There has never been a greater need for the people planning and running our cities, as well as the residents who pay for it, to understand the critical significance of green space in our urban environment.

Working with green is a way to respond to the true needs of people when designing buildings, the public realm, transport and communications infrastructure. This is a goal to which every professional can apply themselves. These guidelines are a starting point so interested parties can come together internationally and discuss techniques for urban development.

Michelle de Roo | landscape and urban designer
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What this set of guidelines shows is that the knowledge is already there. The theory, substantiated by empirical scientific research, proves that green infrastructure is a key element in constructing living spaces that work. This is powerful information at a time when budgets are being cut and every cost scrutinised. This set of guidelines and techniques will demonstrate to practitioners that investment and maintenance in green infrastructure is not a cost but brings value from a social, economic and environmental point of view - in summary the ‘Green City Philosophy’.

A group of leading researchers and practitioners have contributed to this volume and it is to be used as a stimulus for the global adoption of the Green City Philosophy. This book is the beginning of a process that could see green infrastructure responses fully incorporated into policy and practice - in effect become a ‘universal green city standard’. The authors and contributors hope that you will be part of that process.

The ‘guidelines’ project has been made possible with funding from the Dutch Ministry of Economic Affairs, Agriculture and Innovation (EL&I) and with the active support and co-operation of the Dutch nursery stock industry, Plant Publicity Holland (PPH), the International Association of Horticultural Producers (AIPH) and Niek Roozen bv landscape architects.

signed by

Marcel Vernooij (EL&I)
Doeke Faber (AIPH)
Jaap Sproos (PPH)
Niek Roozen
Table of contents

Introduction 4
Guidelines 8
1 Green cities 9
1 The planning process 10
2 Invest together 12
3 Filtering for fresh air 14
4 Green network 18
5 Within walking distance 20
6 The art of nature 22
Case study: Shenyang Hunnan District 24

2 Green neighbourhoods 27
7 Microclimate parks 28
8 Resident participation 32
9 Recreation 34
10 Playgrounds and schoolyards 36
11 Views of green 38
12 Private green 40
13 Semi-private green 42
14 Green business parks 44
15 Urban farming 46
16 Water runoff 48
17 Biodiversity 52
Case study: The High Line, New York City 54

3 Green streets 57
18 Green plazas 58
19 Air circulation & ventilation 60
20 Street layout 62
21 Right tree, right place 64
22 Use existing trees 66
23 Big healthy trees 68
24 Growing conditions 70
25 Quality maintenance 73
Case study: London 2012 Olympics 74

4 Green buildings 77
26 Green oriented to buildings 78
27 Buildings blend into landscape 80
28 Green roofs 82
29 Green walls 84
30 Green indoors 86
Case study: Vancouver Convention Centre 88

Conclusion 91
Literature List 93
Expert Team Participants 96
Photo Credits 97
Colophon 99
Introduction

The ‘Green City Guidelines’ project is an internationally targeted initiative that aims to provide practitioners and decision-makers with the essential information they need to understand and communicate the benefits of urban green space or more accurately green infrastructure. The purpose of this project is to bring this information more into the mainstream in a form that is immediately accessible, yet at the same time supported by the evidence-based substance that practitioners globally need to implement successful green infrastructure responses. The Green City movement has in its heart the belief that the green element is critical to the long-term functioning of healthy, successful, liveable urban spaces. Statisticians from the United Nations estimated that 50% of the world’s population would live in urban areas by 2008, with 70% by approximately 2047. For this reason, it is essential that the true value of urban green space is globally understood and that decision-makers have the tools to guarantee its position.

Objectives of this book

This book is written to provide a wide range of professionals with the stimulus to ask ‘how green is my city?’ It provides tools in the form of practical pointers that show how the contribution of green infrastructure can be enhanced for the benefit of all. This applies both now and for future generations. It is written in the knowledge that the term ‘green city’ has a range of meanings but deliberately focuses on the physical, living green, plants as well as green spaces. The plant features are the elements that underpin the rest of the settlement and can deliver those essential ‘ecosystem services’ that are our life-support systems. “Ecosystem Services” is a term to describe any beneficial function provided by green space that would otherwise require a technical response (flood defence, air quality, countering the urban heat island) or that offers a cultural or other benefit (e.g. biodiversity or aesthetic/heritage benefits). Valuation of ecosystem services is emerging as an important concept for securing investment in green space.

In itself, this book does not seek to provide all the answers. However it offers case studies, references and guidance relating to those subject areas where green infrastructure plays a part in the successful functioning of the human urban environment. The reader can follow up on these as required depending on site-specific needs.

Rationale

Green infrastructure offers solutions to a wide range of the challenges faced by contemporary society. By applying green space solutions with reference to scientifically and economically proven models, outcomes can be predicted. This is an essential stage in the acceptance of green infrastructure as a mature and credible tool that can be utilised as a problem-solver in diverse situations all over the world. The case studies in this book serve to demonstrate the potential of a range of responses and approaches. By bringing them together in one place, they are convenient and accessible. They can be used by practitioners to stimulate thought and to win arguments. They will have greater impact because they have been collated.

“...the relationship between the amount of green space in the living environment and health should not be underestimated. Most of the diseases that were found to be related to the amount of green space in the living environment are highly prevalent in society and are subject of large-scale prevention programmes in many countries. Furthermore, diseases of the circulatory system, mental disorders and diseases of the digestive system, for which we found a relationship with the amount of green space, are among the most expensive diseases in terms of health care costs in many countries (Heijink et al., 2006). Thirdly, the results indicate that people who live in a greener living environment generally feel safer...”

Jolanda Maas in Vitamine G
The Green City Guidelines are founded on the principles of the Green City philosophy. This is an international approach that places green space at the centre of development and regeneration, on a par with red, blue and grey on the masterplan. It uses evidence-based arguments to highlight the importance of green elements and positions them as fundamental solutions and responses to many of the challenges of contemporary life - from stress, burn-out or obesity to climate change preparedness. It argues that investment in green infrastructure is repaid many times over in terms of the benefits it brings.

There are a number of key areas in which green infrastructure offers quantifiable benefits. These topics return at the bottom of every guideline in order to illustrate how each guideline benefits so many of these topics simultaneously, therefore strengthening the integral value of green.

Health
Residents and workers are happier and healthier when they live and work in green surroundings. This is because of the psychological benefits - we are hard-wired to be more at ease in green spaces rather than concrete ones - but also because of shade, air quality and the increased likelihood that we will take healthy outdoor exercise when we have access to green space nearby. Improved health results in lower costs for the health-care sector, benefits the economy and leads to enhanced human well-being. The productivity of workers increases and reported sick days decrease in offices with indoor green, which can save a company € 87 per employee per year. Patients recover up to 10% quicker in hospital rooms with views of green, resulting in the possibility for more patient turnaround and therefore more revenue.

Social interaction
Greener environments encourage people to spend more time in outdoor spaces which in turn increases the rates of social interaction and mixing. Valuable in all situations, this is especially important in multi-cultural communities where barriers of ignorance and distrust can lead to real conflict. Green space and what can be done in it (from growing food to fishing to flying kites) is also an enabler of inter-generational social relationships. Building stronger communities in this way improves social cohesion and helps to bring down the social costs of crime.

Economy
Quality green infrastructure increases house and office values (either rental or freehold). It provides a more attractive environment for inward investment and draws additional visitors to a city.

Green roofs and green walls help reduce energy costs in buildings by € 0.71 to € 19 per m2. The longer life of a green roof can save K 19 per m2 per year on water runoff and treatment. Green parks can save € 19 per m2 per year on water runoff and treatment. Green roofs can save € 10 – € 19 per m2 per year on water runoff and treatment. Green roofs can save K 40 per year per tree.

Climate and pollution
Green infrastructure responses such as street trees, green roofs and walls, parks and gardens all contribute to moderating the impacts of the urban heat island effect - recognised as a significant cause of premature death in cities. In addition all plants and trees remove dust (particulate matter) and gaseous pollution including ozone, nitrogen dioxide and volatile organic compounds from the air, with certain groups being particularly effective. The shade and air-cleaning benefits of urban greenery has an enormous cash-value for a city in improved health of residents. The capacity of an average tree in a “hotspot” in the city has a benefit of € 40 per year per tree.

Water
Water management and climate change resilience are very closely linked and relate directly to the management of the urban green estate. A range of ‘Sustainable Urban Drainage System’ (SUDS) responses are increasingly being put in place by water companies and communities who are seeking to respond to the challenges of increased incidence of extreme rainfall events. SUDS solutions offer considerable cost advantages over engineering solutions, as well as providing amenity areas for wildlife, recreation and even food production.

Structure
The structure of the book is broken down into four scale levels:

1. Green cities
   deals with key elements of the planning process and its relationship to green space.

2. Green neighbourhoods
   examines those green spaces that form part of the wider neighbourhood and contribute to the social and catchment-scale functioning of the community.

3. Green Streets
   introduces the role of street trees and plants and their contribution to the effective functioning of streets in relation to air quality and urban microclimate.

4. Green Buildings
   explores how the performance of buildings can be enhanced through the application of green infrastructure elements. This could include positioning within the landscape, green roofs and walls, as well as interior landscaping.

The information contained within this book is based on the best available knowledge now. It is intended that the reader can follow-up on these case studies as required, with reference to their own local climate and other conditions.

This is a dynamic document that is linked with a central, international Green City website: www.thegreencity.com. New information will be uploaded as it becomes available in order to enhance what has been gathered here and build upon it.
Urban green (in the form of parks, gardens, trees, rooftops and walls) plays an important role in the liveability, attractiveness and sustainability of a city, neighbourhood, street or building. The benefits of each guideline are sometimes limited to two or three topics, but often span the entire spectrum of topics including economy, health, social interactions, ecology, water, climate and pollution.

**Green cities, neighbourhoods, streets and buildings:**

- **Economy**: increase the value of real estate, reduce energy costs, reduce water runoff costs
- **Health**: provide opportunities for relaxation and recreation, improve mental and physical health and the well-being of people
- **Social Interactions**: increase social cohesion resulting in stronger communities with less criminality and anti-social behaviour
- **Ecology**: increase habitats for ecological communities, biodiversity and opportunities for urban residents to experience nature
- **Water**: decrease the amount of impervious surfaces and provide water retention possibilities on site, thus reducing peak runoff problems
- **Climate & pollution**: filter pollutants and dust from the air and regulate temperature extremes

These topics return at the bottom of every guideline in order to illustrate how each guideline benefits so many of these topics simultaneously, therefore strengthening the integral value of green. Each one of these functions contains an ecosystem service element.

**Explanation of the symbols**

**Green cities**

1. The planning process
2. Invest together
3. Filtering for fresh air
4. Green network
5. Within walking distance
6. The art of nature

Case study: Shenyang Hunnan District
“Grey” plans based on green
Infrastructure projects should incorporate green early on in the design of new roads, transit facilities and other projects by assuring ample space (both above ground and underground) and budget for trees and other green. Higher density development that brings people closer to mass transit and takes people out of their cars also increases the “greenness” of an area. The pedestrian experience is therefore very important and can be improved by aesthetic and functional green.

“Red” plans based on green
New development of residential and business areas should incorporate urban forests into the design and use green as a building block. An urban forest is a collection of trees in the urban environment and can vary anywhere from a forest, ecological corridor, park or recreational green space to a green roof garden, street, plaza or front garden. A livable neighborhood in a compact city contains 15-20% green in the direct living environment.

“Blue” plans based on green
The water structure should be designed within a team of engineers plus urban designers, landscape architects and ecologists so green is incorporated into the design.

Consider the multifunctionality of green
Use green not only for aesthetics but also for its ability to raise the value of houses, improve the health of residents and workers, encourage social interactions, regulate temperatures, retain water, increase biodiversity, reduce energy needs in buildings and remove air pollutants.

Convince decision makers to demand green
A long term cost-benefit analysis should be undertaken to help convince decision-makers that green elements are essential in all urban projects. The development of green spaces should also play a central role in policies related to health, nature conservation and spatial planning.

Benefits of planning & green
• Image
  creates a green and healthy image for the city
• Value of real estate
  increases in the vicinity of green
• Air quality
  filters pollutants and dust from the air
• Health
  provides opportunities for relaxation, social contact and recreation, and increases health and well-being
• Aesthetics
  beautifies streets and neighbourhoods
• Climate
  reduces the greenhouse effect by absorbing CO₂
• Microclimate
  regulates temperature extremes through shade and wind and humidifies the air, creating a cooler and more comfortable environment
• Water runoff
  provides water retention possibilities and reduces peak runoff
• Biodiversity
  provides habitats for flora and fauna in the city
• Energy savings
  reduces the need for heat in winter and airconditioning in summer

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Grey + green + cities
In new & existing development:
Inform decision makers of the benefits of green in urban areas so it becomes just as standard an element in projects as roads, parking density. Multidisciplinary teams for all infrastructure and development projects require landscape architects.
Communicate the benefits to various parties

Parties such as the health sector, businesses, engineers, designers, the building sector, developers, cities / local governments and of course the residents themselves can all gain from green in the city. Emphasize the long term benefits.

The cost of green is an investment

Costs for green should be seen as an investment just like any other building investment. Approach a green project as a business case and ask the question: what is the joint ambition and how can it be achieved together? Only then will green have added value. And the costs will be seen as an investment that earns itself back.

Businesses benefit from quality public projects

Businesses tend to look at the public sector that is responsible for the surroundings we live in. By co-investing in public projects they can help improve their business location as well as make the city more liveable for their employees and new talent.

Real estate near green is more valuable

Developers should be aware that houses with quality green in the neighbourhood are worth 4 -15% more than houses of the same type in non-green neighbourhoods and therefore calculate green into the total budget. The range depends on whether the property is adjacent to green, has a view of green or is near green.

Regulation incentives encourage good development

Invite businesses who are looking to invest in green (People-Planet-Profit) to locate their business in the city and invest locally. Give incentives such as a shorter permit process to projects that incorporate green (a technique used successfully in Chicago). Most new buildings in the US now seek certification under the LEED program. Developers and agencies even use it in their real estate marketing efforts.

Benefits of investing together

- More sources of funding for projects is available
- A broad spread of ownership increases the willingness to invest
- Various parties become responsible for the liveability of their own city
- Improve the image of a company and/or city

*“By using sophisticated modelling systems, cash values can be applied to ecosystem services such as moderating temperature fluctuations, improving air quality and buffering intense rainfall events. By using this approach through computer models such as STRATUM (US Forest Service) New York City is able to show that every $1 invested in planting generates more than $4 in direct benefits. Who said money doesn’t grow on trees?”*

Partners who have an interest / experience / or can benefit from quality green:

Policy makers
- Local governments
- Regional governments
- Water authorities
- Waste management
- Social affairs
- Infrastructure
- Transportation
- Urban planners
- Engineers and designers

Investors
- Local and regional governments
- Businesses
- Private sector
- Building sector
- Healthcare sector
- Wellness sector
- Tourism sector
- Education sector
- NGO’s

Users
- Local governments
- Regional governments
- Water authorities
- Waste management
- Social affairs
- Infrastructure
- Transportation
- Urban planners
- Engineers and designers

Philadelphia, USA | According to a study carried out by the Trust for Public Land, green space saves the city annually a total of $1,155,722.00. The total increase in wealth for the city arising from green infrastructure is $729,112.00. The residents also benefit as a result of higher property values and an enhanced sense of well being.

