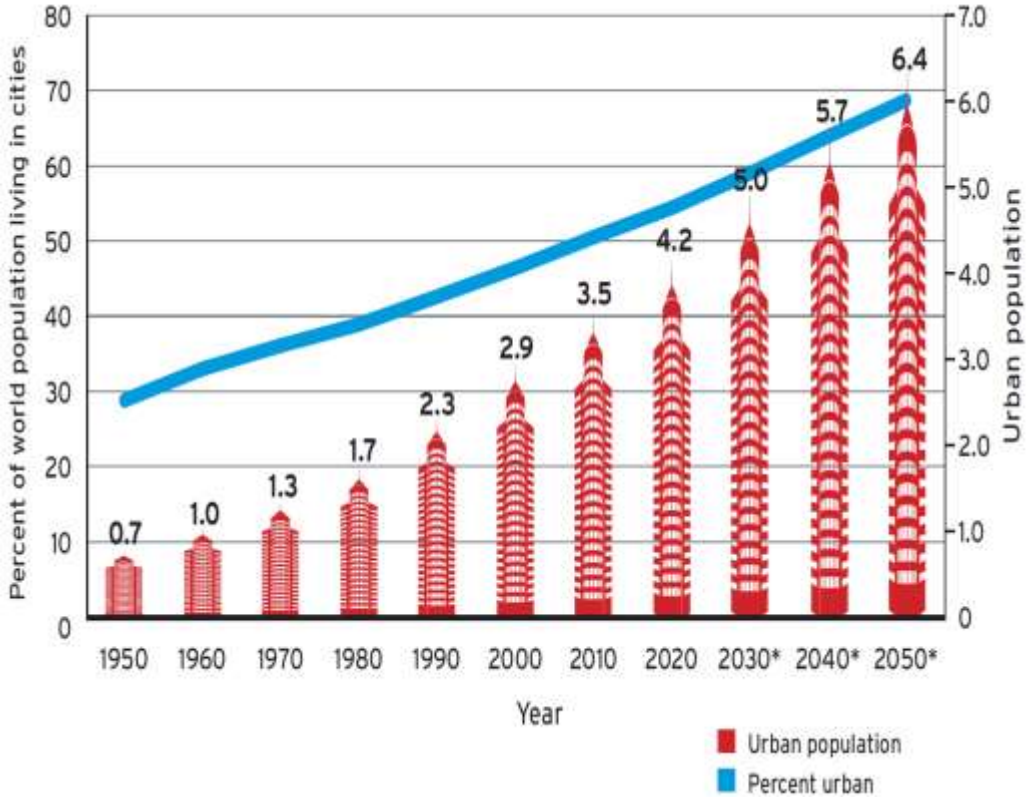
City Adaptation to Climate Change

The global challenge of making cities more green & blue, more resilient, and more inclusive !!!

Yves Kazemi, Friday 23 Mai 2025

Urban Challenges of Climate Change

People living in Cities (World Bank 2010)



Issues and Challenges

- By 2030, **60%** of the world's population will be living in urban areas (70% by 2050) (UN 2016)
- Urban areas represent less than **3%** of the world's land surface (UN 2016)
- Between 1990 and 2030, the urban population is expected to **double** and the urbanized area to **triple**

  (Angel et al. 2005)
- Cities consume **~80%** of the world's energy and produce **~80%** of greenhouse gases (WB 2010)
- Cities offer **70%** of opportunities to reduce greenhouse gas emissions by 2050

  (IEA 2008 in World Bank 2010)

Impacts of Climate and Environmental Change on Cities (World Bank 2023)

In all cities and urban areas, the risks faced by people and assets from the hazards associated with climate change have increased (WB 2023, Chapter 3):

Climate shocks (sudden-onset events)

- Extreme heat and/or Cold
- Heavy precipitation and floods
- Coastal flooding
- Wildfires.
- Wind-related disasters (hurricanes, cyclones, and typhoons).

Climate stressors (slow-onset events)

- Drought
- Air pollution
- Land degradation.
- Rising sea levels

“If you want to win the climate change battle, it will be fought in the cities of the world”

(Andrew Steer, Chief Executive Officer, World Resources Institute in Newman et al. 2017)

Sustainable Urbanisme (Farr 2008)

- Compact and dense cities
- Complete and diverse communities
- Connected and active transportation
- **Green planning and building**
- High performance building/infrastructure

Resilient Cities (Newman et al. 2017)

- More cyclical and regenerative metabolism
- Foster inclusive and healthy cities
- Create sustainable mobility systems
- **Biophilic/green urbanism in the city**
- Invest in renewable and distributed energy

less of the bad things
(reducing ecological footprint)

more of the good things
(regenerating ecological footprint)

(adapted from Newman et al. 2017, p.13)

Concept and Definition of “Green & Blue” Infrastructure

« Green & Blue »

natural features and/or media that provide ecosystem and/or environmental services

« Infrastructure »

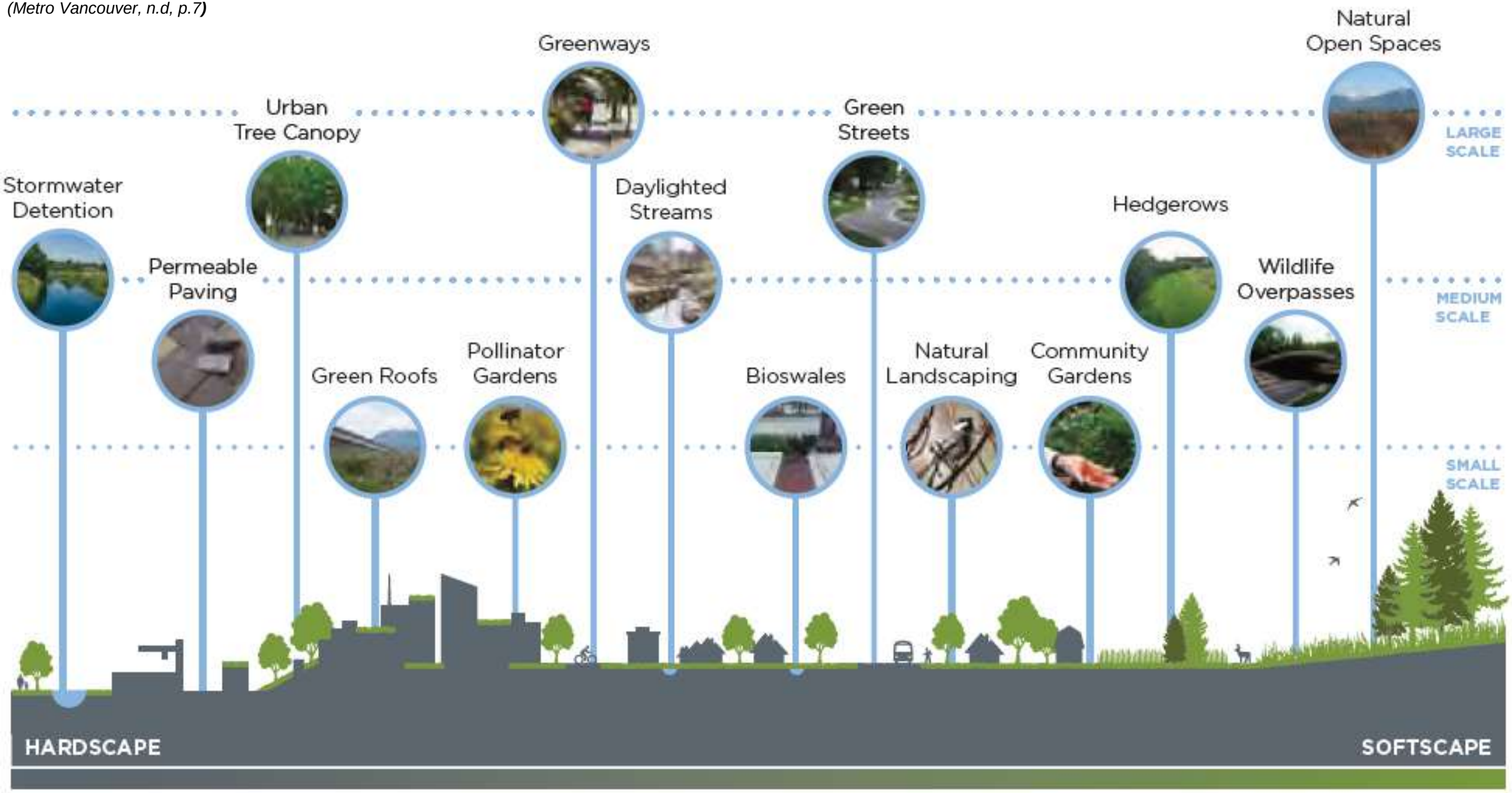
An interdependent set of works, equipment and/or services organized or structured in a network

An **interconnected network** of natural environments and semi-natural developments **strategically distributed** throughout the urban space to produce the **broadest range of ecosystem services** to strengthen the resilience of cities

(adapted from EC 2013 p.3 and Metro Vancouver n.d. p.6)

Green Infrastructure Opportunities across the Urban Landscape

(Metro Vancouver, n.d, p.7)



Urban Ecosystem Services provided by “Green & Blue” Infrastructure

Ecology
Biological diversity
Biomass & Biotopes
Natural Landscapes
Biological Resilience

