limits

Biodiversity conservation pays for itself

The Singapore experience suggests that paying attention to greening as a city develops economically can pay rich rewards in tangible and intangible ways. Mr Lee Kuan Yew, the late founding Prime Minister of Singapore, said in his memoirs that "greening is the most cost-effective project I have launched".

  Recent studies now suggest that greening cities is not just desirable, it is also economically sensible, because of avoided healthcare costs, reduced energy consumption due to cooling, avoided combined sewer and stormwater overflow events, and the pleasant, liveable environment it helps create. Biodiversity programmes in cities, therefore, should be seen in the context of the benefits that biodiversity and greenery provide to cities and their occupants.

  Although Singapore is already a green city, the budget for greening is increasing. The reason is simple: the city has benefited immensely from the modest expenses invested in greenery and its management. Greening and biodiversity conservation programmes will pay for themselves.

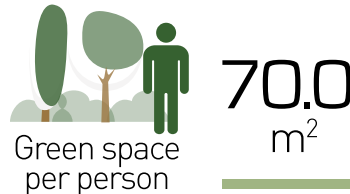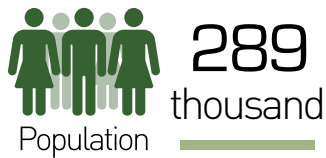## Galvanizing action through a biodiversity conservation plan

A biodiversity conservation plan helps to focus on aspects that are most important for biodiversity conservation. These aspects, in turn, enable the city to communicate its ambition and goals to civil-society groups, academics and the wider community. The Convention on Biological Diversity's National Biodiversity Strategies and Action Plans (NBSAPs) are useful instruments for this purpose. Singapore's NBSAP is complemented by the recently developed Nature Conservation Masterplan, which spells out the key strategies for conservation, including the use of spatial strategies for ecological connectivity, the intensification of scientific input to conservation plans, and citizen science programmes. Singapore was awarded the UNESCO Sultan Qaboos Prize in recognition of this effort.

Urban biodiversity conservation is a work in progress and perhaps always will be. Singapore continues to experience changes in land cover, leading to habitat loss and fragmentation, with the attendant threats to biodiversity. Resources for conservation activities are always limited, and expertise is often in short supply. Although not perfect, Singapore has tried hard to keep its natural heritage as it continues to manage the tradeoffs between economic development and conservation. The city, continues to surprise with the richness of its biodiversity.

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Ljubljana: the "beloved" green capital

289 thousand
Population

27 500 hectares
Land area

2 013 hectares
Public green space

70.0 m^2
Green space per person

According to one theory, "Ljubljana" means "beloved". Given its beauty and green environment, it's easy to see why this Slovenian city would be given such a name. Nature has always exerted a strong influence here. The city developed on a plain, with settlers avoiding hilly areas and low-lying areas near the river.

Natural forest still covers more than 46 percent of the municipality. Most (92 percent) of this forest is privately owned, and involving and educating people about forests, therefore, is crucial.

© City of Ljubljana

Nine-tenths of the forest in Slovenia's capital city is owned privately, so involving and educating people about forests is crucial

Prepared by Zala Strojin Božic, Andrej Verlic, Jurij Kobe, Urša Vilhar and Nataša Jazbinšek Seršen

City efforts

In its "Ljubljana Vision 2025", endorsed in 2007, the City has set a goal to be a sustainable city – a city living in harmony with its natural environment. Various strategies and activities reflect the determination to reach this goal. In 2010, the City declared about 1 150 hectares of natural forest as "special-purpose forest". Forests with this status are designated primarily for recreation with a view to strengthening the physical and mental fitness of residents and visitors.

One thousand hectares of the special-purpose forests are located inside the highway ring – that is, within and around the city centre. The City created an "instrument of land purchase" in 2014 and identified basic spatial priorities in terms of the public interest to be fulfilled for acquisition.

The first priority is land located near public paths and trails to enable cost-effective maintenance and ensure visitor safety. Given the emphasis on maintaining public access to the forests, the second priority is forest adjacent to residential areas or other land uses, and the third priority is enlarging and connecting existing forest patches. The main goal of the instrument of land purchase is to interlink the entire urban and peri-urban forest through a network of paths, trails, skid roads and other forest infrastructure.

Ljubljana was the recipient of the 2016 European Green Capital award, which rewards cities that have a consistent record of achieving high environmental standards. As the holder of the award, Ljubljana hosted the 19th European Forum on Urban Forestry.

Epic ice storm, and the involvement of landowners

Cooperation at the national and international levels is important, but the involvement of residents and landowners at the local level is essential. In February 2014, Slovenia experienced an epic ice storm that had a strong impact on Ljubljana's urban and peri-urban forests. The storm exposed issues in Slovenia's regulatory system, but ultimately it led to close collaboration between the Slovenia Forest Service and the City of Ljubljana.

In the wake of the storm, the main challenge was to salvage damaged and killed trees and to restore the forest. Hindering the operation were factors such as the highly fragmented ownership of private forests and the very long and poorly maintained harvesting roads. Funds were allocated and people were brought in to provide forest owners with access to their forests and to promote efficient harvesting. A workshop was convened to form the first urban and peri-urban forest landowners' salvage logging project. The project achieved positive financial and environmental results: in the beginning, only 25 percent of landowners were willing to cooperate, but ultimately almost 300 landowners participated in the salvage logging of 1 900 cubic metres in 83 hectares of forest.
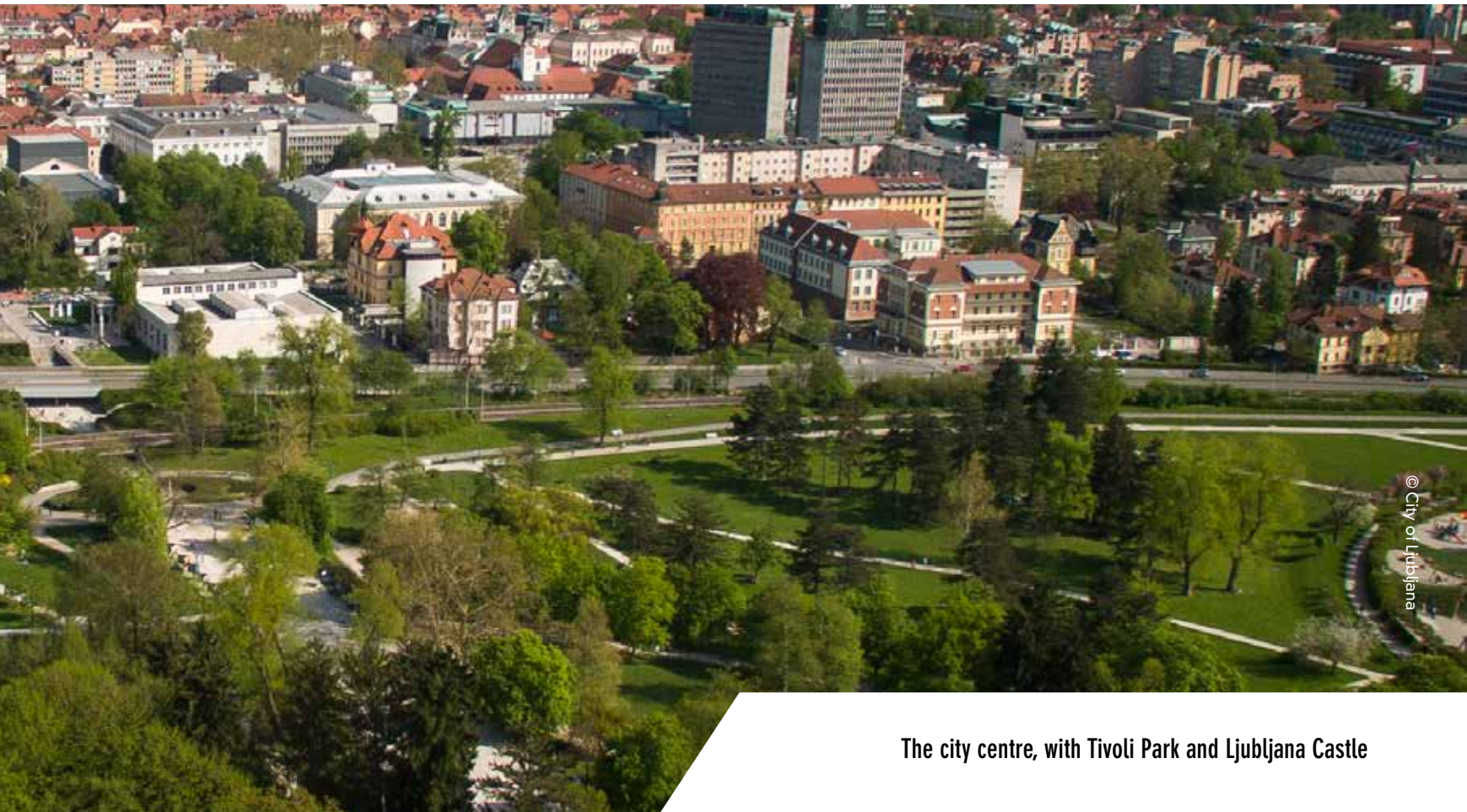
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The city centre, with Tivoli Park and Ljubljana Castle

Children learn about forests in the Forest of Experiments, Ljubljana
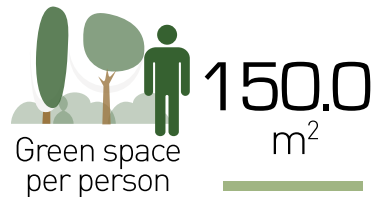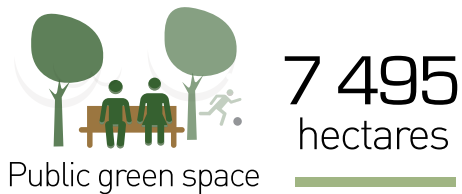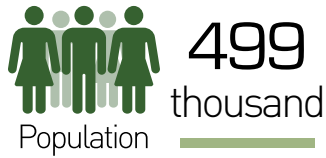
© Forest of Experiments

Forest education

Natural forests in the City of Ljubljana provide a stimulating and diverse outdoor learning environment. The Slovenian Forestry Institute – the country's leading research institute on forests and forestry – is promoting education and hands-on experiences to increase appreciation of forests and their role in people's well-being. Long-term forest monitoring and field research led to the establishment of an innovative environmental education centre called "Forest of Experiments", in which researchers share knowledge on the natural environment. Seminars are held for kindergarten and school teachers at the Slovenian Forestry Institute in the City's forest. The Forest of Experiments boosts creativity and innovation in the process of learning about forests and raises awareness of the importance of science in sustainable forest management.