"Investing in green cities is investing in a healthy population and a healthy economy, with high financial and social returns.”

Ienik Bieker, Minister of Foreign Trade and Agriculture

In new & existing development:
Create a high quality catalyst green project with a multidisciplinary team and market it to the various parties in order to create enthusiasm and encourage future team investments.

Egmond aan Zee | The Green City Post 2011 (Sjerp de Vries, Alterra – Wageningen UR), Eva Stache (Stache architects), Bastiaan de Roo (Chamber of Commerce The Hague);

- Benefits of investing together
- In new & existing development:
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3 Filtering for fresh air

Improve regional air quality with large scale green spaces

The filtering effect of large scale green is the best way to improve air quality at the regional level. Forests are especially suitable for reducing background concentrations before the pollution even reaches the city. By providing as much leaf volume as possible in an area as big as possible, the general air quality can increase. This way the air that reaches the urban area has more capacity to filter pollution from traffic and other local sources at neighbourhood and street level. The capturing of particulate matter only actually occurs at the edges and tops of a forest, but because they usually cover a large surface area, they are very effective.

Plant big trees with more leaf area

Bigger trees and more leaf area are more effective at cleaning the air. An average tree in the city (with a trunk diameter of +/- 30 cm) is able to capture about 100g particulate matter (PM10) while a mature tree captures as much as 1.4kg in the Netherlands [Tonneijck, 2008]. 100g PM10 equals the particulate matter emission from a private car that travels 1,500 km. 1.4kg PM10 equals 20,000 km. The porosity of the canopy should be above 50% so the leaves inside the canopy can also help. Combine trees with broad canopies and undergrowth of herbaceous plants and shrubs to have effective leaves at all levels. Green roofs and green walls also contribute to air filtering.

Some trees are better at cleaning the air

Gaseous air pollution such as nitrous oxide (NOX) and particulate matter (PM10) can be removed from the air by leaves. Nitrous oxides (NOX), sulfur dioxide (SO2) and ozone (O3) are absorbed by the stomata of leaves. Deciduous trees with a large leaf volume are most effective. Organic compounds such as polychlorinated biphenyl (PCB's), dioxins and furans are taken up by the cuticles of leaves (even at night).

Particulate matter (PM10) is captured on the surface of leaves, called impaction, and travels to the ground through wind, rainwater or fallen leaves. After the particulates hit the ground, they are either washed away with runoff or fixed in the soil by organic decomposition. Conifers are most effective because of the large surface area of needles and the fact that the trees keep their needles all year round.

Ozone (O3) concentrations are reduced in the presence of trees because they not only absorb ozone themselves to varying degrees, but they also absorb NOX, keeping humidity higher and temperatures lower to ozone does not have a chance to form.

Do not use any tree species that are sensitive to air pollution (NOX) and limit the use of trees which emit biogenic volatile organic compounds (VOC).

Plant a variety of trees and plants

Include a mix of evergreen and deciduous tree species in the design with different characteristics so the air is filtered of more than one type of air pollution. Include green at different heights / levels to catch more pollutants that would otherwise blow under the canopy of the trees.

Green roofs and green walls also filter the air

Green on roof gardens and green walls are also very effective at removing pollutants from the air. Green walls planted with vines have a very dense leaf area per square metre and thus are good in removing PM10. A wall with Parthenocissus tricuspidata can catch 4g of PM10 per m² of wall and Hedera helix can catch 6g.

Table of air pollution types and leaf effectiveness:

<table>
<thead>
<tr>
<th>Air pollution type</th>
<th>Method</th>
<th>Best tree type</th>
<th>Other good tree type</th>
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<tbody>
<tr>
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<td>absorption</td>
<td>broad leaved evergreen trees</td>
<td>deciduous trees</td>
</tr>
<tr>
<td>2NO</td>
<td>absorption</td>
<td>broad leaved evergreen trees</td>
<td>deciduous trees</td>
</tr>
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<td>O3</td>
<td>absorption</td>
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<td>deciduous trees</td>
</tr>
<tr>
<td>PM10</td>
<td>impaction</td>
<td>conifer trees (evergreen)</td>
<td>conifer trees (evergreen)</td>
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<tr>
<td></td>
<td></td>
<td>cone-shaped needles</td>
<td>needs with a fatty toplayer (cuticle)</td>
</tr>
<tr>
<td>VOC</td>
<td>adsorption</td>
<td>conifer trees</td>
<td>conifer trees</td>
</tr>
</tbody>
</table>

Source: Ceciel van Iperen (CROW), Fred Schemling (Tripla & Knooppunt Innovatief Groen); Pauline de Koning and Peter Schildwacht (BELW Advies bv); Arda van Helsdingen (Copijn Tuinen & Landschapsarchitecten); jelle Hiemstra (Applied Plant Research WUR); ES Consulting | Sources: Groen Loont!; Alle extra groen helpt de luchtkwaliteit verbeteren; Meetproef Groen; Vegetation in relation to air quality in Shanghai; Stadsbomen voor een goede luchtkwaliteit; Bomen, een verademing voor de stad; Leidraad Luchtzuiverend Groen

Chicago, USA | Study by DJ Nowak (1994): Trees were able to remove 1% of the pollutants from the air within the city.
0.5 kg / ha / year of CO2
1.4 kg / ha / year of SO2
3.5 kg / ha / year of NOX
3.1 kg / ha / year of O3
1.5 kg / ha / year of PM10

Continued on the next page →

Hedera helix vines can catch 6g of PM10 per square meter wall area. Because they are evergreen, they are effective all year long.
**Trees, shrubs and vines** that are effective in capturing PM10

- Picea abies
- Pinus mugo
- Pinus nigra
- Pinus sylvestris
- Taxus sp.
- Metasequoia glyptostroboides

**Trees, shrubs and vines** that are effective in absorbing NOx

- Robinia pseudoacacia
- Sophora japonica
- Magnolia
- Salix babylonica ‘Tortuosa’

**Trees, shrubs and vines** that are effective in absorbing O3

- Chamaecyparis lawsoniana
- Crataegus monogyna
- Larix decidua
- Prunus laurocerasus
- Acer platanoides

**Trees and shrubs** that emit biogenic volatile organic compounds (limit widespread planting)

- Liquidambar styraciflua
- Klenreuzeria paniculata
- Quercus
- Robinia pseudoacacia

*Plants used in The Netherlands*

---

**Benefits of green infrastructure for air filtering**

- Less health complaints and premature deaths due to short-term exposure to air pollutants such as PM10 and ozone
- Caeoeus pollutants (O3, NOx, SO2) are absorbed out of the air
- Particulate matter, ash, pollen and smoke are captured out of the air
- Shade and water are provided which result in lower temperatures and less ozone (O3) forming
- Photosynthesis results in more O2 in the air

---

*“The contribution of the city to the regional air pollution can be compensated through the planting of filtering green. For every car in the city one tree.”*  
Peter Schildwacht, BELW Advies bv

---

**Use trees and plants to reduce background concentrations of air pollution. All plants contribute to the improvement of air quality. Some species are more effective than others.**

---

**In new development:**
Place green strategically in new plans in order to maximize the filtering capacity of each tree and prevent conflicts between land uses. Provide enough room (both above and underground) to allow trees to grow to maturity and therefore maximize their filtering capacity.

**In existing development:**
When replacing or adding trees, add a variety of species which are especially good in filtering the air.

---

*Experts: Ceciel van Iperen (CROW), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Pauline de Koning and Peter Schildwacht (BELW Advies bv), Andrea van Helsdingen (Copijn Tuin- en Landschapsarchitecten), Jelle Hiemstra (Applied Plant Research – WUR; ES Consulting)*

*Sources: Groen Loont!; Alle extra groen helpt de luchtkwaliteit verbeteren; Meetproef Groen; Vegetation in relation to air quality in Shanghai; Stadsbomen voor een goede luchtkwaliteit; Bomen: een verademing voor de stad; Leidraad Luchtzuiverend Groen*

Approximately 15% of the available amount of NO2 can be filtered from the air by optimal green. (Wesseling, 2004 in Leidraad Luchtzuiverend Groen).

A coverage of 25% green can reduce the concentration of particulate matter in the air by 10% (Steward, 2002 in Leidraad Luchtzuiverend Groen).

In new development:
Beplanting en Luchtkwaliteit

*Leaves are effective in absorbing NOx*
4 Green network

Incorporate movement into daily life

Encourage daily routine short trips by foot or bicycle instead of using cars. Routes to work, school, public transport, urban forests and parks should be safe, comfortable, attractive and green alternatives. It is also important to provide bicycle parking facilities at popular destinations.

Children do more outside in neighbourhoods with safer infrastructure

Children should be able to walk or bicycle safely through the neighbourhood to schools, parks, sports and recreational facilities. Slowing cars (with speed bumps or smaller street profiles at specific points) or creating car-free areas in neighbourhoods and near schools contribute to safer streets. Create street profiles where pedestrians and bicycles are separated from motorized vehicles and have priority over cars at crossings.

Create one large green park network

Connect public green spaces and parks to create one large urban recreation and ecological network within the city as well as with connections to green and nature outside the city. Ecological corridors which connect green spaces throughout the city raise the value of the urban ecological system. Use existing nature / water / topographical characteristics of the area as starting points to guide the planning and location of the network. Every household should be within 500m of an arm of the green network. This distance allows one to walk to, in and from the green structure in an average of 45 minutes (Bervaes et al., 1996 in Groene Meters I).

Ensure accessibility within the green network

Where unavoidable infrastructural barriers block access within a network, alternatives should be designed such as bridges, tunnels and ecobridges so connections are safe. By creating a green network at the planning stage of a project, many of these conflicts and dangerous intersections can be solved. Semi-public and public buildings can also be used as part of the continuous green network. Green through the building (atriums, galleries) and over the buildings (green roofs) can be made accessible, both physically and visually.

Benefits of a green network

- Safe routes for pedestrians and bicycles to and from parks, play and sports facilities, schools, etc.
- Larger network of habitats for small animals
- Less car use for daily short trips

...The creation of playgrounds and sports complexes is not enough to stimulate children to be more active...Children who are able to walk or bicycle to school, playgrounds or sports facilities perform significantly more physical activity per day...

Bewegertalentrijke wijken voor kinderen

...TNO has developed a calculating model for interactive planning to see the effects that complex planning solutions have on various situations in the surroundings...One of the features is the influence green spaces / land uses have on the physical movement patterns of residents...

Urban Strategy, TNO Innovation for Life

Provide bicycle and pedestrian paths all over the city to bring people from home to the city’s parks, recreational spaces, schools and work.

In new development:

Set up a green structure plan connecting all neighbourhoods to the urban forests / parks from the beginning of a project together with infrastructure so everyone has safe access to green.

In existing development:

Make neighbourhoods safer for bicycles and pedestrians by replacing street crossings with roundabouts or traffic lights along routes to schools, sports and play areas.

Experts:

Marit van Loon (Kenniscentrum Recreatie), Iris Salverda (Alterra – Wageningen UR), Pauline de Koning and Peter Schildwacht (BELW Advies bv), Fred Tonneijck (Triple E & Knooppunt Innovatief Groen), Sanda Lenzholzer (Wageningen University), Eva Stache (Stache architects), Arda van Helsdingen (Copijn Tuin- en Landschapsarchitecten), TNO Innovation for Life.

Sources:

Groene meters II; Vitamine G; Bewegvriendelijke wijken voor kinderen; Kinderen in prioriteitswijken: lichaamlijke (in)activiteit en overgewicht; Recht op Groen; Rotterdam gezond groen gewoon doen; www.west8.nl; www.impala-eu.org; www.tno.nl/downloads/IB.URBAN_STRATEGY_EN.pdf
5 Within walking distance

The amount of recreational green is important
75m2 of recreational green should be provided for every household in an urban area. Some of this green should be within a 50m radius of home and 15m can be incorporated into regional green within a 2.5 km radius. 75m2 / household divided by 2.5 people per household = some green/person. Multiply the number of people in an urban area times 25 and this equals the total amount of green needed in the urban area. Divide the size of the urban area by the amount of green needed in the urban area and you have the percent of green needed in the urban area. (For an example see the Green City case study, page 20-21.)

The quality of recreational green is important
Recreational green should be accessible, usable, varied, inviting and well maintained in order to attract users from the neighbourhood and beyond.

Provide nearby recreational facilities for children
Children between the ages of 6 and 11 are most dependent on their direct living environment in order to fulfill their daily needs and this equals the total amount of green needed in the urban area. Safe routes to the play areas are important as well as safe edges between street and play areas. Prevent children from running into the street and keep play areas visible. Safe walking distance from home to play areas for these age groups at the block level to encourage more outdoor play. Provide nearby recreational facilities for children, as safe edges between street and play areas. Prevent children from running into the street and keep play areas visible.

Size and location of green spaces in urban environments:

<table>
<thead>
<tr>
<th>type of park</th>
<th>distance from house</th>
<th>size of park</th>
</tr>
</thead>
<tbody>
<tr>
<td>pocket park</td>
<td>0 m (no walk)</td>
<td>0.5 m2</td>
</tr>
<tr>
<td>neighbourhood park</td>
<td>10 m (2 min. walk)</td>
<td>1 m2</td>
</tr>
<tr>
<td>community park</td>
<td>20 m (4 min. walk)</td>
<td>2 m2</td>
</tr>
<tr>
<td>large urban park</td>
<td>30 m (6 min. walk)</td>
<td>3 m2</td>
</tr>
<tr>
<td>city-wide park</td>
<td>50 m (10 min. walk)</td>
<td>5 m2</td>
</tr>
</tbody>
</table>

In new development:
25% of the total urban area should be set aside for green recreational uses. Green spaces should be distributed throughout the city in order to vary in size and vary in use so everyone has access to green.

In existing development:
Where a lack of space is available, the quality, use and accessibility of recreational green should be improved to provide maximum enjoyment for as many residents as possible.

Provide recreational possibilities and green for residents who stay closer to home
The elderly and people with a lower socio-economic status have less opportunities to seek green elsewhere. Therefore green in the vicinity of home is essential.

Create parks in inner city neighbourhoods
Include parks in the rehabilitation of declining neighbourhoods. Remove a housing block and replace it with a pocket park, involving the residents in the process. This, in combination with the planned improvements to the remaining buildings, creates a more liveable neighbourhood for the residents.