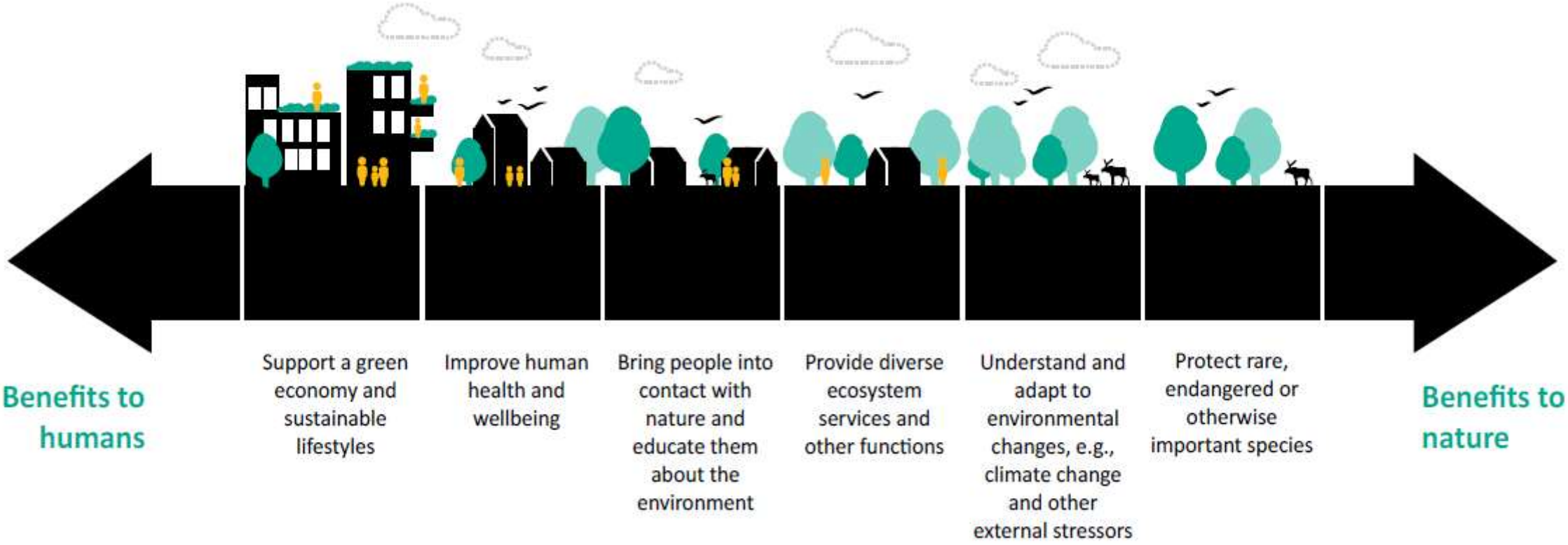
Economy
public finance
Productivity & Efficiency
Local/circular economy
Urban Benchmarking

Environment
Climate & Temperature
Air & Soil & Water Quality
Emissions & pollution
Natural hazards

Society
Education & Learning
Food & Nutrition
Social Health/Cohesion
Incivility & Violence

Wellness & Health
Quality of life
Mental/Psychic Health
Fitness/Obesity
Sports/Leisure/Relaxation

Benefits of Urban Green & Blue Infrastructure to People and Nature



Hansen et al. 2017 (p.12)

Green Infrastructure Planning Principles

Approaches addressing the green structure

- **Integration**
  Seeks to integrate and coordinate urban green with other urban infrastructures in terms of physical and functional relations.
- **Multi-functionality**
  Considers and seeks to combine ecological, social and economic/abiotic, biotic and cultural functions of green spaces.
- **Connectivity**
  Includes physical and functional connections between green spaces at different scales and from different perspectives.
- **Multi-scale approach**
  Can be used for initiatives at different scales, from individual parcels to community, regional and state.

Hansen et al. 2014 (p.517)

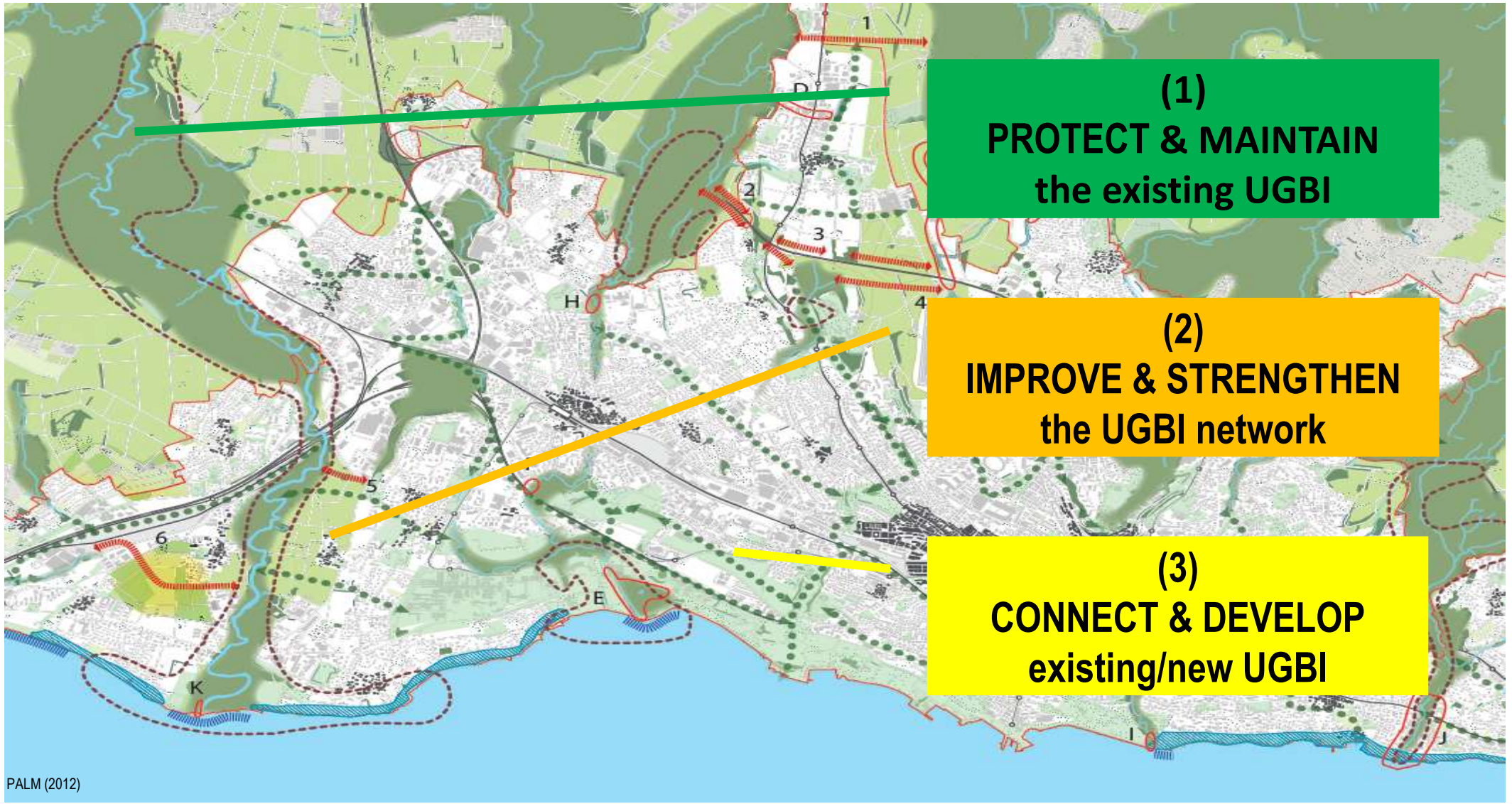
Approaches addressing the green structure

- **Multi-object approach**
  Includes all kinds of (urban) green and blue space; e.g., natural and semi-natural areas, water bodies, public and private green space like parks and gardens.

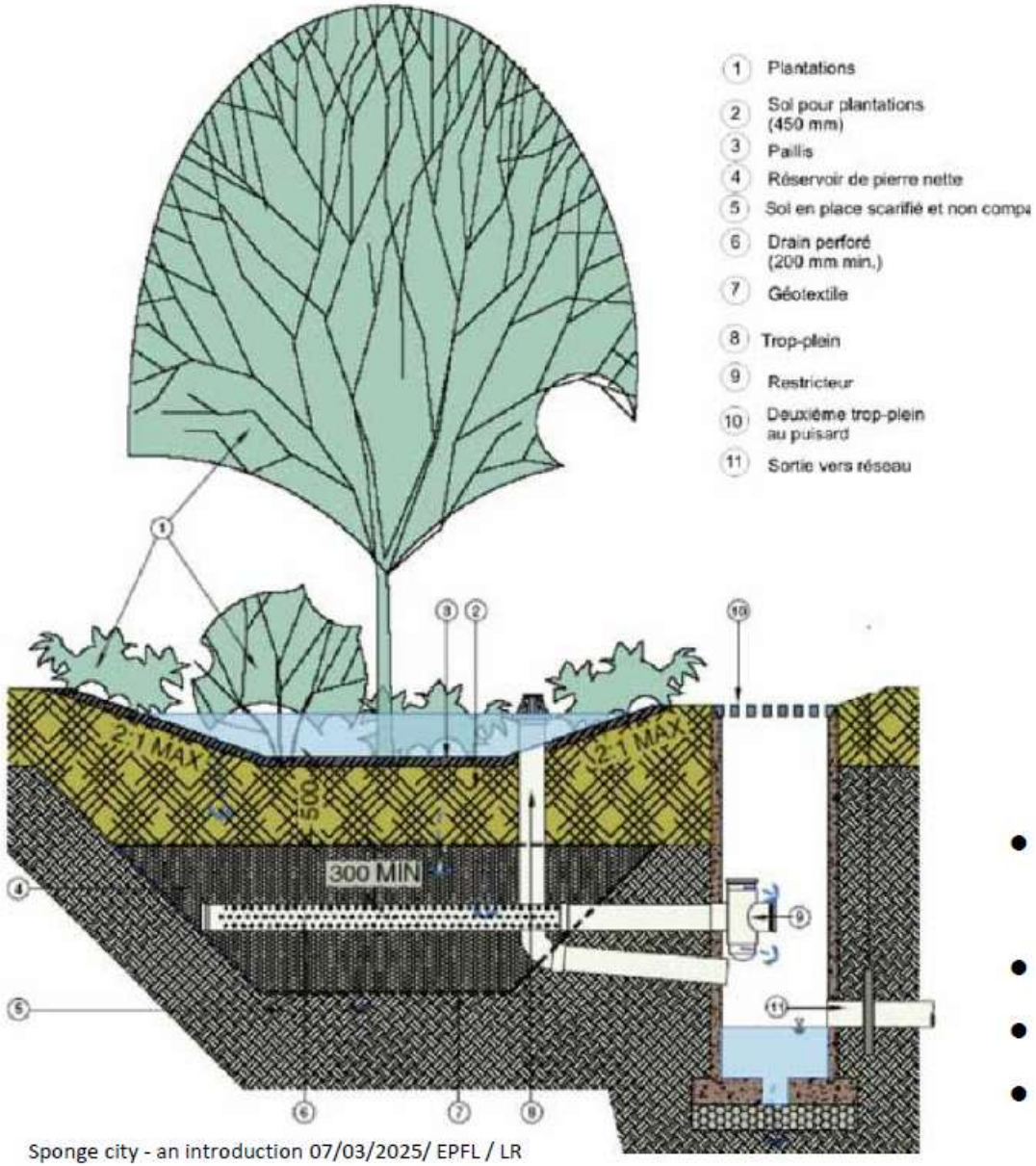
Approaches addressing governance processes

