# Is there still room for nature in the cities of tomorrow ?!?

Contribution of Green & Blue Infrastructure to Cities' Adaptation to Climate Change (introduction)

Yves Kazemi, Friday 21 February 2025

Urban Challenges of Climate Change?!?

MétéoSuisse 2020 in OFEV et al. 2020, p.33.

# Urban Development and Metropolisation
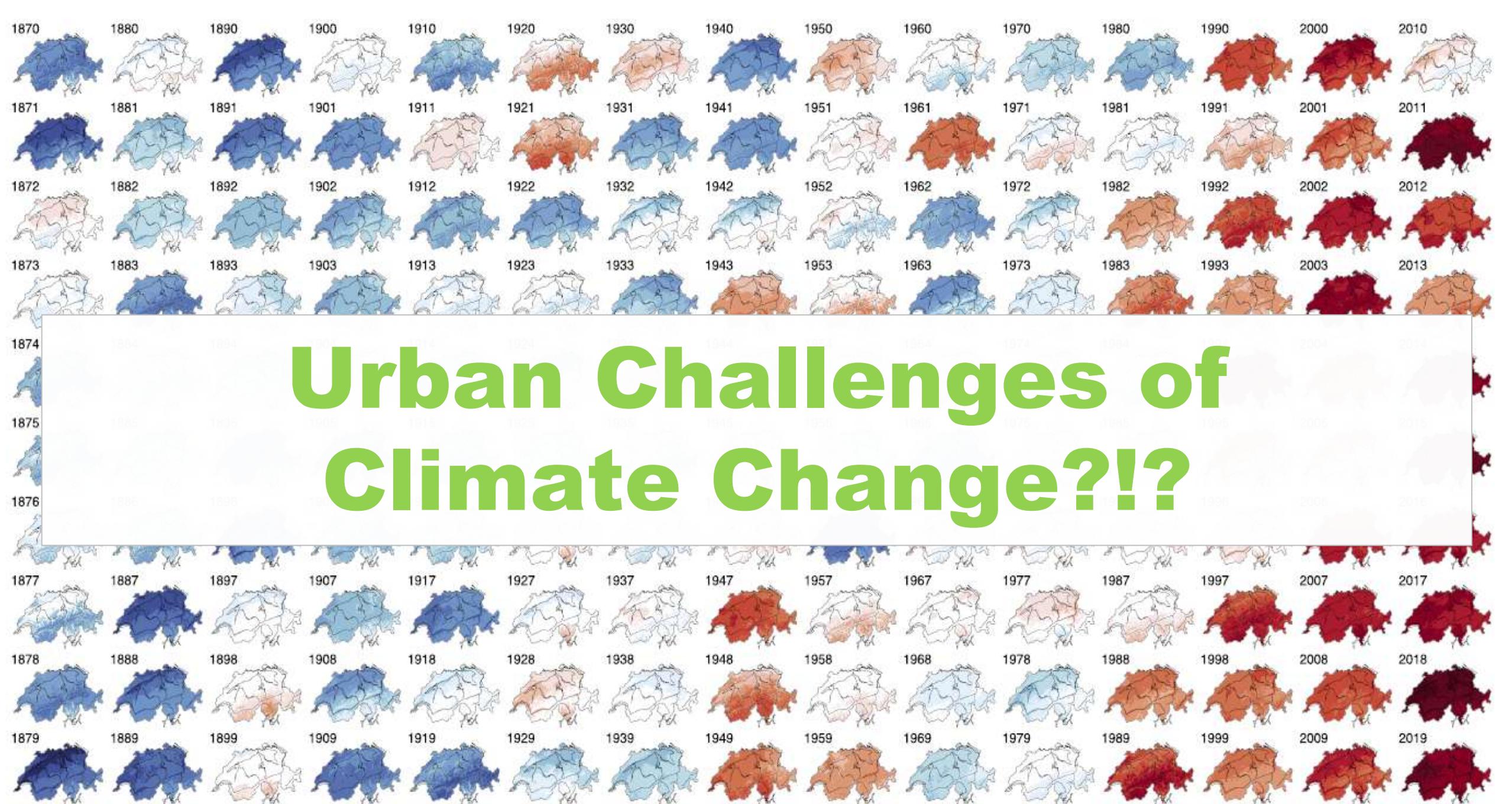
Agglomérations 1960
Définition 1960
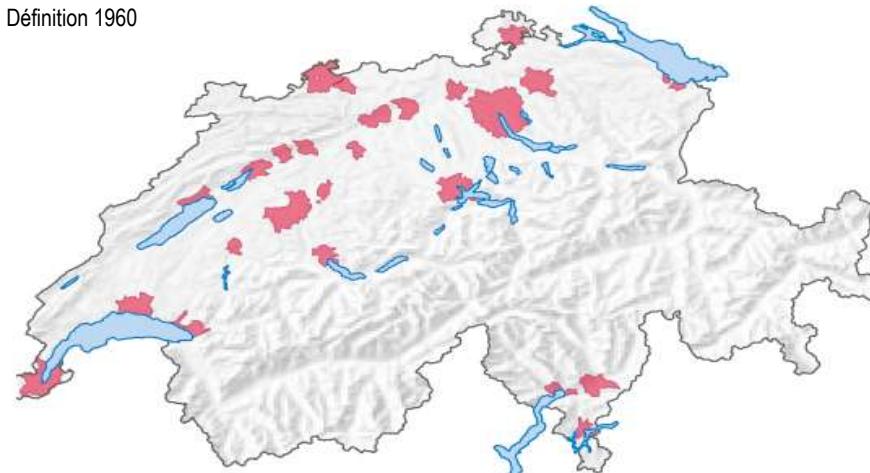
Agglomérations 2019
Définition 2012
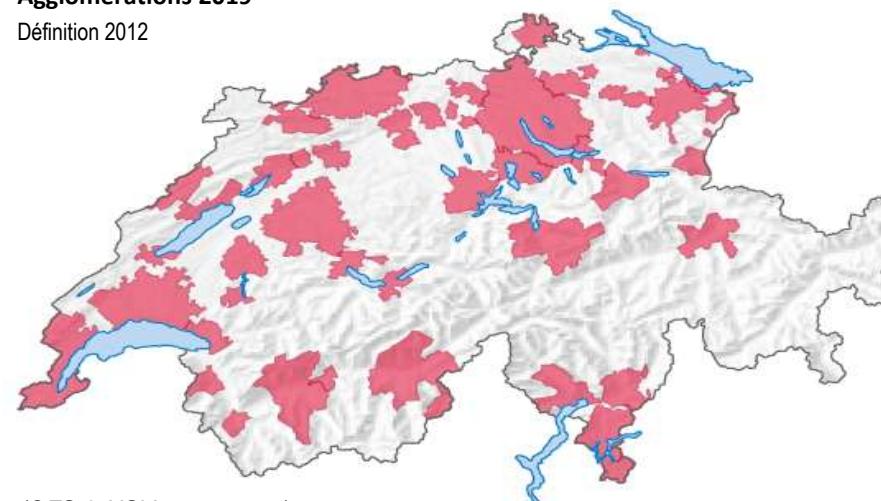
(OFS & USV, 2020, p.16)

Findings for Switzerland (OFS & USV, 2020)

- In 1950, **45%** of the Swiss population (2.1 million) lived in urban centres (24 agglomerations)

- In 2018, **77%** of the Swiss population (8.9 million) lived in urban centres (49 agglomerations)

