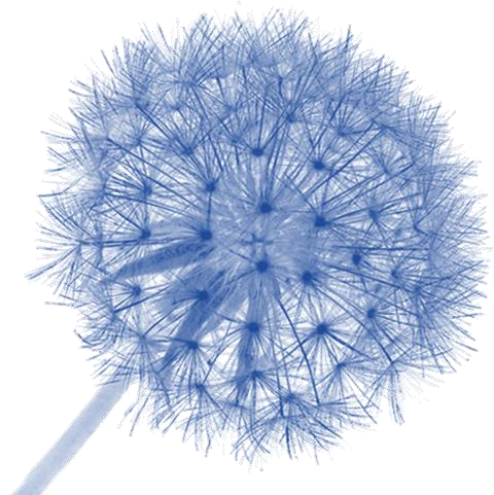


Planting & Maintaining (a) Bosco Verticale

Laura Gatti

SOFT LANDSCAPE WORKSHOP 2018

Ashford (Kent), 24 January 2018



BOSCO VERTICALE, MILANO



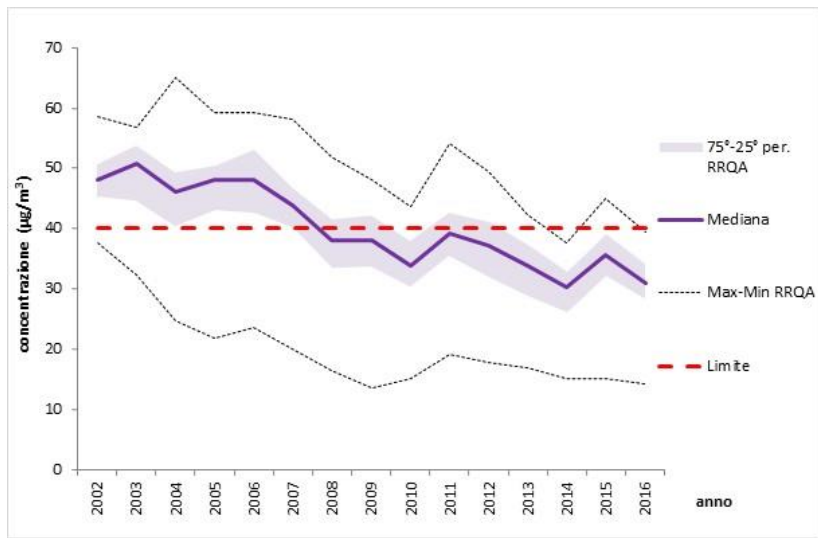
f. Riccardo Groci Torti



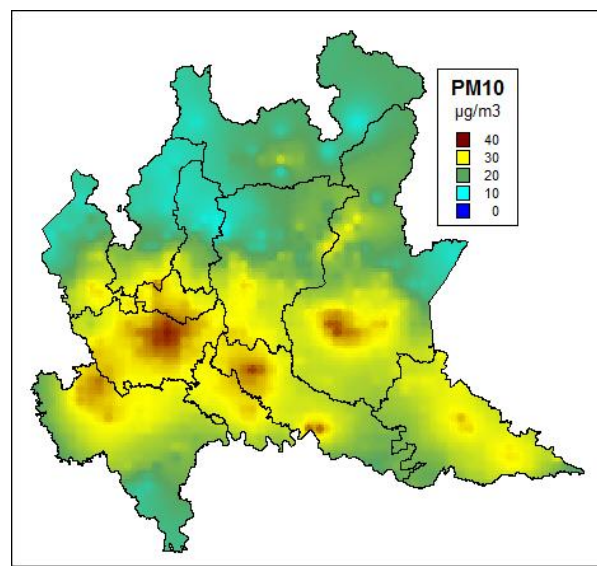
Milano Porta Nuova: one of the most important project of Italy's Urban regeneration

- Total land area over 290.000 m²
- The biggest pedestrian area in Milano with more than 160.000 m²
- Public park 90.000 m²
- Cultural and civic hub more than 10.000 m²
- A mix of features for 400 families and 3.000 workers
- An intermodal hub consisting of 4 subway's lines and 2 railway's stations (high velocity trains)
- An Istitutional hub with new location for Regione Lombardia and Milan's Municipality

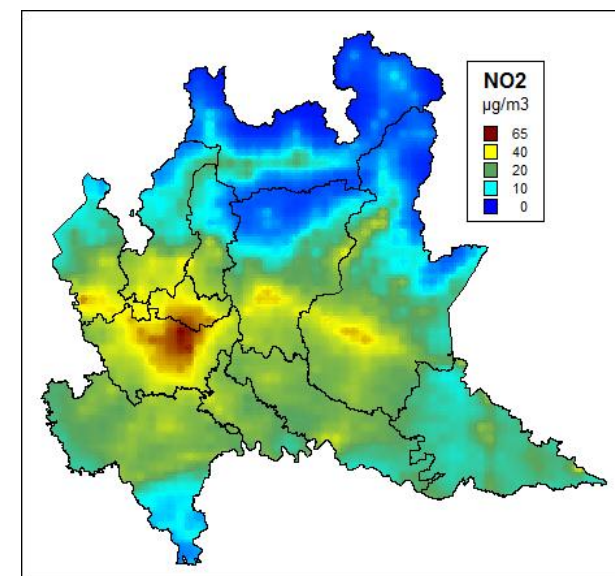




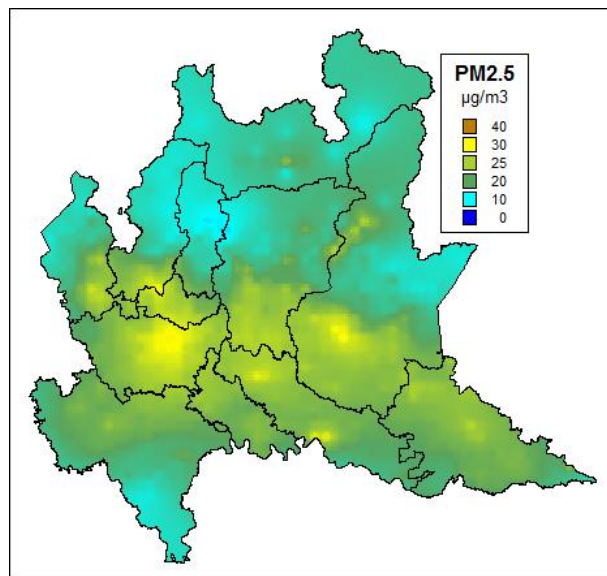
Trend 2002-2016 PM_{10}



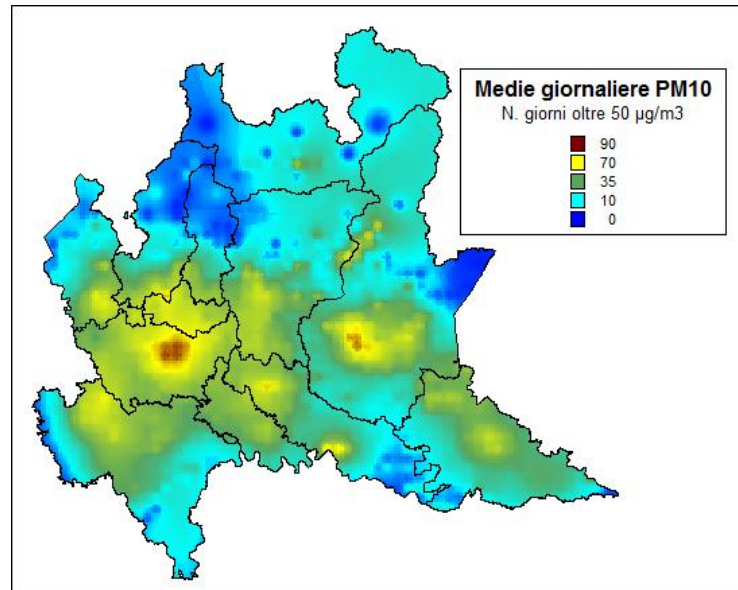
PM_{10}



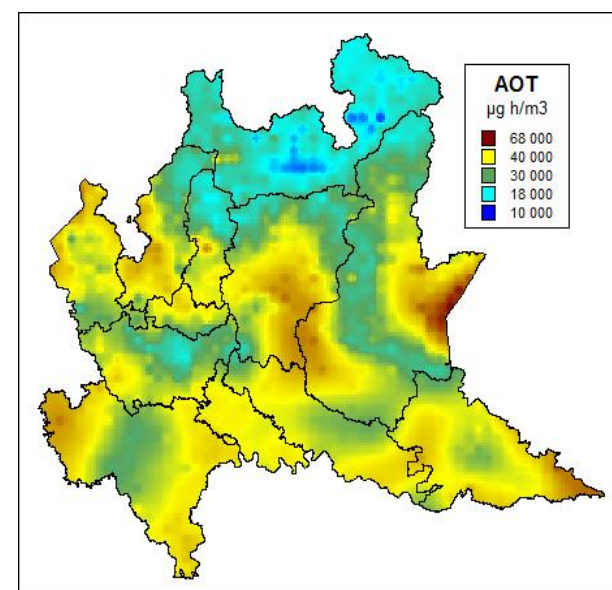
NO_2



$PM_{2.5}$



Days overcoming the limit (max 35)