- **Strategic approach**
  Aims for long-term benefits but remains flexible for changes over time.
- **Social inclusion**
  Stands for communicative and socially-inclusive planning and management.
- **Trans-disciplinarity**
  Based on different disciplines such as urban ecology, regional planning, and landscape architecture and developed in partnership with local authorities and stakeholders

The 3 Steps for Tactical Design of **UGBI**



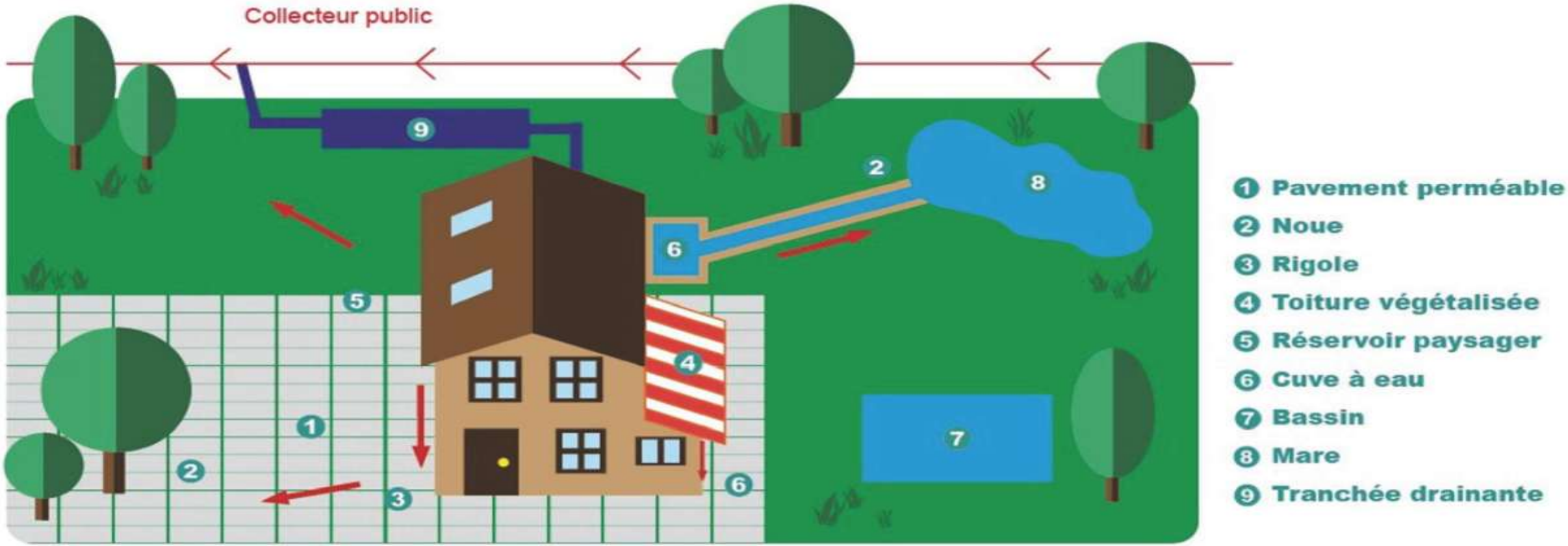
Sponge city examples



- It looks green and natural, but can be highly engineered
- To be adapted to local conditions
- Very sensitive to small alterations
- Public information highly recommended

1.3 Gestion des eaux pluviales – Techniques alternatives

DIFFÉRENTES TECHNIQUES ALTERNATIVES pour gérer les eaux pluviales
(source : directive Evacuation des eaux, état de Genève)



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Urban Heat Island (UHI): PROCESS

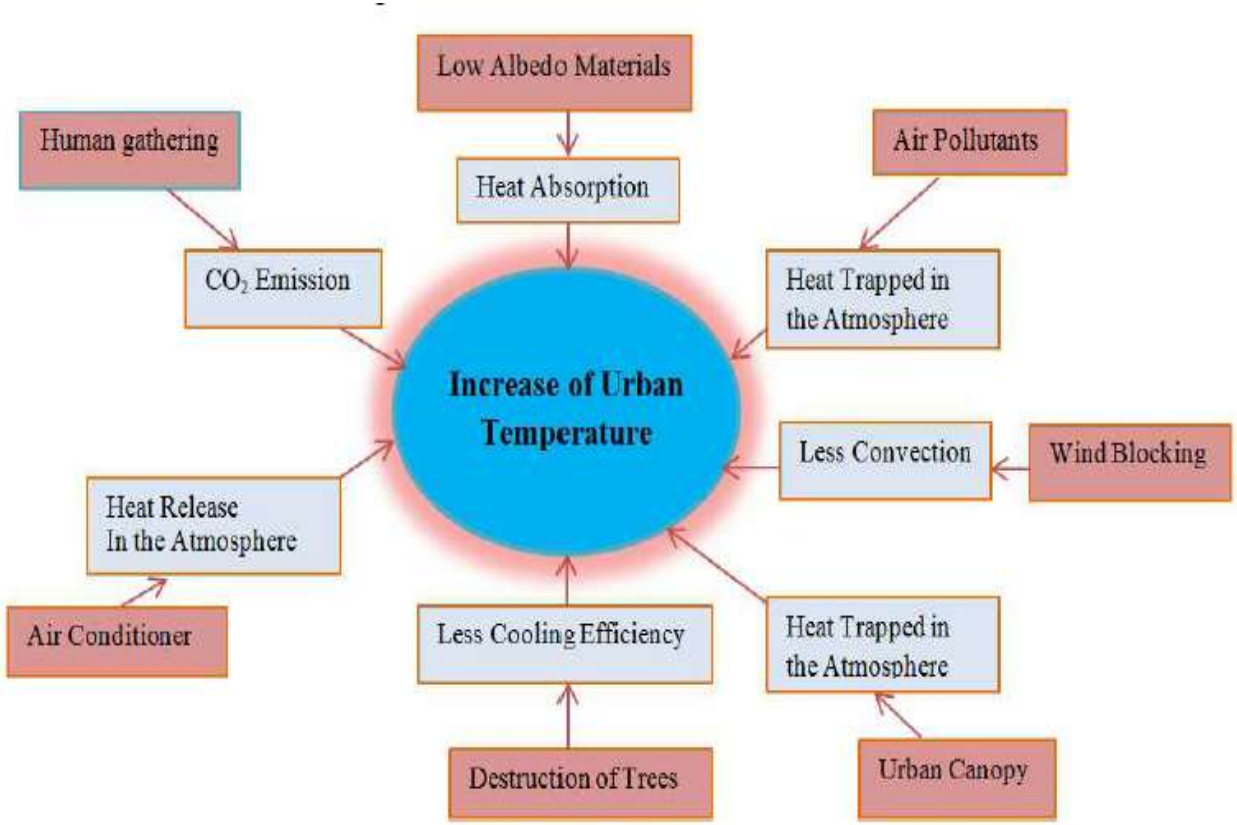


Figure 1. Process of Urban Heat Island (UHI) Formation.

(Nuruzzaman 2015, p.68)

UHI Factors

- Climatic and meteorological conditions
- Geographic location
- Urban and architectural geometry
- Thermal trapping and ventilation
- Properties of urban materials
- Increased impervious surfaces
- Reduced vegetation and permeable surfaces
- Anthropogenic heat emissions
- Air pollution and local greenhouse effect

(OFEV 2018 and US EPA 2008)