- In 2018, **79%** of jobs in Switzerland (CHF 4.1 million) were located in urban areas

- Between 1950 and 2019, Switzerland's urban space increased from **5%** to **28%** of the land (ARE 2003)

- In urban areas, there are **517** cars per 1,000 inhabitants, compared to 612 in the rest of Switzerland

Climate Change and Challenges (CH)

Observed changes (as of 2019)

Sunshine
−15 % 1950–1980
+20 % since 1980

Heatwaves
more frequent and intense
since 1901

Heavy rainfall
12 % more intense
30 % more frequent
since 1901

Winter precipitation
+20 % to 30 % since 1864

+2°C
since 1864

Cold
up to −60 %
frost days
since 1961

Snow days
−50 % below 800 m
−20 % above 2000 m
since 1970

Zero-degree line
0 °C
+300 to 400 m
since 1961

Vegetation period
+2 to 4 weeks
since 1961

Glacier volume
−60 %
since 1850

(NCSS 2018 in FOEN et al., 2020, p.30)

Climate challenges (FOEN 2012)

- Accentuation of high **temperatures**
- Increasing summer **drought**
- Increased risk of **flooding**
- Increase in landslides
- Snowline Elevation
- Deterioration of air, soil, water quality
- Modification of natural environments
- Spread of pests

Urban Challenges of Climate Change

People living in Cities (World Bank 2010)
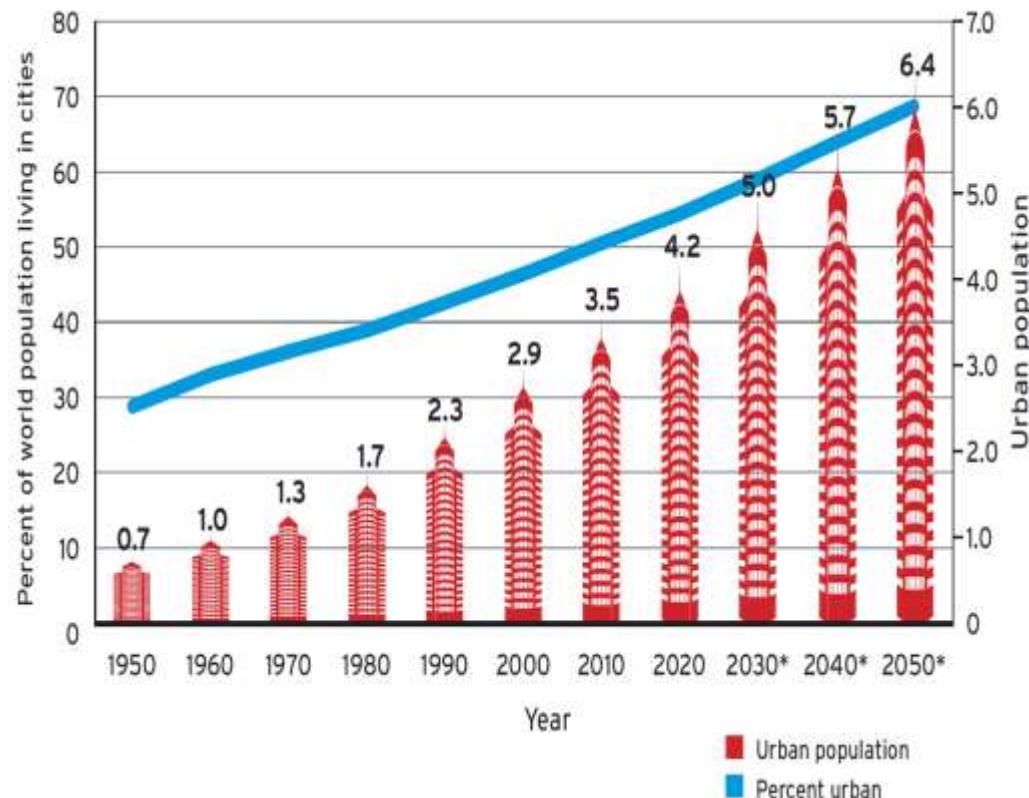
Issues and Challenges

- 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)

"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)

Ecosystem Services of "Green & Blue" Infrastructure

From "Natural Environment" TO "Green & Blue" Infrastructure

Environmental scien

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

GREEN INFRASTRUCTURE

Natural
Grasslands
Riparian areas
Forests
Fields
Wetlands

INTERCONNECTED
NATURAL SYSTEMS AND
ECOLOGICAL PROCESSES

Human-made
Street trees
Rain gardens
Green roofs
Porous pavement
Bioswales

Clean water, clean air,
wildlife habitat and higher quality of life

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

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

"Ecosystem services are the benefits people obtain from ecosystems" (MEA 2005)

- **Provisioning Services**
  Products obtained from ecosystems

- **Regulating Services**
  Benefits obtained from the regulation of ecosystem processes

- **Cultural Services**
  Nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences

- **Supporting Services**
  Are necessary for the production of all other ecosystem services

(MEA, 2005, p.40)

Source: Millennium Ecosystem Assessment

Millenium Ecosystem Assessment (2005, p.50)
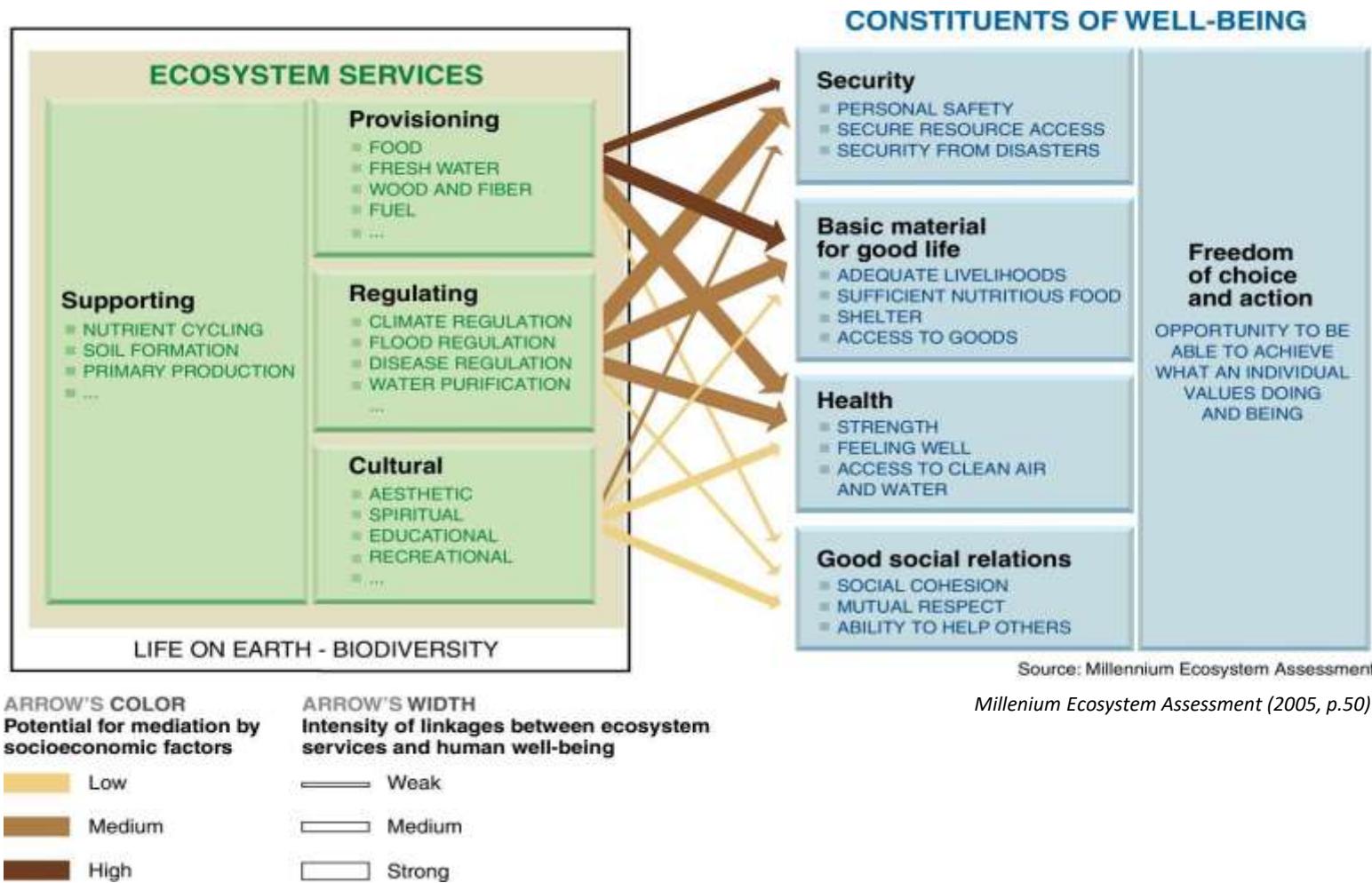
Urban Ecosystem Services provided by "Green & Blue" Infrastructure