AOT40

From: Regione Lombardia' Environmental Protection Agency - 2016

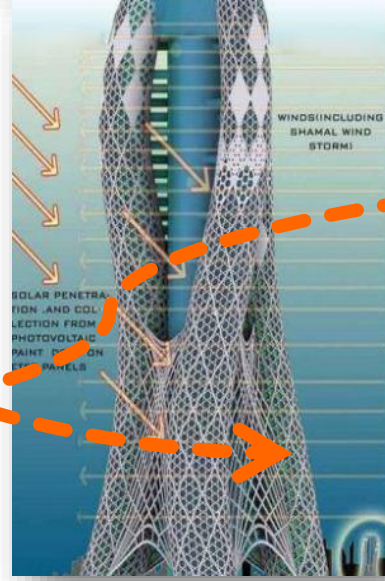
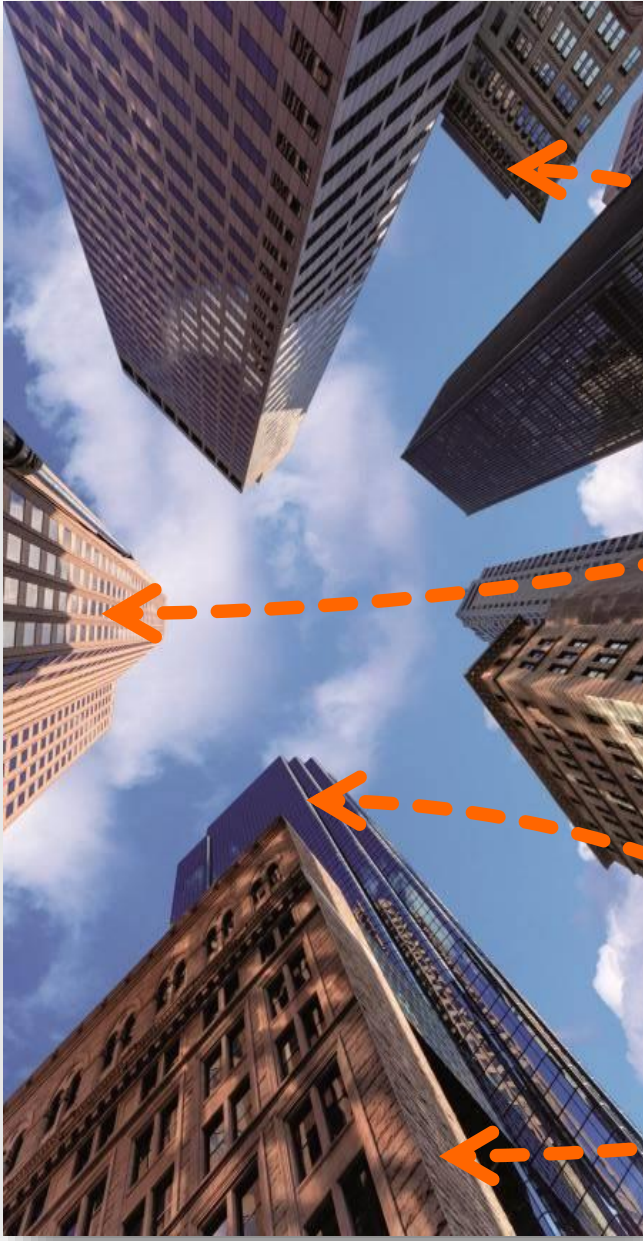


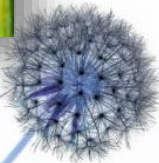


Starting from 1955, the sealed soil in Lombardy has grown from 4 to 14.5%



Tall buildings and sustainability







Ken Yeang



Mumbai Tower



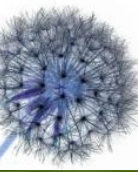
W. McDonough Tree Tower



Mardi Vertical Farming



Beirut – Food Tower

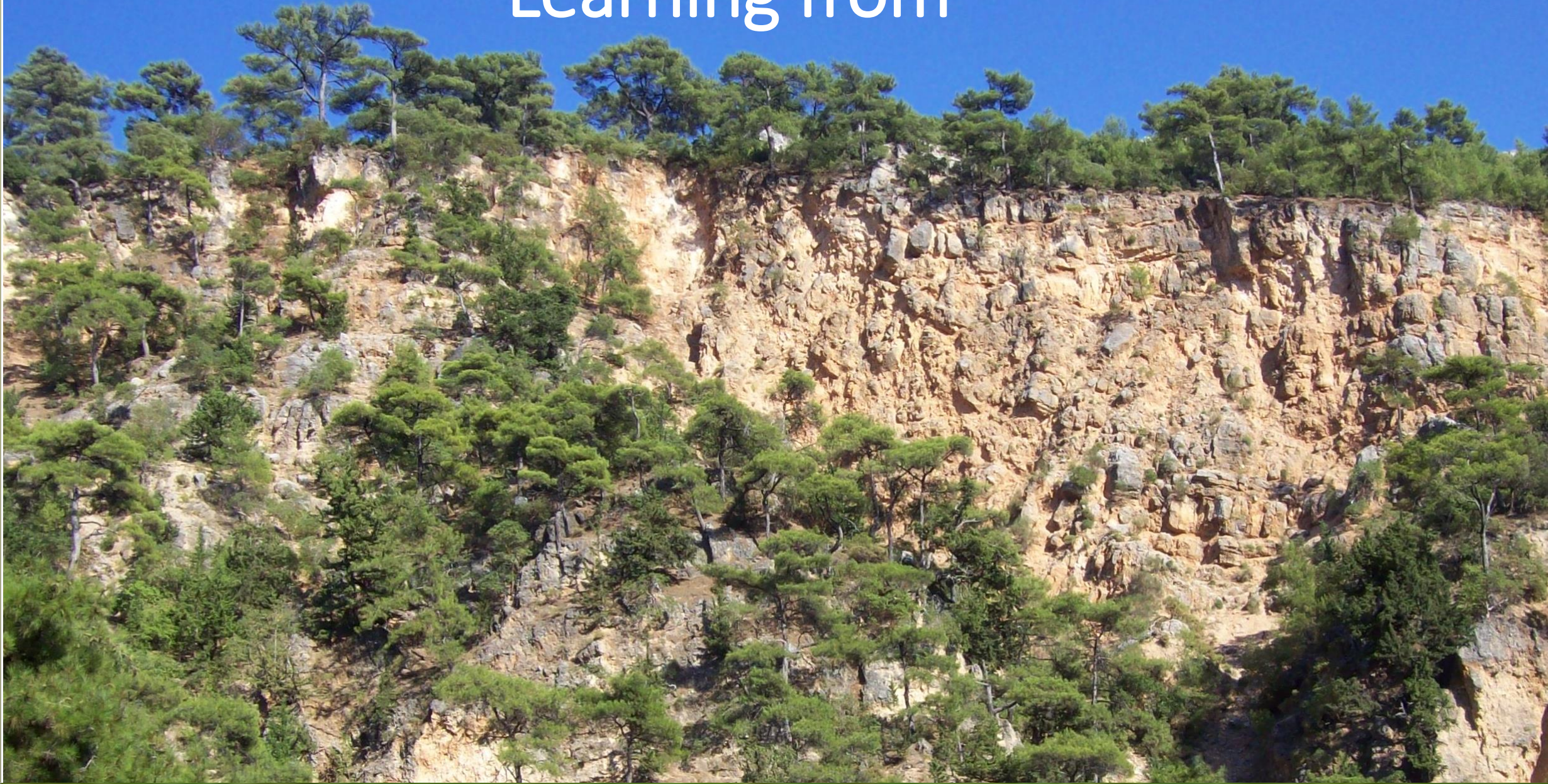




f. Dario Fusaro

Learning from

Antalya region (Turkey)



Working for



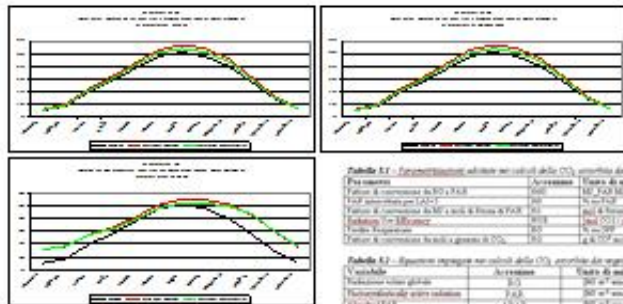


Tabella E1 - Caratteristiche statistiche nei valori delle CO₂ emesse dai vegetali

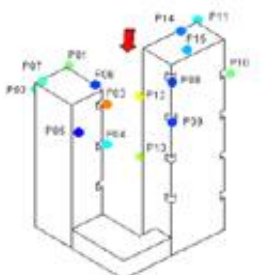
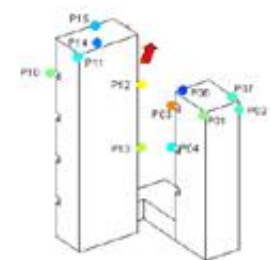
| Parametro | Valore | Unità | Valore | Unità |
|--|--------|----------------|--------|----------------|
| Volume di vegetazione | 1000 | m ³ | 1000 | m ³ |
| Volume di vegetazione in CO ₂ | 1000 | m ³ | 1000 | m ³ |
| Volume di vegetazione in CO ₂ | 1000 | m ³ | 1000 | m ³ |
| Volume di vegetazione in CO ₂ | 1000 | m ³ | 1000 | m ³ |
| Volume di vegetazione in CO ₂ | 1000 | m ³ | 1000 | m ³ |