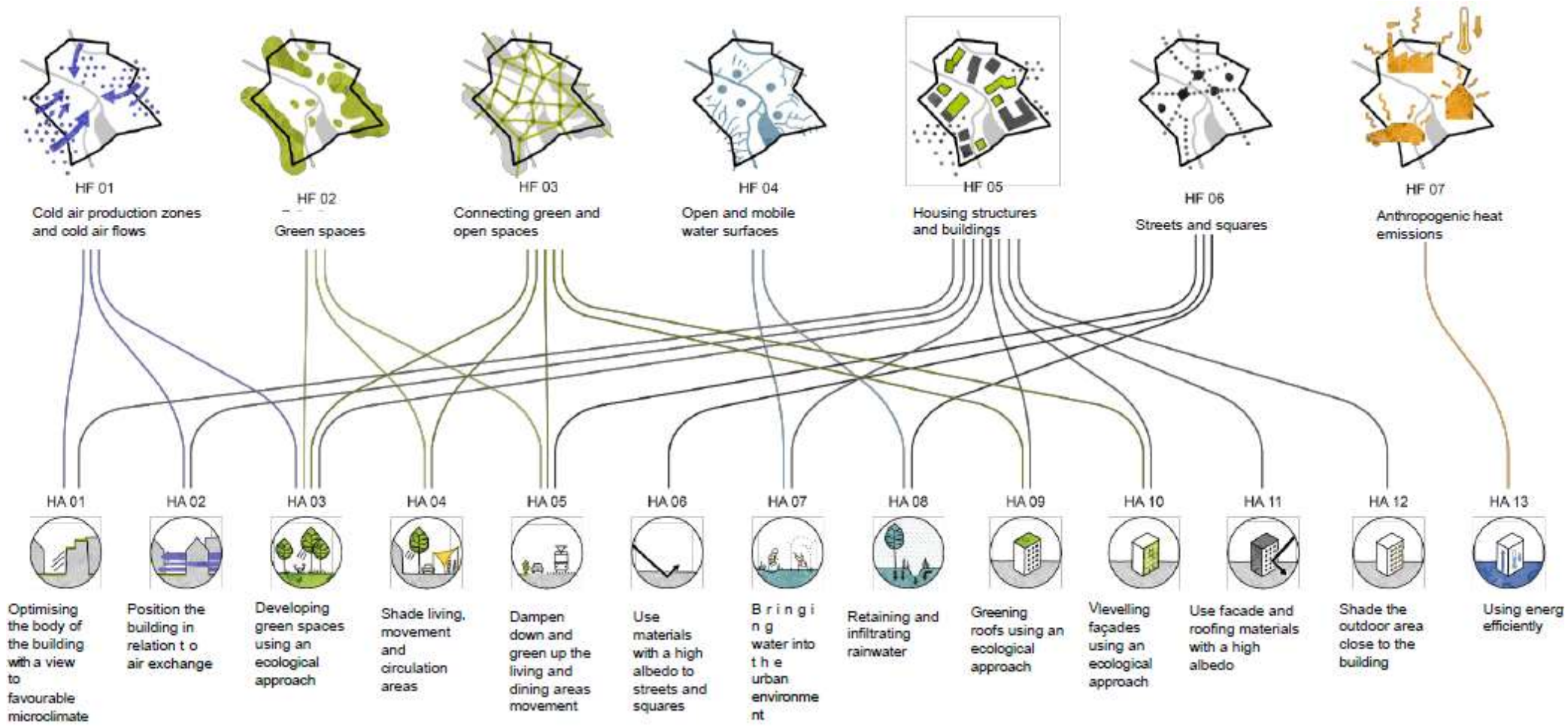
Urban Heat Mitigation by Green and Blue Infrastructure

(Kumar et al. 2024 , p.1)

City of Zurich, 2020 Specialised Planning for Heat Mitigation: FIELDS AND LINES OF ACTION

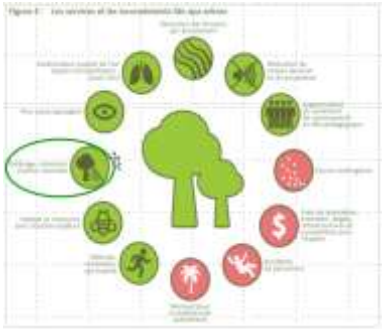
7 Fields of action →

13 Lines of action →



(1)
Diagnosis
GE canopy

(2)
Selected services



(3)
Deficits / Priorities
GE canopy

Figure 3 : Densité d'arbres par hectare sur le canton de Genève (2009).

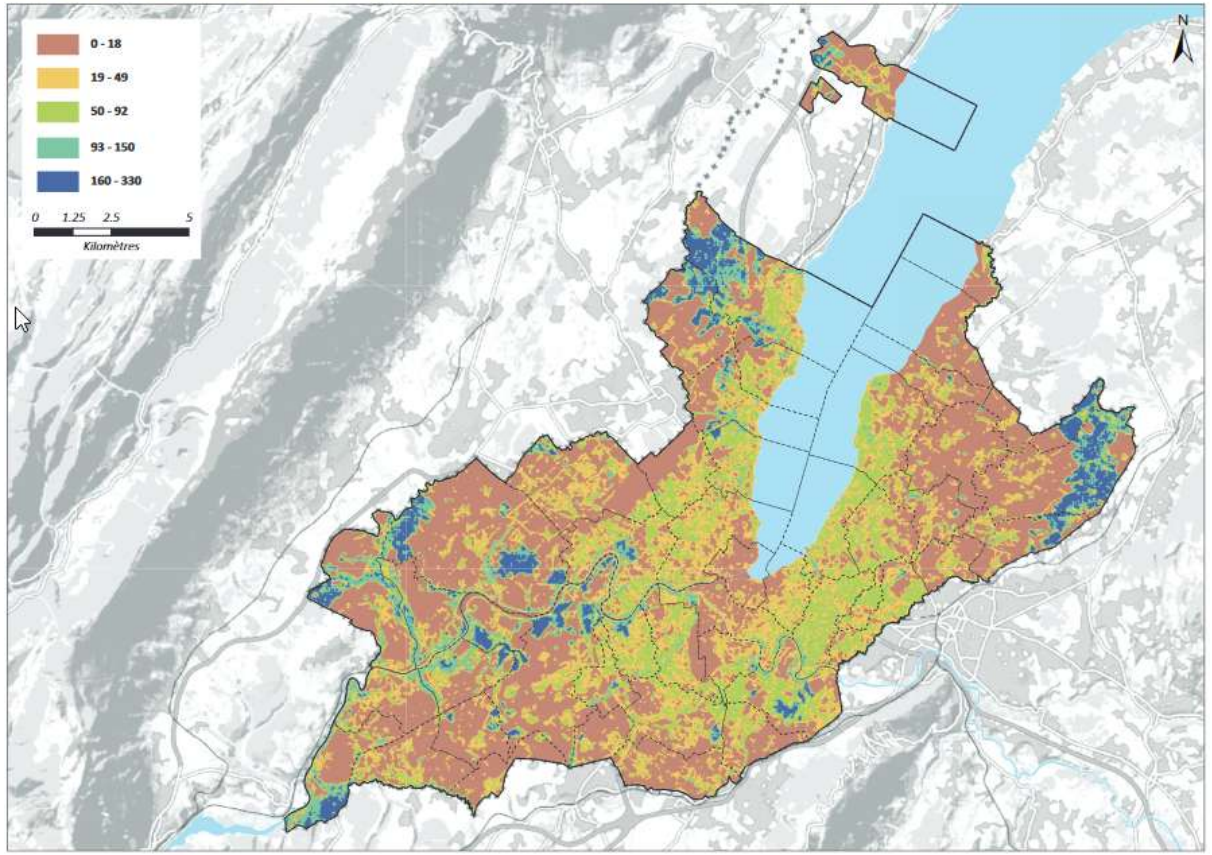
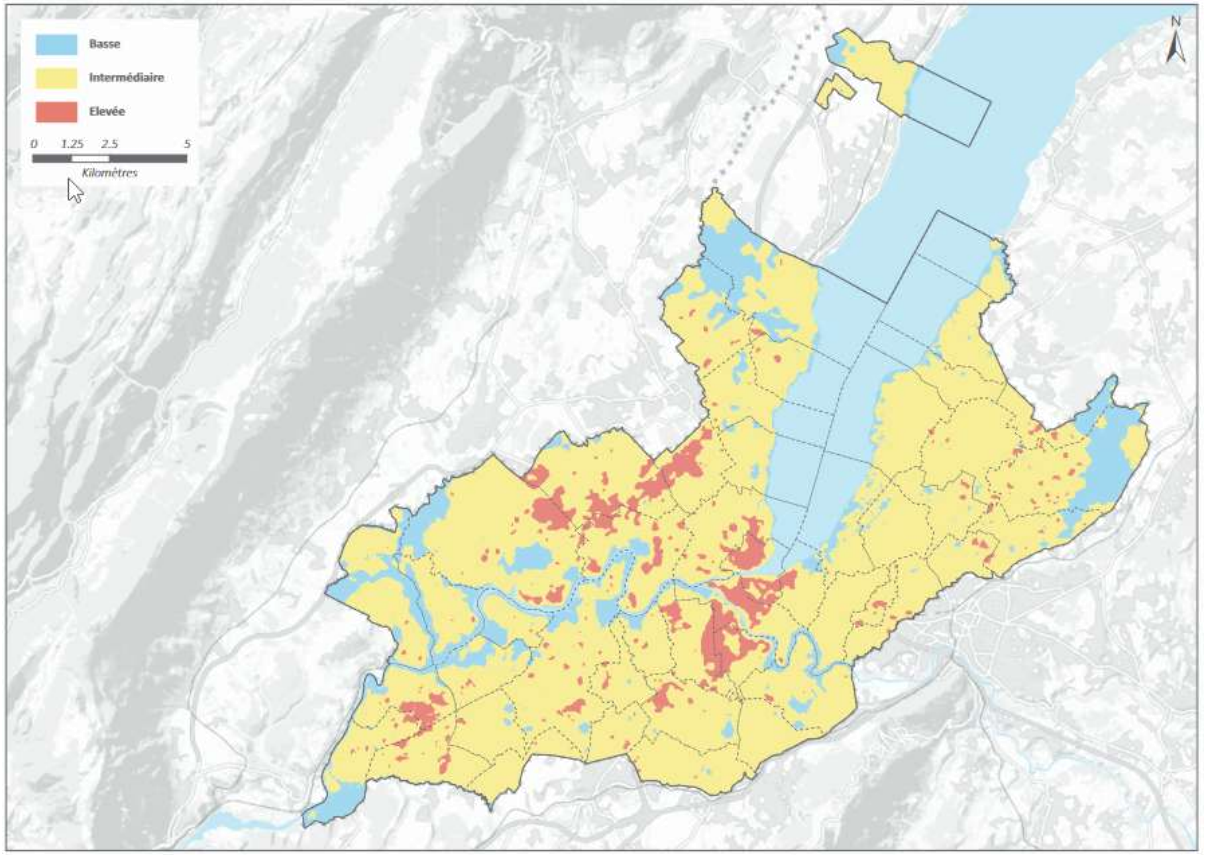