A forest "classroom" for sight-impaired people was established in the Tivoli, Rožnik and Šišenski hrib Landscape Park in 2016. The aim of the forest classroom is to raise awareness among the wider public about the differences between city parks and natural forests. It consists of an access path, a sand platform and a wooden terrace, and it is enclosed on three sides by a wooden fence. The design enables visitors to get to know the elements of the classroom by moving along its edge, guided by the wooden fence rail and, where there is no fence, by a raised terrace curb. The wooden terrace is constructed to provide access to individual trees, enabling visitors (using information boards, which are adapted for sight-impaired people) to touch the tree trunks. All elements are designed to assist spatial orientation.

Today, Ljubljana residents enjoy a high quality of life, partly because of the strong interaction between the constructed and natural environments and the great diversity and easy accessibility of valuable natural features. Involving residents in the upkeep and improvement of the city's forests will help ensure the continued beauty of the "beloved" city.

The urban forests we want: Niterói

499 thousand
Population

13 392 hectares
Land area

7 495 hectares
Public green space

150.0 m^2
Green space per person

With more than 13 million inhabitants, Rio de Janeiro is the world's 17th largest metropolitan area, comprising 18 municipalities around Guanabara Bay. The city of Niterói, across the bay from Rio in the very heart of the metropolis, has a population of 500 000 people. Providing residents with a high living standard and a sustainable future in such a complex urban area is a huge challenge for government, planners and community leaders.

Niterói has one of highest levels of education in Brazil and a long tradition of environmental activism, and it hosts nine universities and research centres. These are ingredients for making Niterói a leading force in innovation and urban sustainability.
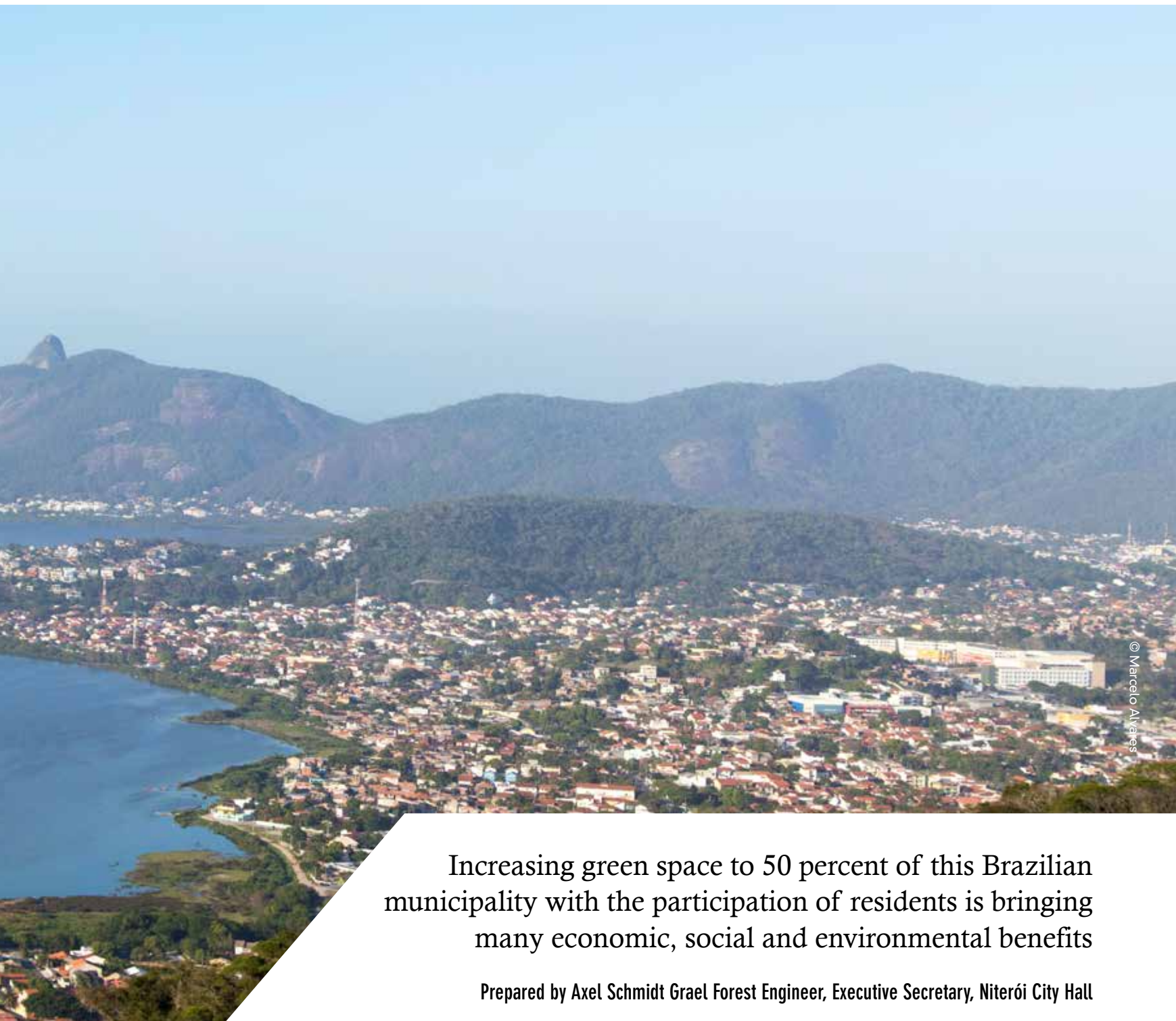
Increasing green space to 50 percent of this Brazilian municipality with the participation of residents is bringing many economic, social and environmental benefits

Prepared by Axel Schmidt Grael Forest Engineer, Executive Secretary, Niterói City Hall

The Morro da Boa Vista hillside in Niterói, Rio de Janeiro, before reforestation

©Companhia de Limpeza Urbana

The Morro da Boa Vista hillside in Niterói, Rio de Janeiro, after reforestation

© Companhia de Limpeza U...

The Niterói We Want

In 2013, 10 000 people, including youth and students, participated in a public hearing process called *Niterói Que Queremos* ("The Niterói We Want") to establish a strategic plan for the development of the city over the next 20 years (to 2033). One of the main targets that was included in the plan as a result of the consultation is that 50 percent of the city's land area is to be covered by parks and other protected areas.

Niterói is blessed with precious remnants of the endangered Atlantic rainforests, as well as mountains, beaches, lakes and scenic Guanabara Bay. Its people understand that protecting natural resources and providing appropriate infrastructure that benefits both residents and tourists offers a great opportunity to develop the economy, provide jobs and promote education, recreation, social development and equity.

Under the *Niterói que Queremos* plan, in 2014 the City of Niterói expanded the local park system, creating an extra 2 657 hectares of protected areas to complement existing green areas, including a significant state-managed parkland (of 3 493 hectares) inside the municipal limits. Thus, 45.9 percent of the city's territory is now under legal protection, with 123.2 square metres of forest for every inhabitant – probably the largest area of protected land per capita of any municipality in a metropolitan region in Brazil. The significance of the Niterói park policy is clear, given that the total metropolitan area of Rio de Janeiro protects only 16.5 percent of the land area.

Bringing back green and blue

Simply creating parks is not enough, however. They must be equipped with trails, bikeways, visitor centres and staff to manage them. For that purpose, Niterói has raised about USD 14.3 million from its own resources, the Development Bank of Latin America and the National Bank for Economic and Social Development to cover infrastructure investments and management expenses in 2017–2020.

A forest-fire prevention and control service was started in 2014 after a very dry summer in which 602 fires were recorded, affecting 4.7 percent of the city's territory. The City has established its own meteorological service and a preventive fire monitoring system, and it has trained 207 volunteers to work with civil-defence officials.

Niterói's priorities for protecting its green areas resulted in the elevation of the municipality in the rankings of ICMS Verde ("Green Royalties System") from 19th in 2013 to fifth in 2017. ICMS Verde compares the environmental performance of the 92 municipalities in the state of Rio de Janeiro.

In the Paris Agreement on climate change, Brazil committed to restoring 15 million hectares of forests. Reaching this target will require the massive participation of local governments, and Niterói is contributing to this end. One of the challenges facing the municipality is to restore forests on steep slopes, especially in the north where they have been lost to fire and unauthorized occupation. These areas are highly vulnerable to landslides: in 2010, heavy rains caused the city's largest natural tragedy, when landslides claimed 169 victims. The Disaster Prevention and Emergency Center has been created and about USD 30 million is being invested in stormwater control and slope containment works.

Watershed protection and Niterói Eco-Social

Restoring natural forest cover is another priority for preventing erosion and protecting watersheds. A pilot programme in the Boa Vista hills has already restored

9.5 hectares, and the aim is to restore another 150 hectares through three programmes: Niterói Eco-Social, Ecosystem Restoration and the Forest Compensation System.