Tabella E2 - Ripartizione spaziale nei valori delle CO₂ emesse dai vegetali

| Vegetale | Area | Volume di vegetazione | Volume di vegetazione in CO ₂ |
|----------|------|-----------------------|--|
| Platanus | 100 | 1000 | 1000 |
| Alnus | 100 | 1000 | 1000 |
| Quercus | 100 | 1000 | 1000 |
| Castanea | 100 | 1000 | 1000 |
| Fraxinus | 100 | 1000 | 1000 |
| Salix | 100 | 1000 | 1000 |
| Ulmus | 100 | 1000 | 1000 |
| Populus | 100 | 1000 | 1000 |
| Abies | 100 | 1000 | 1000 |
| Picea | 100 | 1000 | 1000 |
| Larix | 100 | 1000 | 1000 |

Tabella E3 - Fattore di CO₂ emessa dai vegetali nel tempo

| Vegetale | Area | Volume di vegetazione | Volume di vegetazione in CO ₂ |
|----------|------|-----------------------|--|
| Platanus | 100 | 1000 | 1000 |
| Alnus | 100 | 1000 | 1000 |
| Quercus | 100 | 1000 | 1000 |
| Castanea | 100 | 1000 | 1000 |
| Fraxinus | 100 | 1000 | 1000 |
| Salix | 100 | 1000 | 1000 |
| Ulmus | 100 | 1000 | 1000 |
| Populus | 100 | 1000 | 1000 |
| Abies | 100 | 1000 | 1000 |
| Picea | 100 | 1000 | 1000 |
| Larix | 100 | 1000 | 1000 |



sezioni delle vasche e ancoraggi

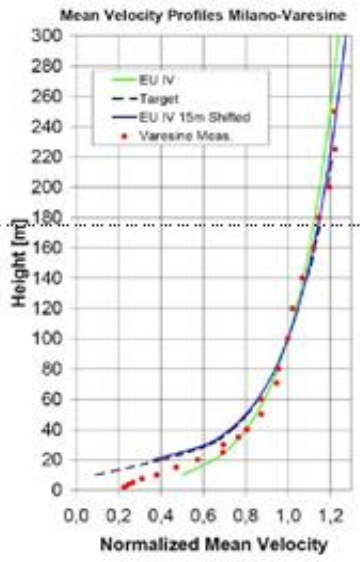
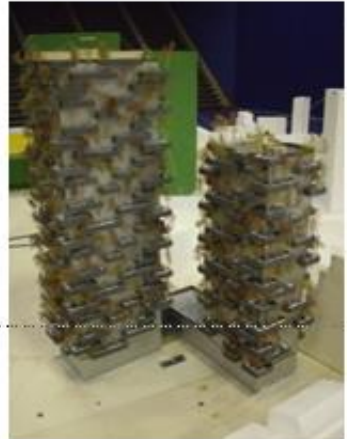
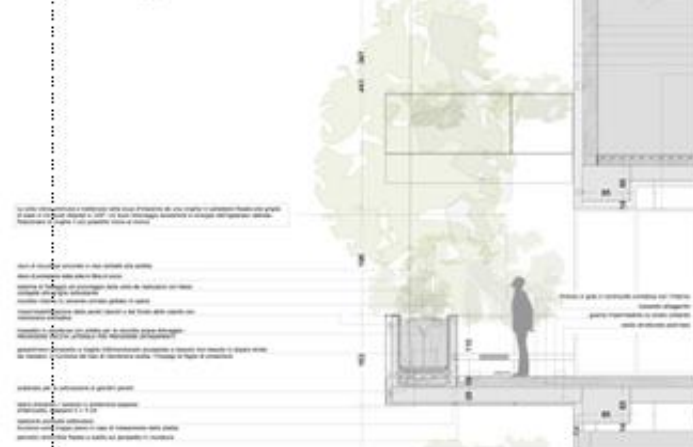


Figure 3.6- Mean wind velocity vertical profile.

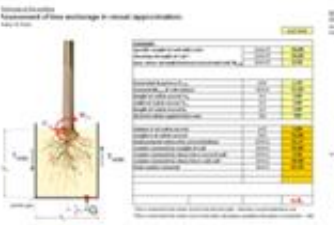


Tabella E4 - Parametri di riferimento per la scelta delle specie vegetali

| Specie | Altezza (m) | Volume (m ³) | CO ₂ (kg) |
|----------|-------------|--------------------------|----------------------|
| Platanus | 15 | 100 | 1000 |
| Alnus | 15 | 100 | 1000 |
| Quercus | 15 | 100 | 1000 |
| Castanea | 15 | 100 | 1000 |
| Fraxinus | 15 | 100 | 1000 |
| Salix | 15 | 100 | 1000 |
| Ulmus | 15 | 100 | 1000 |
| Populus | 15 | 100 | 1000 |
| Abies | 15 | 100 | 1000 |
| Picea | 15 | 100 | 1000 |
| Larix | 15 | 100 | 1000 |

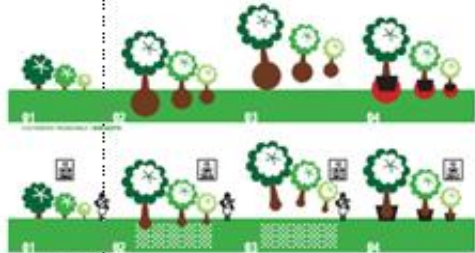
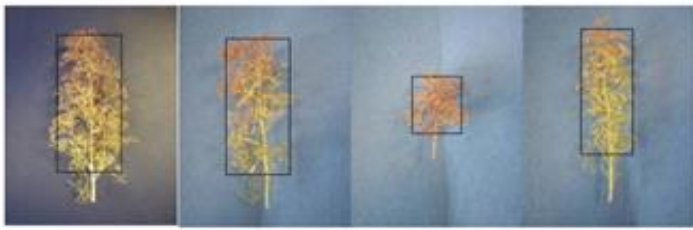
Tabella E5 - Parametri di riferimento per la scelta delle specie vegetali

| Specie | Altezza (m) | Volume (m ³) | CO ₂ (kg) |
|----------|-------------|--------------------------|----------------------|
| Platanus | 15 | 100 | 1000 |
| Alnus | 15 | 100 | 1000 |
| Quercus | 15 | 100 | 1000 |
| Castanea | 15 | 100 | 1000 |
| Fraxinus | 15 | 100 | 1000 |
| Salix | 15 | 100 | 1000 |
| Ulmus | 15 | 100 | 1000 |
| Populus | 15 | 100 | 1000 |
| Abies | 15 | 100 | 1000 |
| Picea | 15 | 100 | 1000 |
| Larix | 15 | 100 | 1000 |



| Altezza [m] | Volume [m ³] | CO ₂ [kg] | CO ₂ [kg] | CO ₂ [kg] | CO ₂ [kg] | CO ₂ [kg] | CO ₂ [kg] | CO ₂ [kg] | CO ₂ [kg] |
|-------------|--------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| 100 | 100 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| 200 | 200 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| 300 | 300 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 |
| 400 | 400 | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 |
| 500 | 500 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 |
| 600 | 600 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 |
| 700 | 700 | 7000 | 7000 | 7000 | 7000 | 7000 | 7000 | 7000 | 7000 |
| 800 | 800 | 8000 | 8000 | 8000 | 8000 | 8000 | 8000 | 8000 | 8000 |
| 900 | 900 | 9000 | 9000 | 9000 | 9000 | 9000 | 9000 | 9000 | 9000 |
| 1000 | 1000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 |

Consultants Structures: Arup
 Italia s.r.l.
 Facilities design: Deerns Italia
 S.p.A.
 Detailed design: Tekne s.p.a.