Figure 7 : Lieux prioritaires pour atténuer l'îlot de chaleur



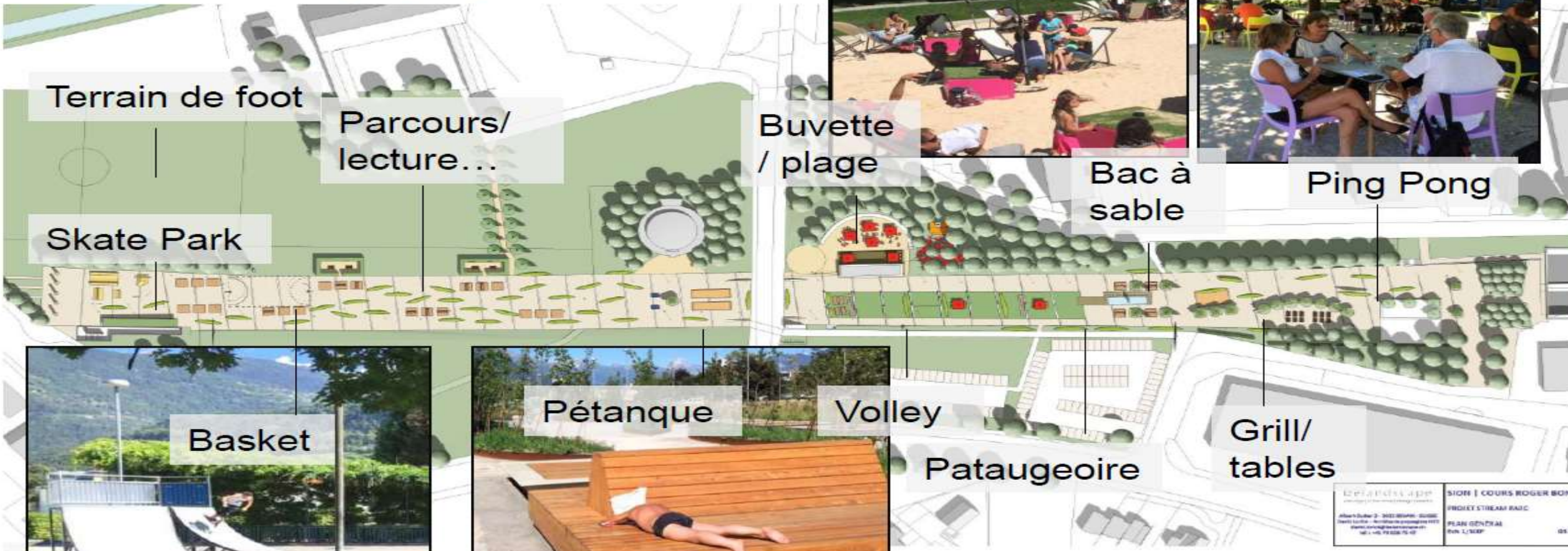
(Schaelpfer et al., 2018, p.14 & 21)

SION

ACCLIMAT ASION

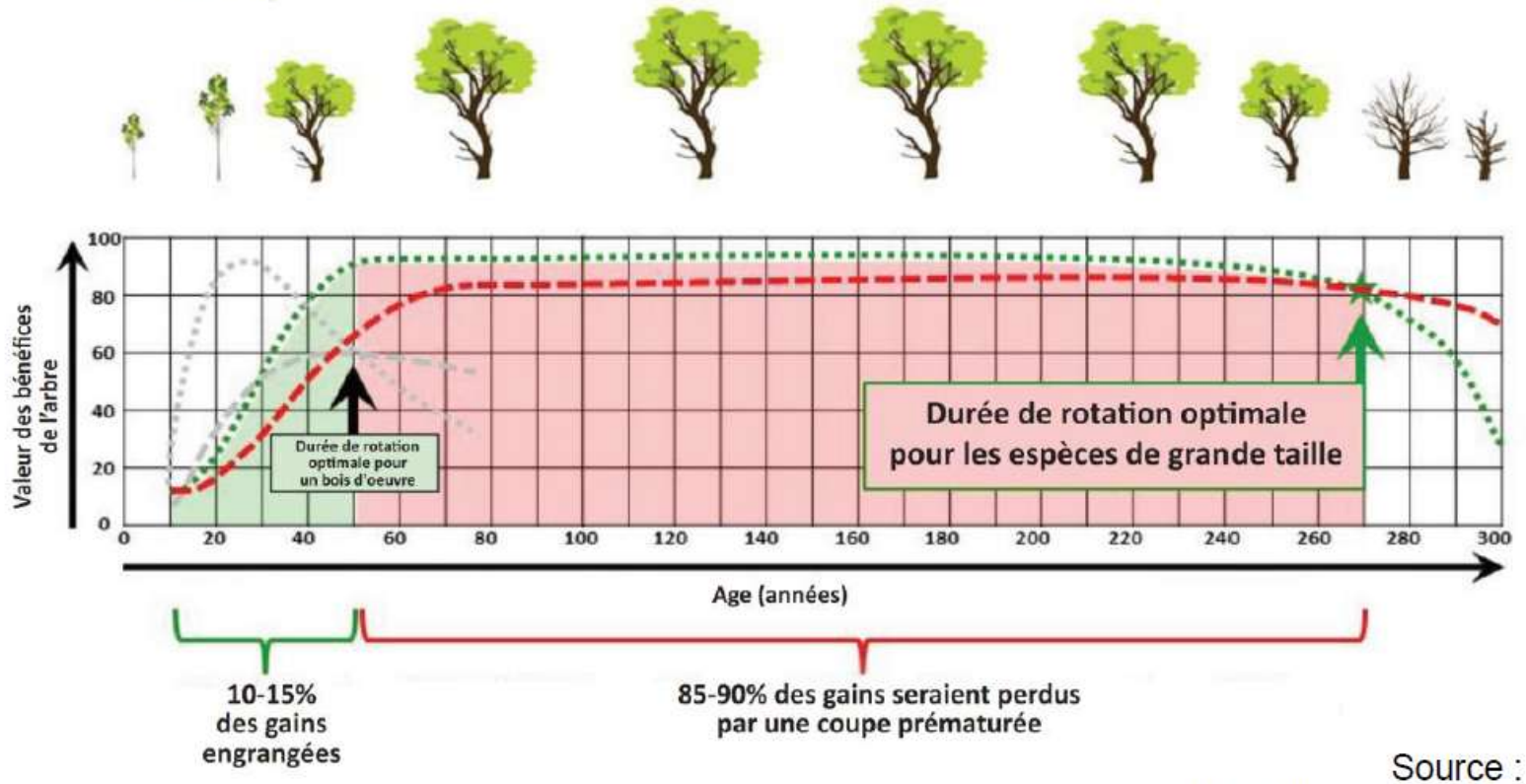
COURS ROGER BONVIN

Composantes physiques



L'arbre : plantation et entretien

Figure 11 : Schématique idéalisée des bénéfices d'un arbre au cours du temps (source : Jeremy Barell)



Source :
Nos arbres - Genève

De grands arbres...

1. Bien les choisir
2. Les faire pousser
3. Les laisser pousser
4. Les conserver

Michaël Rosselet
Délégué aux arbres - Lausanne

L'arbre : plantation et entretien

Des plantations de qualité…

…un sol de qualité

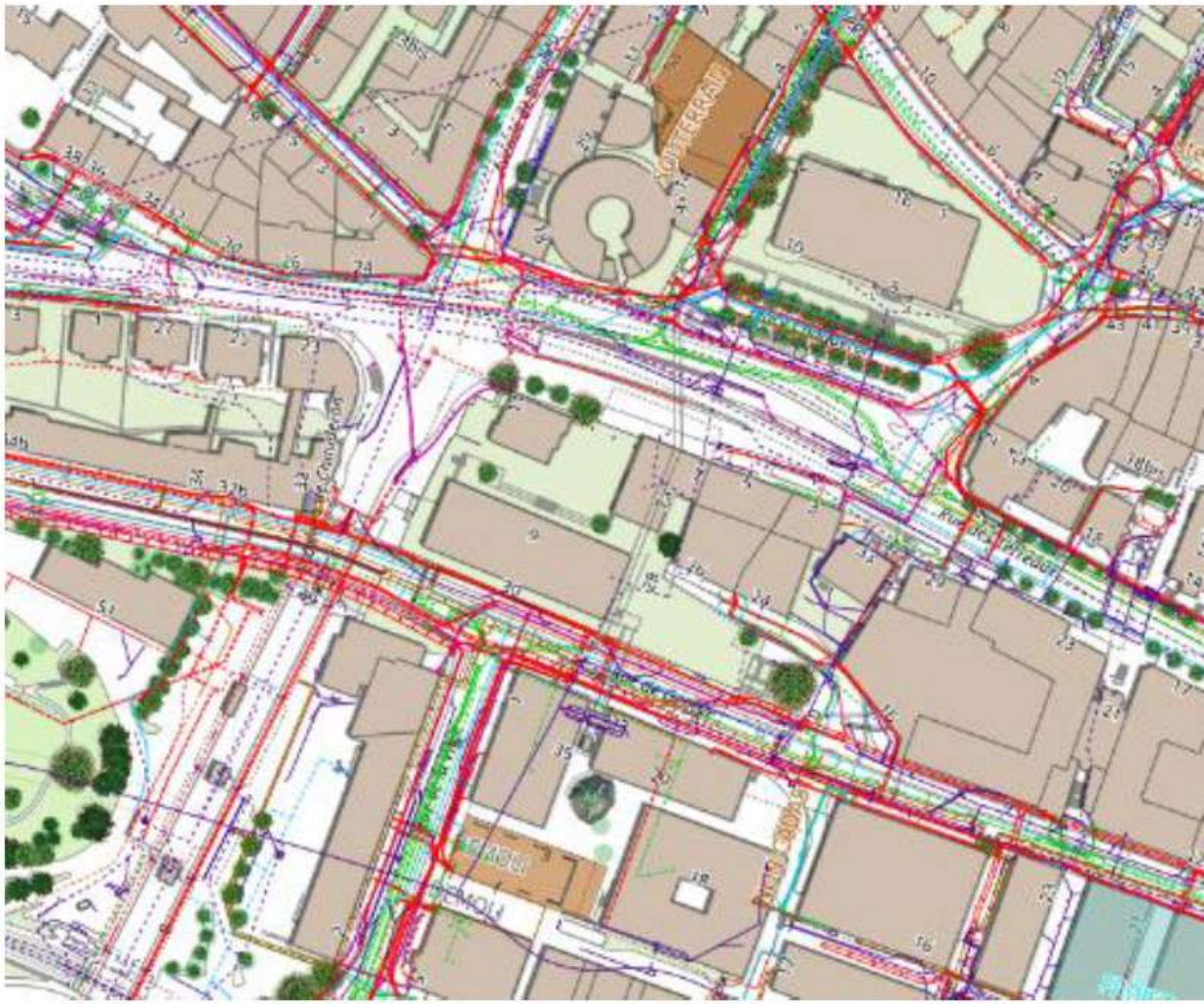
Les mêmes arbres, en même temps, dans des sols différents