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

PORTLAND GREEN STREETS

Figure 6-3
Community Boulevard with Median Bio-Filtering Swale

Green Streets
Innovative Solutions
for Stormwater and
Stream Crossings

2002 Green Streets: innovative solutions for stormwater and stream crossings, Metro Portland

Portland, OR, Metro 2002 (slide courtesy of Cynthia Griling, LARC 553, UBC, 2017)

Stormwater Management in Cities

Urban Road Networks (North Amercia)

~ 20% of the urban area

~ 50% of impermeable surfaces

~ 50% of runoff

~ 65% of pollutants in clear water

Portland OR Metro 2002

Slide courtesy of Cynthia Griling, LARC 553, UBC, 2017

Conventional Water Pollutants

Cadmium	Particulate matter
Copper	Dust & Soot
Organic	Herbicides Lead
Polycyclic	Aromatics Zinc
Hydrocarbons	Salt chlorides

OFEFP 2002

SW 12th Avenue Green Street (Portland/USA)

Street Stormwater Planters

- 4 bio-planters of 6.7 m2 (5.5m*1.8m*0.3m)

- Built in 2005 at a cost of ~ $38,850.

- Drainage area ~ 700 m2

- Limits peak flows **~80%** (T=25-years/6-h)

- Reduces annual runoff volume **~70%**

- Bio-depollutes surface water **~ 80%**

- Uses/Enhances residual road space

Portland Bureau of Environmental Services n.d. (slide courtesy of Cynthia Griling, LARC 553, UBC, 2017)
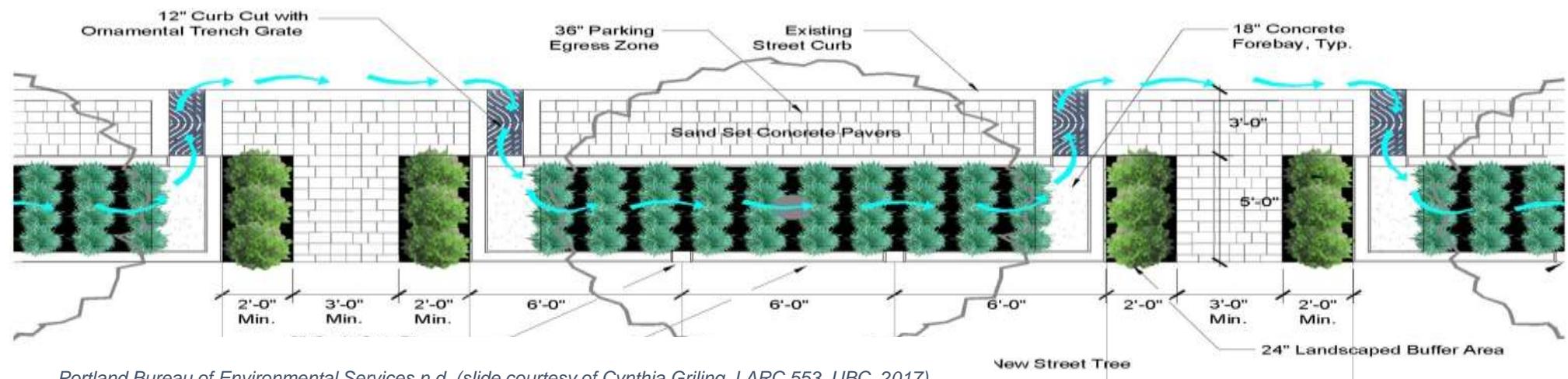
From "Storm" to "Rain" Water Management

PORTLAND GREEN STREETS

(Portland, OR, Metro 2002)
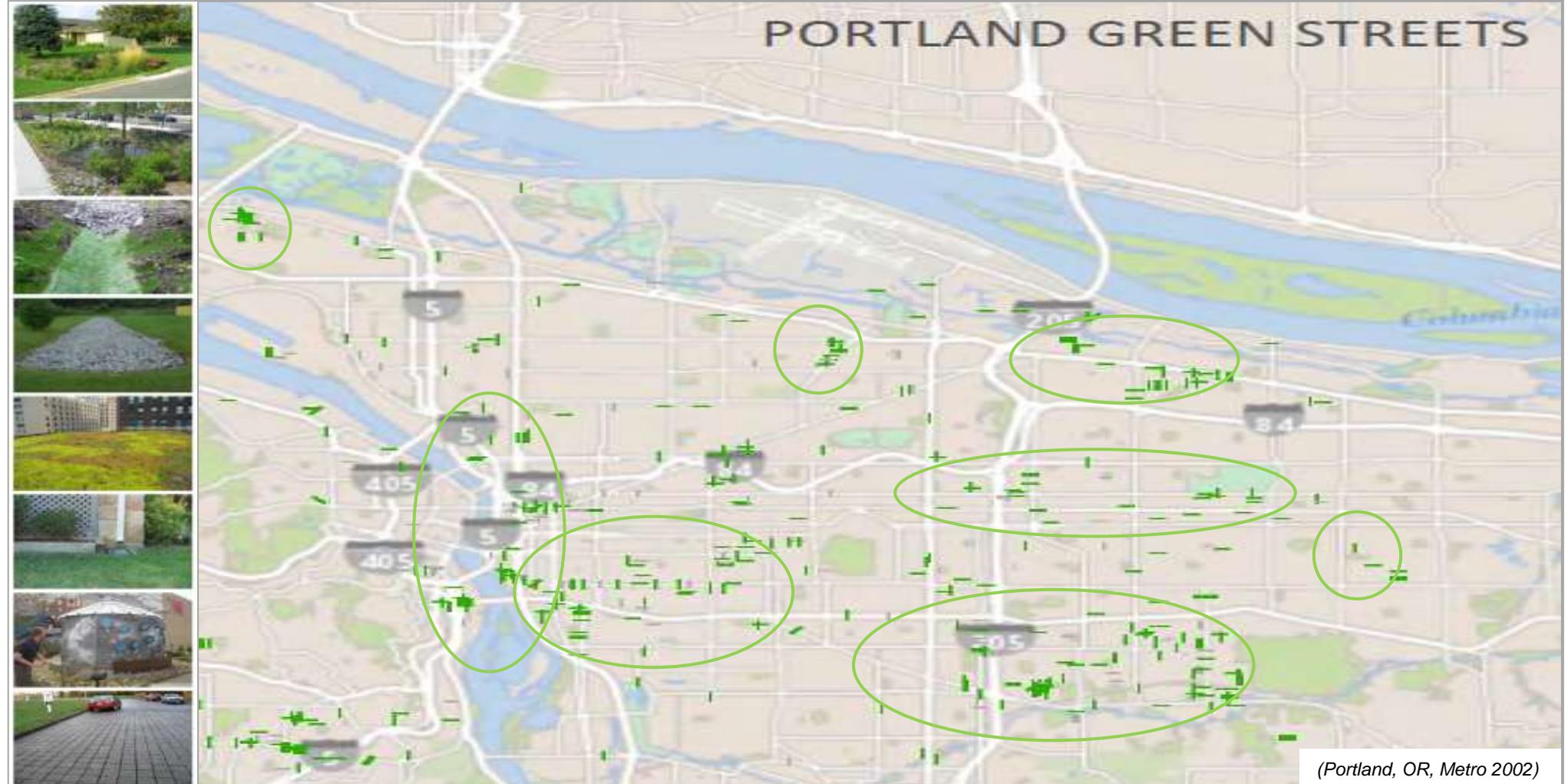
Cost/Benefit Ratio between "Traditional" and "Green & Blue" Infrastructure