Pre-cultivation contract

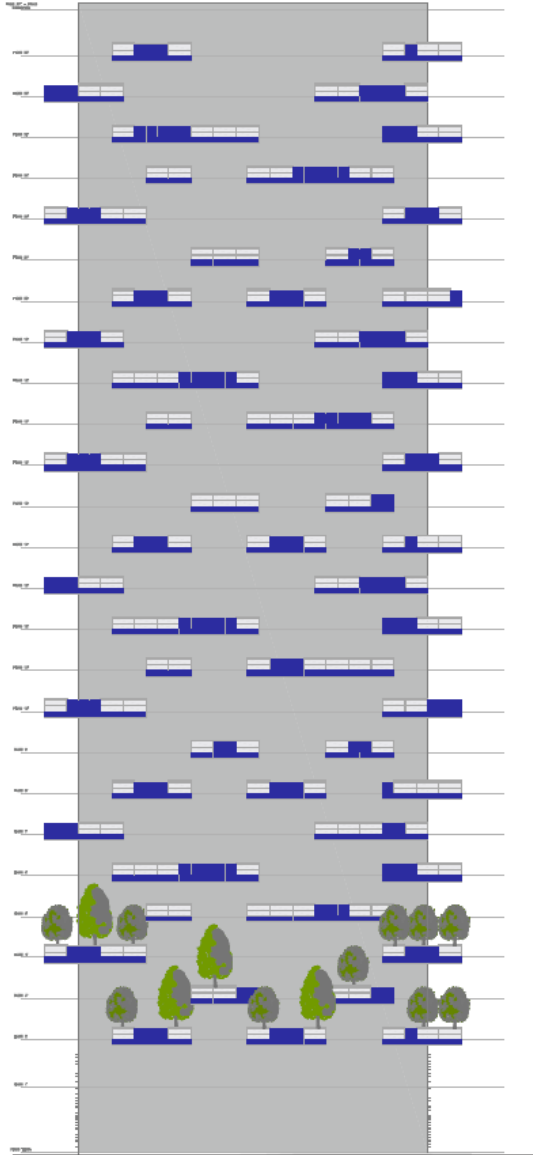
TREE'S SELECTION IN NURSERY



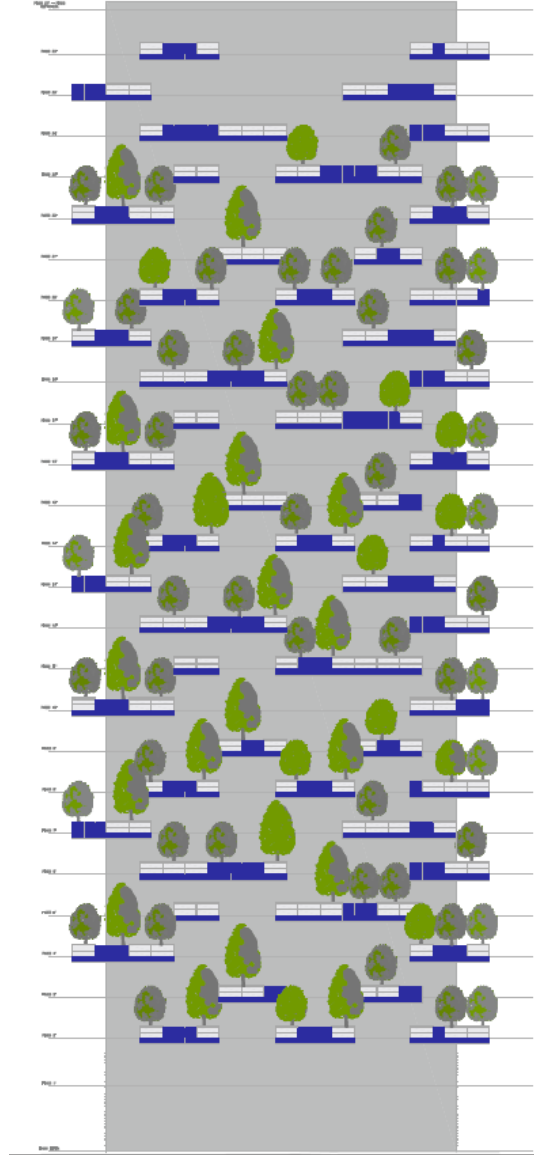
TREE'S SELECTION IN NURSERY



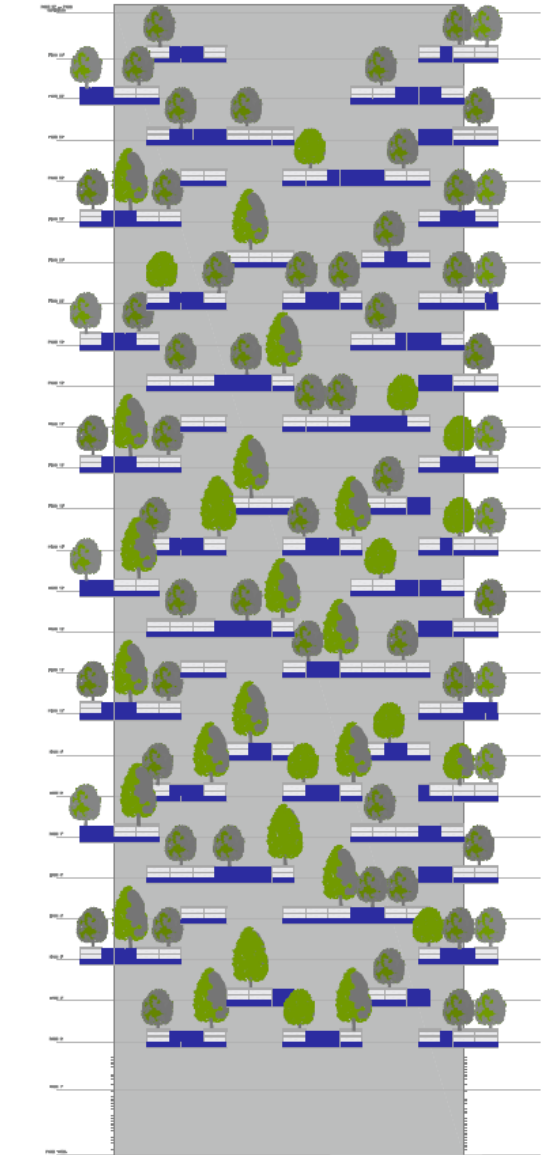
2012



2013



2014



2012



2013



2014



2013



2017



2013



2017



CARE AND MONITORING



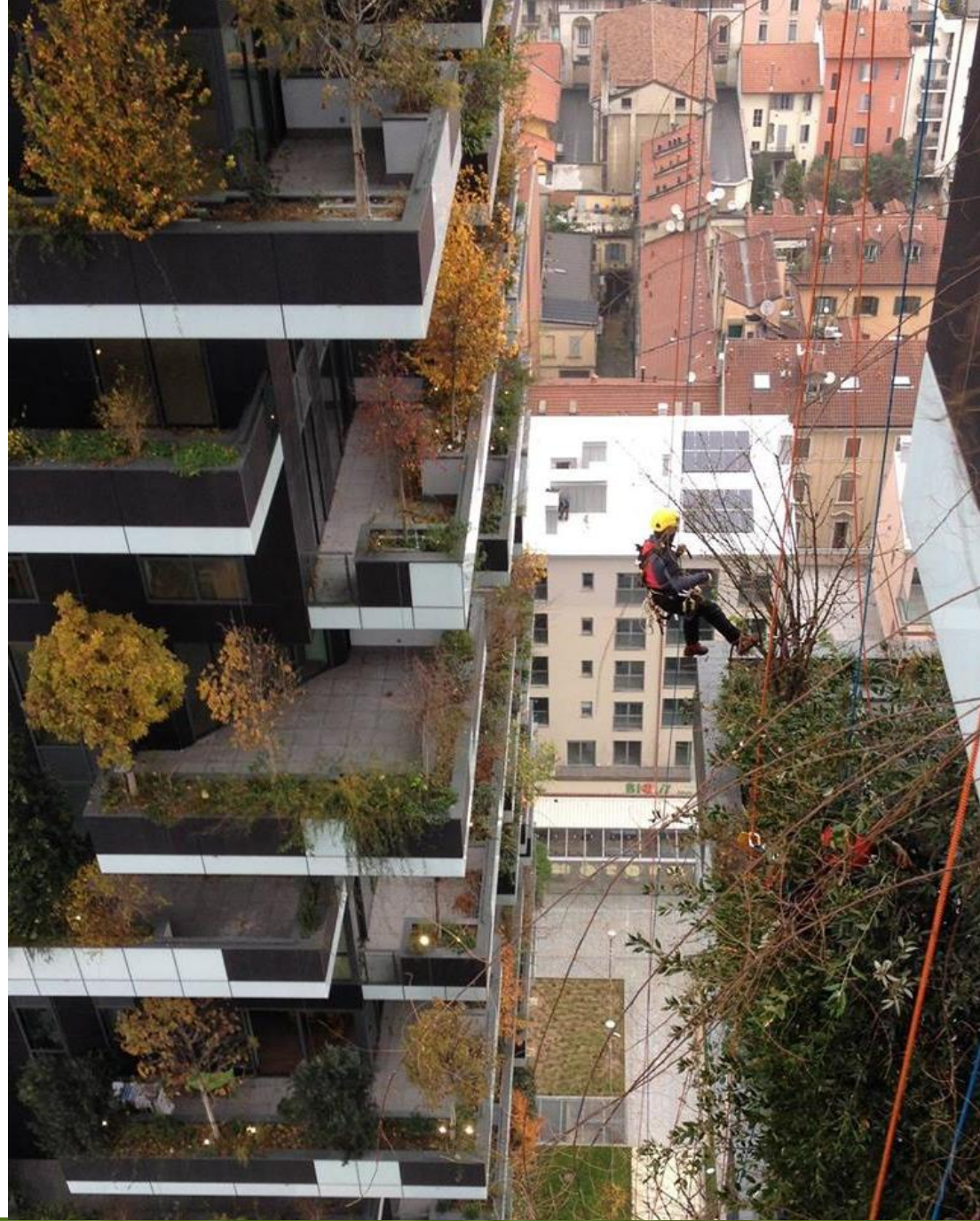
- Monitoring
- Biological pest control
- Pruning