Michaël Rosselet
Délégué aux arbres - Lausanne

L'arbre : plantation et entretien

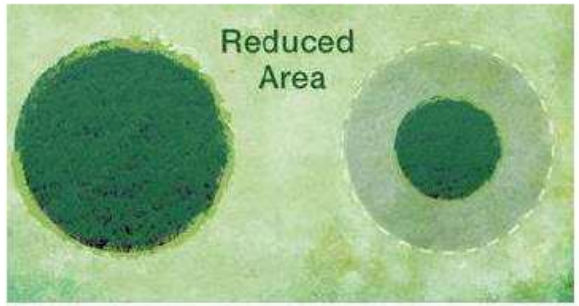
Des plantations de qualité…

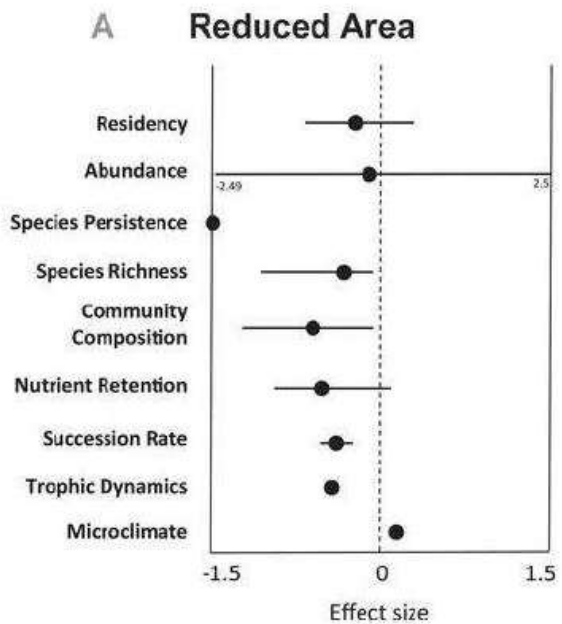
… difficile parfois

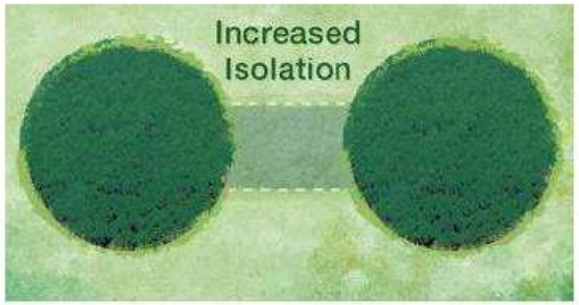


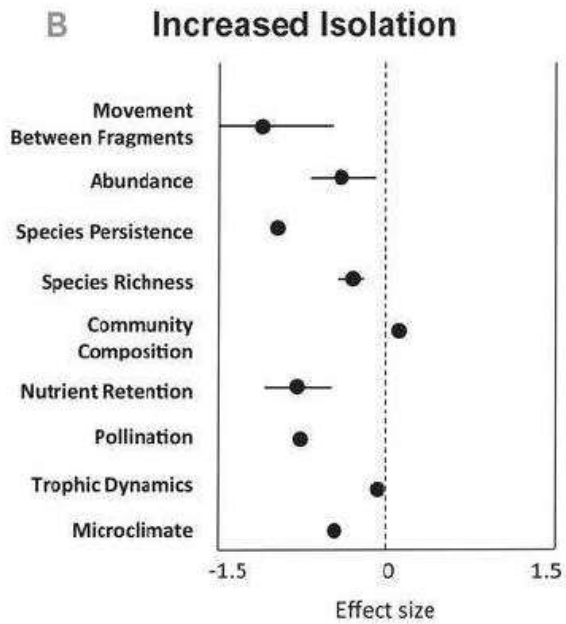
Michaël Rosselet
Délégué aux arbres - Lausanne

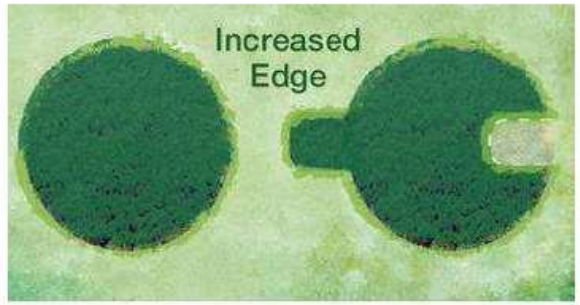
Habitat fragmentation and edge effects

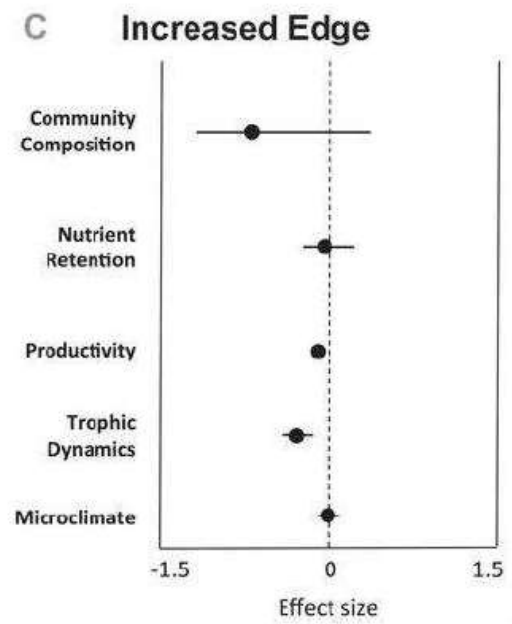












Haddad et al. Sci Adv 2015

Core areas + corridors = ecological infrastructure

Forêt naturelle, îlots de vieux bois, forêts clairsemées

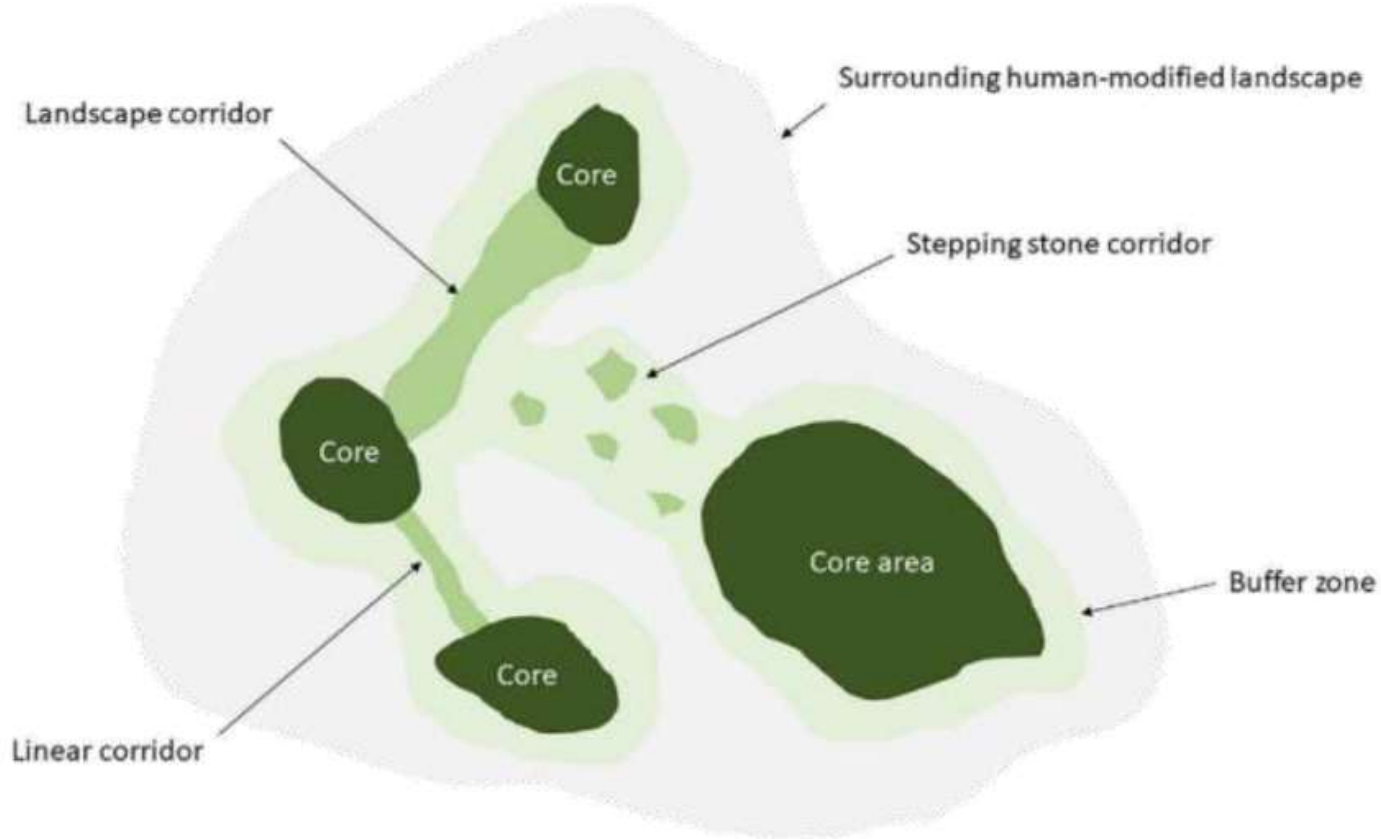
Haies, bosquets, vergers, allées

Bas- et hauts-marais, étangs, mares, lacs

Cours d'eau, zones alluviales, sources

Habitats secs (p.ex. prairies et pâturages)