Niterói Eco-Social is designed to give opportunities to "out-of-school and out-of-job" youth living in troubled communities, where crime and violence is a social threat. The programme will hire about 400 people to perform reforestation works on 100 hectares and to maintain park facilities. In addition to positive environmental outcomes, Niterói Eco-Social aims to help beneficiaries return to the school system and increase their employability. Designed by the city administration, the programme has the support of private business and community organizations. With an estimated budget of USD 1.5 million funded by the City of Niterói, the programme started in early 2018. The City is leading the programme in partnership with local business and community organizations.
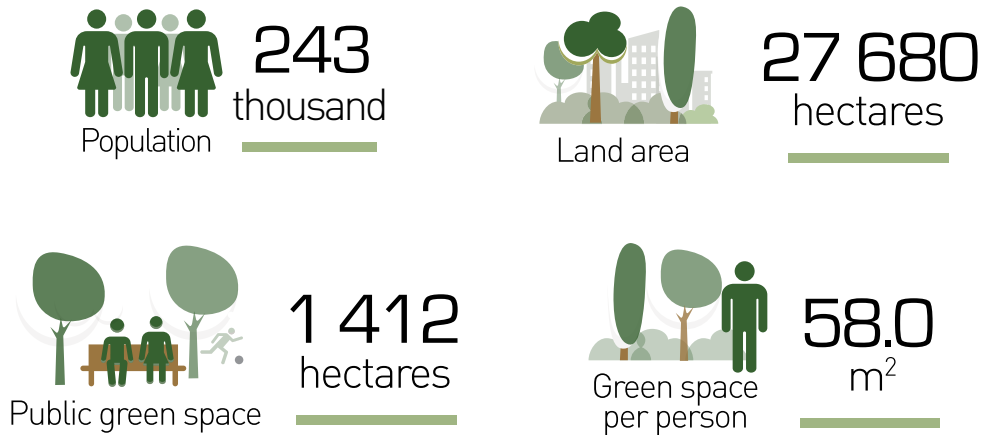
The Ecosystem Restoration programme, which is funded by the Brazilian Development Bank, will restore habitats on offshore islands and enrich degraded forests. The Forest Compensation System is a legal process that requires the replacement of cleared native forests in private and public development projects.

As mayor Rodrigo Neves says, "the importance of facing the challenges of a city like Niterói using innovative public policies goes much further than our local boundaries. As long as we commit to share, it has the driving force to inspire action elsewhere, to demonstrate that sustainability and social justice must advance together and that building a better future is indeed a feasible dream".

© Amanda Jevaux

A newly planted reforestation site in Niterói, Rio de Janeiro

Growing the "roots of tomorrow" in Vitoria-Gasteiz

243 thousand
Population

27 680 hectares
Land area

1 412 hectares
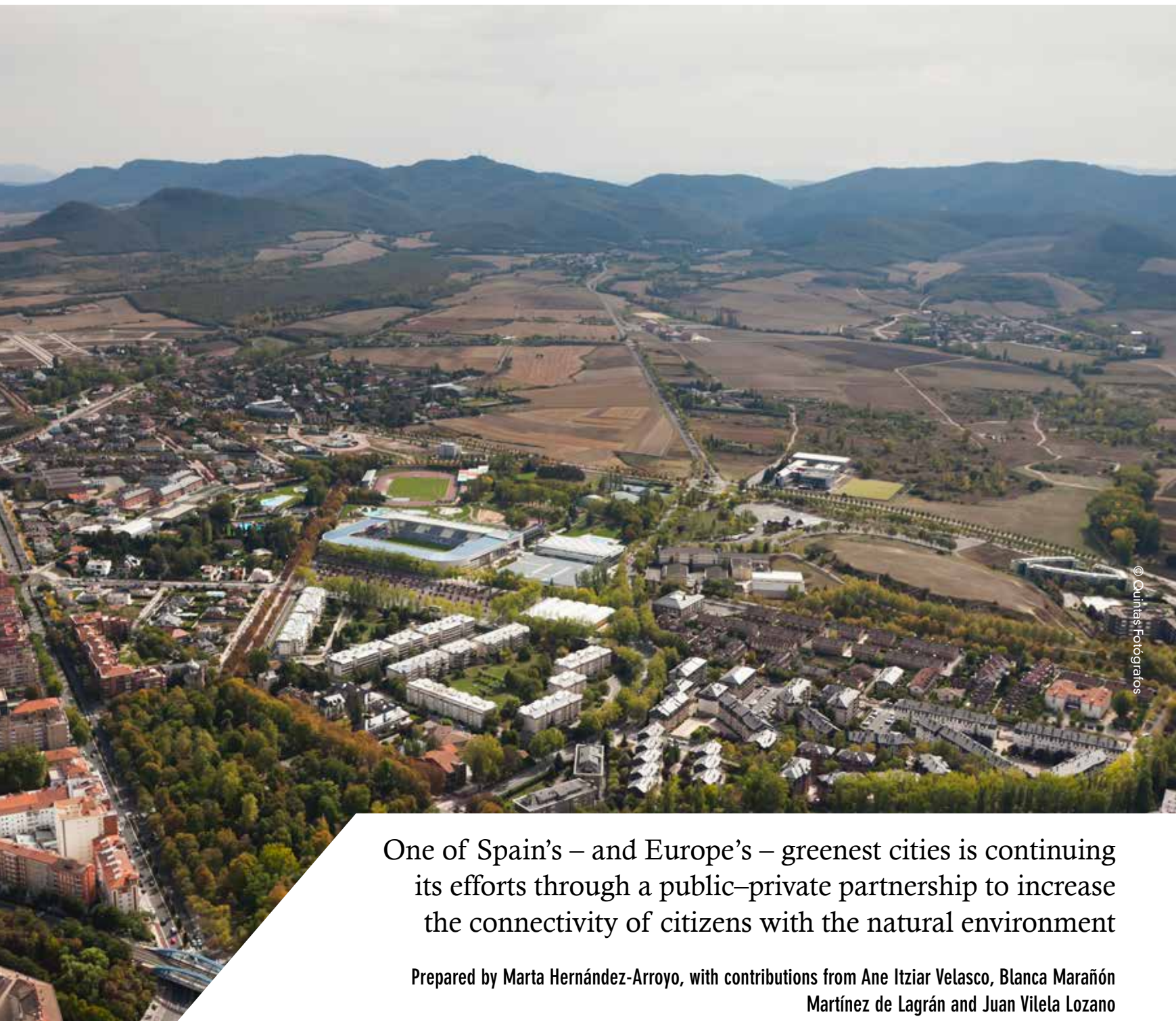Public green space

58.0 m^2
Green space per person

The people of Vitoria-Gasteiz live in one of the greenest cities in Europe. This didn't happen overnight: it has taken an enlightened vision and many years of hard work – and the work continues.

Vitoria-Gasteiz is the capital city of Álava, a province in the Basque Country in northern Spain. It is situated in the great ecological corridor of southern Europe that connects the Alps with the northern mountain ranges of the Iberian Peninsula. Vitoria-Gasteiz nestles on a plain surrounded by the Vitoria and Badaia mountains to the south and northwest and the Zadorra River to the north. A landscape of broad agricultural fields lies between the mountains and the city.

As Vitoria-Gasteiz grew, the urbanization process and its associated dynamics led to the degradation of the peri-urban land. Nevertheless, this land had the potential to be an important interface in which the rural and natural lands beyond the city meet the urban landscapes and the citizens of Vitoria-Gasteiz. The peri-urban land was not entirely abandoned, and there were many informal small settlements, but there was a general perception that it was "nobody's land", leading to degrading activities such as the illegal dumping of waste. To address this problem, the city administration set out to restore the peri-urban land and increase the sense of ownership among its citizens.

One of Spain's – and Europe's – greenest cities is continuing its efforts through a public–private partnership to increase the connectivity of citizens with the natural environment

Prepared by Marta Hernández-Arroyo, with contributions from Ane Itziar Velasco, Blanca Marañón Martínez de Lagrán and Juan Vilela Lozano

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Civil society, companies and the Centre for Environmental Studies worked together to plant thousands of trees in the green belt of Vitoria-Gasteiz

The green belt project

Starting in the 1990s, the ambitious "green belt" project, led by the Centre for Environmental Studies (CEA), aimed to create a great green area for recreation around the city while restoring its valuable landscape functions. Now, 25 years later, after various projects, the outcome is a green area almost 800 hectares in size, comprising six large parks of ecological significance – such as the natural gall oak forests in Armentia, the Zadorra and Errekaleor river systems, and the Salburua wetland, one of the most valuable continental wetlands in the Basque Country. The Zadorra River and the Salburua wetland are "special conservation areas" and part of the Natura 2000 Network; the Salburua wetland is also recognized as a Ramsar wetland. Today, the green belt is a key element of the city's urban green infrastructure, and it represents the beginning of a new mindset. Among other things, it features 90 kilometres of cycleways and footpaths.

The Roots of Tomorrow initiative

Nevertheless, despite the progress made over many years, much still needs to be done to rehabilitate degraded areas and establish ecological corridors to ensure connectivity along the green belt and between urban green spaces.

In 2012, the CEA launched the project "Roots of Tomorrow: 250 000 Trees and Citizens" to consolidate the green belt and get people involved in ecological restoration. The aim of the project was to plant 250 000 trees and shrubs – one per city resident – in a three-year campaign. The initiative was designed to reinforce the bond between citizens, the green belt and the local environment. Concurrently, it aimed to improve the most threatened areas by reforesting 73 locations in the green belt. Native species were used to the greatest extent possible.