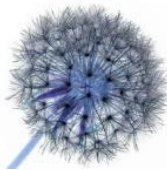
TREE CARE OPERATIONS

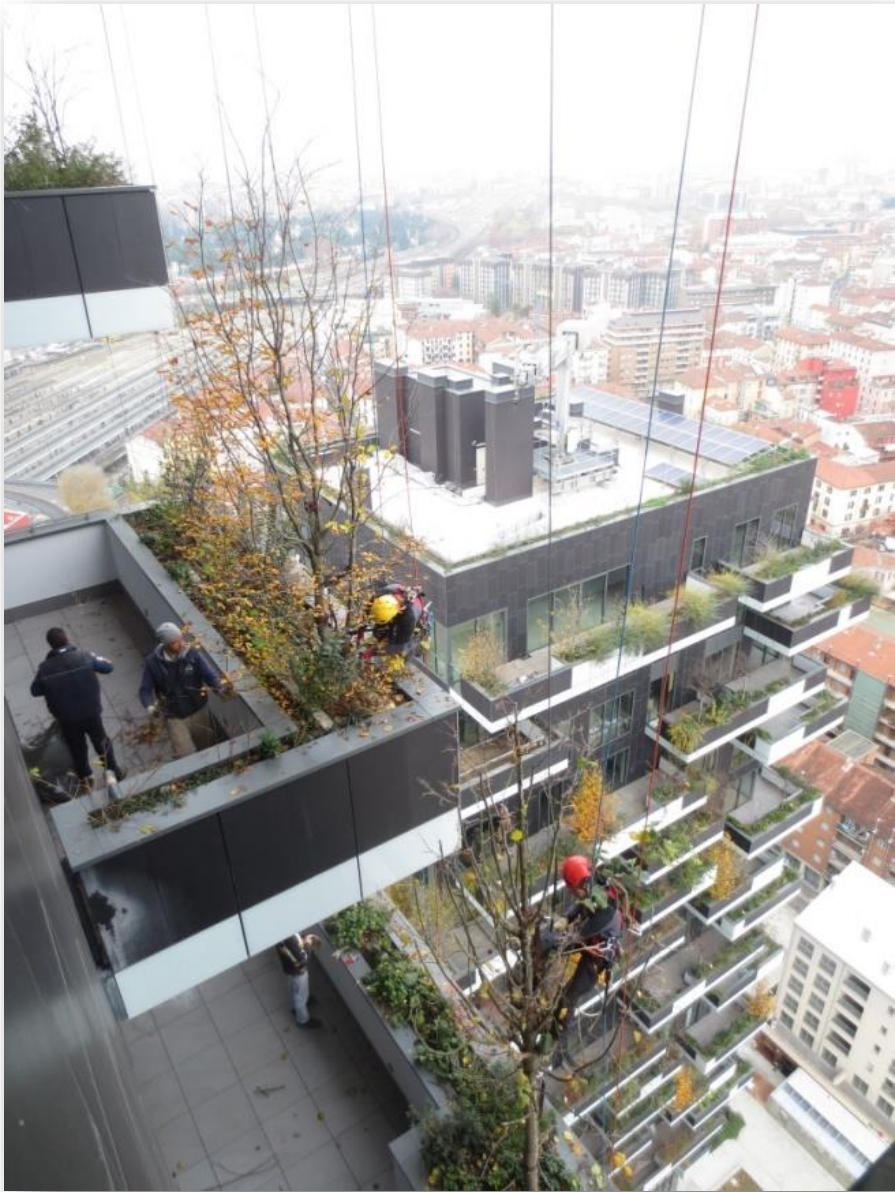


TREE CARE OPERATIONS



TREE CARE OPERATIONS





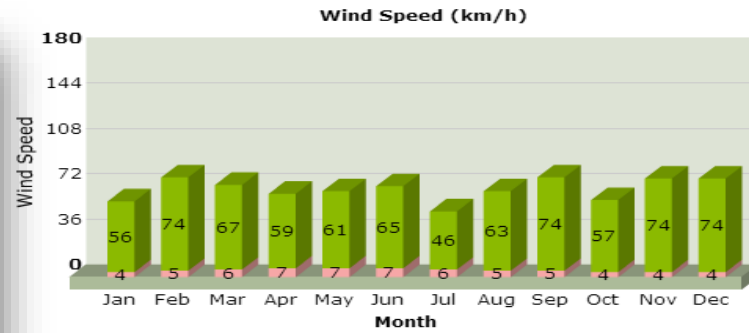
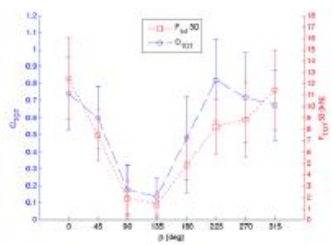
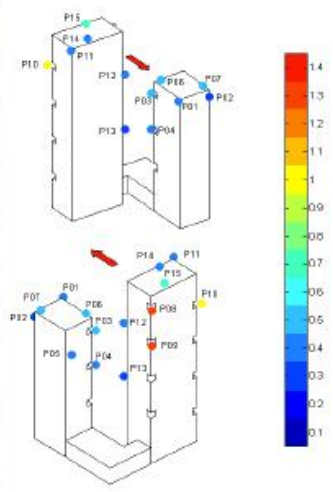
- Tree pruning – first intervention (2014) 900 hrs
- second intervention (2015) 480 hrs (twelve days)
- 2016/2017 : 448 h

- *Shrubs and perennial pruning, cleaning and weed removal*
- 2014/2015 (5-6 entrances)
- 2016/2017 (4 interventions)

- *Monitoring, plant health control*
- 144 hrs (2014, 2015) – 110 hrs (2016, 2017)
- *Water system control*
- Total 40 hrs/y
- **1,2 h/m² (2014, 2015) - 0,75 h/m² (2016, 2017)**

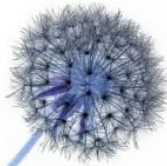
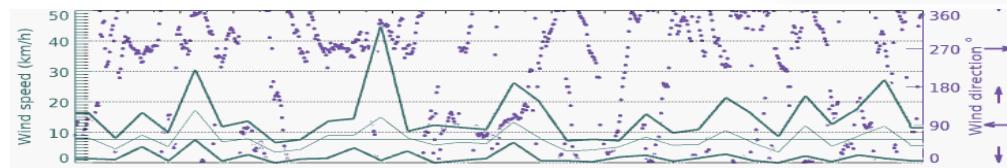
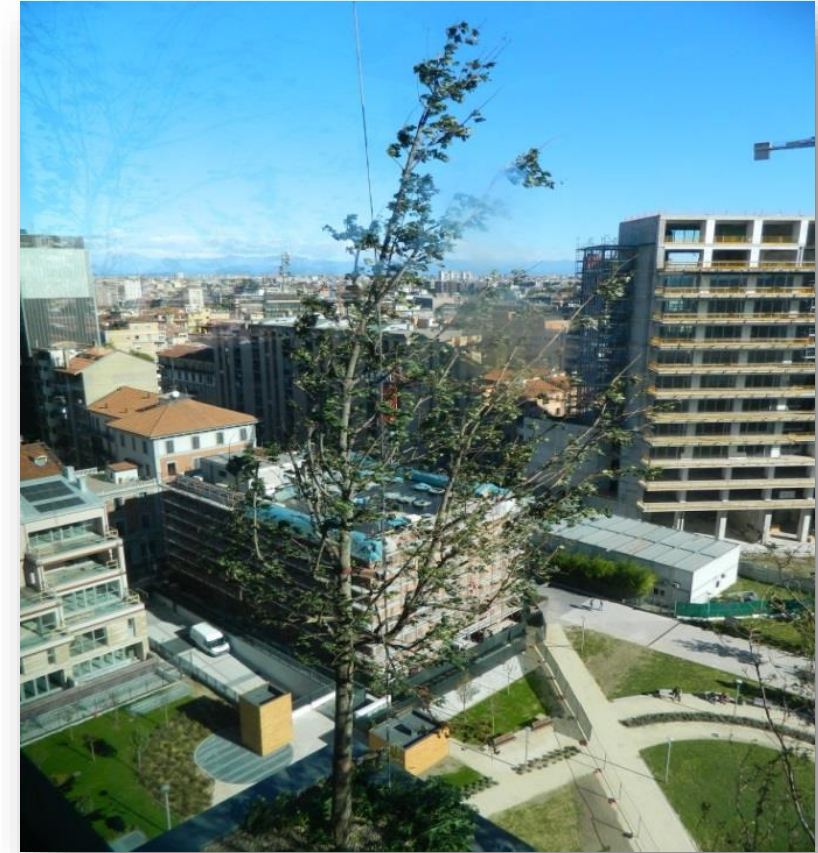
Debris 1,8 ton (2014, 2015) 1,4 ton (2016, 2017)