Benefits of neighbourhood green space
• Healthier, happier residents (15%-25% more)
• More outdoor play (10% more)
• More social contact and social cohesion
• Less overweight or obese residents (15% less)
• Less doctor visits, less depression, for some diseases up to 33%* if green space is easily accessible

* especially noticeable with children, the elderly and people with a lower social/economic status

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* especially noticeable with children, the elderly and people with a lower social/economic status

...In the Netherlands, the direct costs of people being overweight are thought to be 3%–5% of the healthcare budget...

Green Leont!
The number of obese adults in England has tripled over the last 20 years and is still rising. The number of obese 6-year-olds has doubled in the last 10 years. Inactivity is identified as being the primary cause of obesity. The cost to the UK olds has doubled in the last 10 years. Inactivity is identified as being the primary cause of obesity. The cost to the UK...
6 The art of nature

Use green to beautify the city
Residents, workers and visitors are attracted to green and flowers in the urban environment. Green for aesthetic reasons is still a legitimate investment. (The fact that green has so many other benefits only adds to its value.)

Planting design is a creative process
Planting design is the art of combining plants based on their colour, texture, bloom time, bloom colour and growing conditions (sun, soil, wind, water). In public open spaces it is also important to consider the use of the space, possibilities of vandalism and level of maintenance. The softscape (green) is just as important in terms of design as the hardscape (layout, paving, benches, lighting, etc.). Use the right plants for public spaces and avoid dangerous situations such as high plants which block views at intersections or poisonous plants near playgrounds.

Use existing conditions as the basis for design
Start the design process with an inventory of what exists on the site (or what once existed). Use elements such as existing trees, water, topography and native plants to inspire the design and give it a local character which fits into the surrounding neighbourhood or environment. The use of historical and cultural elements also adds to the character.

Quality and maintenance are important
Nature is beautiful, but in the urban environment it needs help staying beautiful. Every square metre of green needs to be high quality and well maintained for city residents to keep this positive image of green.

Benefits of the art of nature
- Creates a positive image for the city
- Gives residents a positive perception of green
- Inspires residents to take pride in their neighbourhood
- Attracts tourists / visitors
- Offers rest and inspiration

In new development:
Create green spaces which combine the character of the place and the needs of the users with a hardscape and planting design that is aesthetically pleasing.

In existing development:
Replace planting which does not add to the aesthetics and function of an area with planting combinations which do.

Use plants to beautify streets and neighbourhoods and add to the overall image of the city.
The 5750ha site is located south of downtown Shenyang between the Hun River and the airport. The team began the design process from the green perspective: first an inventory of the existing conditions including the natural landscape and the villages that have organically grown over time and then a layout of the desired amount of green space. In the masterplan, the green land uses were given a place before the infrastructure of roads and other land uses.

Some parts of the final concept green plan, such as a few city parks and the central main axis, are currently under construction, including Mozi Mountain.

Park design by Niek Roozen bv, Roodbeen Architectuur, Urhahn Urban Design and Loos van Vliet.

The grid was faded back and used as the basis to design the overall masterplan in a new creative way, resulting in a dynamic green urban plan.

The green infrastructure of the street system was also designed in order to reduce the negative impact of air pollutants for residents by locating trees and green in the right place.

<table>
<thead>
<tr>
<th>Type of green</th>
<th>Max distance</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>block green</td>
<td>200 m</td>
<td>&lt; 1 ha</td>
</tr>
<tr>
<td>street park</td>
<td>400 m</td>
<td>3 ha</td>
</tr>
<tr>
<td>neighbourhood park</td>
<td>800 m</td>
<td>15 ha</td>
</tr>
<tr>
<td>sub-district park</td>
<td>1600 m</td>
<td>100 ha</td>
</tr>
<tr>
<td>district park</td>
<td>3200 m</td>
<td>500 ha</td>
</tr>
</tbody>
</table>
Literature:

- Greenspaces Reloaded
- Groen lastest [Green Pays]
- Alle extra groen helpt de luchtkwaliteit verbeteren [All extra green helps improve the air quality]
- Recht op Groen [The Right to Green]
- Vegetatie in relation to air quality in Shanghai
- Leidraad Luchtzuiverend Groen [Manual Air Purifying Green]
- Integrale beplantingsmethode levert geslaagd [Integrated planting method is a success]
- How much value does the city of Philadelphia receive from its park and recreation system?
- Who said money doesn’t grow on trees?
- Beweegvriendelijke wijken voor kinderen [Exercise-friendly neighbourhoods for children]
- Rotterdam gezond groen, gewoon doen [Rotterdam healthy green, just do it]
- Vitamine G
- Kinderen in prioriteitswijken: Lichaamlijke (in)activiteit en overgewicht [Children in problem neighbourhoods: Physical (in)activity and overweightness]
- Luftqualität und Stadtkultur Ursprung [Lifestyle and city culture origin]
- Met hijs rood alleen: buitengoed en sociale cohesie [Not with red alone: neighbourhood green and social cohesion]
- Websides:
  - www.impala.eu
  - www.inforel.nl/downloads/URBAN_STRATEGY_EN.pdf
  - www.woe.nl
  - www.bovenbouwrichting.nl
- Experts:
  - Eva Stache, Architect Stache Architects bna
  - Fred Tonneijck, Senior Advisor/Researcher Triple E and Knooppunt Innovatief Groen
  - Arda van Helsdingen, Director Copijn Tuin- en Landschapsarchitecten
  - Mark Hinske, Director of Urban Design LVM Architects
  - Vincent Kupfers, DLO Researcher Almere – Wageningen UR
  - Barry de Vries, DLO HBO Researcher Almere – Wageningen UR
  - Basisscholendirecteur, School Leiden
  - Fred Tonneijck, Senior Advisor/Researcher Triple E and Knooppunt Innovatief Groen
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  - Barry de Vries, DLO HBO Researcher Almere – Wageningen UR
  - Barry de Vries, Director Leiden Chamber of Commerce The Hague
  - Sarg de Vries, Senior Scientist Researcher Almere – Wageningen UR
  - Paulien de Vries, Landscape Architect Frese Schielenhout; Specialist, Botanist B.E. de Vries
  - Corina van Veen, Project Manager Living Environment CEDON
  - Jelle Kromer, Senior Researcher Applied Plant Research, Wageningen UR
  - Martine van Loon, Project Office Knooppunt Recreatie
  - Sandra Landshoff, Assistant Professor Landscape Architecture Wageningen University
  - Filip Fraga, Project Manager TNO Innovation for Life
  - Julieta Manz, Senior Researcher EMGO Institute, VU Medical Center
  - Inti Salvador, DLO Researcher Almere – Wageningen UR
  - Robbert Spaay, Researcher Urban Ecology and Green Businessparks Almere – Wageningen UR
  - Niek Roozen, Landscape Architect Niek Roozen bv landscape architects
  - ES Consulting
  - Suizanne Stadnianauer

Websites:

- www.impala.eu
- www.inforel.nl/downloads/URBAN_STRATEGY_EN.pdf
- www.woe.nl
- www.bovenbouwrichting.nl

For a complete list of literature and expert participants, see pages 94-97.

Green+ cities

Green+ neighbourhoods

2

7 Microclimate parks
8 Resident participation
10 Recreation
10 Playgrounds and schoolyards
11 Views of green
12 Private green
13 Semi-private green
14 Green business parks
15 Urban farming
16 Water runoff
17 Biodiversity

Case study: The High Line, New York City
7 Microclimate parks

Plant more trees to increase the overall canopy cover

Studies in Chicago show that increasing tree cover in the city by 10% may reduce the total energy used for heating and cooling by 5-10%. Trees and vertical green prevent sunlight from reaching the surface and converting into heat. They also create more humidity, which in turn reduces the strength of the sun’s rays and thus reduces the temperature.

Reduce the amount of impervious surfaces in the city and replace them with green

Surface temperature can be reduced just by reducing the amount of paved surfaces, which in return reduces the amount of latent heat in the city. For every 10% of green surface area that is increased, the temperature drops by 1°C.

Use trees to decrease wind velocities

Trees and plants are physical obstacles and have an effect on wind speed and turbulence. These in turn influence how effective trees are in removing air pollutants. Wide tree plantings such as forests drive wind upwards and act as a solid barrier. Wind speeds beyond the forest return to normal after a short distance. The wind speed behind a row of trees returns to normal at a distance of 10 times the height of the trees.

Prevent trees from reducing wind speeds too close to the source of pollution

Where possible, plant rows of trees perpendicular to the direction of polluted air and allow a sideways flow of air along the trees for ventilation near a source of pollution.

Create large areas of green outside the city as a buffer

A forest planted outside the city can help reduce the urban heat island effect.

Benefits of parks on microclimate

- Shade from trees regulates temperature extremes
- Green humidifies the air and makes the environment cooler and more pleasant
- City streets, plazas and parks are comfortable to use in hot weather
- Less ozone is produced if temperatures are reduced in hot periods
- Less temperature extremes in the summer result in less premature deaths due to excessive heat (especially for elderly people)

Experts:
Sanda Lenzholzer (Wageningen University), Vincent Kuypers and Barry de Vries (Alterra – Wageningen UR), Triple E, ES Consulting

Sources:
Groen Loont!; Alle extra groen helpt de luchtkwaliteit verbeteren; Groen voor Klimaat; Bomen: een verademing voor de stad; Leidraad Luchtzuiverend Groen

The following plays a role in the Urban Heat Island Effect:
- The amount of impervious surfaces in the city
- Local weather patterns (temperature, wind)
- The location (on the water / inland)
- Design (height of buildings, density)
- Wind patterns + ventilation + cooling
- Green / water vs. buildings / paving in the city
- Air pollution

...The use of green to create microclimates and protect against wind, etc. is simply farmer’s wisdom. The techniques can be applied to the urban environment as a fresh new way to approach the use of green. The scientific and academic proof is building to support what farmers have known for centuries...

Leidraad Luchtzuiverend Groen

Microclimate parks

The urban heat island effect | Source: Alterra - Wageningen UR

The use of green to create microclimates and protect against wind, etc. is simply farmer’s wisdom. The techniques can be applied to the urban environment as a fresh new way to approach the use of green. The scientific and academic proof is building to support what farmers have known for centuries...
Green+ neighbourhoods

Leidse Hout, Leiden NL | The Leidse Hout is a recreational forest on the edge of the most densely populated city in the Netherlands. It is frequently used by residents for recreation, relaxation, walking, bicycling, picnicking, education, etc.

EXPO Park, World EXPO 2010, Shanghai, China | The EXPO Park along the river was used as a cool green oasis away from the crowded warm EXPO site. After the EXPO, it will serve as a community park for the future urban residential development. Designed by Niek Roozen bv

Cooling effects of parks

<table>
<thead>
<tr>
<th>1 large park</th>
</tr>
</thead>
<tbody>
<tr>
<td>park</td>
</tr>
<tr>
<td>affected area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2 small parks</th>
</tr>
</thead>
<tbody>
<tr>
<td>park</td>
</tr>
<tr>
<td>affected area</td>
</tr>
</tbody>
</table>

Spread city parks and green areas throughout the city

City parks are themselves cooler, but can also cool the surroundings both day and night. The influence of two smaller parks spread out in a city have more effect in cooling the surroundings than one larger park. The cooling effect can be significantly measured up to 300m from the park (and felt up to 2km away). Evaporation at night from trees and shrubs transports cool water from the ground to the air which reduces the air temperature. There is a strong relationship between the reduction of temperatures and the density of planting.

Parking areas need shade too

Trees in parking areas keep cars cooler and reduce the amount of hydrocarbon vapor emissions from parked cars.

In new development:
Create pocket parks spread throughout the city in order to reduce temperature extremes, limit the amount of impervious surfaces and provide shade where it is needed.

In existing development:
Determine where the hot spots in the city are and replace impervious surfaces where possible with green (parks, green connections, trees, green roofs, etc.) in order to reduce the urban heat island effect in the city.

Prevent city-wide hot spots by spreading parks and green around the city and increasing the overall tree canopy area.
Green neighbourhoods

8 Resident participation

Listen to what the residents want
Resident participation leads to the creation of quality green because it responds to the needs and wishes of the people who will actually use it.

Adopt green right outside the door
Allow planting beds or trees to be “adopted” in parks or along streets. The residents can choose their own planting as long as they care for the plants themselves. An agreement can be signed between the city and the residents if either of the parties do not fulfill their agreed level of participation.

Create respect for public green space
By allowing residents to take part in design, construction and maintenance they respect the green spaces and care for them as their own instead of waiting for the city to fix them up. People are more likely to pick up litter on “their own street” than on a “public street”, as well as ask others to do the same.

Plan green activities for residents
Bring residents together at key moments to create enthusiasm and involve them in the process of creating green spaces in the neighbourhood. Use publicity to spread the enthusiasm to other neighbourhoods. Organize activities such as tree planting events or the UK’s “Love Parks Week”.

Transform unused space in the city with green
Give people on the waiting lists for permanent community/allotment gardens and others the chance to garden plots of temporarily vacant land in their own neighbourhoods. The neighbourhood becomes greener, the gardeners are happy and surrounding residents and passersby are inspired.

Benefits of participation
- Liveability of the neighbourhood increases
- Criminal and anti-social behavior decreases, safety improves
- More social control and social cohesion
- People identify more with their neighbourhood and green space

In new development:
Include residents in the design and maintenance of green spaces in their direct living environment.

In existing development:
Allow residents to adopt nearby green spaces and participate in the construction and maintenance of these spaces.

De Tussentuin, Gaffelstraat, Rotterdam, NL | The Tussentuin, a local resident initiative, not only provides gardening plots but also activities such as music workshops, concerts and neighbourhood events | Photos: Wolbert van Dijk

The Garden, Eden Project, UK | Sensory Trust and Eden Project worked together to run community consultation seminars with a mix of people so the garden could be inspired by and designed to their wishes. The participants were kept involved throughout the process in order to offer feedback and continue support | Photo: Sensory Trust

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In new development: Invite residents to be a part of the planning and design process of public green spaces.

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The Garden, Eden Project, UK | Sensory Trust and Eden Project worked together to run community consultation sessions with a mix of people so the garden could be inspired by and designed to their wishes. The participants were kept involved throughout the process in order to offer feedback and continue support | Photo: Sensory Trust

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9 Recreation

Provide a variety of spaces for physical activity
Outdoor active recreation not only occurs on formal sports fields but also other spaces such as playgrounds, skateboard parks, bicycle and jogging/walking paths and open lawn. Spontaneous ball games in informal green spaces are flexible and do not require specific dimensions or amount of players.

Relaxation is an important form of recreation
Places to meet or be alone, benches or grass for resting and watching, paths for walking, forests and water for contact with nature and environmental education, etc. are examples of passive recreation. A variety of spaces and uses are important to accommodate all the users of neighbourhood parks. Green near offices also allows workers to take a walk during breaks for fresh air and relaxation.