Reducing Stormwater Costs through Low Impact Development Strategies and Practices (EPA 2007, p. 12)

Project	Conventional Development Cost	LID Cost	Cost Difference[b]	Percent Difference[b]
2nd Avenue SEA Street	$868,803	$651,548	$217,255	25%
Auburn Hills	$2,360,385	$1,598,989	$761,396	32%
Bellingham City Hall	$27,600	$5,600	$22,000	80%
Bellingham Bloedel Donovan Park	$52,800	$12,800	$40,000	76%
Gap Creek	$4,620,600	$3,942,100	$678,500	15%
Garden Valley	$324,400	$260,700	$63,700	20%
Kensington Estates	$765,700	$1,502,900	−$737,200	-96%
Laurel Springs	$1,654,021	$1,149,552	$504,469	30%
Mill Creek[c]	$12,510	$9,099	$3,411	27%
Prairie Glen	$1,004,848	$599,536	$405,312	40%
Somerset	$2,456,843	$1,671,461	$785,382	32%
Tellabs Corporate Campus	$3,162,160	$2,700,650	$461,510	15%

Portland Green Street Program 2002-2013

Storm Water Management Facility Monitoring Report 2013[1]

- Reduces **~ 90%** of peak flows (T=25-years/6-h)

- Absorbs **> 80%** of the annual flow volume

- Captures **> 90%** of pollutants in runoff water

- Reduces **~ 40%** costs compared to grey infrastructure[2]

- Utilizes and enhances residual and/or underutilized spaces

- Enhances safety for pedestrians and cyclists

- Increases green spaces and urban biodiversity

- Improves air quality and lowers temperature
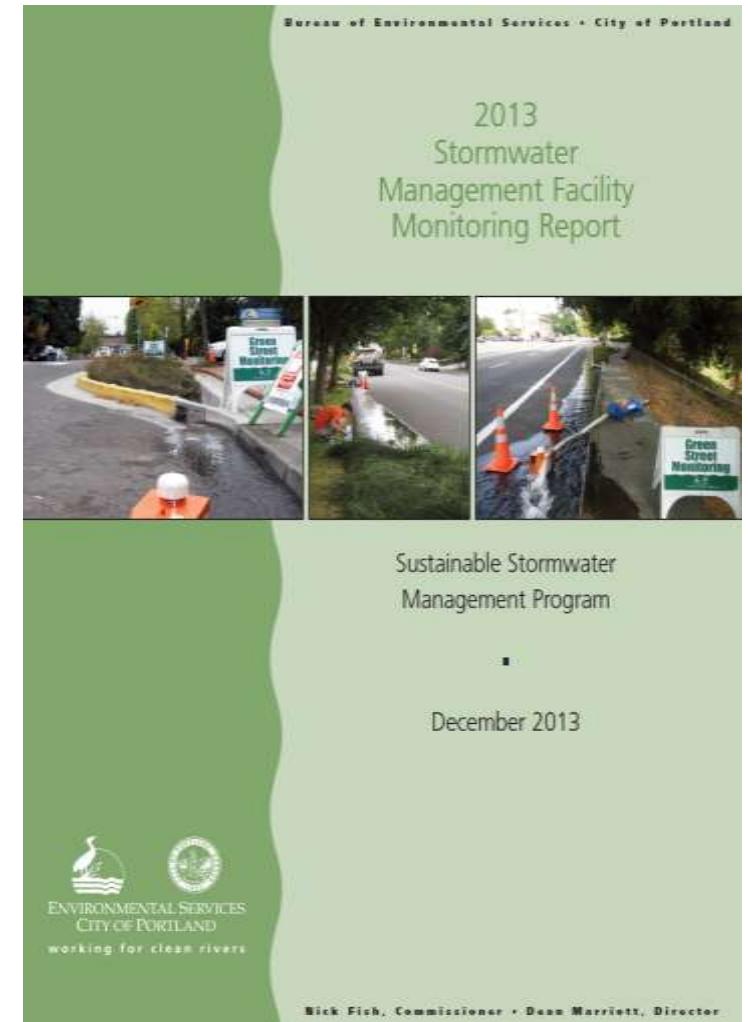
[1] Portland Bureau of Environmental Services (2013) [2] City Parks Alliance (www.cityparksalliance.org)

Urban Heat Island (UHI)

Principles

1. Urban temperature higher than in peri-urban and rural areas [1]

2. Accentuates daytime warming and reduces nighttime cooling [2]

Factors [2]

- Atmospheric and climatic conditions
- Anthropogenic heat production
- Urban and architectural morphology
- Thermal trapping and disturbed ventilation
- Increase in impervious surfaces
- **Reduction of permeable/green surfaces**
- Air pollution and the local greenhouse effect

[1] IPCC 2013, [2] OFEV 2018

Legend:
- Surface Temperature (Day)
- Air Temperature (Day)
- Surface Temperature (Night)
- Air Temperature (Night)