Prairies maigres, jachères fleuries, surfaces rudérales



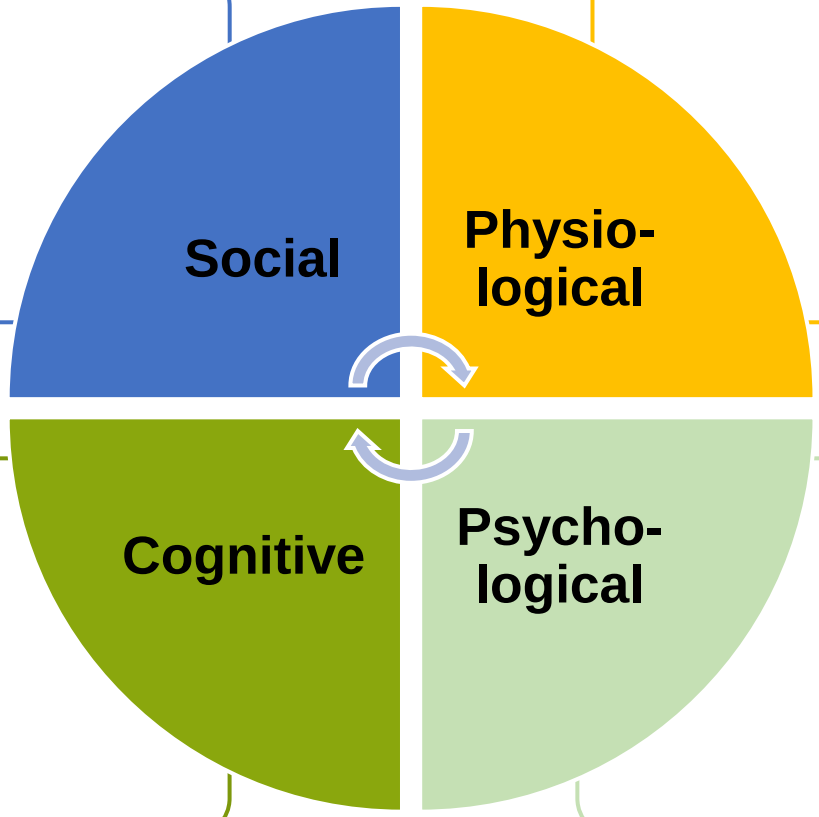
Common mistakes when planning an EI

- "Too little, too late": restoring ecological connectivity requires ambitious investments and long-term planning.
- General measures, not specific enough. The diagnostic stage is crucial, it defines the measures necessary to restore the EI. It requires a biological eye.
- Measures too focused on one or a few target and charismatic species, not on the restoration of ecological processes.
- Greenwashing. No real understanding of what is at stake (e.g. anecdotical tree planting, honeybee hives, very temporary ponds that act as ecological traps...)

Physiological, Psychological, Cognitive and Social Benefits in Interaction with Nature

Meta-analysis of 57 scientific studies published between 1973-2011 (Lucy et al. 2013, p.917-918)

Increases **social cohesion**
Facilitates social interactions
Promotes social empowerment
Decreases crime rate
Decreases urban violence
Promotes interracial exchanges

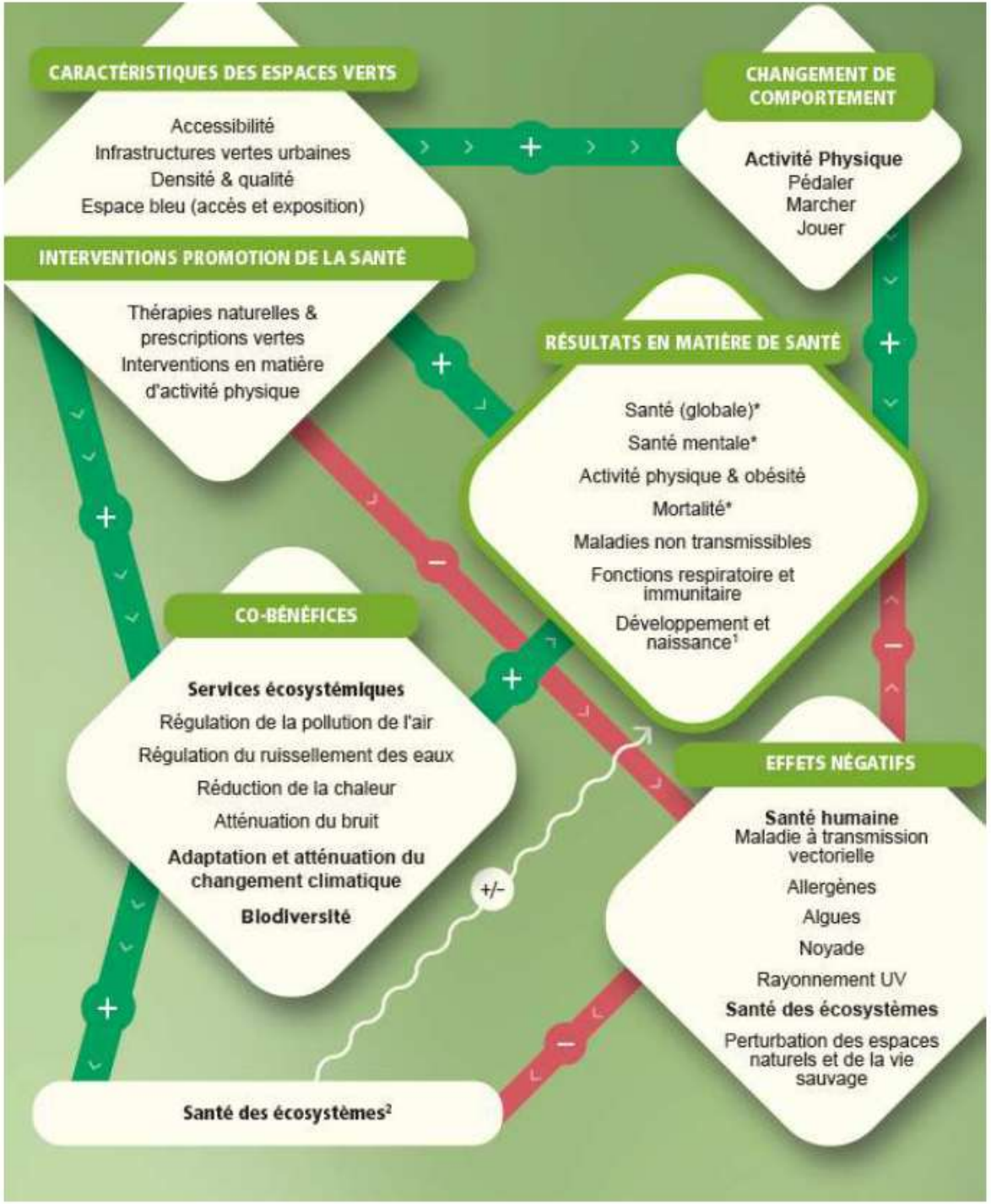


Stress Reduction
Decrease in vascular/respiratory diseases
Decreased disease episodes
Faster recovery
Reduced headaches
Perception of health and well-being

Attention & Performance Restoration
Learning Opportunities
Increases productivity
Decreases mental fatigue
Improves academic performance
Better cognitive function in children
Better ability to multi-task