Accommodate the user groups
Children, people with a lower socio-economic status and the elderly are more dependent on their direct living environment to fulfil their exposure to green recreational opportunities. The smaller scale parks spread throughout the neighbourhoods should cater to these groups. Larger parks that are more spread out should include these uses plus uses for other user groups. Provide separate areas for dogs and provide bins for dog waste so the play areas remain clean.

Quality and usability are essential
There are four factors which determine the success of recreational spaces in the city:
- availability (area and distribution of spaces)
- usability (maintenance, policy, provisions, social safety)
- accessibility (service area, walking / biking distance)
- utilization (users and possible activities)

Recreation also encourages recreation related business
Businesses such as restaurants and cafés, kiosks, tourism, water sports, etc. can also benefit economically from recreation in the city.

Benefits of recreation
- Encourages people to live healthier lifestyles
- Stimulates children to grow into healthy fit adults
- Provides a public space for social contact

“The Big Greenery Study”, conducted by Amsterdam’s own Physical Planning Department, showed that visits made to the city’s green spaces have increased enormously in recent years. Not only are more ‘Amsterdammers’ visiting parks, but they are also doing so more often...

Piet Eilander (Amsterdam’s Greenery, Ecology, Urban Recreation and Water team)

Experts: Filip de Fraga and Joram Nauta (TNO Innovation for Life), Martine van Loon (Kenniscentrum Recreatie) | Sources: Groen Loont!; Recht op Groen; Groene meters II; Beweegvriendelijke Stadswijken voor Kinderen; Rotterdam gezond groen, gewoon doen; The Green City Post 2011; www.impala-eu.org

Create a variety of choices for active and passive recreation throughout the city for all ages.

In new development:
Spread ample green parks of various sizes throughout the city. Vary the types of recreational accommodations to reach a broad user group and design with flexibility because user groups can change over time.

In existing development:
Take an inventory of the available recreational spaces and determine how to make existing accommodations more useful and attractive for residents.

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10 Playgrounds & schoolyards

Create variations in the landscape
Differences in high-low, dark-light, open-closed, dry-wet make a play area more interesting, less predictable and more natural. Unexpected (natural) differences in the terrain such as hills, horizontal tree trunks and rocks for climbing, etc. are encouraged.

Use various natural materials
Ground: clay, sand, mud
Water: pumps, fountains, streams, wetlands, ponds
Planting: groundcover and flowers, shrubs, trees
Materials: wood and steel

Cater to the needs of children
Encourage active movement such as climbing and running, provide peaceful sitting areas while allowing others to play together and make noise. They should feel at home and be comfortable in the seasons, with the trees and among the butterflies.

Allow children to explore the possibilities of nature
Create opportunities to playfully change the surroundings with sand, mud and water, use loose natural elements as play equipment, allow them to exercise their own fantasy and creativity and make it inviting to explore nature.

Encourage children to make something useful and beautiful from natural materials. Make it possible for hands-on nature and environmental education in the city.

Involve children in the design process, realisation, maintenance and use
Educate and demonstrate how nature can be created in the city and encourage continuing interaction with the seasonal changes of nature.

Benefits of playing in green
- Stimulates creativity and imagination
- Children can come into contact with nature in a creative way
- Offers space to move, play and dream
- Stimulates motor skills, interaction with other children and physical activity

Provide children with the opportunity to experience and play in nature within the city

In new development:
Situate school buildings to provide optimal outdoor spaces for play and education. Create new green public playgrounds accessible to all children.

In existing development:
Transform existing playgrounds and schoolyards by replacing paving with green. Install play equipment made of natural materials which both stimulates play and allows children to experience nature.

Criteria for construction, maintenance and safety of green playgrounds

<table>
<thead>
<tr>
<th>Aspect of design</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting</td>
<td>the right tree in the right place, must be central in design, functional and offer more than just aesthetics</td>
</tr>
<tr>
<td>Ecological value</td>
<td>fruit, color and structure are important, attractive for animals, native plants</td>
</tr>
<tr>
<td>Maintenance plan</td>
<td>must be set up and responsibility should be taken</td>
</tr>
<tr>
<td>Design</td>
<td>must be flexible and multifunctional, be realized within 3-5 years, be presented to the users as well as the nearby residents</td>
</tr>
<tr>
<td>Surroundings</td>
<td>should fit into the surroundings, connect to existing water storage, ecological connections, educational functions or other special interests</td>
</tr>
<tr>
<td>Safety</td>
<td>design should be transparent for social safety, have visible entrances/exits to traffic, avoid poisonous plants and must fulfil the safety criteria for all play areas</td>
</tr>
</tbody>
</table>

Vrijeschool Valenijn, Harderwijk, NL. | The pavers were removed from the schoolyard and replaced by plant beds, a separate ball field, sitting areas, bat gardens, paintings, hills, an amphitheater, play equipment and a dry stream bed with a water pump connected to the school building’s rain pipes.

Ieper, Belgium | Use of natural materials.

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Ieper, Belgium | Use of natural materials.
**Green® neighbourhoods**

11 Views of green

**Not all green needs to be accessible**
Views of green are also important for the overall green image of a city. Green roofs, green walls, private gardens, street trees, sports fields, cemeteries, agricultural land and surrounding landscapes all contribute to the green of a city.

**Physical health improves with views of green**
Patients recover up to 15% quicker in hospital rooms with views of green. Green park-like settings around hospitals, parking lots full of trees, courtyards, green walls and green roofs are all ways to increase green views from every room.

**Mental health improves with views of green**
Residents as well as workers with views of green report less cases of depression and stress than those with no views of green from their homes and offices. Planting strips between houses and the street, front gardens, offices surrounded by green and trees and parking areas with green buffers are ways to increase views of green from houses and offices.

**Property with views of green are more valuable**
Houses and apartments with views of green (adjacent parks, surrounding landscapes, etc.) are worth 4-12% more than houses of the same type without views of green.

...Patients who have a view of trees use less pain killers than patients who have a view of a wall...

*Green Loant!*

**Benefits of green views**
- **Physical health**: less doctor visits, shorter stays in hospitals (10% less)
- **Mental health**: reduction of depression and stress
- **Views of green increase employee productivity**
- **Employees take up less sick days**
- **Properties with views of green are 4-12% higher**

**Borrow views of private / semi-private green because of its impact on the urban green experience, both mentally and physically.**

*In new development:*
Consider the layout of buildings and their relationship with green elements.

*In existing development:*
Multi-layered buildings with views over rooftops should replace grey roofs with green roofs. Parking areas adjacent to buildings should include trees and green elements so views are more attractive from indoors.
Diversity of choices means a diversity of green
People are free to choose their own plants and layout which increases the diversity of green in the neighbourhood for everyone. Plants can be used for their ornamental value or functionality. Edible gardens provide fresh produce and herbs for individuals. A varied planting design allows residents to experience the four seasons right outside their windows.

Rediscover the art of plants
Many urban residents fill their private gardens with paving for ease of maintenance, lack of knowledge of plants and their care or practicality. By bringing the interest back to plants in the garden, the impervious surfaces in the city can be reduced. Plant nurseries, retailers and community groups can show people how easy and attractive (low maintenance) gardening can be.

Every square metre counts
Increase the surface area of green no matter how small by planting green walls, balconies, private gardens and roofs.

Benefits of private green spaces
• Increases biodiversity in the city
• Helps keep streets and houses cooler
• Helps intercept water runoff
• Makes neighbourhoods attractive

...What we tend to forget is that our lawns, flower beds and vegetable patches add up to a significant share of the capital’s land — approximately 2% of London’s total land area. Their habitat potential is enormous...
Anna Simpson, Gardens: the hidden capital revealed

Use the potential that private gardens have to add to the amount of green spaces and impervious surfaces in the city.

In new development:
Provide room for small private gardens in front of, behind or on top of houses.

In existing development:
Create campaigns to encourage more plants and less impervious surfaces in private gardens. Involve the media and plant nurseries in offering advice and techniques for making gardens beautiful and easy to care for.

Expats: Robert Snep (Alterra – Wageningen UR), Soontiëns Stadsnatuur | Sources: De Levende Tuin; Leidraad Luchtzuiverend Groen; www.forumforthefuture.org/greenfutures/articles/gardens-hidden-capital-revealed; www.eva-lanxmeer.nl
13 Semi-private green

Combine efforts to improve the direct living environment
Semi-private green provides an opportunity for those urban residents who either have no private green space, have no time or desire to garden themselves or are not able to maintain an entire garden on their own. Collective funds can be set aside for routine maintenance if there is no one who takes the initiative to organize this between residents. They can also decide how the space is used and when and set quality standards for maintenance.

Design with flexibility for potential users
Users change over time and everyone has a different idea of how common private green spaces are or should be used. (Peace, quiet, relaxation and healing versus gardening, socializing, playing). Unless the intent is clear in the design and fellow residents set up the ground rules, the success of the space is limited.

Horticultural therapy benefits special needs groups
People who otherwise cannot maintain their own gardens are sometimes those who profit the most from gardening activities and exposure to green. People in hospitals, elderly homes, mental illness facilities, children’s hospitals, Alzheimers facilities, etc. can all benefit. Provide accessible therapeutic gardens including raised beds, barrier-free paths, sensory-stimulating environments which awaken the five senses and places to relax. People with dementia that are able to work in the garden have less negative reactions and anger episodes than patients with no access to gardening.

Courtyards and roof gardens are ideal semi-private spaces
Spaces which can be occasionally or partially closed off and are within view of the user groups add to the success of semi-private green. The chances of low quality maintenance, misuse of the space and vandalism are reduced. rooftops are also beneficial because of their multifunctionality in dense urban settings.

Benefits of semi-private green spaces
- People with no private garden can enjoy their own piece of nearby green
- Takes the elderly out of their social isolation
- Many residents take pleasure in performing (physical) activities outdoors

In new development:
Provide space in dense urban development not just for parking and planting between buildings, but for usable green space. Consider the multifunctionality of spaces such as green roofs above parking.

In existing development:
Consolidate existing parking and unusable green and transform it into usable green spaces for adjacent residents.

Provide city residents / workers / patients in dense urban environments with usable green space they can collectively call their own.

Amsterdam, NL | Common courtyard with kitchen garden for the cooking students of Nowhere, a community centre.

Amsterdam, NL | All the residents of Sciencepark are able to use the courtyard located between the buildings on top of the shared parking garage | Designed by Niek Roozen bv

De Hagewoek, Waap, NL | The wings of the building with 9 accompanying courtyards were designed with various themes to stimulate early memories of the people with dementia who live there. Architect: Molenaar en Koeman | Designed by Niek Roozen bv

Culemborg, NL | A shared green space in the neighbourhood EVA Lanenmeer | Photo: Copijn Tuin- en Landschapsarchitecten

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Green business parks attract companies and employees

Companies are attracted to business parks with a green character in order to improve their own corporate image. Employees are attracted to companies who provide a pleasant working environment. By providing green views from office windows, worker productivity increases. Outdoor spaces for employees include lunch areas with a pleasant microclimate, walking and bicycle paths, benches and sports facilities.

Benefits of green business parks

- Provides attractive multifunctional spaces for business, recreation and ecology
- Helps create a positive green image many companies / industries aim for
- Provides a healthy environment for employees
- Increases the real estate value of parcels within the business park

"The quality of the workplace directly affects the work itself."

Three scenarios for adding green to business parks

Source: Biodiversity conservation at business sites

- Convert flat roofs into green roofs
- Improve the ecological quality of the existing green
- Create habitat corridors throughout the site

Make the “parks” in business parks and the “estates” in industrial estates true to their names.

In new development:
Design new business parks with functional green spaces / corridors that are linked to the surrounding landscape or urban park network.

In existing development:
Convert flat roofs into green roofs and improve the existing green spaces within the business park in order to provide usable outdoor spaces for employees and increase biodiversity.
Reserve room in neighbourhoods for community/allotment gardens

Inventory the demand and provide space throughout the city, no matter the size, for people to grow their own food. By scattering gardens across the city, people are able to garden closer to home, exchange ideas and seeds with neighbours, stimulate others to participate, and reduce the waiting lists for the larger community garden complexes on the edge of the city.

Claim land in the city for urban farming

Cities can encourage and educate residents about the temporary development of vacant lots into green oases of food and flowers. They can sponsor events and plants or they can allow ‘guerilla’ gardening to emerge from resident initiatives. This not only provides healthy food for residents, gets them active and engaged in healthy outdoor activities, but also helps buffer water runoff in neighbourhoods and beautifies otherwise empty holes in the urban landscape. When development does eventually reclaim the land, the city can help the residents find a new parcel to garden. Larger parcels of land on the edge of the city where traditional industry is declining can provide more space for market gardens and allotment gardens.

Provide areas for edible green in public parks

Involves nearby residents in the design and maintenance of public green spaces and allow them to share in the harvesting of fruits, vegetables and herbs. Only provide edible plant beds if neighbouring residents are enthusiastic, and keep the design flexible so changes can be made to the gardens as residents and needs change over time.

Reach residents who do not participate directly

Demonstrations for children, programs for the homeless and needs change over time.

Benefits of urban farming

- A place to grow safe fresh food with less “food kilometres”
- Children and adults learn where food comes from
- Opportunities for social projects for marginalised or socially excluded groups
- A social element that brings residents from different backgrounds and cultures together

Havana, Cuba

The citizens of Havana were able to make it through the “Special Period” in 1996 by cultivating their own food and medicine on ‘huertos’ – unused land where crops are grown. Eventually the government established large organic market gardens (organoponicos) where local residents are employed to work the land and food is sold locally. By 2002, Havana was growing 90% of the city’s fresh produce within the city limits.

In new development:

- Provide space in the city for community gardens and make them an integral part of urban development.

In existing development:

- Create temporary community gardens or allow crops to grow on unused parcels of land in the city. This will either stimulate development of the unused lots or act as a catalyst to green more areas of the city.

“In Detroit, urban farming has immense potential to catalyze change within the city, create thousands of greatly needed jobs and provide vast quantities of fresh, locally grown produce for the remaining citizens. However, urban farming is only a piece of what creates a successful green and self-sufficient city and must be integrated with various forms of sustainable development in order to provide a desired result.”

Griffin Felski; Landscape Architect

“Cuba was forced to develop ‘resilience’ and fast. It had to feed its people when the previous routes for doing so were closed off overnight. Urban agriculture is something that the rest of the world could develop – before it is forced to.”

Mark Long, Director, UK Green Forum
Integrate water into planning and design
Surface storm water management solutions should be integrated into the overall design and planning of an area and involve a multidisciplinary team of professionals. This way technical as well as aesthetic issues are addressed at all phases of design. Be sure to consider maintenance requirements in the design in order to guarantee performance and quality.