Temperature — DAY — NIGHT

Rural | Suburban | Pond | Warehouse or Industrial | Urban Residential | Downtown | Urban Residential | Park | Suburban | Rural
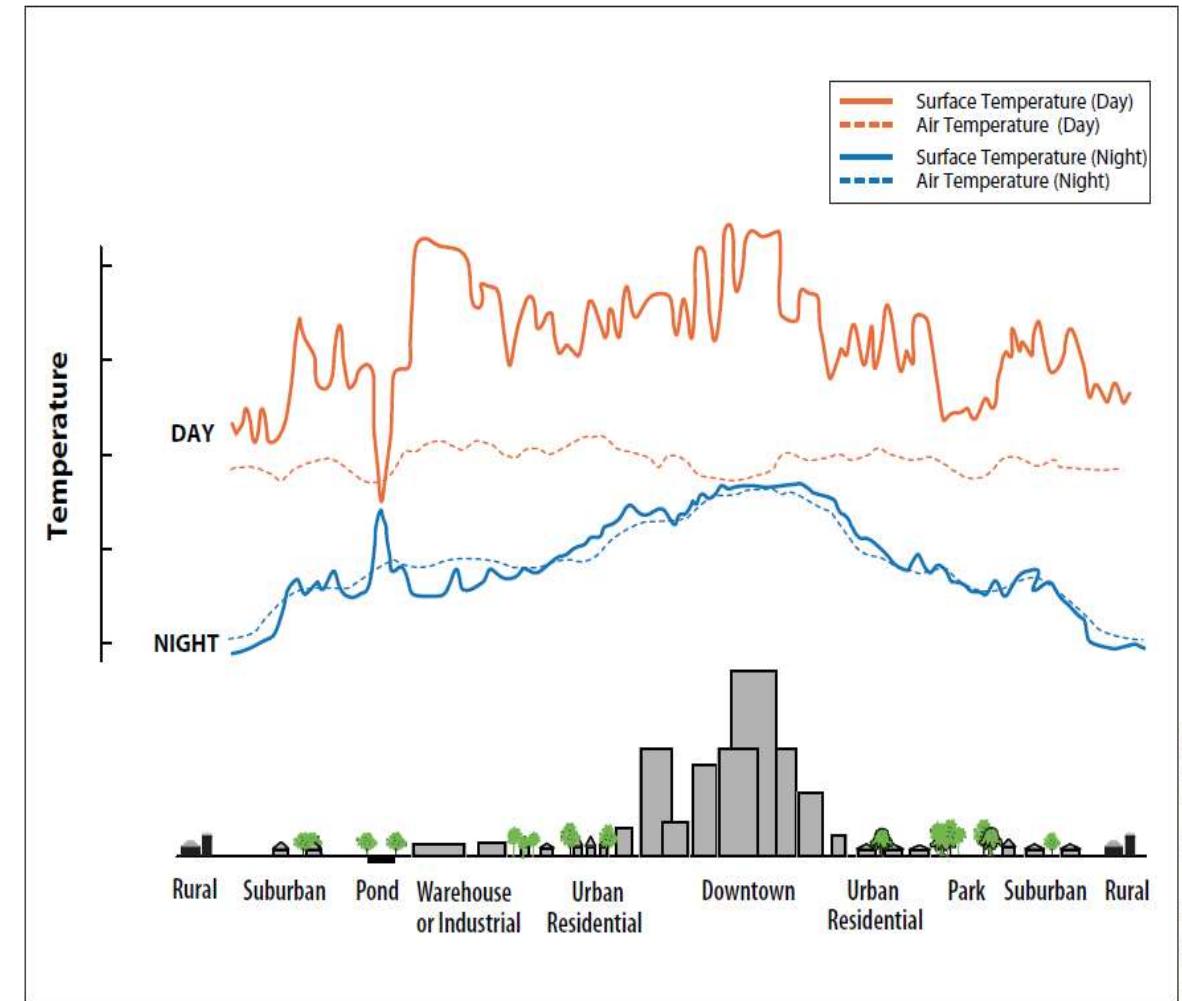
Modified from Voogt, 2000

EPA 2008 (p.4)

Microclimatic Effects of Tree Vegetation on Urban Temperature

Effects [1]

1. Reflection (albedo) and absorption (photosynthesis) of solar radiation

2. Decrease in floor temperature and ambient temperature (shading)

3. Reduction of sensible heat and air temperature (evapotranspiration)

Benefits [2]

- Moderation of room temperature and ICU

- Reduced energy requirements

- Reduction of greenhouse gases and air pollution

- Improving the quality of life in the city

- Population Health Benefits

[1] Gunawardena et al. 2017, [2] EPA 2008 et OFEV 2018
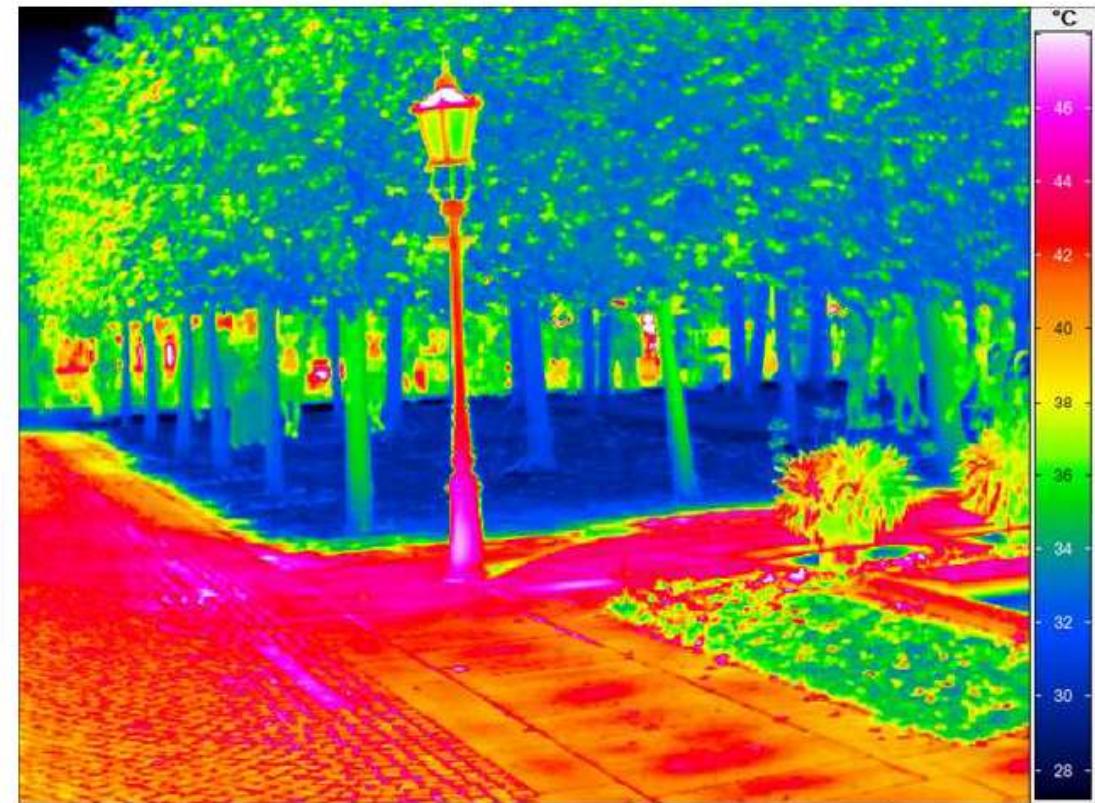
Cooling effects of street trees in Dresden, Germany, Summer 2013 (T_{min} 28° T_{max} 46° T_{Δ} 18°) courtesy of Gillner et al. (EFUF 2014 n.p.)

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)

Social

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

Physio-logical

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

Cognitive

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

Psycho-logical

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

Quick Talk...

Task

- Groupe of 3/4 people (along the row)

- 5 minutes discussion

- Sum up 3 key answers

- 1 speaker/group

Question

- Based on your first impression, discuss **what is happening in your mind/body** when you look at the picture on the left?