To further extend the concept of green infrastructure to the large area of green spaces already present in the city, in 2014 the CEA released a proposal for an "urban green

infrastructure strategy". Under this strategy, a network of green spaces would be created to increase connectivity and increase the wide range of ecosystem services those spaces provide.

The backbone of Vitoria-Gasteiz's green infrastructure is its rivers, wetlands, parks and street trees. In fact, the city has one of the largest areas of green space per habitant in Europe; in 2012 the European Commission recognized it as Europe's "green capital of the year". The Salburua wetland is a good example of a nature-based solution: its recovered ponds now constitute a buffer against flooding.

Public–private involvement

A lack of resources is an ongoing challenge. Indeed, the aforementioned green belt project had suffered budget cuts in a poor economic climate. To overcome this constraint, the local administration, in an innovative solution, established the "Roots of Tomorrow" campaign as a public–private initiative. The CEA led the project, along with almost 50 social entities, businesses and formal institutions, more than 3 000 students, and many thousands of other citizens.

The project provided an opportunity for people from all walks of life to be part of the reforestation effort. One participating institution, Red Cross Álava, reported that "it is imperative that we be allowed to participate in the management and care of the natural environment at all levels in order to achieve sustainability of ecosystem services and so human well-being ... When we got to know the project Roots of Tomorrow, which sought the support and involvement of citizens, companies, professionals and all kinds of citizen organizations in tree planting, we did not hesitate to mobilize Red Cross volunteers to collaborate with this citizen initiative".
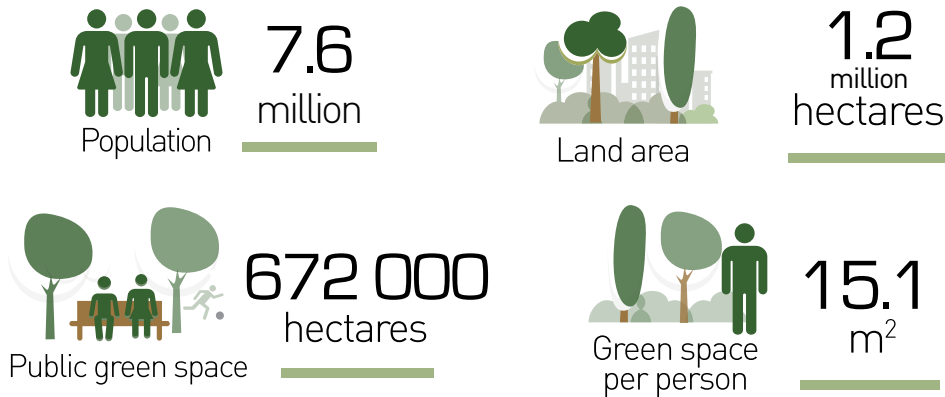
Local businesses were also involved, such as Viveros Eskalmendi, a garden centre and forestry company. Viveros Eskalmendi offers the following advice to other cities planning similar initiatives: "It is fundamental that citizens are aware of the benefits that this kind of initiative provides. Being involved at a personal level in simple initiatives like tree planting helps build a sense of belonging. Once people feel that it is "theirs", they will collaborate more in the conservation and enjoyment of the natural environment".

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The present and previous three mayors of Vitoria-Gasteiz plant the last tree of the project at the closing ceremony of the "Roots of Tomorrow" tree-planting campaign

Fuzhou's great green umbrella

7.6 million
Population

1.2 million hectares
Land area

672 000 hectares
Public green space

15.1 m^2
Green space per person

Fuzhou has a magnificent green cover of trees. Its skies are clear and the air is fresh. People who come to Fuzhou are gladdened by the harmony that exists between the city and its landscape and environment. The city is simply full of green. There is green in the parks and in residential areas. The city's river and streets are strung with green lines of trees, like necklaces. Imagine a beautiful picture of a city in a forest, and people living in the cool green world beneath the canopy. You can see many people outdoors – exercising, spending leisure time, and enjoying the green environment on sunny mornings and weekends. The city has long had a friendship with trees, but the creation of the "forest city" is the result of farsighted city planning.

Fuzhou, also known as Rongcheng, is the capital of Fujian province in southeastern China. It has a long history of growing Chinese banyan, which has become one of the city's defining characteristics. Chinese banyan is not only a major city tree in Fuzhou, it is a spiritual symbol, inspiring local people to be positive and self-reliant. With economic development and improvements in the standard of living, satisfying the desire of residents to live in a high-quality environment has become one of the tasks of city managers. In the framework of the "Forest City Programme" launched by the Government of China in 2004 to improve the liveability of its cities, Fuzhou is improving its urban forest ecosystem comprising a variety of tree species and beautiful landscapes with the goal of "letting the forest grow in the city".
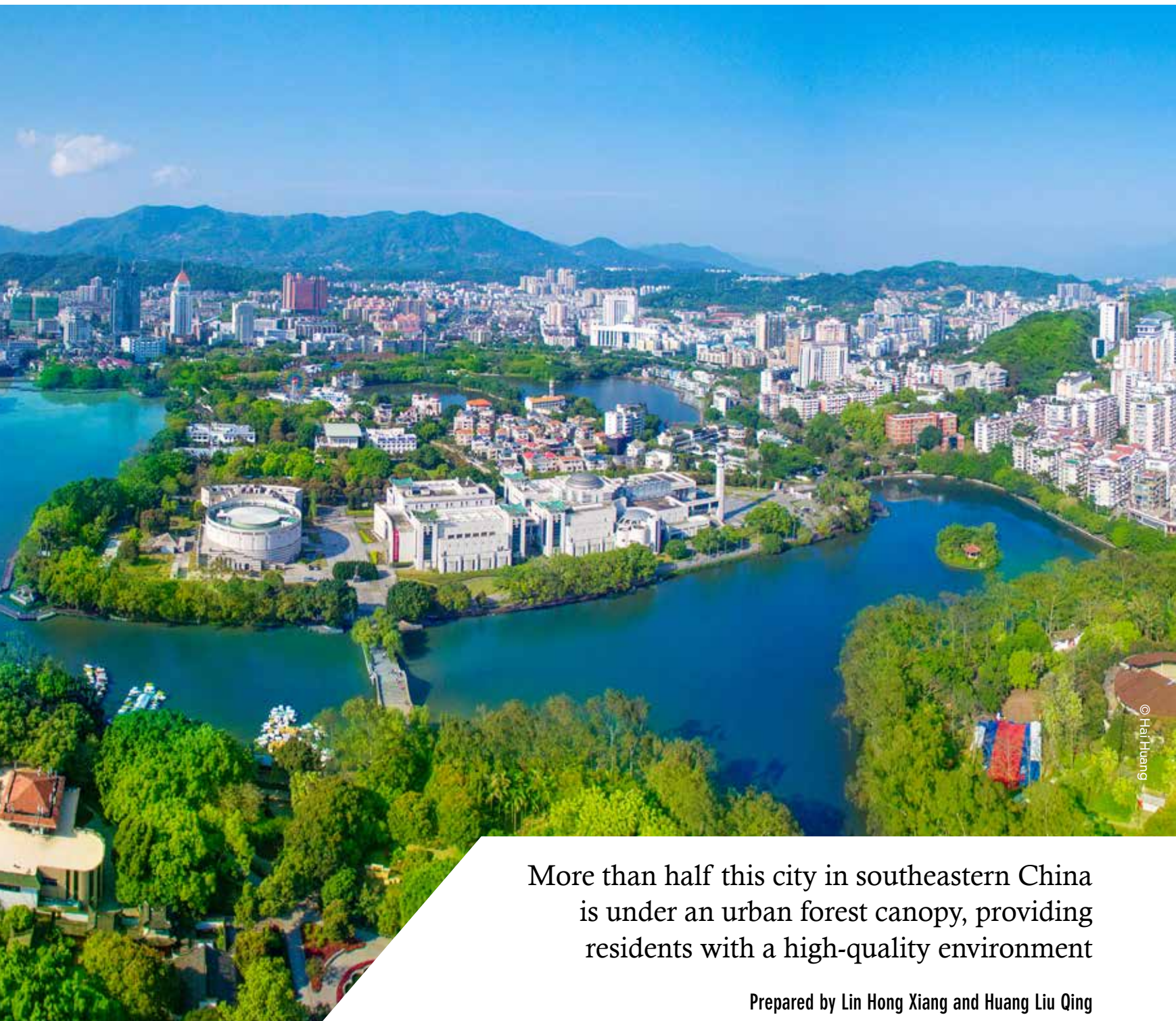
More than half this city in southeastern China is under an urban forest canopy, providing residents with a high-quality environment

Prepared by Lin Hong Xiang and Huang Liu Qing

© Hai Huang

Street trees and boulevards

Jianxin South Road is one of Fuzhou's main roads. It features five rows of tall Chinese banyan trees, as well as camphor trees and other species that separate sidewalks, non-motorized lanes and motor lanes on both sides. The canopy is like a giant open umbrella, shading pedestrians and motor vehicles on hot summer days.

Fahai Road, in the central part of the city, is planted with the golden rain tree; an industrial road is lined with orchid trees. These roads are not just full of green; in spring and autumn they boast other colours, too.

In recent years, Fuzhou has created 100 tree-lined boulevards, planting more than 200 000 trees. These boulevards connect seamlessly with parks, mountains, fitness plazas and other green spaces, forming a vast network of trees across the city.

Fifty-six percent of Fuzhou is forested, ranking second among all provincial capitals in China. There are 17 202 hectares of green space in the built-up area, a green coverage of 43.9 percent.

Walkways and trails

Fuzhou is building walkways across the city to enable residents to extend their "footprints" further into the forest and to fully integrate the city with nature. They enable people to see, walk in and touch the forest.