Psychological **well-being**
Improved self-esteem
Improves mood
Reduces anger/frustration
Decreases anxiety
Behavioural Enhancement

la santé en ville (1): Espaces verts

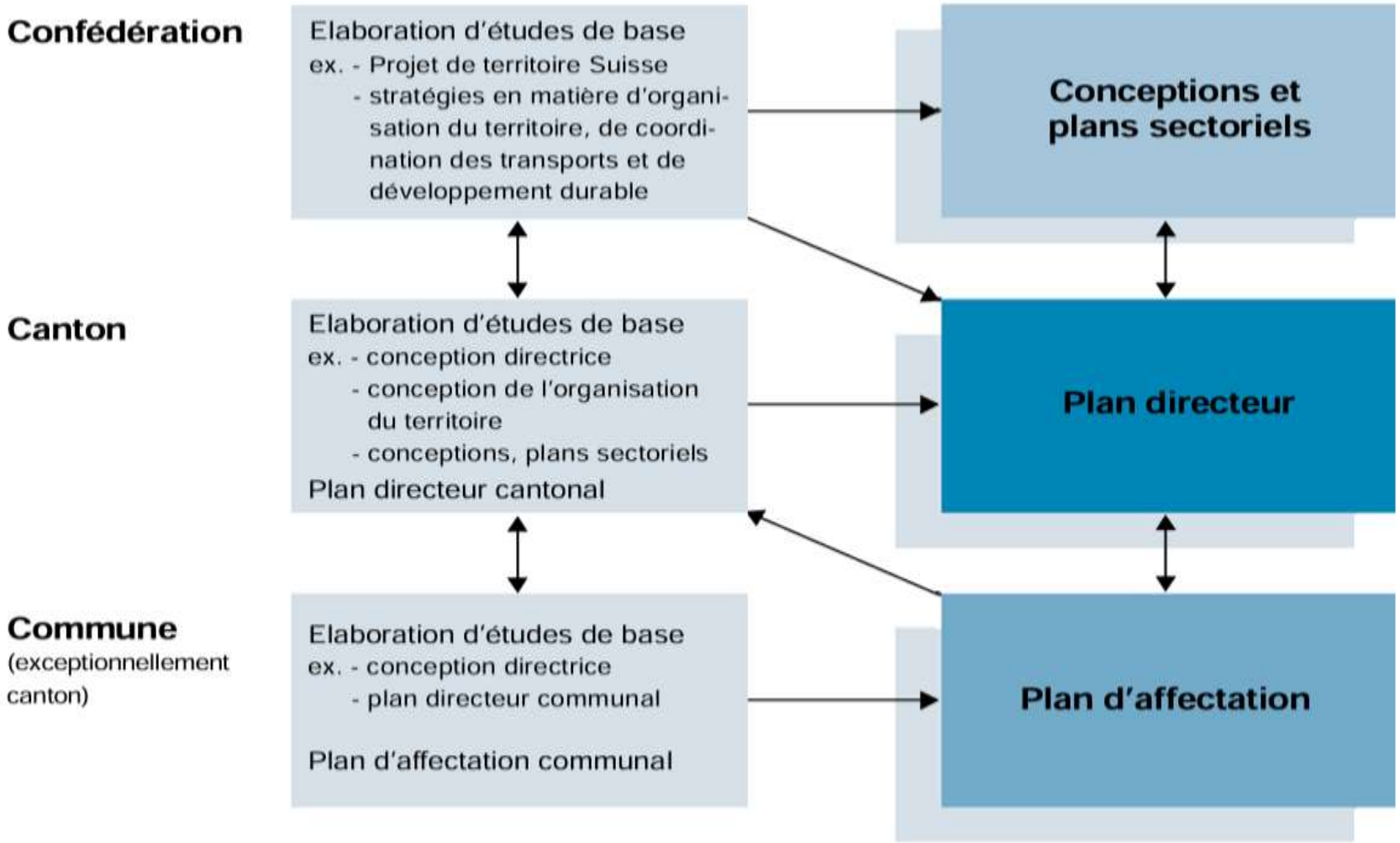


Ref: Banwell et al, Public Health Rev, in press

Règlements et instruments de l’aménagement du territoire en Suisse

Niveau	Outils	Caractère
Fédéral	LAT	Loi
Cantonal	LATC, Règlement d’application, PDCn	Loi + plan directeur
Régional	Plans directeurs régionaux	Stratégique
Communal	PDCom, PACom, Plans spéciaux (PQ, PPA)	Contraignant (PACom)
Intercommunal	Projets d’agglomération, plans directeurs intercommunaux	Stratégique / opérationnel
Transversal	EIE, plans de mobilité, stratégie climat	Complémentaire

Responsabilités en matière d'aménagement du territoire en Suisse



Source : ARE, 2012

Urban Green Equity

Fair access to and governance of urban forests, regardless of differentiating factors, such as socioeconomic status, racialization, cultural background or demographics

Urban forest distribution in Vancouver

Neighbourhoods with residential instability, material deprivation, ethnic concentration:

- Lower access to public parks
- Lower residential exposure to vegetation & water
- Higher residential exposure to buildings and pavement

Pathways to Equity
mosaic governance

- Multicultural cities have high biocultural diversity
- Biocultural diversity growing & changing
- Diversity absent from dominant urban forestry discourses

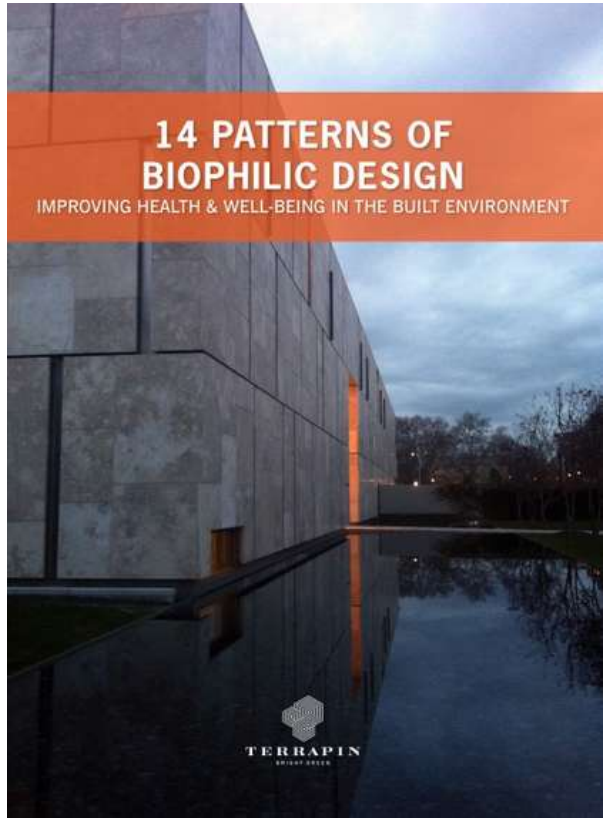
- **Recognition**: recognition of the diversity of people, communities and their (biocultural) experiences, and the importance of their participation in urban forest processes (decision making, stewardship)

Green is the new GOLD of cities!

easyCredit headquarters, Nuremburg, Germany

14 Patterns of Biophilic Design (Browning and Clancy, 2014)

"Biophilic architectural design" can reduce stress, improve cognitive function and creativity, increase our well-being, and speed up healings



NATURE IN THE SPACE

1. Visual Connection with Nature
2. Non-Visual Connection with Nature
3. Non-Rhythmic Sensory Stimuli
4. Thermal & Airflow Variability
5. Presence of Water
6. Dynamic & Diffuse Light
7. Connection with Natural Systems

NATURAL ANALOGUES

8. Biomorphic Forms & Patterns
9. Material Connection with Nature
10. Complexity & Order

NATURE OF THE SPACE

11. Prospect
12. Refuge
13. Mystery
14. Risk/Peril

Green is the new GOLD of cities!

Bosco Verticale, Milan, Italy

Best management practice for «High Performance» Infrastructure (HPI)

(New York City 2005)

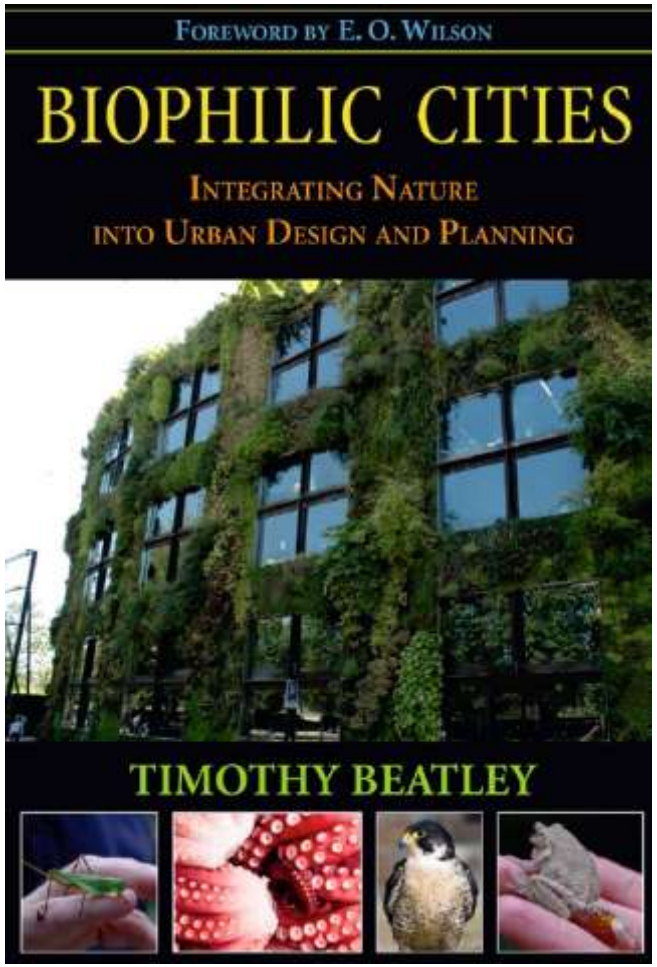
- Maximize urban **ecosystem services**
- Disseminate and interconnect HPI **strategically**
- Develop **tridimensional** spatial planning and design
- Integrate HPI through **cross-disciplinary** teamwork
- Optimize HPI **performance**, efficiency and lifecycle
- Promote infrastructural **synergies** to adjacent systems
- **Restore ecology** and **functionality** of urban natural system
- **Reduce detrimental** impacts to air, water, soil, vegetation

(Adapted from New York City 2005 and Singelton et al. 2018)

Green is the new GOLD of cities!

Garden by the Bay, Singapour

Biophilic Cities: Integrating Nature into Urban Design and Planning (Beatley 2011)



- Restore large **interconnected** green system
- Trees, parks and forests within **100m** of where people live
- Insert nature and **biodiversity** in urban interstices
- Protect and **restore** natural urban hydrology
- **Design biophilic** urban street and infrastructure
- Grow food and develop **agriculture** in the city
- Green **retrofit** existing urban neighbourhoods
- Creates safe spaces for **walking** and **biking**
- Promote **healthy** building and working environment
- Green the **vertical** dimension (Walls/Rooftops)

Green is the new GOLD of cities!

Liuzhou Forest City, région autonome du Guangxi, Chine
(ville-forêt de 3’750’000 habitants conçue par Stefano Boeri)