# Nature's Effects on Metabolism and Biomarkers of Stress
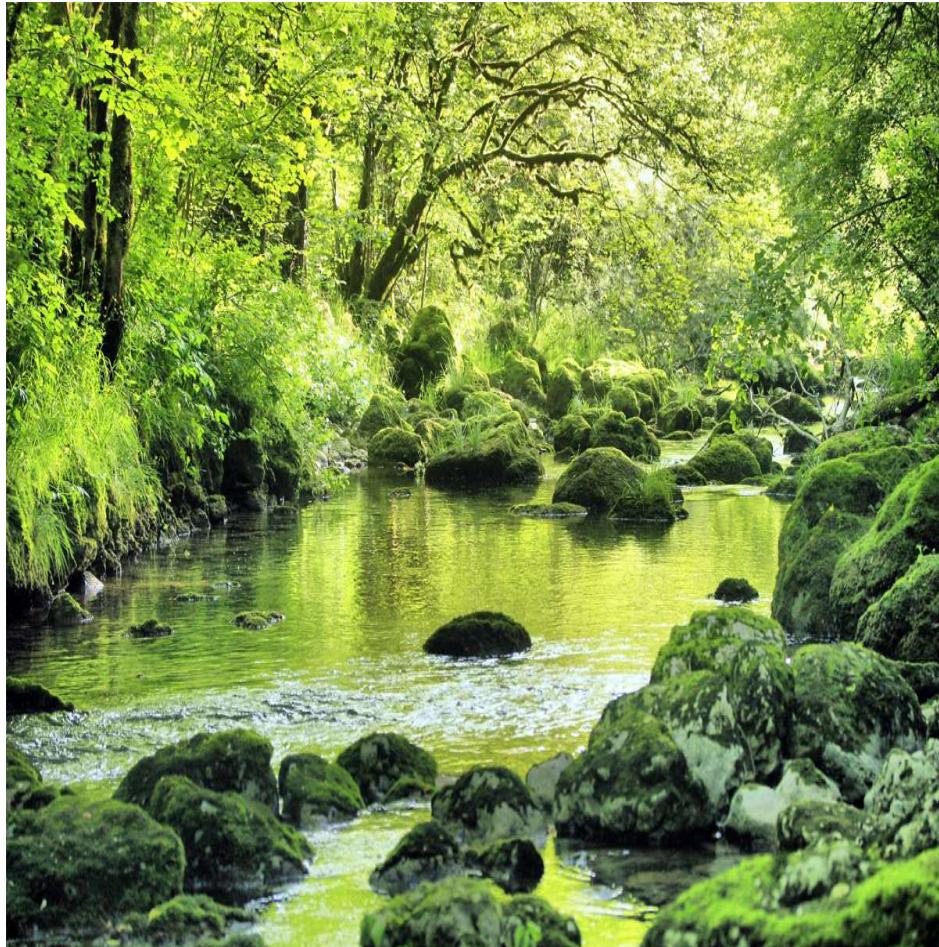
E.g. Change in salivary cortisol concentration and in pulse rate after forest walking and viewing (Bum Jin Park et al. 2009)


cortisol
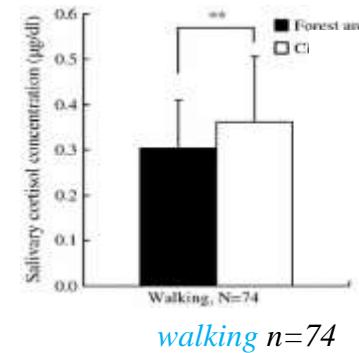
walking n=74
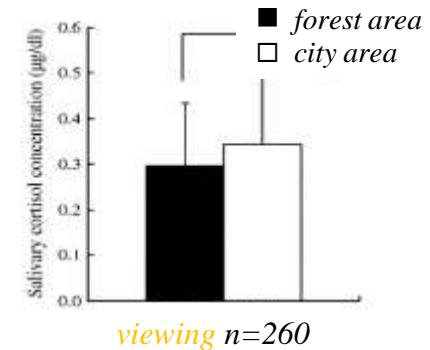
viewing n=260

pulse rate
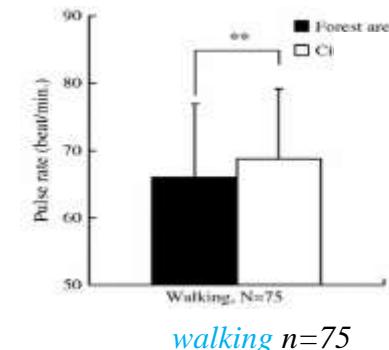
walking n=75
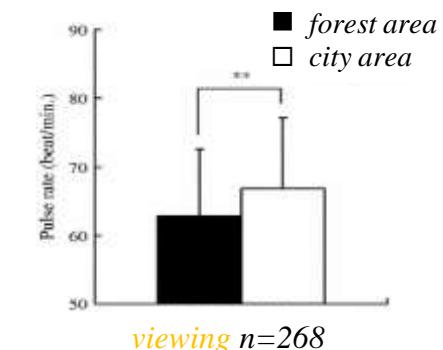
viewing n=268

Influences the Natural Environment on Health and Socio-Health Disparities

Effect of Exposure to Natural Environment on Health Inequalities (Mitchell and Popham 2008)
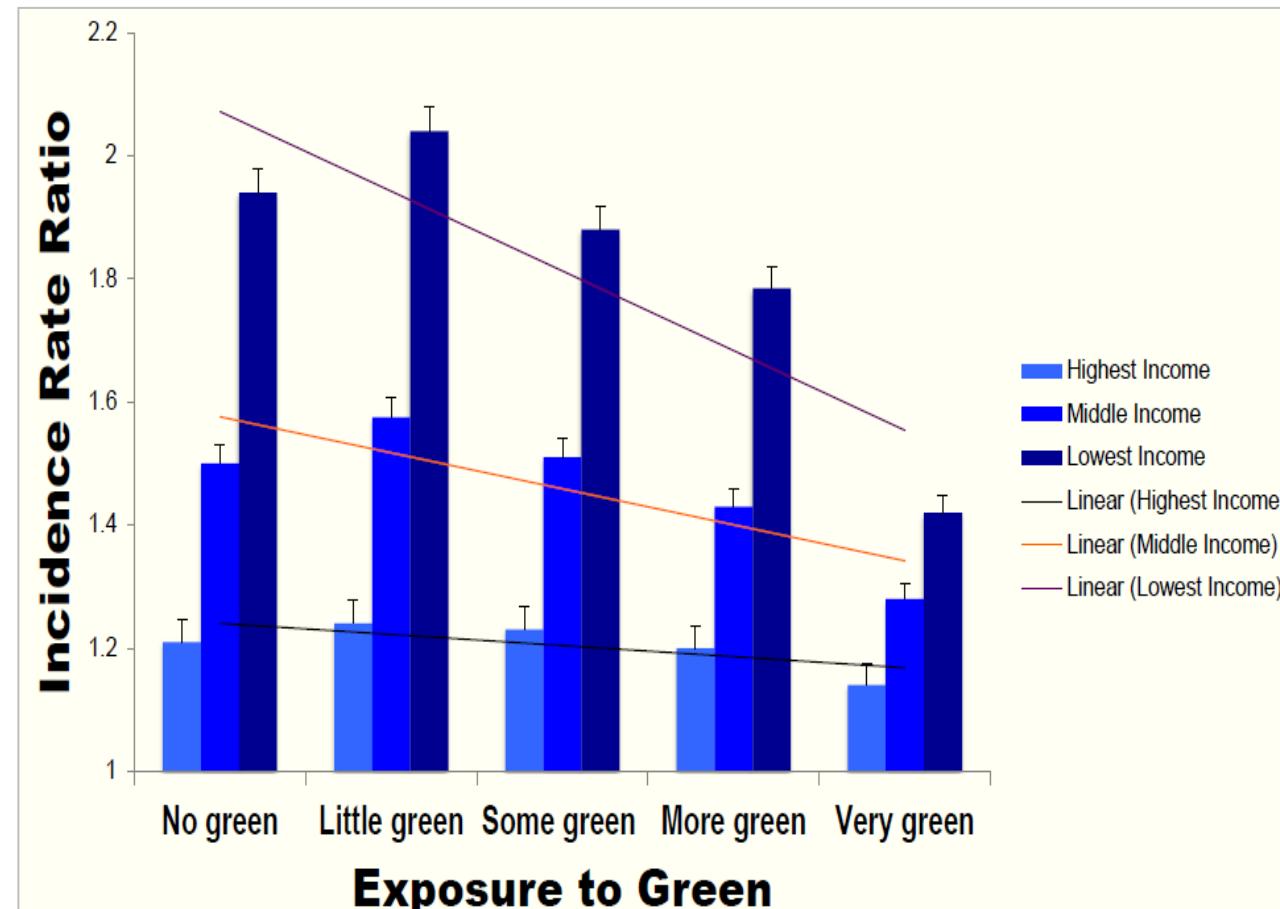
Rates and causes of death of the English working population over the period 2001-2005 (n = 40,813,236)