A forest trail called "Fudao" has been built in the west of the city, surrounded by mountains, rivers and green forests.

In the late autumn, the forest is splashed with red, yellow and green. The red is from the leaves of maple trees and the needles of pond cypress; the yellow is from the leaves of ginko trees and washnut; and the green is from Chinese banyan, camphor and mango.

Fuzhou has built 12 forest trails like Fudao in a short time, and the work continues.

The vision

Today, Fuzhou has realized its vision of "opening the window to see the green; going out to see the garden; and walking in the shade". It has created a pattern of urban ecological living, combining mountains, water, forests and the city.
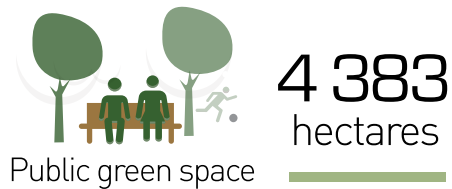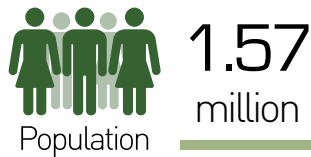
"In creating the Fuzhou city forest, the aim was to put people in the centre of the development of ideas in order to build a higher-quality living environment and meet people's yearning for a better life", says Tong Guirong, the president of the Fuzhou Forestry Bureau.

The Urban Forest trail of Fuzhou, where citizens can walk through a dense, healthy forest

© Dongming Wang

Philadelphia:
a "green countrie towne"

1.57 million
Population

34 700 hectares
Land area

4 383 hectares
Public green space

28.0 m²
Green space per person

Philadelphia is reviving the 1682 vision of its founder, William Penn, of a "Greene Countrie Towne". Today, green infrastructure planning has taken root in the nation's first capital and now World Heritage city. The following important initiatives point the way to the city's revival:

- the Greenworks Philadelphia plan, which envisions a sustainable city in which all residents have access to parks, healthy food and water, and clean air, and are prepared for climate change;

- the TreePhilly programme, which has the bold goal of increasing tree canopy in the city to 30 percent of the surface area in all neighbourhoods;

- ongoing work to reclaim the city's watershed forests; and

- the 25-year Green City, Clean Waters plan, which is designed to protect and enhance city watersheds by managing stormwater with innovative green infrastructure.

All these initiatives share one goal: to improve the quality of life of Philadelphians.
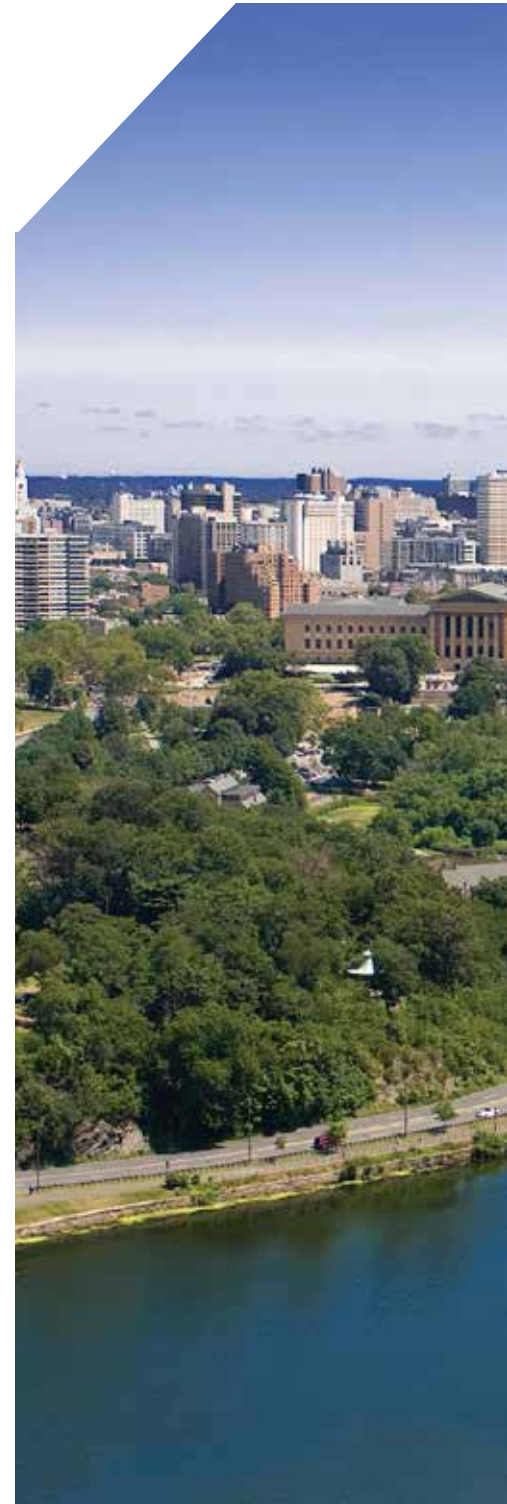
© Bonnie Jacobs

A community-based programme to improve the quality of life of residents of this American city is increasing the area of forests and other green spaces and reducing stormwater flows

Prepared by Phillip Rodbell, Erica Smith Fichman, Tom Witmer and Joanne Dahme

Philadelphia's green stormwater infrastructure

© Philadelphia Water Department

Growing a greener city

Greenworks Philadelphia is the city's sustainability plan, renewed by current Mayor Jim Kenney with eight visions on the topics of food and water, air, energy, climate, natural resources, transportation, waste, and civic engagement. Progress is tracked annually through key metrics responsive to public health and welfare concerns, such as food access, air quality index, clean energy consumption, walkable access to open space, and community engagement. As noted in the 2012 progress report, "Trees play an integral part in achieving several Greenworks targets, including reducing energy use and greenhouse gas emissions, improving air quality, and managing stormwater". But there are also specific targets around the city's urban forest, including the planting of 300 000 new trees on public and private property.

To help reach the target of increasing the neighbourhood tree canopy to 30 percent by 2025, Philadelphia Parks and Recreation (PPR) conducted an assessment of the urban tree canopy in 2011 with the help of the United States Forest Service. This assessment showed it would be possible to reach the 30 percent goal only if impervious surfaces in targeted places were removed. The other key finding was that the front and back yards of private homes present the greatest opportunity for expanding tree cover. Thus, PPR realized that, if the tree-canopy goal was to be achieved, private landowners had to be engaged. From there, the TreePhilly programme was born.

TreePhilly is a partnership between PPR and the non-profit organization Fairmount Park Conservancy. It was launched in February 2012 with the goal of engaging Philadelphians in tree planting and maintenance on their own properties. An analysis using a geographic information system identified eight target neighbourhoods where the programme could make a significant difference. The programme began making connections with residents, holding events and coordinating with existing groups.

Community tree tenders

Much of the city's green community network can be traced to the Pennsylvania Horticultural Society, a non-profit organization, which was founded in 1827 and aims to "connect people to horticulture and create beautiful, healthy, and sustainable communities". In 1993, the society launched the Tree Tenders programme, which provides community members with hands-on tree-care training.

Creating partnerships and networks is one of the biggest challenges in sustaining healthy urban forests, but it can pay big dividends in the long term.

"Tree Tenders is a really powerful network", says Erica Smith Fichman, TreePhilly programme manager. "You have these advocates in a lot of the neighbourhoods in Philadelphia, where they plant trees twice a year or have pruning clubs. It's a nice network of community-oriented work".

To meet the goal of increasing tree canopy in yards across the city, TreePhilly has given away more than 18 000 trees since 2012 for planting in private residences, with support from corporate sponsors. The programme relies on the green network of volunteers to make a long-term impact.

PPR is working with the Philadelphia Water Department, the Fairmount Park Conservancy and numerous other organizations to restore and improve more than 2 000 hectares of existing forests in its watershed parks. Many of these forests have suffered years of decline due to a number of factors; in the last 20 years, however, invasive vegetation and trash have been removed from hundreds of hectares, and tens of thousands of native trees have been planted. An increasing number of trees are propagated and grown in PPR's native plant nursery. Large deer exclosures have been installed to help natural tree regeneration and protect plantings. Trees in natural areas are expected to provide long-term improvements in water and air quality and wildlife habitat.

© TreePhilly

Staff from Philadelphia Parks and Recreation demonstrate the proper way to plant a tree during a volunteer tree planting at McPherson Square

1 000 greened acres

Some of the best examples of successful partnerships in Philadelphia centre on a plan to reduce the volume of stormwater reaching the Delaware River and its tributaries.

The plan is called Green City, Clean Waters. It was launched by the Philadelphia Water Department (PWD) in 2011 as the first large-scale programme of its kind in the United States of America. The plan was driven by a "triple bottom line" analysis that showed how investments in green infrastructure at a watershed scale can meet state and federal regulations for reducing stormwater runoff and sewer overflows at less cost and with greater public benefit than engineered solutions.

The success of the Green City, Clean Waters plan is measured in several ways, the most prominent of which is by the number of "greened acres" established. A green acre established using green infrastructure elements such as plants, soil, stones and water-absorbing pavements can soak up and filter 102 804 litres of stormwater. The aim is to take pressure off Philadelphia's sewer system and add new, landscaped green spaces to neighbourhoods.

In collaboration with PPR and the Pennsylvania Horticultural Society, the PWD has developed a design manual and cost-sharing programmes for tree planting in stormwater management facilities. The PWD has also developed maintenance and "adoption" programmes for these installations, in collaboration with local groups.

In undertaking the work, the PWD charges residential and commercial customers on a parcel-based approach. Essentially, the stormwater fee is based on the percentage

of impervious land on a given property. This provides an incentive (i.e. a reduction in monthly fees) for property owners to establish new green spaces.