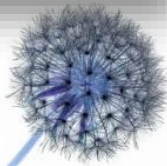


● Average Expected Wind Speed ● Maximum Recorded Wind Speed

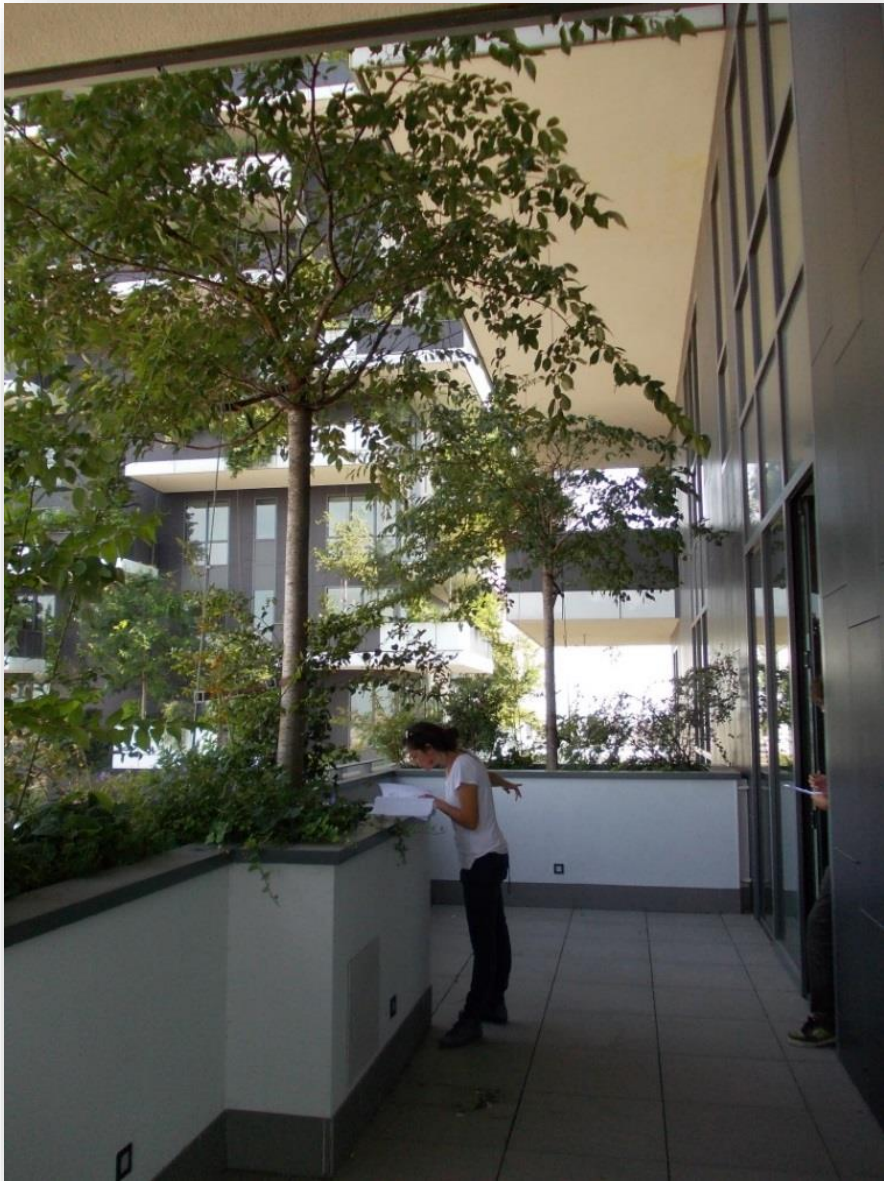
- 25 May 2013 + SSE
- 10 October 2013 ++ NNW
- 15 April 2014 + SE
- 11 May 2014 + SW
- 14 May 2014 ++ NNW
- 15-16 June 2014 + NW
- 22-23 October 2014 ++ NNW
- 11 January 2015 + WSW
- 27 March 2015 + SW
- 23 September 2015 + WNW
- 19 May 2016 + NNE
- 13 July 2016 +++ N
- 05 August 2016 + NW



LIVING IN A VERTICAL FOREST



BOSCO VERTICALE'S CO₂ FIXATION

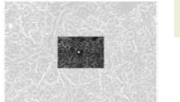


| | | | |
|-----|--------------------|------|-----------|
| ACC | Kg CO ₂ | 47,5 | 2011/2016 |
| PSA | Kg CO ₂ | 62 | 2011/2016 |
| CC | Kg CO ₂ | 96 | 2011/2016 |
| GS | Kg CO ₂ | 57 | 2011/2016 |

STOCCAGGIO CO₂

|  | CO ₂ stoccata (kg) | CO ₂ assimilata (kg/anno) |
|---|-------------------------------|--------------------------------------|
| Nuovo impianto | 8 | 3 |
| Esemplare maturo | 499 | 120 |

ABBATTIMENTO INQUINANTI

|  | (kg/anno) | | | |
|---|----------------|-----------------|-----------------|------------------|
| | O ₃ | NO ₂ | SO ₂ | PM ₁₀ |
| Esemplare maturo | 0.1 | <0.05 | 0.1 | <0.05 |

© Prof. F. Ferrini, Piante MATI®, Commons wikimedia





BOSCO VERTICALE 2.0

**An hotspot for biodiversity
A model for next generation cities**



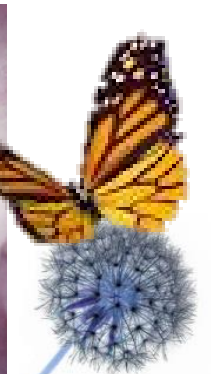
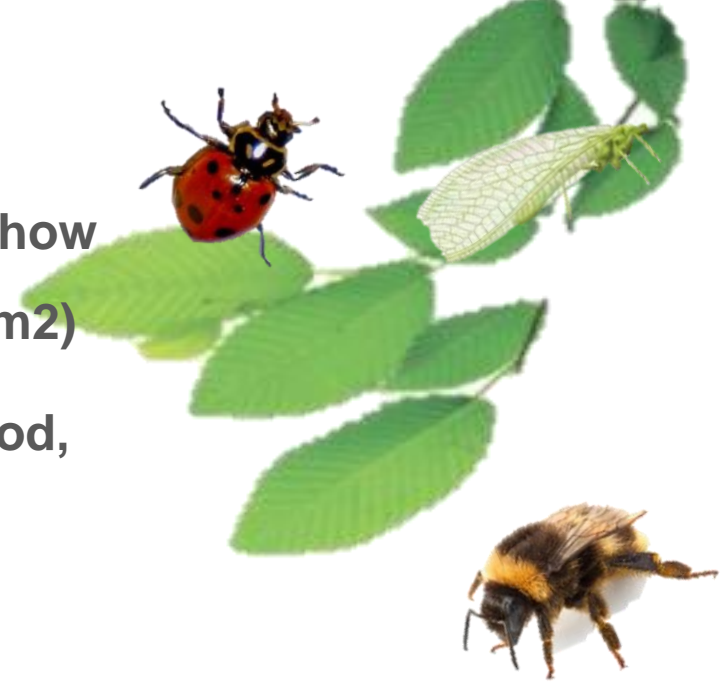
THE BOSCO VERTICALE'S POTENTIAL

- Bosco Verticale stands as a stepping stone in a central zone, connecting wildlife to the city's larger green areas





- **94 different plant species**
- **60 different plant species of trees and shrubs** (more than how commonly found in a neighborhood public park of 5-6,000 m²)
- **33 different evergreen species** that provide shelter and food, also in winter
- **66 useful species** for pollinators
- **59 useful species** for birds (food, building nests)
- **62 species** attractive to butterflies

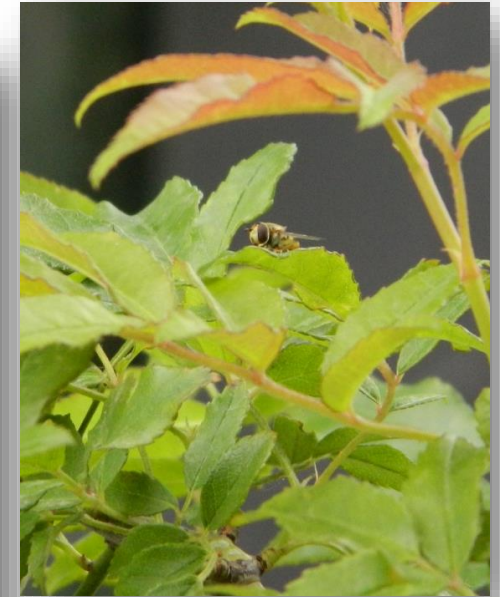
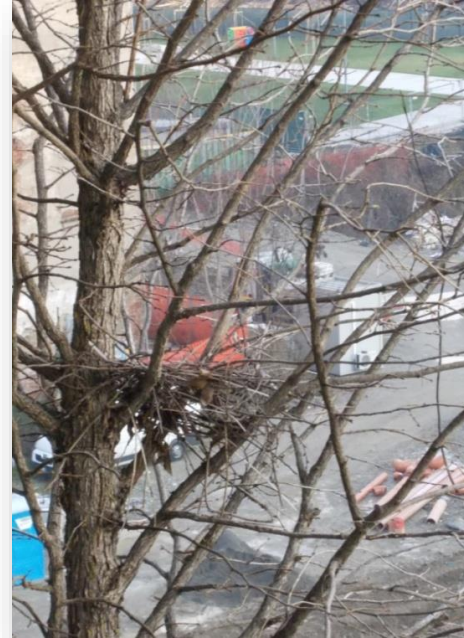


THE BOSCO VERTICALE'S POTENTIAL

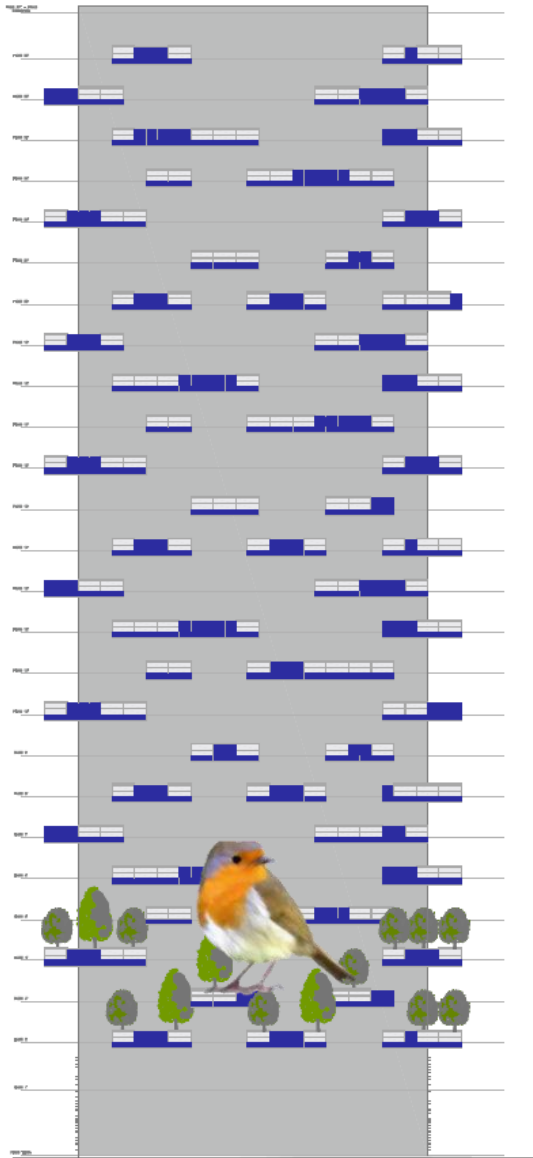
▪The Vertical Forest is a green system that extends vertically for more than 12,000 m²; as it is made, it provides a multiplicity of conditions for the formation of microhabitat whose potential is still unknown.