Use water as a green solution
Combine water with the need for recreation and nature in the city or other green city solutions such as green roofs and green streets. Be sure that the solution appropriately ties in with the land use. Make stormwater visible in the design of public and private open spaces. Features add to the amenities in urban public green spaces. Create ways to not only buffer water but also to use it in times of drought.

Compensate paving with water
All newly paved surfaces should be compensated by extra open water which equals at least 10% of the paved surface area.

Use trees to catch water runoff
Trees are very effective at slowing runoff. They intercept peak rainfall, improve the infiltration capacity of the soil and can improve the quality of the water that is buffered. They also bring groundwater from the roots up to the surface where some evaporates and the soil is kept moister. Conifers are 3x more effective than deciduous trees.

Use plants to help purify water
Biofiltering wetlands can be designed as functional and aesthetic solutions to surface water pollution. As water gradually filters through the plants into a series of basins, the pollution sediments are able to sink to the bottom.
Green neighbourhoods

Techniques and technical solutions for Surface Stormwater Management

<table>
<thead>
<tr>
<th>Technique</th>
<th>Description</th>
<th>Function</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>harvesting</td>
<td>above or underground cisterns</td>
<td>rainwater use</td>
<td>fountains, pools, etc.</td>
</tr>
<tr>
<td>bioretention</td>
<td>shallow landscaped depressions which drain by filtering through the vegetation and soil</td>
<td>water treatment</td>
<td>landscaped element</td>
</tr>
<tr>
<td>biotopes</td>
<td>ecologically stable landscape of plants and animals</td>
<td>water treatment</td>
<td>wetlands, biofiltering wetlands</td>
</tr>
<tr>
<td>gravel / sand filters</td>
<td>above or below ground chambers to treat runoff</td>
<td>water treatment</td>
<td>edging along green spaces, channels, buildings</td>
</tr>
<tr>
<td>rooftop retention</td>
<td>extensive or intensive green roofs or brown roofs</td>
<td>detention + infiltration</td>
<td>green roofs</td>
</tr>
<tr>
<td>permeable paving</td>
<td>paving that allows water to pass to a gravel subgrade where it can evaporate, infiltrate or be drained</td>
<td>detention + infiltration</td>
<td>parking areas, paved areas</td>
</tr>
<tr>
<td>infiltration zones and plant areas with layers for retention, filtration</td>
<td>detention + infiltration and infiltration</td>
<td>open spaces trenches and parks</td>
<td></td>
</tr>
<tr>
<td>swales</td>
<td>linear planted drainage feature which allows water to travel downstream or infiltrate</td>
<td>detention + infiltration</td>
<td>open spaces and parks</td>
</tr>
<tr>
<td>geocellular systems</td>
<td>prefabricated underground structures to store and slowly infiltrate water</td>
<td>detention + infiltration</td>
<td>use in high density urban settings</td>
</tr>
<tr>
<td>detention pond (dry)</td>
<td>surface storage basin holds stormwater and slowly drains and settles particulates (otherwise dry)</td>
<td>detention + infiltration</td>
<td>landscape and recreational uses</td>
</tr>
<tr>
<td>detention pond (wet)</td>
<td>surface storage basin stores / holds rainwater and circulates through other treatment techniques</td>
<td>detention + infiltration</td>
<td>ponds, lakes, recreation</td>
</tr>
<tr>
<td>channels</td>
<td>open stormwater channels instead of sewerage</td>
<td>conveyance pipes underground</td>
<td>channels, streams, canals</td>
</tr>
<tr>
<td>passive</td>
<td>all green spaces with vegetation</td>
<td>evapotranspiration</td>
<td>urban green spaces, gardens</td>
</tr>
<tr>
<td>active</td>
<td>use water to directly influence temperature or evapotranspiration</td>
<td>evapotranspiration air quality</td>
<td>rainwater walls, pools, fountains</td>
</tr>
</tbody>
</table>

Benefits of water runoff in green
- Decreases impervious surfaces in the city
- Increases public awareness of water
- Microclimate is cooler and more humid
- Decreases the risk of flooding and storm sewer overflow
- Less stormwater needs to be transported and processed in the sewerage system

...The Holftgrabenbächer housing development includes 265 private homes and 9 apartment buildings on a 16.7ha site in Stuttgart, Germany. The design aimed to save costs of storm water management through the application of green roofs, cisterns and pervious pavement instead of enlarging the sewer system for rain water drainage.

Investment costs: The investment costs for conventional storm water management = € 938,000. The investment costs for a decentralised storm water management = € 532,900.

Running costs: The savings per year for not using the conventional storm water management system = € 25,680. The total savings over 30 years = € 1,177,900...

Water Sensitive Urban Design

"If the design of a new development is actually based on the surface stormwater management solutions, with its accompanying green spaces, the amount of green spaces will also increase."

In new development: Consider surface storm water management needs and solutions from the beginning of the planning and design process in order to provide the best integrated solutions for future runoff.

In existing development: Reduce the amount of impervious surfaces by replacing them where possible with the surface stormwater techniques (see next page) based on size, capacity, budget and surrounding development.

GWL, Amsterdam | Photo: Robert ten Elsen

Techniques and technical solutions for Surface Stormwater Management Solve runoff problems closer to the source in urban areas with surface storm water management instead of draining all the water into the sewer system.

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Solve runoff problems closer to the source in urban areas with surface storm water management instead of draining all the water into the sewer system.
17 Biodiversity

Green+ neighbourhoods

Plant a wide variety of plants

Pollens and nectar-rich trees, shrubs and perennials attract bees, butterflies and other insects which are essential for the pollination of plants. The pollinators themselves are food for many birds and small animals. Plant a variety of berry and nut producing trees and shrubs to allow birds and other small animals to sustain themselves in urban areas. Create sheltered areas with dense shrubs as nesting, hiding and foraging places for birds and other small animals.

Develop new / existing biotopes

Create stepping stones of wildlife habitats in between the paved urban environment to attract various sorts of plants and animals. In areas with water such as shallow ponds, natural processes provide habitat for water plants, amphibians, dragonflies and other aquatic insects, etc. The use of the right set of plant species will support the provision of sufficient food for native animals.

Plant choices are not limited to native species

Many non-native plant species are well adapted to urban conditions as well as being colorful and attractive for use in parks, gardens etc. Combinations of native and non-native plants enhance the urban setting while giving a sense of the native character. Select those non-native species, such as Buddleia, that have added value for wildlife.

In new development:
Integrate wildlife habitats in architecture and public and private green by using plant species and vegetation structures with added value for biodiversity. Interconnect the green of the development project with the overall green network in and surrounding the city, to support the migration of animals.

In existing development:
Replace pavement where possible to create habitats for urban birds, bees and butterflies using a diverse mix of selected plants and flowers.

Benefits of biodiversity

• Opportunity for citizens to experience wildlife in the place where they live and work
• Create habitats and food sources for (endangered) insects, birds and small animals
• Biodiversity creates more biodiversity (through cross pollination, more plants means more bees which means more plants)
• Adds colour and interest to the urban landscape

Example of plants used in The Netherlands that benefit the biodiversity in the city

<table>
<thead>
<tr>
<th>trees, shrubs, vines &amp; perennials</th>
<th>bees &amp; bumblebees</th>
<th>butterflies</th>
<th>birds</th>
<th>shelter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crataegus laevigata x media</td>
<td>x</td>
<td>x</td>
<td>x</td>
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</tr>
<tr>
<td>Salix sp.</td>
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<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Buddleia davidii</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Rubus fruticosus</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>hydranthera</td>
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<td>Agastache</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Monarda</td>
<td>x</td>
<td>x</td>
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</tr>
<tr>
<td>Sedum spectabile / telephium</td>
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<tr>
<td>Arnica sp.</td>
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<td>trass</td>
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</tbody>
</table>

Experts: Robbert Snep (Alterra – Wageningen UR), Marco Hoffman (Applied Plant Research, Wageningen UR), Soontiëns Stadsnatuur | Sources: Biodiversiteit in tuin en plantsoen; Groen Werkt Beter; Bedrijventerreinen kan bijdragen aan behoud biodiversiteit

Attention for urban biodiversity makes that citizens have unique opportunities to experience the diversity of plant and animal life in their living and working environment.”
Dr. Robbert Snep, researcher urban ecology, Alterra – Wageningen, UR

Plant mix for biodiversity | Plants selected for their added biodiversity value (e.g. nectar source for butterflies and bees) can be attractive for people too.

A Soontiëns Stadsnatuur project | Photo: Soontiëns Stadsnatuur

In in new development:
Integrate wildlife habitats in architecture and public and private green by using plant species and vegetation structures with added value for biodiversity. Interconnect the green of the development project with the overall green network in and surrounding the city, to support the migration of animals.

In in existing development:
Replace pavement where possible to create habitats for urban birds, bees and butterflies using a diverse mix of selected plants and flowers.

Benefits of biodiversity

• Opportunity for citizens to experience flora and fauna in the places where people live and work.

Add to the opportunities to experience flora and fauna in the places where people live and work.

In in new development:
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In in existing development:
Replace pavement where possible to create habitats for urban birds, bees and butterflies using a diverse mix of selected plants and flowers.

Benefits of biodiversity

• Opportunity for citizens to experience wildlife in the place where they live and work
• Create habitats and food sources for (endangered) insects, birds and small animals
• Biodiversity creates more biodiversity (through cross pollination, more plants means more bees which means more plants)
• Adds colour and interest to the urban landscape

Plant mix for biodiversity | Plants selected for their added biodiversity value (e.g. nectar source for butterflies and bees) can be attractive for people too.

A Soontiëns Stadsnatuur project | Photo: Soontiëns Stadsnatuur

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The High Line, New York City case study

**Friends of The High Line**
The original freight rail line was scheduled for demolition in the nineties and was only saved from this fate by the passionate advocacy and fund raising of a dedicated group of campaigners.

Robert Hammond, Co-founder of the Friends of the High Line comments: "The High Line is many things – an historic artefact; a unique urban landscape, a social centre for a changing neighbourhood. But it is also an inspiring example of what can be accomplished when communities and their elected leaders work together for the common good. The High Line would not be here today were it not for the support our elected officials, neighbours, volunteers, and partners at civic organizations who rallied around us at the very beginning, when the idea was unpopular, and supporting it was truly visionary."

**Support**
The High Line is a public park built on an historic freight rail line elevated above the streets on Manhattan’s West Side. It is owned by the City of New York, and maintained and operated by Friends of the High Line, the non-profit conservancy that raises the essential private funds to support more than 90 percent of the High Line’s annual operating budget pursuant to a licensing agreement with the New York City Department of Parks & Recreation.

**Phasing**
The first section of the park, which runs between Gansevoort to West 20th Streets, opened in June, 2009. The second section, which runs between West 20th and West 30th Streets, opened in June, 2011. Friends of the High Line continues to advocate for the preservation and transformation of the High Line at the Rail Yards, the third and final section of the historic structure, which runs between West 30th and West 34th Streets.

**Benefits**
Preserving and developing the High Line has brought enormous benefit to Manhattan’s West Side. It brings much needed green space into the heart of the city, which in turn results in a whole raft of benefits, from recreational opportunities for people of all incomes and social/ethnic backgrounds, environmental benefits such as improved air quality and reduction of the heat island, right the way through to enhanced property values along the line.

**Visitors**
Since the first section opened in June of 2009, the High Line’s popularity has exceeded expectations. The public park has welcomed more than four million people, comprising nearly equal proportions of New Yorkers and out-of-town visitors, making it one of the most highly visited public parks per acre in the city.

**Revitalization**
Recognized as a significant contributor in the revitalization of Manhattan’s West Side, the High Line has become a defining feature in its neighborhood and a powerful catalyst for private investment. In 2005, the City rezoned the area around the High Line to encourage development while protecting the neighborhood character, existing art galleries, and the High Line. The combination of the rezoning and the park has helped to create one of the fastest growing and most vibrant neighborhoods in New York City. From 2000 to 2010, the population within the rezoned area has grown more than 60 percent. Since 2006, after the rezoning was approved and construction of the High Line began, new building permits in the immediate vicinity of the High Line doubled and at least 29 major development projects have been initiated (19 completed, 10 underway). Those 29 projects account for more than $2 billion in private investment, 12,000 jobs, 2,558 new residential units, 1,000 hotel rooms, more than 423,000 square feet of new office space and 85,000 square feet of new art gallery space. In May, construction began on a new downtown home for the Whitney Museum of American Art, which will serve as a major cultural anchor at the southern end of the High Line when it opens in 2015.
Green+ neighbourhoods

- **Green Lease!** [Green Pay!]
- **Alle extra groen helpt de luchtkwaliteit verbeteren** [All extra green helps improve air quality]
- **Green voor Elmaat** [Green for Elmaat]
- **Bomen een voorraad voor de stad** [Trees: Belief for the city]
- **Unilandal Leucitewond Groen** [Manual Air Purifying Green]
- **in herstelcomplexen groen is geen sociale verbeter** [In revitalization plans, green is a social enhancer]
- **Buurtgroen en Sociale Cohesie** [Neighborhood Green and Social Cohesion]
- **Lecht ap Groen** [The Right to Green]
- **Green meters II** [Green m. II]
- **Kweenvriendelijke wijken voor Kinderen** [Exercise-friendly neighborhoods for children]
- **Beiderden gezend groen, gewoon doen** [Better healthy green, just do it!]
- **The Green City Fest 2013**
- **Prijswinnaars Green Speelplaatsen 2011** [Design Competitions Green Playgrounds 2011]
- **Een Groene Garenste van [A Groene Healthy Neighbourhood]
- **Kam je button spelen?** [Come out and play!]
- **Vlaer Eet Bergrisstaat** [Honey: A Resident Initiative]
- **De Jasande Tan** [The Living Garden]
- **Biodiversity conservation at business sites**
- **Water Sensitive Urban Design**
- **Over Bomen en Bosjes** [About Trees and Bushes]
- **Green World Better** [Green World Better]
- **Bedrijven kan bijdragen aan behoud biodiversiteit** [Business can help preserve biodiversity]
- **Biodiversiteit in tuin en planten** [Biodiversity in gardens and parks]

**Websites:**
- www.evao-lammert.nl
- www.groenwachterplannen.nl
- www.atlas.org
- www.buurtontverdeleri.org/greenfuture/articles/gardens-hidden-capital-invisible
- www.impale.eu.org
- www.park2020.com
- www.stroom.nl
- www.bomenstichting.nl

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- **Irene Salverda**, CSU Researcher Alterna – Wageningen UR
- **Sharon Johnson**, Chief Executive Trees for Cities
- **Arts van Niehuys**, Director Coppice Tree – Landscape Architects
- **Mohsen Dij**, Garden Design Landscape Architect & Urban Designer De Tuinmaker
- **Jake van der Zwaan**, Urban Sociologist De Tuinmaker
- **Pik Tope**, Project Manager Irene Naas, Project Manager TED Innovation for Life
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- **Alpera – Wageningen UR
- **Bastiaan de Ro, Director Lardien Chamber of Commerce The Hague**
- **Mark Long**, Director UK Green Forum
- **Griffin Feliks**, Landscape Architect Droog Landscape
- **Marco Hoffman**, CSU Researcher Applied Plant Research – Wageningen UR
- **Robert Hammons**, Co-Founder Friends of the Highline
- **ES Consulting**
- **Soontiens Stadsmaster**

**Green+ streets**

- **18 Green plazas**
- **19 Air circulation & ventilation**
- **20 Street layout**
- **21 Right tree, right place**
- **22 Use existing trees**
- **23 Big healthy trees**
- **24 Growing conditions**
- **25 Quality maintenance**

Case study: London 2012 Olympics
18 Green plazas

Use trees and green as an urban shelterbelt
Wind across an open urban plaza makes the space unattractive for people. Place planting and trees strategically to create comfortable spots for people to sit, walk and play.