"Green City, Clean Waters takes something as common as managing stormwater and turns it into an architecture for the future of the city", says Philadelphia managing director, Michael DiBerardinis. "It brings value to the neighbourhoods; it's present in the day-to-day lives of the citizens; it pays back well and it pays back early".

In October 2017, the city celebrated completion of its first 1 000 greened acres, capable of treating 103 million litres of stormwater. The city, therefore, is well on the way to achieving the goal of more than 5 000 greened acres by 2036. When completed, the installation of this green infrastructure will reduce the volume of stormwater and overflow pollution entering city waterways by 85 percent.
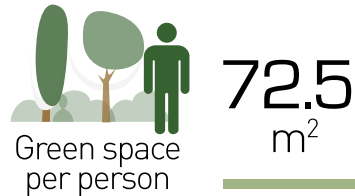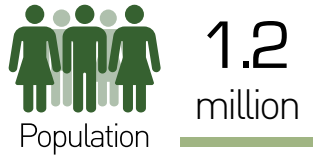
The net result of this activity – in addition to partnership building, stewardship and innovation – could be the fulfilment of the vision of William Penn of a "Greene Countrie Towne". It could also achieve the goal of Greenworks Philadelphia to make Philadelphia the greenest city in the country.

A forest for all and for always, near Brussels

1.2 million
Population

16 140 hectares
Land area

8 554 hectares
Public green space

72.5 m²
Green space per person

Each year, millions of people walk through the ancient Sonian forest, a 5 000-hectare green treasure on the edge of Brussels, Belgium. It is remarkable that the forest has thrived as it has for so long, so close to a bustling urban centre. But will it survive in this era of rapid change?

Even though humans have exerted influence on the Sonian forest for more than 5 000 years, its soils and topography are relicts of the last ice age and have changed little in more than 12 000 years. The forest boasts breath-taking landscapes and a rich biodiversity. It features ancient beech stands, which, on average, are about 140 years old. The forest has about 35 000 tall trees, which equates to an exceptional seven tall trees per hectare, similar to the concentration of tall trees in primeval beech forests. The Sonian forest is part of "Natura 2000", Europe's network of protected areas; strictly protected areas in the heart of the forest have outstanding conservation value.

The Sonian forest was designated recently as part of a serial natural World Heritage area together with ancient beech forests in Albania, Austria, Bulgaria, Croatia, Germany, Italy, Romania, Slovakia, Slovenia, Spain and Ukraine.

© Stéphane Vanwijnsberghe

Adept management is needed to ensure that the ancient Sonian forest, in Belgium, survives in this era of rapid change

Prepared by Frederik Vaes and Stéphane Vanwijnsberghe

Ancient history, threatened future

The Sonian forest contains well-preserved traces of the first humans who settled in the region in the Neolithic Age (4 000–5 000 years ago). When Brussels was founded in the tenth century CE, the forest was a source of cattle fodder, fuel and construction material. Laws were passed to regulate forest use as early as the thirteenth century, but this could not prevent the degradation of more than 1 000 hectares of the forest by the eighteenth century. The Austrian governors of the time reforested these lands with beech as the dominant tree species. Today, the beech-dominated stands contain trees exceeding 50 metres in height, forming pillars resembling those in Gothic cathedrals. Beeches aren't the only species in the forest: they love company, and they grow alongside species such as sessile oaks, birches, maple trees, lime trees and hornbeams.

The Sonian forest had been reduced to its present size by the beginning of the twentieth century and fragmented by roads and development. Today, strict laws are in place to protect the forest, but its future is still not assured: the impacts of air and water pollution, visitor pressure and urbanization are clearly visible and measurable. The stresses are unlikely to abate: for example, the population of Brussels, already about 1.2 million people, is predicted to grow by 28 percent by 2060. But the greatest challenge lies in increasing the forest's resilience to climate change. Storms, lengthening summer droughts, and disease could destroy or degrade these "cathedrals".

The beech is a sensitive tree. Despite the great heights it can attain, its root system is shallow, making it vulnerable to drought and strong winds. In the storm known as Daria in 1990, for example, thousands of large beech trees across Europe were toppled in winds that reached hurricane force. Such storms are projected to become more common as the climate changes. In addition, the effects of summer drought are evident. Since 2005, for example, mast years (seasons with massive seed production) have been occurring every two or three years, which is two to three times the rate considered normal for beeches. It's clear that climate change is already having an impact.

Unity makes strength

The Sonian forest crosses the boundaries of three of Belgium's regions, meaning that cooperation is needed for effective management. The designation of the area a UNESCO World Heritage site is the result of close and effective cooperation among the three regions. The jointly developed management plan, expected to be implemented from 2018, champions the sustainable and multifunctional management of the area and aims to increase the resilience of the forest to the effects of climate change. This aim will be achieved by gradually reducing the proportion of even-aged and single-species stands, promoting the regeneration of more resilient tree species, using ecological approaches (e.g. active dead wood management), tending towards more mixed stands, improving the vertical and horizontal structure of forest stands and creating multilayered forest edges. Collaborative initiatives such as reducing fragmentation by connecting fauna and flora across roads and other barriers via tunnels and bridges are underway to help safeguard the forest and its ecological value. The impacts of tourism are managed by concentrating visitors at six "welcome gateways" on the edge of the forest, with clearly marked and well-maintained paths. Finally, interregional walking, cycling and riding paths will be granted legal protection and there will be joint information boards and the same style of wooden furniture throughout the forest.

Coping with change

Everyone wants the Sonian forest to stay the way it is in all its splendour. The forest faces many challenges, however, which seem to be arising at an ever-increasing pace, and we all share responsibility for tackling them. Appreciation is the best protector of a treasure like the Sonian forest, and raising awareness through education and communication, therefore, is essential. The Internet and social media can re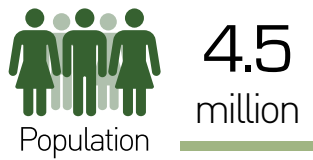duce the distance between foresters and forest visitors – presenting an opportunity to achieve positive change, both locally and globally.

"We are lucky to have the beautiful and rich Sonian forest right on Brussels' doorstep. This is a unique patrimony. But the increasing pressure caused by Brussels' development as a city may put the forest at risk. It's our responsibility to take steps to preserve this heritage, so we can hand it over to the next generations in all its richness", says Céline Fremault, Belgian Minister of the Environment.

© Frederik Vaes

Old beech trees in the Sonian forest World Heritage Site

Melbourne's forest: from the centre to the fringe

4.5 million
Population

266 400 hectares
Land area

24 000 hectares
Public green space

53.3 m^2
Green space per person

"Dear Algerian oak, Thank you for giving us oxygen. Thank you for being so pretty …"

This was one of hundreds of messages received by the City of Melbourne in response to its "Email a Tree" campaign – part of a process in which the City of Melbourne became a global leader in the development of holistic urban forest strategies.

Now the challenge is to connect these efforts in the centre of Melbourne with those at the city's fringe.
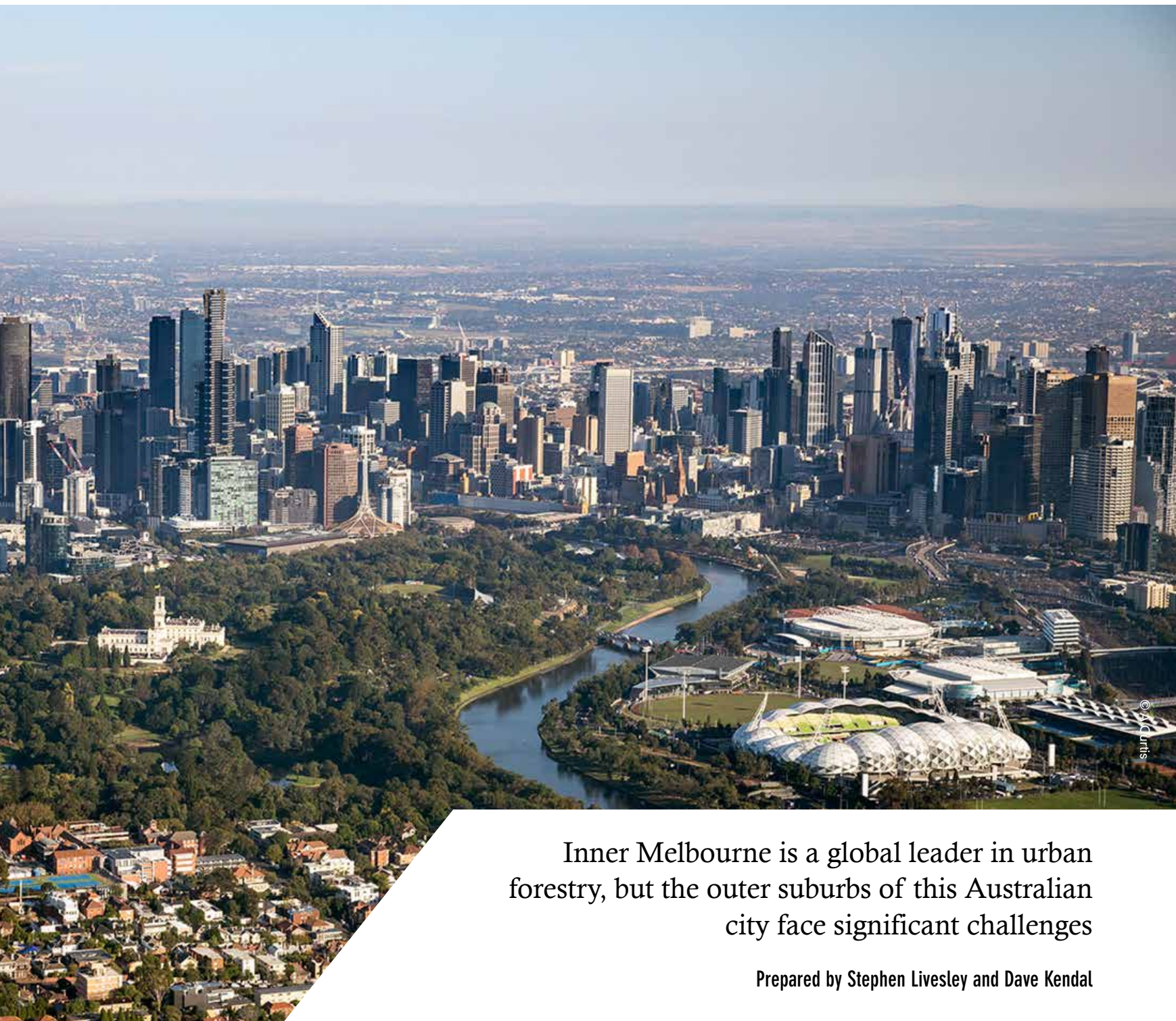
Inner Melbourne is a global leader in urban forestry, but the outer suburbs of this Australian city face significant challenges