▪ The Vertical Forest is an extraordinary opportunity for the implementation of biodiversity in urban areas, for the following reasons:

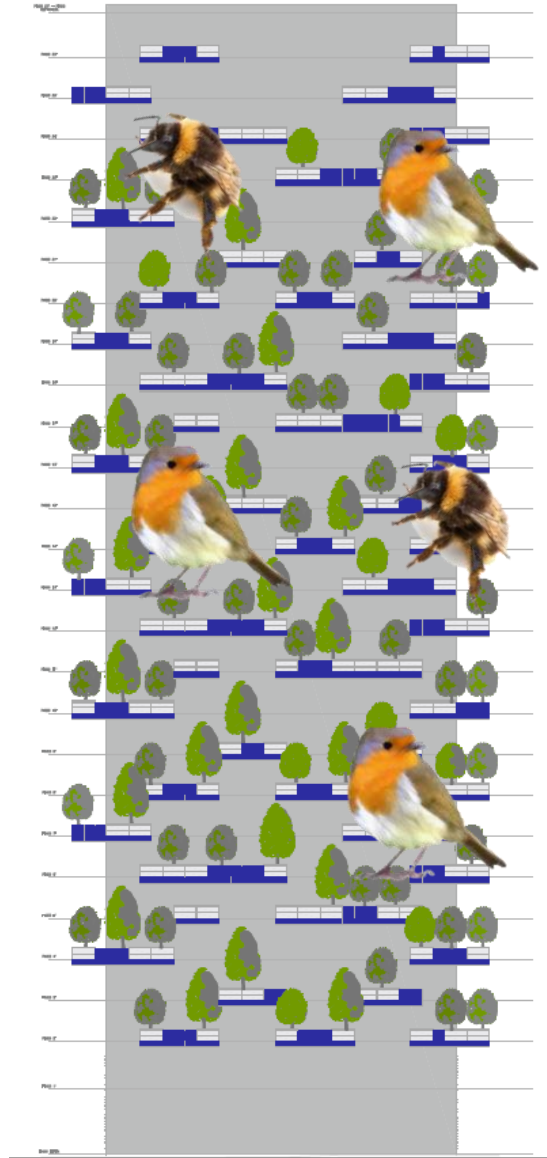
- the depth of the substrate
- the structural diversity
- the different microclimates generated



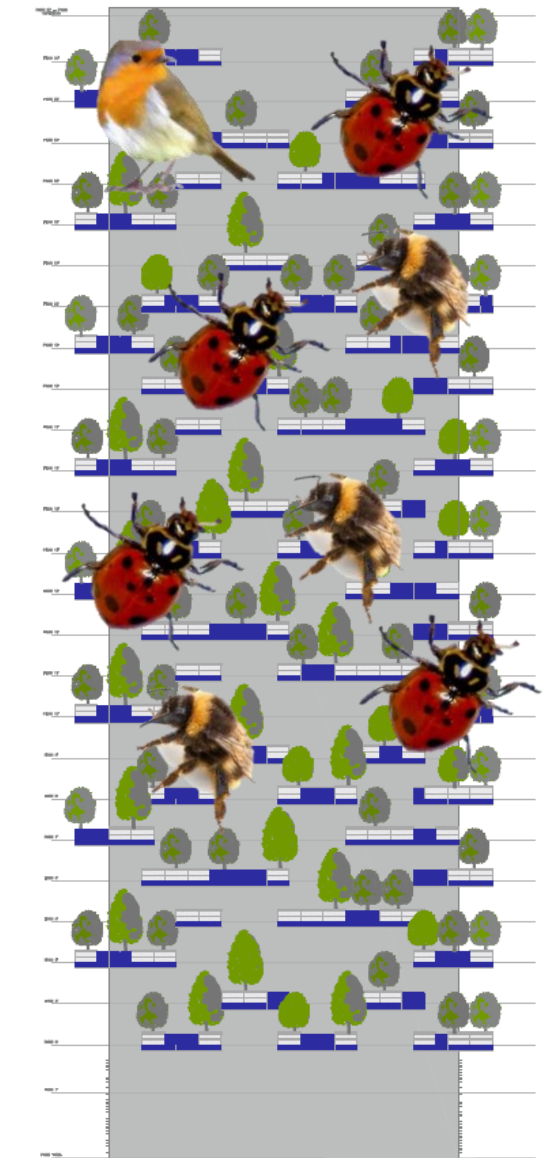
2012



2013



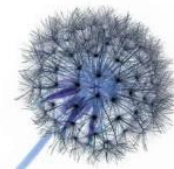
2014



BIODIVERSITY



© Marco Peterle



The Bosco Verticale's potential



A model for next generation's cities

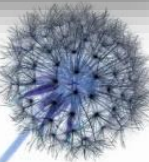


LA FORÊT BLANCHE VILLIERS-SUR-MARNE (F) 2017

INVENTONS LA MÉTROPOLE DU
GRAND PARIS

MARNE EUROPE – VILLIERS-SUR-MARNE Balcon sur Paris

Concepteurs : Architectes : Kengo Kuma & Associates ; XTU Architects ; Stefano Boeri Architetti ;
Michael Green Architecture ; OXO ; Koz Architectes; Paysagistes : James Corner Field
Operations ; Atelier Paul Arene



LA FORÊT BLANCHE VILLIERS-SUR-MARNE (F) 2017



Pyrus salicifolia 'Pendula' *Elaeagnus angustifolia*



Salix purpurea 'Nana' *Caryopteris* × *clandonensis*



Stachys byzantina *Artemisia arborescens* 'Powis Castle'



Kenon Kuma & Associates + TU - Stefano Boeri Architetti
© Stefano Boeri Architetti
Michael Green Architecture + OXO Architects + Koz Architects

Balcon sur Paris - Diorama pour Compagnie de Phalsbourg

TOUR DES CEDRES

Chavannes-Prés-Rennes (CH) 2015-2022



Location **Chavannes-Prés-Renens, Lausanne, Switzerland**
Project period **2015**
Client **Commune de Chavannes-près-Renens, CH**
Services **Concept design - competition, final design**
Consultants **Agronomist and Landscape Architect:**
Studio Laura Gatti – Milano
Dott. Agr. Paysagiste Laura Gatti
Engineering:
BuroHappold Engineering | Building Environments – London
Weinmann-Energies SA – London
Project area
Status **On going**



WONDERWOODS

Utrecht (NL) 2017-2022

Location **Utrecht, Netherlands**
Project period **2017**
Client **G&S Vastgoed**
KondorWessels Projecten
Services **Concept design, competition**
Partners **Stefano Boeri Architetti (plot A), MVSA Architects (plot B)**
Project area **plot A 32.846 sqm**
Status **On going**



TOREN K Eindhoven (NL) 2017-2020





Nanjing (CN)

NANJING VERTICAL FOREST

NANJING (CH) 2016-2019



NANJING VERTICAL FOREST

NANJING (CH) 2016-2019

SBA China - Shanghai

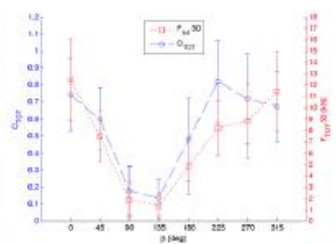
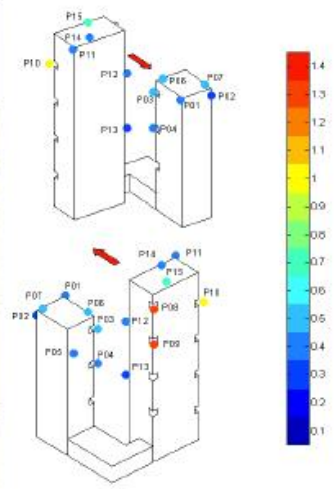
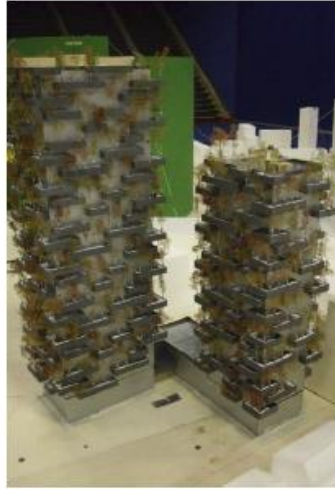
with