Trees create comfortable outdoor spaces
Shade under a tree can make the apparent temperature at ground level 5-10°C cooler. The perceived temperature under a tree is lower due to the reduction of direct sunlight that reaches the ground and evapotranspiration of water via the leaves. Deciduous trees allow sun to reach the ground and heat the surface in winter and prevent the sun from reaching the ground and heating the surface in summer. Not only trees but also vine-covered pergolas and other planting can add to the shade solutions. Lower plants also help reduce surface heat.

Create a comfortable oasis of clean air in the city
Protect outdoor spaces from air pollution through the use of green elements and trees. Green can act as a buffer to prevent local sources of pollution such as from traffic from entering the plaza. Trees and shrubs can force the polluted air upwards so it blows over the plaza and not through it. A continuous canopy of trees over a plaza can prevent background air pollution from settling in the plaza.

Vary the microclimate within the park
The temperature, season and time of day determine where people prefer to sit in a plaza. Personal preferences also vary: some people enjoy sitting in the full sun, others prefer to sit in the shade. Provide a variety of places to sit, walk or play so everyone has a choice.

Benefits of green plazas

• Shade under trees makes outdoor areas usable on hot days
• Sunny areas with no wind are usable on cold winter days
• Green plazas are oases in the hard urban environment

“People want green and trees in plazas. Trees can function as protection from the wind and sun. But they need to be planted in the right spot, otherwise they can actually create a wind tunnel effect.”

Sanda Lenzholzer, Wageningen University

Shade in Madrid RIO Park, Spain
Photographer: Jeron Masich (copyright city of Madrid)

In new development:
Base the design and layout of new urban spaces on the microclimate and existing conditions of the space and the way the plaza will be used. Use green to make spaces more comfortable.

In existing development:
Plant trees with wide canopies in order to increase the amount of shade on the surface in plazas, public outdoor spaces and along streets where shade is desired. Use shrubs, pergolas and green walls where wind protection is needed.

Prevent local hot spots in urban plazas by planting trees to increase shade and reduce wind and make outdoor spaces more comfortable.
19 Air circulation & ventilation

Use green to drive the polluted air upwards

The air pollution from a local source can be reduced by thinning the polluted air with cleaner air. Encourage the mixture of local high concentrations of air pollution with cleaner air to prevent local hot spots. Air filtration alone cannot provide enough reduction. By creating a barrier effect, the air is driven upwards where it can mix with cleaner air in higher air layers. A continuous, closed, and linear barrier is most effective. The ability of the air to return to background concentrations of air pollution when it reaches ground level depends on conditions such as weather, barrier type, barrier height and the local air pollution concentration. It is important to provide enough ventilation behind the barrier.

Prevent the green tunnel effect

It is important that the green solution does not increase the concentration of pollution locally. Tree canopies which form a tunnel (along narrow streets) have a negative effect on the flow of fresh air into the street and the flow of polluted air away from the street. The tunnel effect can be prevented by eliminating the obstruction, for instance by choosing a row of trees on only one side of the street or creating green façades on adjacent buildings.

The size and spacing of the green structure are important in forming an effective barrier

A dense leaf structure, smooth regular habit and compact form create a solid barrier and keep turbulence down. The porosity should be as low as possible, preferably less than 5%, when used as a wind barrier. Create a closed (leaf) surface for optimal effect: horizontally (choose a planting distance which is smaller than the tree crown or plant width so there are no gaps between the plants) and vertically (use a combination of trees and shrubs for effect at various heights in the vegetation structure). Evergreen plants have a better effect than deciduous plants. Low hedges or green screens between the street and pedestrian zone act as a barrier to reduce the amount of gaseous pollutants and particulate matter emitted by cars near ground level that reach the pavement.

Benefits of air circulation

- Buffers people from local sources of pollution
- Reduces health risks due to exposure to air pollutants

Drive air upwards

A vegetation barrier works best if the wind hits it at a 90° angle (taking into account the prevailing wind direction). On the top of the barrier, the turbulence in the air mixes the polluted air with the passing cleaner air. The polluted air is forced upwards, where the concentrations will lower because of mixing with cleaner air. The air stream will flow back down to ground level after approximately 10-15x the height of the barrier.

In new development:

Lay new streets and neighbourhoods out based on the wind direction and possible sources of air pollution.

In existing development:

Adjust existing green structures to avoid the green tunnel effect and encourage the flow of polluted air away from people and buildings.
20 Street layout

Use trees to control wind
Street trees work best if wind is not too strong yet enough ventilation is provided. Wind turbulence remains above the tree canopy in narrow streets while ventilating wind flows through the tree canopies and filters the particulate matter (PM10) and gaseous pollutants from the cars. Porosity of the canopy should be more than 40% in order to allow trees to function optimally as air filters.

The planting layout is more important than the plant species
Street design which uses green elements to improve air quality needs to be designed on a site-specific basis. A row of streets trees along a 30m wide street with low adjacent buildings may help clean the air, but those same trees along a 10m wide street with high buildings will worsen the air quality. The size of the trees, the distance to and height of adjacent buildings and the porosity of the trees all affect the capacity of the design to improve the experience at street level.

Choose other green alternatives if space is limited
If there is not enough room in the street profile for trees, use other methods such as hedges, green roofs, green walls (min. 5m high) and pergola structures with green to perform air filtering and/or ventilation functions. Groundcover plants also capture particulate matter at pedestrian level. Natural, uneven, extensively maintained plant mixes are more effective than mowed lawn.

Provide bioretention water in the streetscape
Integrate green solutions for storm water management within the street right-of-way by reducing unnecessary impervious surfaces and replacing them with green swales, pavement planters and green curb extensions. This not only helps reduce the stress on storm sewer systems, but also adds to the aesthetics of the street.

Benefits of street layout
- Improves air quality at street level by up to 30%. Creates a comfortable microclimate along streets for pedestrians and bicycles
- Provides structure and orientation in urban environments

The sources and distribution of PM10 in a street with buildings on both sides

Total concept for the use of green in a street in order to improve the local air quality

Plant green along the street so it is functional, aesthetic and does not hinder the flow of traffic.

In new development:
Include enough room for green in the planning of infrastructure in order to optimize the effects on the air quality, wind and water runoff. 20% of the infrastructure surface should be reserved for green.

In existing development:
Determine whether existing trees help or hinder the air quality of the street and adjust the design to provide optimal functioning of the trees and other green layers. Check the availability of space for green, as well as the traffic safety regulations.

Nijmegen, NL: Effective use of a green screen to capture PM10 along a street
Photo: Fred Temmeijk
**Green+ streets**

**21 Right tree, right place**

*Choose tree species which adapt well to urban conditions*

Urban conditions (soil compaction, tolerance of salt, drought, low maintenance), local climate conditions (rain, wind, temperature, humidity, winter hardness) and the soil type all need to be considered when choosing which tree to plant.

*Plant trees whose full grown size fits in with the scale of surrounding uses*

Avoid the "green tunnel effect" along streets where polluted air is trapped by too dense or too large trees and no ventilation. Either plant smaller trees or be sure that the porosity is more than 40% by choosing trees with open canopies or through sufficient maintenance. Also consider the amount of space available underground where the roots need to develop and above ground for crown development.

*Trees should enhance and not hinder their desired function*

Trees for shade should have big canopies in the warm months, trees for streets should have a high branch structure to prevent obstacles in the streetscape, use columnar trees in narrow streets, trees in small gardens should not overtake the entire space, park trees should fit with their location and function, etc. A tree that outgrows its boundaries will create negative opinions of trees in urban settings.

*Prevent hazardous situations*

Do not plant trees with falling fruit, seeds, uplifting roots or branches that fall in the wind in areas where they can cause damage, such as along streets, in parking areas and next to houses.

*Choose tree species which require low maintenance for public spaces and streets*

Trees should be able to survive in changing weather or climate conditions or periods when the public maintenance budget is not secure.

**Benefits of the right tree**

- The right tree in the right place requires less maintenance
- A tree that can adapt to the urban conditions can reach maturity
- Properly placed trees have the most effect on air quality and provide shade where it is most needed
- The appropriate choice of tree species avoids damage to property

"Trees can only fully mature and function when they are carefully selected, taking into consideration their growth characteristics, site conditions (including available space) and the functions to be performed by the trees. These three aspects are equally important and always need to be considered simultaneously."

*Jelle Hiemstra (Applied Plant Research - Wageningen UR)*

*In new development:*

Trees should be included in the design at an early stage so they can be used for aesthetics and perform other beneficial functions such as air filtering, shade and wind. Let trees determine the character of development instead of the other way around: The right place for the right tree.

*In existing development:*

Existing conditions should be studied to determine which tree variety, size and characteristics fit best aesthetically and functionally in the space.
22 Use existing trees

**Perform a tree survey**
Be sure that a tree is worth being saved before taking measures to design and build around it. First take an inventory of the size, location and species of all existing trees on the site. Ask a tree specialist to check the trees that are considered to be worth saving. The life expectancy, condition, stability and quality of the tree should be determined.

**Plan ample space around existing trees**
Do not place buildings too close to an existing tree. Keep at least 5m between a building and the trunk of the tree (or more if the canopy is already larger than 10m in diameter). This allows the canopy and roots to develop to maturity. Do not cut large structural roots near the trunk to avoid instability of the tree.

**Avoid underground conflicts**
When renovating underground situations such as cables and pipes, do not use heavy digging equipment around existing trees. Dig by hand near the roots to avoid damage.

**Protect trees during construction**
Building specifications should clearly state what the protocol is around existing trees and green. Place a fence around a tree at least as big as the canopy in order to keep growing conditions optimal and protect the roots and canopy from machinery. Be sure that the area around the tree does not become storage for building supplies and equipment or a dumping ground for building waste and oil. Inspect the ground water tables in case of (temporary) level changes or pollution that could damage the trees. Include a penalty clause in the contract if trees are damaged.

**Guarantee growing conditions after construction**
After all construction is completed (including the new surrounding landscaping), trees and plants should be checked for damage and soil conditions should be monitored for quality. Maintenance should begin immediately thereafter.

**Benefits of existing trees**
- New development automatically gets a mature green character
- Mature green is more valuable both aesthetically and economically
- Existing tree structures provide a spatial quality only achieved after many years with new plants
- Old trees have history and meaning for people and the site
- Mature trees are most effective in providing the desired functions

“*A mature beech tree with a trunk diameter of 80cm removes 17x more PM10 than a corresponding tree with a trunk diameter of 20 centimetres.*”
Fred Tonneijck (Triple E & Knooppunt Innovatie Green)

**Consider existing trees as assets to a development from the beginning phases of design through construction.**

In new development:
Let existing valuable / characteristic trees inspire or become the basis for new development. Be sure the design incorporates the needed space for trees and green to thrive in the new surroundings. Protect and monitor the trees during the entire construction process.

In existing development:
Trees and green should be incorporated into the redesign of areas and be given more room if needed so the trees can reach their optimal form. Be sure to protect trees both above and underground during the construction process.

- Existing tree protection during construction.

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Soussien: Fred Tonneijck (Triple E & Knooppunt Innovatie Green), Jelle Komen (Applied Wood Annoarch - Vappendingen 86), Willem van Heijningen (Conceit Tree - en landschapsarchitectuur).
Green+ streets

Green character is established quicker with large healthy trees and mature green
Healthy trees planted in a healthy environment have more influence in the short term as well as the long term on the green character, value and usability of green spaces, real estate and the health of surrounding residents. The usability, attractiveness and effectiveness is not only visible right after construction, but improves as time goes on. These benefits should be weighed into the budget of green projects.

Canopy area should be compensated, not the number of trees
Cities should base their tree regulations on the quality of the trees more than on the amount of trees planted. When mitigating the loss of existing trees (which has a negative effect on air quality), the canopy area of the removed trees should be compensated, not the number of trees.

23 Big healthy trees

Large healthy trees have a better survival rate
Trees with a trunk diameter of 30-35cm (measured 1m from the ground) have a better rate of survival because they are more established and less susceptible to diseases, molds, bacteria, wind, etc. Vandalism occurs less to trees with a minimum trunk diameter of 20-25cm. The root ball should also be large, compact and contain some fine roots. The costs of replacing dead trees are high when compared to the price of larger specimens.

Trees should be able to adapt to the urban conditions
The suppliers of plant material should take into account the eventual conditions that the plants will need to survive in. The production process should include a period of adaptation (transplanting, etc.) so the plants are not shocked in their new urban environment.

Benefits of big trees in green spaces
- Big healthy trees give a project an instant green character
- Large healthy trees require less maintenance and have a less chance of dying
- Larger trees are less susceptible to vandalism

Tree planting in urban green spaces

The Traditional Forest Thinning Method
Originaly used in forests planted for wood production
- Small tree seedlings planted in rows
- Tree seedlings spaced from 1.5m between trees planted on a grid

Plant costs are low, maintenance costs are high
(15 years of removing and pruning trees)

Takes about 15 years to fill in and gain a forest or mature park character

Sources: Integratie beplantingsmethode (wettige gelagden) Prins Bernhardbos op. Green (scien); De homptrener; Tentoonstelling sfeerwaarden Green

Plants big quality trees and shrubs in urban areas in order to achieve the desired green result directly after realisation.

"Scientific and market-conform calculations show that the Integrated Planting Method actually saves money in the long term. The construction costs are two times more expensive than the traditional forest thinning method, but the maintenance costs are actually 60 - 70% lower."
Dr. Frits Buyten, landscape architect, Integratis PP

In new & existing development:
Convince developers of the short term as well as the long term benefits of using big plant material in projects and secure the budget for quality planting and design.

Laden, NL | Newly planted trees along the IJsselmeerdijk

Florida, 2002, Heartlenmoer: NL | Large trees with healthy rootballs were planted at the Florida 2002 site so the desired landscape character could be achieved quickly. | Designed by Wilk Beznik bv
24 Growing conditions

Trees need quality soil to grow

Soil should have good air circulation, organic content, porosity, water storage capacity and soil biology. Enough decomposition should occur in the ground in order to convert some of the compounds from the dust particles collected by the trees into harmless compounds. Remove sterile building sand and replace with the appropriate soil mixture depending on the situation.