Prepared by Stephen Livesley and Dave Kendal

©ACurtis

Melbourne downtwon

© Kym Crowley

City of Melbourne, and the drought

Despite the international image of the "huge red outback", Australia is one of the world's most urbanized countries, with 90 percent of the population living in cities in 2018. Melbourne, the state capital of Victoria, is a rapidly growing city in southeastern Australia, and its population of 4.5 million people is projected to increase to 8 million by 2051. Greater Melbourne comprises 31 local government areas that vary in size from 2 000 hectares to more than 50 000; each is responsible for the management and maintenance of its own trees and green spaces.

The City of Melbourne, which includes Melbourne's central business district and its tourism and sporting heart, has an area of 3 700 hectares. Its residential population is only 189 000 people, but this bustling financial and cultural city centre has an average weekday commuting and visiting population of 903 000. The well-funded, innovative council provides leadership and support to other city councils within the state and nationally.

The "millennium drought", which led to irrigation bans in many iconic parks and green spaces, was a turning point in the management of urban trees in the City of Melbourne. The city centre has a large population of aging or overmature trees, and the drought caused extreme tree stress and many tree deaths. Old age and poor health means that almost half the City of Melbourne's trees will need to be removed in the coming 20 years.

In response, the City of Melbourne developed a "society-wide" urban forest strategy that was supported by data, clearly communicated its objectives and the need it was meeting, and, most importantly, sought and gained community-wide support. Initially, the strategy emphasized water conservation, drought adaptation and urban forest renewal. Later, it focused on climate change and city cooling and now encompasses biodiversity, urban ecology and human connectedness with nature.

Passion for trees

The City created the Urban Forest Visual Map as a novel means to communicate tree species, age and useful life expectancy and to empower the community to identify issues with individual trees via email. What happened was an outpouring of passion and love. "Email a Tree" became an international sensation that demonstrated the strong emotional connectedness that people develop with trees in their streets, on their way to work, and outside their offices.

Communities are passionate about trees – they can love them and hate them! A key component of the City of Melbourne's urban forest strategy is its engagement with the local community.

"The public participation process was able to defuse conflict over urban forest change and renewal and increase species diversity by including the views of a wide range of people", says Dave Kendal, who facilitated many community engagement events.

The City of Melbourne went beyond informing the community of its plans, involving it in decision making and collaborating with it in identifying local solutions relevant to each street in the municipality. Innovative techniques such as values-based mapping, photo sorting and questionnaires were employed to co-design ten precinct plans. This approach was time-intensive and costly, but the rewards have been significant – most notably in an empowered and engaged public.

City of Moreland

Moreland City Council is north of the City of Melbourne in the same metropolitan area. A strong multicultural community with relatively low socio-economic status, it covers 5 100 hectares and has a population of
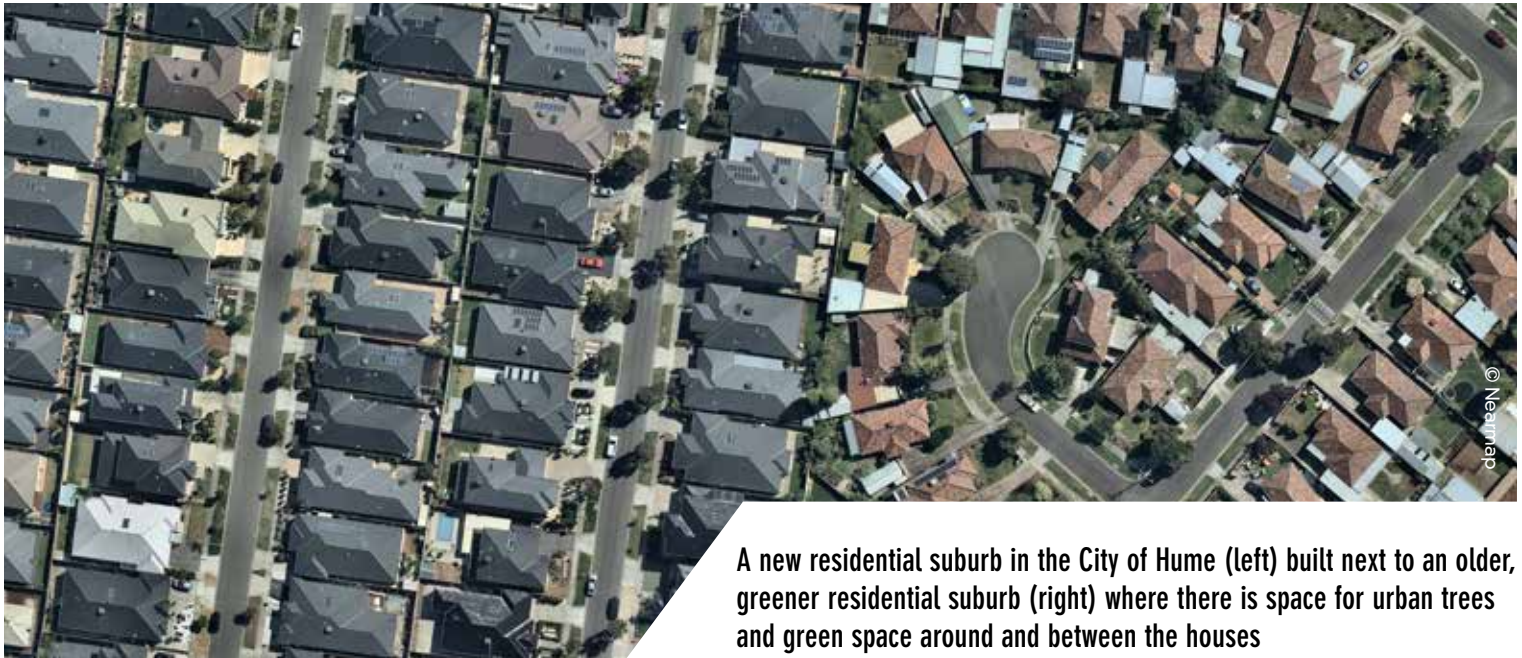
A new residential suburb in the City of Hume (left) built next to an older, greener residential suburb (right) where there is space for urban trees and green space around and between the houses

167 000 people. Heat and community vulnerability were the central drivers for developing the Moreland urban forest strategy, released in 2017. Most of Moreland's urban forest is on private residential property, and the Council is focusing its urban forest strategy on reversing a decline in private tree canopy.

"Urban consolidation or in-filling is the real issue in Moreland that is leading to tree canopy loss faster than we can grow trees in our parks and streetscapes", says Alex English, Moreland's Open Space Planner. "Moreland has prioritized areas that need trees based upon a combination of thermal heat mapping and social vulnerability mapping – which has led to our focus on areas around schools, old-age centres, health centres and social housing".

Community engagement has been crucial to success, albeit on a fraction of the budget of the City of Melbourne. Alex English visited schools, community groups and festivals to gauge community interest and gather ideas to inform the draft urban forest strategy, which received over 250 individual contributions – a record for any Moreland government consultation programme. In response to the strategy, Moreland Council has increased urban forest funding by 50 percent.

City of Hume

Further north is the City of Hume, with a population of 210 000 people in an area of 50 300 hectares. Hume has

a rapidly growing population and an increasing number of housing estates and suburbs. In contrast to Moreland, there is little opportunity for trees in private gardens because block sizes have decreased and house sizes have grown.

"The majority of tree-growth opportunities are in streetscapes or parks", says Jason Summers, Parks Manager at Hume. "So we have focused on filling in the gaps in streets and replacing any street trees lost from drought. Hume's streets are now pretty-much full".

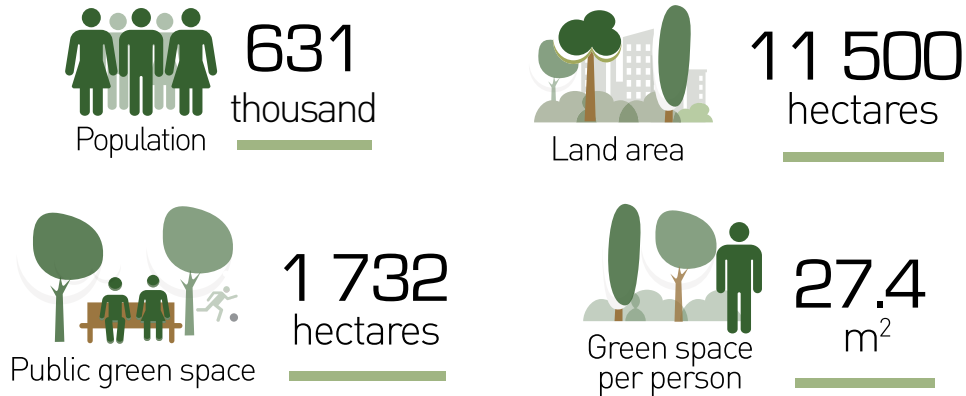Hume is working to green its car parks, public parks and other council properties.