*Arup
Studio Laura Gatti*



© Stefano Boeri Architetti

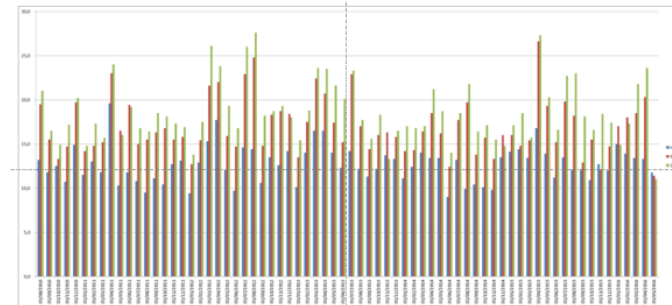




地调查时间为 2001 年。
 藏经阁样地, 位于 32°04' N, 118°43' E, 海拔为 93 m, 群落郁闭度为 0.95, 林冠层主要树种有白栎、枫香、栓皮栎, 平均高度分别为 15, 25, 18, 6, 19, 43 m, 平均胸径 21, 5, 22, 4, 35, 57 cm, 林冠层还伴生有栎类 (*Firmiana simplex*)。林下层主要树种有三角枫、买办、卫矛、木荷、糙叶木 (*Aphananthe aspera*)、茶条木 (*A. ginnala*)、白栎 (*Symplocos paniculata*)、盐肤木 (*Rhus chinensis*) 等物种。草本层主要物种有苔草、天门冬等中生草本植物, 总盖度 85% 以上。
 龙山样地的温带落叶阔叶林位于 118°51' E, 32°03' N, 海拔为 111 m, 是由栎树和化香 (*Platanus strobilacea*) 为主要成分的次生天然林, 群落郁闭度为 0.9, 林冠层主要树种有白栎、化香、构树 (*Broussonetia papyrifera*), 平均高度分别为 15, 11, 5, 13, 2 m, 平均胸径 25, 1, 17, 5, 18, 2 cm。林下层主要树种有白栎、山胡椒 (*Lindera glauca*)、狭叶山胡椒 (*L. an-*

在所观测的枝条上选取 3-5 个中等大小的叶片带回, 每个物种至少 30 个叶片, 用扫描仪扫描, 再用 MapInfo 软件数字化, 计算其面积, 扫描后的叶片在 80°C 下烘干至恒重, 以确定其单位叶面积干重。
1.3 数据处理
 在验证数据正态分布的基础上, 应用 t 检验比较林冠层和林下层物种间的叶面积 (经过对数转换), 单位叶面积干重的差异; 应用非参数检验 (Mann Whitney-U 检验) 比较林冠层和林下层物种间的展叶开始期和展叶持续期等的差异; 应用 Spearman 相关分析确定叶面积、单位叶面积干重和展叶起始时间、展叶持续时间的相关性。考虑到每个调查样地的物种数量有限, 而且经检验 3 个样地间没有显著性差异, 所以根据需要我们还将 3 个样地数据进行了合并, 分别分析了以上有关参数。另外, 由于灵谷寺植物群落所包含物种较少, 其林冠层和林下层物种间参数的差异有时没有进行显著性检验。

WIND SPEED 2010-2016



Janziji station

Usually below 30 m/sec
 MODA 0-100: 1.38
 MODA 100-200: 1.55

Large deciduous tree 植物选择
 落叶大乔木 | Plant selection

银杏
Ginkgo biloba 选择要点: 阳性, 喜生, 喜土壤无盐碱, 喜半阴少
 Ø: 8 H: 500 P: 200 B: 200 土壤大小: 60
 春 夏 秋 冬

栎树
Koelreuteria paniculata 选择要点: 阳性, 喜半, 喜阴, 喜半阴, 喜半阴
 Ø: 8 H: 400 P: 350 B: 200 土壤大小: 60
 春 夏 秋 冬

黄连木
Pistacia chinensis Bunge 选择要点: 阳性, 喜半, 喜半阴, 喜半阴
 Ø: 8 H: 400 P: 300 B: 200 土壤大小: 60
 春 夏 秋 冬

白玉兰
Magnolia denudata 选择要点: 阳性, 喜半, 喜半阴, 喜半阴
 Ø: 6 H: 300 P: 180 B: 150 土壤大小: 45
 春 夏 秋 冬

二乔玉兰
Magnolia soulangiana 选择要点: 阳性, 喜半, 喜半阴, 喜半阴
 Ø: 6 H: 300 P: 180 B: 150 土壤大小: 45
 春 夏 秋 冬

To be herbaceous 植物选择
 草本植物 | Plant selection

玉簪
Hosta japonica 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴
紫萼
Wittrockia canna 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴
吉祥草
Reinckia carnea 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴
石蒜
Lycoris radiata 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴

鸢尾
Iris tectorum Maxim 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴
番蓝草
Sedum sarmentosum 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴
阔叶麦冬
Liriope japonica 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴
日本麦冬
Ophiopogon japonicus 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴

矾根
Heuchera micrantha 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴
红花酢浆草
Oxalis corniculata 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴
蓝草
Hemerocallis fulva 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴
紫茉莉
Mirabilis jalapa L 选择要点: 阴性, 喜阴, 喜阴, 喜阴, 喜阴

Evergreen shrub 植物选择
 常绿灌木 | Plant selection

无刺枸骨
Sax. Corunata 选择要点: 喜阴, 喜阴, 喜阴, 喜阴
 H: 100 P: 100
大叶栀子
Gardenia jasminoides 选择要点: 喜阴, 喜阴, 喜阴, 喜阴
 H: 70 P: 70
茶梅
Camellia sasanqua 选择要点: 喜阴, 喜阴, 喜阴, 喜阴
 H: 150 P: 100

山茶
Camellia japonica 选择要点: 喜阴, 喜阴, 喜阴, 喜阴
 H: 100 P: 100
海桐
Pittosporum tobira 选择要点: 喜阴, 喜阴, 喜阴, 喜阴
 H: 50 P: 50
小丑火棘
Pyracantha fortuneana 'Harlequin' 选择要点: 喜阴, 喜阴, 喜阴, 喜阴
 H: 50 P: 30

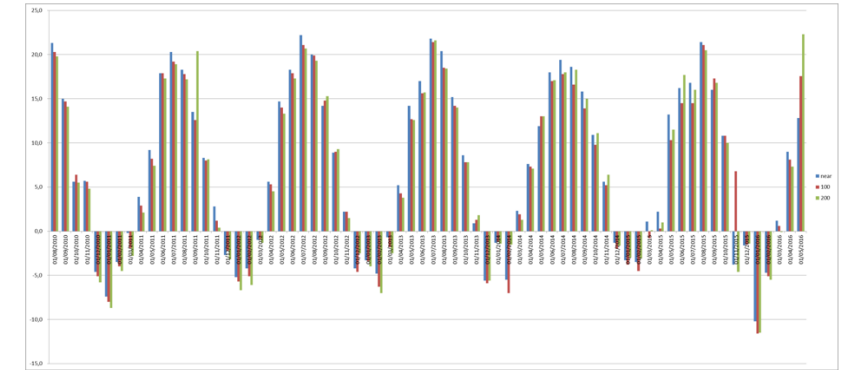


NANJING VERTICAL FOREST

FEASIBILITY
SUSTAINABILITY
MOCK-UP TRIALS
WIND TESTS
CONTRACTOR'S
SELECTION

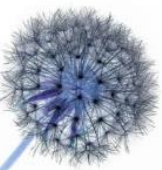
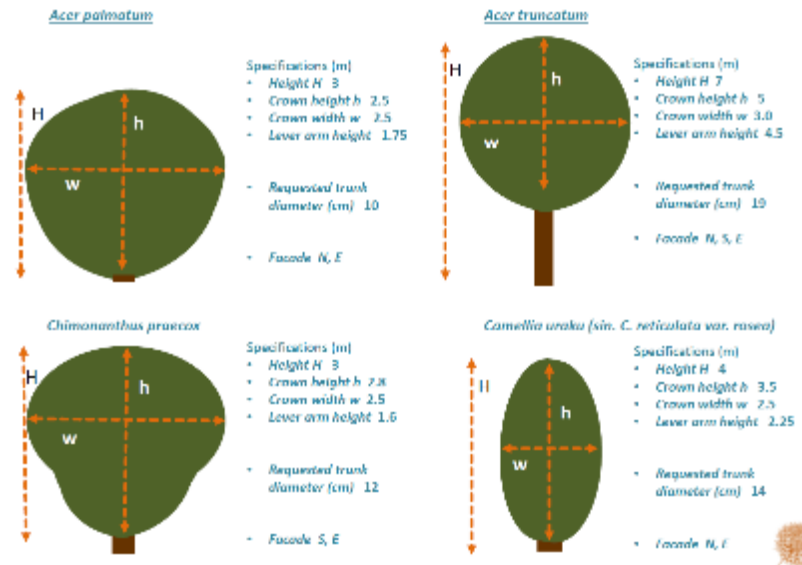


Lowest temperatures 2010-2016



Janziji station

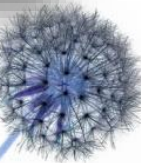
Usually below -5°C
minus 12°C (January 2016)
MODA 0-200 : 0.56
Corresponding USDA hardiness area : 8



VERTICAL FOREST NANJING



IDENTIFYING USEFUL SPECIES



- Nanjing Vertical Forest Tower A1: 393 tall trees and 143 medium trees
- Nanjing Vertical Forest Tower A2: 176 tall trees and 87 medium trees



Prunus cerasifera 'Pissardii Nigra'



Ginkgo biloba



Prunus × *yedoensis*



Prunus mume



Photinia serrulata



Osmanthus fragrans



Lagerstroemia 'Red Rocket'



Zelkova schneideriana



Acer buergerianum



VERIFYING MARKET AVAILABILITY



SELECTING TREES IN NURSERIES



Do we need more technology?

A sensitive design can combine several goals in the same solution: for example, it is not necessary to design a green building tool differently if your focus is the rainwater management or the endangered species preservation.

Certain benefits (of the heat island, reduction of runoff) are certainly achieved more effectively only if the intervention is carried out on a large scale. The favorable impact on biodiversity can also be exercised with individual projects.

The green building industry must proceed to find functional and low-cost solutions.

Policymakers can do much. It is not by chance that where environmental policies have been activated promoting the green building, prices are lower than elsewhere.





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