Roots need room to grow

Prevent the “flower pot effect” by providing enough underground growing room with the right conditions. The size of the tree planting area depends on the surrounding uses above ground (park or yard vs. street or building), the size of the tree, and how high the water table is. The rule of thumb is 1m² space underground per growing year for healthy root growth. At the design stage, the mature size of the tree should be considered. Excessive pruning due to adjacent buildings, powerlines, etc. denies the tree its necessary energy (leaves are the lungs of the tree).

Trees have specific water needs

Especially during the first year of planting, maintenance and water should be budgeted into the project to guarantee that the trees grow. Avoid digging planting beds deeper than 50 cm above the groundwater table. Do not use the planting beds around trees as drainage for surrounding pavement because of the damage resulting from the excess water or salt.

Do not allow soil compaction to occur

If too much compaction occurs under pavement (traffic areas) then root growth is limited due to less porosity, air circulation and water drainage / availability. Compacted soil does not allow water to infiltrate and reach the root zone and groundwater table.

Tree roots need adequate oxygen

This can be achieved by the proper soil type with porosity or with a perforated pipe network with 40% perforation under the pavement. Pavement which is damaged by roots is usually caused by roots searching for oxygen closer to the surface.

Benefits of good conditions

- Trees are able to reach maturity
- Trees are healthier and more vigorous
- Trees perform optimally (provide shade, clean the air, etc.)
- Trees require less maintenance and control which saves money in the long term
- Less problems such as damaged paving, diseases and pests
- Healthy roots have a positive effect on the capacity of the ground to buffer water

Creating the proper growing conditions for urban trees so they are healthy and can perform optimally.

In new development: Remove building sand in all tree and plant beds and replace with planting soil. Design not only above ground but also underground so there is ample room for trees to grow.

In existing development: Street renovation should not only be based on traffic circulation but also the optimal growing space for the new or existing street trees. Street profiles, space underground and soil type should be adjusted to prevent problems such as paving damage due to roots.

Characteristics of soil used for trees in urban settings

<table>
<thead>
<tr>
<th>Characteristics of soil used for trees in urban settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>tree soil                                           tree sand                                           tree granulate</td>
</tr>
<tr>
<td>organic matter                                     high content (5-7%)                                4-5%                                          60% rocky material mixed with 40% compost, peat or clay</td>
</tr>
<tr>
<td>structure                                          open and loose                                     mix of course sand and organic matter           (50% light traffic)</td>
</tr>
<tr>
<td>porosity                                           65%                                                 50% light traffic                              medium to heavy traffic</td>
</tr>
<tr>
<td>amount of traffic                                  no traffic within canopy radius                     light traffic                                  under streets (with good circulation)</td>
</tr>
<tr>
<td>location                                           open ground parks, green areas, green strips between paving and grass/planting</td>
</tr>
<tr>
<td>min. points                                       not suitable under pavement and traffic             must be professionally mixed to avoid compaction, lack of oxygen and drying out</td>
</tr>
</tbody>
</table>

**Source:** Kwaliteitsverein en fut toepassing

In new development

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Space needed for various tree sizes

<table>
<thead>
<tr>
<th>Tree Size</th>
<th>Large</th>
<th>Medium</th>
<th>Small</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. height</td>
<td>11-21m</td>
<td>6-12m</td>
<td>1-6m</td>
</tr>
<tr>
<td>Max. canopy dia.</td>
<td>10-15m</td>
<td>7-12m</td>
<td>2-7m</td>
</tr>
<tr>
<td>Length of bed</td>
<td>6-12m</td>
<td>4-8m</td>
<td>2-3m</td>
</tr>
<tr>
<td>Min. width of bed</td>
<td>3-4.5m</td>
<td>2.5-3.5m</td>
<td>1.5-2m</td>
</tr>
</tbody>
</table>

**Source:** Beheerreglement boomheer behoorenlijke(view 2007 NOCB, Beheerboomheer en fut toepassing)
**25 Quality maintenance**

**Maintenance is a long term commitment**
A plan should be set up for all green projects in order to guarantee the quality and functionality of the trees and other plants. A systematic multi-year maintenance plan includes water schedules and amounts, pruning schedules, fertilizing and control of soil.

**Maintenance is an investment**
Well maintained quality green is more attractive, thereby raising the value and usage of green spaces as well as the value of the surroundings. Unmaintained and overgrown green creates negative attitudes toward green in urban areas. Falling branches are dangerous to people and property and are more costly to repair than routine pruning. Funds should be reserved for maintenance based on a cost-benefit analysis.

**Design and maintenance go hand in hand**
From the beginning of the planning process through the choice of landscape and plant materials, designers should take into account the effects these have on maintenance after it is built. There should be a balance between design and maintenance capabilities, including budget, initiative and ability.

**Involving all parties who are affected by the results**
Are everyone's expectations being met with the level of maintenance provided, including the local government, the contractor, the residents, the users and the businesses. If not, bring everyone to the table to understand what their impression of quality maintenance is compared to the available resources (money, manpower) and find solutions to achieve this. Find funds from various sectors who also profit from an attractive urban environment. Ask residents to communicate with the maintenance experts when the agreed-upon standard is not being met.

**Benefits of maintenance**
- Attractive well maintained green is treated with respect by users and surrounding residents
- Attractive well maintained green raises the value of surrounding properties
- Preventable accidents such as falling branches and uplifted pavement can be avoided by timely control and maintenance
- Well maintained green spaces are perceived as being safer green spaces that are well maintained

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**Allow trees to reach their full potential by providing proper maintenance from day one.**

**In new development:**
Guarantee proper maintenance, especially in the first years after planting, by stating clearly in the project specifications the requirements for care, water and fertilizer. Budget the time and money for maintenance from the beginning so it is not seen as an extra cost later.

**In existing development:**
Take an inventory of maintenance needs in the city based on a desired level of quality, set up a yearly plan, train the people who will carry the plans out and reserve a budget to raise the quality of the existing green.
**Green streets**

**Green Infrastructure**

The London 2012 Olympics is an iconic event with green space at its heart. The site of the London Olympic Games was made up of contaminated and derelict land, leftover following the slow decline of a range of polluting industries including tanning, rendering and vehicle dismantling. Not only did it offer the space for the development of an outstanding sporting facility, it also had the potential to contribute to the economic recovery and environmental improvement of the site itself and surrounding area.

Working with leading landscape architects and designers, landscape contractors and the nursery stock industry, the ODA has set a standard for putting green infrastructure at the heart of developments like this and ensuring that green space is a central part of the sustainability of the project.

**Quality Green Space**

From the start, the Games have set out to deliver superb sporting facilities, supported by the kind of public realm that will allow athletes to rest and relax between events and as a result, perform to their best ability. This environment includes quality green infrastructure, a ‘green canopy’ that provides habitat and shade, and 10 hectares of new wetlands and parkland. It includes more than 2000 new trees and 100,000 plants and space for cycling, picnics and play.

As well as providing a wonderful environment for athletes and spectators, when the games are over, the Olympic park will become a resource for the residents of the 3500 homes that will be created from the athletes’ accommodation, and for residents of the surrounding boroughs.

**London 2012 Olympics case study**

"London is the first summer host city to embed sustainability in its planning from the start... we have used the Games as a catalyst for the regeneration and improvement of quality of life in East London. A multi-functional landscape addressing biodiversity, flood risk management, carbon sequestration, energy, water use, walking and cycling will set the context for continuing legacy development for new and existing communities.”

John Hopkins, Project Director, Olympic Delivery Authority

**London, UK | designers: LDA Design & Hargreaves Associates | Clients: Olympic Delivery Authority | 2012**

**The ‘Greenest’ Games**

The green space element is key to London 2012 – an event that sets out to be the ‘Greenest Games’. It is a core element of its sustainability thrust, itself a cornerstone of the event.
Literature:

- Green Loot! [Green Pay!]
- All extra green helps to improve the air quality!
- Green for Elmaat [Green for Cilantro]
- Bomen: een verademing voor de stad [Trees: A Relief for the city]
- Leidraad Luchtzuiverend Groen [Manual Air Purifying Green]
- Effecten van groen op de luchtkwaliteit [Effects of green on air quality]
- IPL-rapport 1b: Toepassingsadvies Schermen [IPL report 1b: Advice for applying screens]
- IPL-rapport 2b: Toepassingsadvies Vegetatie [IPL report 2b: Advice for applying vegetation]
- De boomplanner [The Tree Planner]
- The Green City Team 2011
- Integrale beplantingsmethode laten geslaagd [Integrated planting method in a success in the Pries Bernhardus]
- Practischebrochure Bomensubstraten en kunstgras [Practical brochure Tree soils and their application]
- Community Green: using local spaces to tackle inequality and improve health

Websites:

- www.west8.nl
- www.functioneelgroen.nl
- www.straatbomen.nl

Experts:

- Fred Tonkien, Senior Advisor/Researcher Triple E and Knooppunt Innovatief Groen
- Pauline de Koning, Landscape Architect Peter Schelthuis, Art Specialist, Botanist BEOW Advies bv
- Sandra Landhuisen, Assistant Professor Landscape Architecture Wageningen University
- Arda van Hulstegem, Director Capital Turn - en Landschapsarchitecten
- Casper van Ipen, Project Manager Living Environment CROW
- Eva Stache, Architect Stache Architects bv
- Jolle Hiemstra, Senior Researcher Applied Plant Research - Wageningen UR
- Frank Bauman, Director Cyber Advisors
- John Hopkins, Project Director Olympic Delivery Authority
- Mark Long, Director UK Green Forum
- ES Consulting
- London 2012

Green+ streets

Green+ buildings

26 Green oriented to buildings
27 Buildings blend into landscape
28 Green roofs
29 Green walls
30 Green indoors
Case study: Vancouver Convention Centre
26 Green oriented to buildings

Prevent cold winter winds near the building
Coniferous windbreaks planted between cold winter winds and a building reduce heat loss inside buildings. Wind speed can be up to 20% less directly behind a planting structure. Avoid dense trees in the direction of cooling summer breezes. The induction of relatively low wind speeds (max. 40 m/s = 1.5 to 10 mph) can mean an annual savings of 10% on energy consumption for heating. For greenhouses the savings are 15 to 40%.

Prevent excess sun from reaching the building
Trees planted on the east and west sides of buildings block summer sun before it enters the building, therefore reducing the need for air conditioning. Large deciduous trees on the south side not only block summer sun but also allow winter sun to filter through the empty branches and warm the building. Temperatures are also reduced by transpiration in the warm growing season.

Prevent air pollution from entering the building
Trees planted outside as a pre-filter for the air that eventually enters the building. The air has already gone through a filtering process by flowing through the tree canopy first. Place planting structures close to buildings so polluted air rises above the building or is led along the building.

Place planting near ventilation ducts
Place evergreen plants near the in-going ventilation ducts of a building. This improves the quality of the air that enters the building. Deciduous plants also help shade and cool the areas around the ventilation ducts in summer and allow the sunlight to warm the ingoing air in the winter.

Use trees to filter background pollution
Do not only place trees to filter pollutants next to the source of pollutants (industry, streets, etc.) but also around sensitive objects such as schools, hospitals, elderly homes, etc. These are the groups most susceptible to the health hazards of air pollution.

Benefits of adjacent green
- Reduces the energy demands of buildings by up to 10%
- Reduces the use of air conditioning in the summer
- Reduces the use of heating in the winter
- Maintenance on building façades is less if shielded from excessive wind and sun
- Indoor ventilation and climate is improved

Green+ buildings

Hotel in Abu Dhabi, UAE | The hotel is surrounded by a lush green landscape which not only provides a comfortable climate just outside the lobby for guests and passersby, but also helps shade the lower levels of the building against the sun.

Deciduous trees along the south-facing office window provide shade in the summer and allow sun to pass through in the winter.

Mouse de Quai Branley, Paris, France | Design by ECO Architect Patrick Blanc

Photo: Robert van Eemen

In new development: Include green around buildings as a sustainable building technique used to calculate the energy coefficient. Calculate green into the budget for new buildings because of the integral role it plays in meeting these standards.

In existing development: Plant trees in the right place to change the microclimate directly outside a building so fluctuations in sun and wind are less dramatic, resulting in a more consistent indoor climate.
Green buildings

27 Buildings blend into landscape

Anchor the form of the building in its surroundings

Use the natural characteristics of the site itself and its surroundings (not just the program and functions) to determine the size and form of a building. Situate the building based on the climate, microclimate, topography, existing trees and water. Connect the building to these characteristics by providing views to and from the landscape and creating physical links for people. The urban cityscape is also a type of landscape that can guide the principles of a building’s design.

Encourage the multi-functionality of buildings

By combining functions and uses within buildings, such as parking below offices or retail under housing, more room is left in the urban landscape for green spaces. Green can also be incorporated into the building itself through the use of green roofs, green walls and atriums.

Use the landscape to help create energy-efficient buildings

Energy usage inside buildings can be reduced by using the landscape as insulation in the form of green roofs, green walls or semi-underground spaces. The orientation of buildings and the location of windows should be designed based on the position of the sun and prevailing winds. Water management of a building site can be combined with the architectural design. The location of the building should not interfere with the natural drainage patterns of the site. Green roofs decrease the amount of water runoff and storage areas for water allow buildings to re-use grey water for toilets or irrigation. The use of local materials also adds to the sense of place of a building while also reducing the carbon footprint.

Blend the landscape into the buildings

The surrounding landscape can also be extended into, over or around the buildings. Landscape design can be used to enhance the character of the site and create a balance between the architecture and the natural characteristics of the site and its surroundings.

Benefits of blending

- Saves on energy costs inside the building (cooler indoors in summer and warmer in winter)
- Enhances the sense of place
- Encourages sustainability practices in the design

...Ypenburg which is located next to the Delftse Hout nature reserve. “Here, ecologists, city architects, landscapers and real estate developers teamed up. The final result gave the Ypenburg residents the impression they were living in a natural beauty spot as opposed to actually living next to it...” Willem Weeda, Mostert de Winter in The Green City Post 2011

Capture the sense of place and use the natural characteristics of a site to inspire the design of buildings.

“The problem with sustainable building is that the environmentally friendly construction practices often remain hidden to the eye.” Wyts Algra, Dura Vermeer in The Green City Post 2011

In new development:
Situate buildings based on the existing conditions of a site and use them to the design’s advantage.

In existing development:
Connect the building to its surroundings by providing views to and from the landscape. Combine functions by creating parking garages in the city to make room for more urban green spaces.

De Hoek, Haarlem, NL | The business park near Schiphol Airport, developed by Segro and designed by Urbahn Urban Design, is an endogenously sustainable concept with green roofs, inspired by the surrounding polder landscape | Image: Urbahn Urban Design

Kralijk, NL | Harris and materials used on the site to root the buildings into the surrounding dune landscape.