Mortality from all causes and circulatory disease:

1. Significant variation between socio-economic disparities and mortality rate

2. Significant variation between exposure to a natural environment and mortality rate

3. Significant correlation between socio-health disparities and exposure to the natural environment

Effects of Nature on Cognitive and Productive Functions and Performance

"Significant **learning improvement** were found in classes with plants with increases of 10 to 14%"
(Daly et al. 2010, p.4)
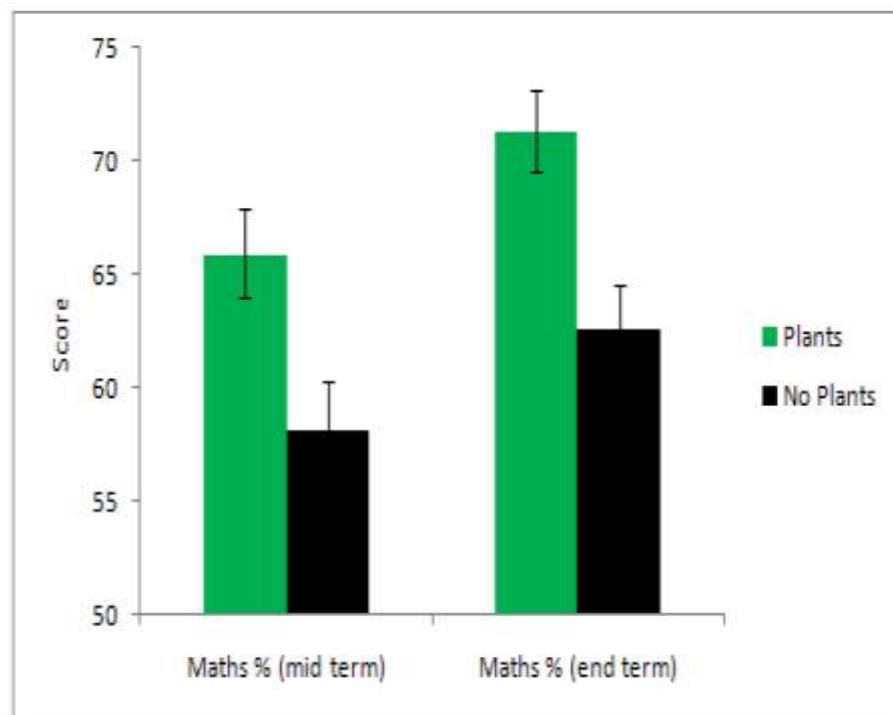
"Enriching a previously spartan space with plants served to **increase productivity** by 15%"
(Nieuwenhuis et al. 2014, p.11)

[n=360 year 6-7 students]
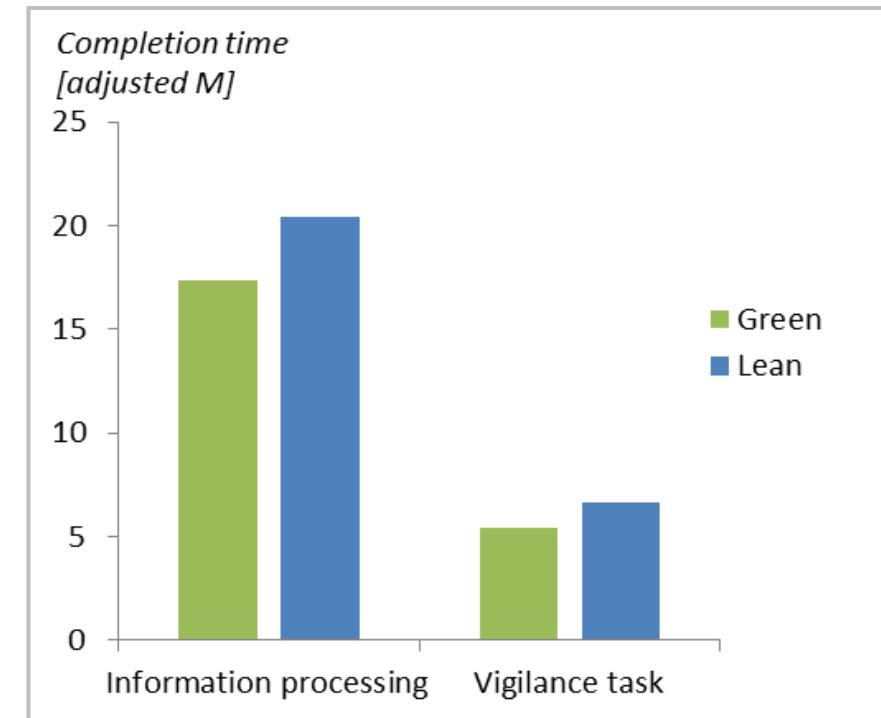

[n= 24 employees]

Influence of Urban Green Spaces on Social cohesion and Public Safety

The role of public green space for **social inclusion** of youths from different cultures

(Seeland 2008, p.13)

[1] **Park, playground**
[2] Cinema, discotheque
[3] Sports events
[4] Holidays abroad
[5] Courses, camps