"It gets pretty hot and dry out our way, so the trees don't grow as fast or as big as they do elsewhere", says Summers.

"We have to plant more [trees] to get the same results".

Hume manages a vast urban tree population, which increases annually as the suburbs grow and creep further north, supplying more public green space and street trees that require maintenance. There is little time or money for community-wide consultation, but the task of increasing public green spaces and maintaining the existing tree population is urgent because suburb construction is creating an urban heat island.

© Casal Partiu

Vancouver: envisaging the world's greenest city

631 thousand
Population

11 500 hectares
Land area

1 732 hectares
Public green space

27.4 m²
Green space per person

The city of Vancouver, on the Pacific coast of British Columbia, Canada, is set in a stunning landscape of wide ocean views and forested mountains. The city, which was incorporated in 1886, is the fourth-largest in Canada. Many of its inhabitants were born outside Canada, and immigration, especially from Asia, continues at a rapid pace. Population growth had led to high demand for new housing, and property and rental prices have soared.

Vancouver was established on the traditional lands of several First Nations, including the Squamish, Musqueam and Tsleil-Waututh nations. Unlike in some other parts of Canada, no treaties were signed between the aboriginal populations and the Canadian government, meaning that the original inhabitants have still not ceded the lands. Vancouver emerged as a municipal centre when the timber industries of British Columbia boomed, but it has since developed into a multifaceted city, with a well-developed service economy, creative industries and several universities.

Vancouver's politics have had a strong "green" component for many years. In 2011, the city government drew up the Greenest City Action Plan to realize its aim of becoming the world's greenest city by 2020. Vancouver wants to be a global leader in sustainability by combining the development of a strong local economy with that of vibrant, inclusive neighbourhoods. It has set targets for realizing its vision, such as zero waste, zero carbon, and healthy ecosystems.

The urban forest of this Canadian city has been under pressure, but a new strategy is bringing trees back through community engagement

Prepared by Cecil Konijnendijk, Lorien Nesbitt and Bill Stephen

Vancouver's urban forest

The city's urban forest is playing an important role in realizing the "greenest city" vision. Although large, attractive parks such as Stanley Park, Queen Elizabeth Park and Van Dusen Gardens stand out as "crown jewels", the city has a diverse urban forest. It has an extensive park system in which beaches and coastal green spaces are important. The city government's detailed street-tree inventory shows that it manages 150 000 street trees and about 35 000 ornamental trees in parks. The Park Board has conducted tree maintenance on public trees for more than a century. An unknown number of trees, accounting for about 60 percent of the city's canopy cover, grow on private land.

A wide range of species can be planted in Vancouver's temperate-rainforest growing conditions, and this is reflected in the composition of the urban forest. Cherry, plum and maple species make up more than half the city's street trees, but native trees dominate in forested areas.

Parks and other green spaces are popular for outdoor recreation and tourism, and trees also provide important habitat for urban wildlife and pollinators and help moderate air pollution. The watershed forests outside the city play a crucial role in protecting the city's supply of drinking water; access is restricted in these areas, which are managed by the Metro Vancouver regional authority.

The challenge: maintaining the canopy

The city has had to deal with an influx of thousands of new residents in recent years, leading to demands for additional housing and the replacement of single-family residential lots with medium- and high-density housing. Many private trees have fallen victim to development, with more than 23 000 mature trees felled in the past 20 years and a consequent drop in the city's tree canopy cover from 22 percent to 17.5 percent. There has also been an increase in the area of impervious surfaces, posing challenges for urban resilience; for example, stormwater runoff increases as the area of impervious surfaces increases. It is ironic that the city's green policies and its extensive urban forest have contributed to its attractiveness and thus to pressure on land for housing and development.

In addition to development pressure, the city's urban forest has suffered from the impacts of climate change, such as drier summers. Various tree pests and diseases are adversely affecting urban trees.

Another challenge for urban forestry in Vancouver is the uneven distribution of trees and the tree canopy. The western, more affluent neighbourhoods are well catered for, with canopy cover reaching almost 30 percent. Some of the eastern neighbourhoods, however, have less than 10 percent canopy cover.

"The biggest challenges Vancouver faces in regard to its urban forest are equitable distribution and protection of the urban forest in the face of developmental pressures."

Thomas Ikeda, urban forestry student, University of British Columbia

Vancouver's urban forests are under pressure from development and other factors, but a new strategy is bringing trees back through community engagement

Strategy to address the challenge

In 2014, the Vancouver City Council, led by its Board of Parks and Recreation, endorsed an urban forest strategy to address these challenges and to contribute to Vancouver's "greenest city" vision. The strategy highlights the important role of the city's urban forests and outlines targets and activities under the banner of "protect, plant and manage (and engage)". "Protect" is aimed at halting canopy loss. An analysis of tree loss showed that more than half of all tree removals were due to a clause in the tree by-law that allowed property owners to remove one tree per year, irrespective of size, species or other parameters. A change to the tree by-law has removed this clause, making it much more difficult for owners to fell large, mature trees.

 "Plant" refers to the planting of 150 000 new public trees by 2020 on streets, in parks and golf courses, and on private property. The planting is being done strategically across the city, addressing, for example, shortages in some neighbourhoods. Moreover, the strategy aims to increase species diversity to develop an urban forest that is more resilient to the impacts of climate change. The "manage" component of the urban forest strategy stipulates that the forest should be managed as a vital living asset. Street and park succession plans are being developed to prepare for the replacement of ageing street-tree populations.

 In its efforts to maintain and further develop a healthy urban forest that provides local communities with many benefits, the city is engaging with a wide range of partners, such as non-profit-making organizations, neighbourhood groups, businesses and local universities. The city's collaborative approach and partnerships will help ensure the long-term viability and success of its urban forest strategy.

"Proactive tree maintenance will save the city a lot of money in the long run, and enhance public safety."

Member of the city's urban forestry maintenance crew

Conclusions

The United Nations 2030 Agenda for Sustainable Development and the New Urban Agenda both recognize cities as key players in sustainable development. Cities account for more than 70 percent of global greenhouse gas emissions and consume two-thirds of the world's energy; they are ideally positioned, therefore, to drive local action.

The stories in this publication show how trees and green spaces can provide many tangible and intangible benefits and values that improve quality of life, safety and public health in cities. This has been the case in Melbourne (Australia) and Philadelphia (United States of America), with their innovative green-infrastructure-based strategies for managing water and watersheds, and in Beijing (China), where forests are being used to restore degraded urban and suburban areas, leading to remarkable improvements in aesthetics and ecosystem functioning.

Implementing policies for equitably sharing the benefits of urban forests and trees is key for increasing social equity and reducing the gap between rich and poor. The stories from Bangkok (Thailand), Halifax (Canada), Nairobi (Kenya) and Niterói (Brazil) demonstrate how engaging stakeholders in the planning, design and management of urban forests is vital for ensuring a city's effective and inclusive governance. Multi-actor and multisectoral approaches, and building partnerships between governments, the private sector and civil society, are essential for developing strategic visions and the necessary policies, norms, incentives and regulations.

The story from Lima (Peru) shows how taking into account the needs and requirements of local communities through participatory approaches and transparent public discussions can lead to the adoption of innovative strategies for managing urban environments. The same applies to the conservation of high-value natural forests near cities, as in the case of the Sonian forest in Brussels (Belgium), and to the implementation of long-term approaches to fulfil a "green city" vision (as in Fuzhou, China; Ljubljana, Slovenia; Singapore; and Vancouver, Canada).

The cities featured in this publication are at varying stages of investment in their urban and peri-urban forests. Some have been active for decades and have more results to show, others have started more recently. The objectives vary according to the local context – from temperature regulation to erosion control or simply recreational value. Nevertheless, all cases, large and small, can provide useful lessons and inspiration for others. Forests and trees have the power to transform cities into greener, healthier and happier places in which to live. As the world continues to urbanize, integrating forests and trees into land-use planning and sustainable urban development strategies is essential for making progress towards sustainable cities.

The story in numbers

In Bangkok, **10** new parks with a focus on native vegetation have been created since 2014

The 3.16 million trees in Phoenix provide estimated benefits of more than **USD 40 million** per year

In Independencia (Lima), local people have planted **14** hectares with trees to protect an informal settlement from landslides and as a model for **7** more forest parks in the area

In Beijing, over **54 million** trees were planted between 2012 and 2016

The Karura forest in Nairobi is visited by **16 000** people per month

In Halifax, **111** neighbourhood-level subplans were combined to form a city-wide urban forest master plan
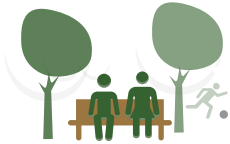
In Singapore, the urban greening programme was initiated more than **50** years ago

The City of Ljubljana designated **1 150** hectares of natural forest for recreation

The Niterói Eco-Social programme will hire 400 young people to reforest 100 hectares and maintain park facilities

The Green Belt project in Vitoria-Gasteiz has created 6 large parks of ecological significance on a total of 800 hectares

The City of Fuzhou has created 100 tree-lined boulevards, planting more than 200 000 trees

Since 2012, the TreePhilly programme has given away more than 18 000 trees for planting in private residences in Philadelphia

In Brussels, 3 of Belgium's regions are cooperating effectively in the management of the Sonian forest

Following public consultation, the City of Moreland, in Greater Melbourne, has increased urban forest funding by 50%

The City of Vancouver manages 150 000 street trees and about 35 000 ornamental trees in public parks