High Tech Campus in Eindhoven, NL | Photo: Robert ten Cate

Sportploeg Mercator, Amsterdam, NL | The use of green walls blends the building with its surrounding sports facilities. The building is located in downtown Amsterdam | Photo: Copijn Tuin- en Landschapsarchitecten

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La Haye, Leidschendam, NL | The use of green walls blends the building with its surrounding sports facilities. The building is located in downtown Amsterdam | Photo: Copijn Tuin- en Landschapsarchitecten

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In existing development:
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Only choose hardy plants which are able to survive in rooftop conditions

Extensive roof garden plants should be able to survive and grow in high temperatures, full sun, high wind speeds and periods of drought. The should be able to survive in a thin substrate layer, a small waterbuffer and fluctuating temperatures.

The best plants for extensive roofs are:
• Perennial, low, seed-bearing, drought tolerant plants
• Succulent plants with grey hairs or a thick blue layer on the leaves (sedum and sempervivum are available as plants or as ready-made living mats)
• Plants with strong woody twigs or thin leatherlike leaves
• Annuals that bloom once and go to seed so they always return

A larger variety of plants can grow on an intensive roof garden

The plants have more soil, water and fertilizer availability. Location factors for plants include the height of the roof, wind speeds, irrigation availability, sun position, relation to other buildings, climate zone

The best plants for intensive roofs are:
• Plants that don't get too big (maximum weight capacity), grow in full to half sun, can tolerate wind (do not use plants with lots of seeds that blow away, high plants with breakable or falling stems or plants with strong spreading roots)
• Perennials should be suitable for full sun and fully cover the ground
• Eco-roofs should consist of native plants
• Shrubs should be winter hardy, not be sensitive to wind, grow in full sun and grow in normal to dry soil, solitary shrubs can be pruned like trees. Low, drought tolerant shrubs are good choices
• Trees should only grow up to 6m high, not be sensitive to wind, have a crown that is not too big and open
• Trees with shallow roots must be anchored

Benefits of green roofs
• Life of the roof is up to 20 years longer
• Insulates the building against cold and warm
• Gives a “green” image
• Absorbs noise and vibrations
• Makes solar panels more efficient
• Eases the peak flow in stormwater sewers; lessens the urban heat island effect; produces oxygen; absorbs carbon dioxide
• Captures particulate matter; absorbs gaseous pollutants
• Improves the living and working environment

Criteria for building a green roof
Depth of soil:
• 7-10 cm for sedum, moss
• 25 cm for shrubs
• 80 cm for trees (0.75m2 per m2 canopy)

Weight:
• 30-100 kg for 2-15 cm soil
• 150-300 kg for 15-20 cm soil
• 250-1000 kg for 1-20 cm soil

Maintenance:
• A conventional roof requires inspection 1x per 5 years
• An extensive green roof requires inspection 1x per year and weeding (no irrigation required)
• An intensive green roof requires inspection 8x per year (weeding, pruning and fertilizing) and always requires irrigation in dry periods.

List of trees successfully used on roof gardens in The Netherlands:
- Nothofagus antarctica
- Amelanchier lamarkii
- Taxus baccata
- Cornus mas
- Pyrus salicifolia ‘Pendula’
- Pinus nigra ‘Nigra’
- Betula utilis ‘Dooembos’

28 Green roofs

In new and existing development:
Check local building codes and permits and have a structural engineer check the plans to be sure the roof is strong enough to hold the weight. It is also wise to compartmentalize the roof so it is easier to find the sources of possible leaks and prevent damage to neighboring roofs.

In existing development:
The existing roof must be in good condition, strong enough, insulated and waterproof. Check if the insulating layer is under the waterproofing layer or over it and design accordingly. A layer of root barrier is also needed.
29 Green walls

Green walls can be created with vines
Use twining or climbing self-climbers and provide support if needed. Be sure to replace building sand with proper soil so the vines can grow. The advantages of vines are that they grow from the ground up, they do not need irrigation and they can reach a height of up to 20-35m. The disadvantage of vines is that they take a long time to establish. Self-climbing vines include Hedera helix and Parthenocissus tricuspidata (not on north-facing walls). Twining or climbing vines on climbing racks include Ampelopsis, Aristolochia, Celastrus orbiculatus, Humulus lupulus, Wisteria and Vitis.

Green walls can be created using planters
Use climbing and hanging plants and shrubs in the planters. Hang planters on the wall or install ready-made planters with climbing racks. The advantages of planters are that irrigation is needed but the plants can survive if it is temporarily not used, fertilizer can be provided directly into the soil or given in the water and the results can be seen after 1-2 years. The disadvantages of planters are that they can be expensive and maintenance is needed a few times per year. Climbing plants for planters include Hedera, Acmispheta, Actinidia and Periploca. Hanging plants include Hedera and Jasminum nudiflorum.

Green walls can be created with façade panels
Use annuals, perennials and small shrubs which grow in special growing panels. “Living wall” techniques include a geotextile cloth with holes and sacks where plants are rooted, vertical hanging plastic plates, façade modules with soil or mineral wool substrate, vertical sedum mats (no irrigation needed) and free-standing wall systems. The advantage of façade panels is that the results can be seen after only a few months. However irrigation is always necessary, the panels are relatively expensive and they need weekly maintenance. Plants for façade panels include hanging plants, annuals, perennials and groundcover plants. Choose perennials and shrubs for leaf form and colour more than their temporary flower colour. All annuals are good if they are not too big and some even absorb NO, such as Nicotiana, Petunia and Cosmos.

Benefits of green walls
• Improves the indoor climate and reduces energy needs indoors
• Absorbs noise
• Offers unique possibilities for design and advertising
• Insulates the façade against cold and warm
• Protects the wall from water and sun
• Helps lower summer temperatures in the city
• Helps improve air quality in the city
• Brings nature to the city
• Creates more views of green in the city
• Is an efficient use of space for green in the city

Conditions for determining wall type:

- Façade
  - orientation to the sun, weight-bearing capacity, sensitivity to damp, wind turbulence
- Planting
  - preferred density, perennial or seasonal, evergreen or deciduous, adapted to dry/wet panels
- Irrigation
  - tap water or rainwater, fertilizer, recirculation, distribution after watering, timed irrigation or damp sensor, empty hoses after watering or not
- Façade panels
  - accessibility to wall, ornamental value throughout the year, necessary maintenance, procedure of replacing panels/plants

...Greenpark Rotterdam, Westblaak is a parking garage in Rotterdam with a 5.000m2 green façade which is due to be completed in 2011. The green façade was designed by Kuhne © Co Architecturop for West Star. This is a project associated with the Rotterdam Climate Initiative. www.vroegveengebieden.vara.nl

In new development:
Façade panels can be integrated into the building design if planned at the beginning of the building design process and engineered to hold the weight (80-100 kg/m²).

In existing development:
Use vines planted in the ground or light planter systems where the plants can grow on climbing racks against the façade or use hanging plants in planters as a curtain in front of the façade. A planter built in front of the wall (but attached) is also possible.
**30 Green indoors**

**Use plants to improve indoor climate**  
Ventilation is improved when trees are placed in open areas, hallways and in individual rooms. Transpiration of the leaves creates humidity in the air which is more comfortable and regulates the temperature indoors. If plants occupy 5% of a room volume, the relative humidity in winter goes up by 20% and the room temperature rises by 1-1.5°C and the room temperature decreases by 1.5°C in the summer.

**Use plants to improve air quality**  
Air pollution (such as benzil, nicotine and other volatile organic compounds and gases) are absorbed by indoor plants. These pollutants, along with dust, can be reduced by 30%. The leaves transport the pollutants down into the root zone where microorganisms convert them into nutrients in the soil. Allow air to flow along as much green as possible indoors as it moves from room to room. Atriums, wintergardens, halls and plants in individual office spaces are all effective.

**Indoor green improves health**  
- **(both physical and psychological)**  
Studies show that sick days from work are reduced by 3.5 days per employee in offices with plants. The presence of green can improve the healing of patients in hospitals. The effects are especially psychological. There is a therapeutic impact just by looking at plants. Green fosters neutral and relaxed feeling without negative feelings. Oriental style flower arrangements stimulate the right brain functions while western style flower arrangements stimulate the left brain functions. Plants and flowers also affect the 5 senses to varying degrees which stimulates different parts of the brain.

**Maintenance is essential for quality plants**  
Good healthy soil, potting techniques, water and pruning are necessary to guarantee the continued vitality of indoor plants.

**Benefits of green indoors**
- Improves indoor air quality  
- Reduces indoor dust particles and microorganisms  
- Adjusts seasonal temperature and humidity  
- Reduces fatigue and stress  
- Employes who work in offices with green take up less sick days  
- Enhances work efficiency  
- Reaction time and productivity of employees increases by 13%  
- Concentration of employees increases  
- Has a high impact compared to the costs  
- Is easy to install and remove  
- Has a horticultural therapeutic impact on mind and body

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**List of best indoor plants**

- *Monstera deliciosa* L.  
- *Alse barbadensis*  
- *Ficus elastis*  
- *Ficus benjamina* L.  
- *Syngonium podophyllum*  
- *Chrysalidocarpus lutescens*  
- *Chamaedorea elegans*  
- *Dracaena draco*  
- *Graptoveria dentata*  
- *Dracaena deremensis* cv. Warneckii Compacta

**The effects of plants on the well-being of office workers**

<table>
<thead>
<tr>
<th>Health complaints without green</th>
<th>with present</th>
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<tr>
<td>Exhastion</td>
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<tr>
<td>Headaches</td>
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<tr>
<td>Dry skin</td>
<td>20% less</td>
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<tr>
<td>Peeling scalp / ears</td>
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</tr>
<tr>
<td>Facial irritation</td>
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</tbody>
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(Source: Green laureat and Bea & Bev, 2008 Agricultural University)

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**Image:** Sunlight, Magnolias, Ml | The greenhouse construction  

 creates a link between inside and outside and provides the needed light for the plans. Designed by Luc van Dam (GUM), Coppersyn & BENI Architekten | Photo: Coppersyn & Landschapsarchitecten

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**Image:** 40 Cheek Inn (Designed by Conference Square, 2013), Axel Müllgen (GUM Architects), Anita van Hedelgics (Coppersyn & Landscaparchitecten), Tripti 6 | Photo: Ana M. Sastrawan

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**Image:** 8786

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**Image:** Create a more comfortable climate indoors with the use of indoor plants, which has a positive effect on the psychological and physical well-being of the users of the building.

**In new development:**  
Design buildings with permanent places for green and plenty of natural light to guarantee that green is valued and maintained by the users.

**In existing development:**  
Add indoor plants inside buildings in open areas, hallways and individual rooms to maximize the benefits for all users.
Green+ buildings

Vancouver Convention Centre case study

Connectivity & Sense of Place

matter of the roof forms the terminus of a chain of waterfront parks that rings the harbor and created continuous green space between the Convention Centre and Stanley Park.”

The interior spaces, full of windows and views of the waterfront and downtown, keep the visitors in constant contact with the surrounding context and daylight, “setting up an extroverted, community-friendly relationship with the exterior.”

The Vancouver Convention Centre West received a 2010 “What Makes It Green?” Gold Award from the Seattle Chapter of the American Institute of Architects.

Connectivity & Nature

The Vancouver Convention Centre West is a building with real environmental quality, most visible in the project’s ecology-based approach to land use and its living roof. The site was a contaminated brownfield with traces of its historical past as an industrial site and train yard. The building’s design features a 24,281 m² living roof and a foundation system around the building’s waterfront perimeter designed as an artificial reef. A team of marine biologists consulted the architects and designers so it would function as a restoration of the natural shoreline.

The living roof is not only an attractive addition to Vancouver’s skyline, but also functions as a large permeable surface in the city to control rainwater, slow storm water runoff and reduce the heat island effect in downtown. The roof contains over 400,000 plants, all native or adaptive to Vancouver’s climate. When the plants are established, they will only require limited irrigation in late summer.

“The living roof itself has no public access points, allowing it to develop as a fully functional habitat for non-human species, while the landforms fold in specific ways to open views onto its lush vegetation from inside and outside the building.”

“The design of the new Vancouver Convention Centre West presented an opportunity to fully engage the urban ecosystem at the interface between a vibrant downtown core and one of the most spectacular natural ecosystems in North America.”

City Zoning required strict regulations regarding view corridors from the downtown streets to the water. The form of the building and its sloping green roof responded to these issues and was inspired by the topography of the region, connecting it to Stanley Park and the mountains on the other side of Burrard Inlet.

Sources: Eschbacher LMN Architects. What Makes It Green? Vancouver Convention Centre West
Many of the principles contained within these guidelines are similar to those of Ebenezer Howard’s 1902 Garden Cities of Tomorrow, where parks, houses and gardens, boulevards and grand avenues were at the heart of the city. This utopian vision, part of the Garden City Movement, was a reaction against the conditions in cities during the Industrial Revolution. People in the 19th century came to the cities to work and subsequently lived under unhealthy, crowded and polluted conditions. There were only a few of these “utopian” plans built before the Great Depression. After that, the mass use of the car became a significant driver for urban planners and those “garden city” principles were put to one side.

The Green City approach described in this book focuses on improving the conditions of the urban (inner) city environment in order to create healthy liveable cities where people want to live and work. By providing green spaces where people can relax and exercise, green streets which help refresh the air and green buildings that remind us of nature beyond the city limits, The Green City has a chance to bring people back in touch with nature in their everyday lives. Liveable urban neighbourhoods within the city limits will make living in the city in which people work a desirable option. And those with no choice have a right to live in a healthy urban environment. By drawing people back into the city, the reduction in car usage can help reduce background air pollution, carbon emissions, congestion and the social problems associated with high levels of road traffic that cities are struggling with today.

Green spaces and trees in the city have proven positive influences on the image of cities in terms of livability, attractiveness and sustainability. The cities that strive for sustainable solutions are the cities that will be able to provide healthy growth and development in the future. As mentioned in our summary chapter, it is expected that in the year 2024, 70% of the world’s population will live in urban areas. The professionals, politicians, community leaders and others who help to shape our cities have a responsibility to ensure that the developers and designers work hand in hand with the green sector in order to provide enough space for green, whether it be in the form of a parks, a gardens, a trees or green roofs rooftop. The key is to remember that investment in green outweighs the costs. No one green solution will solve the complex problems which cities face, and many of the benefits are difficult to translate into monetary terms. However the integral benefits of green are far-reaching and cannot be ignored.

The guidelines in this book are suggestions as to how a city can become “greener” with plants, trees and parks. They are grounded in the knowledge and ideas that have been brought to the mainstream by many researchers and designers today. This book represents the beginning of an evolving, dynamic process of updating, enhancing and expanding the Green City guidelines in order to reach a truly international handbook that can be applied in cities around the world.

www.thegreencity.com
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