[6] Friends, neighbours
[7] In public buildings
[8] Internet
[9] Other
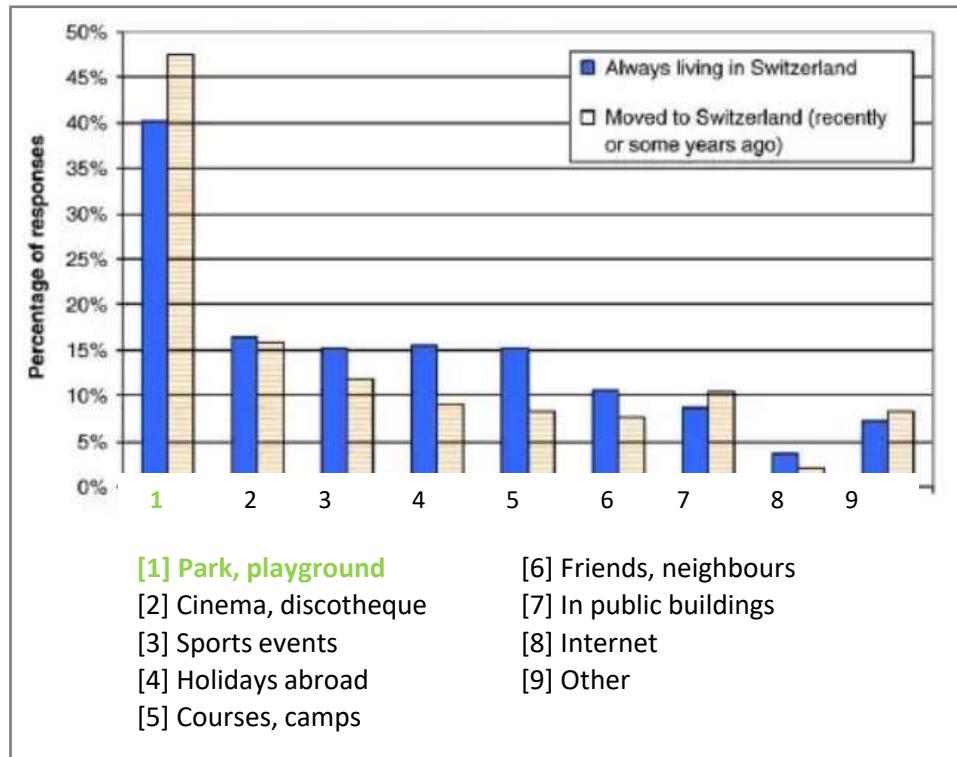
[n=437]

Environment and crime in the inner city:

Does vegetation reduce Crime ?

(Kuo et al. 2009, p. 35)
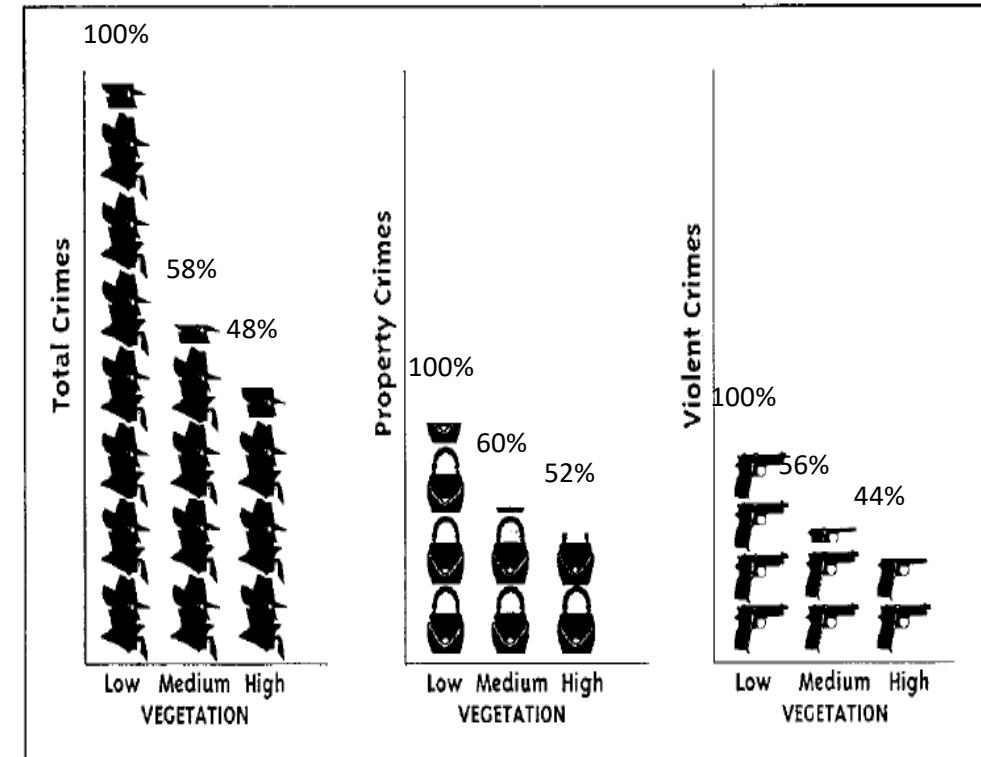
# Economic and financial values of "green & blue" infrastructure

The benefits of green infrastructure
Estimates based on the 2010 NYC Green Infrastructure Plan

ANNUAL SAVINGS
per one hectare of GI

ONE HECTARE
of fully vegetated
green infrastructure

$21,049 in reduced energy demand

$410 in reduced CO_2 emissions

$2,579 in improved air quality

$11,671 in increased property value
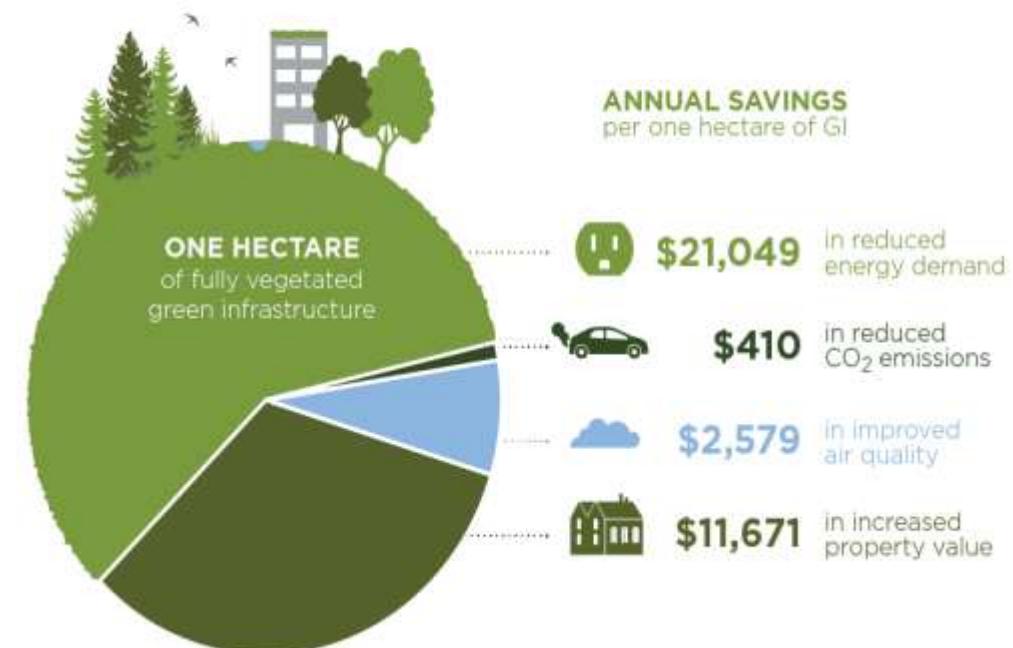
Metro Vancouver n.d. p.12

Outside our Doors: The benefits of cities where people and nature thrive (House et al., 2016)

➢ Predisposition to individual purchase increases by **9 to 12%** in commercial areas with rich trees
(Joye et al. 2010)

➢ Real estate value of residential property near park or green space can increase by up to **20%**
(Donovan et al. 2010)

➢ Workplace considered up to **33%** more attractive depending on the quality of the natural environment
(Sears 1998)

➢ Setting up companies favors the presence of green spaces and outdoor leisure areas
(Crompton 2007)

Influence of Urban Development on Nature, Landscape and Biodiversity (1)

On average, the number of species in urbanized areas is much higher than in agricultural or forestry areas (FOEN 2023, p.73)
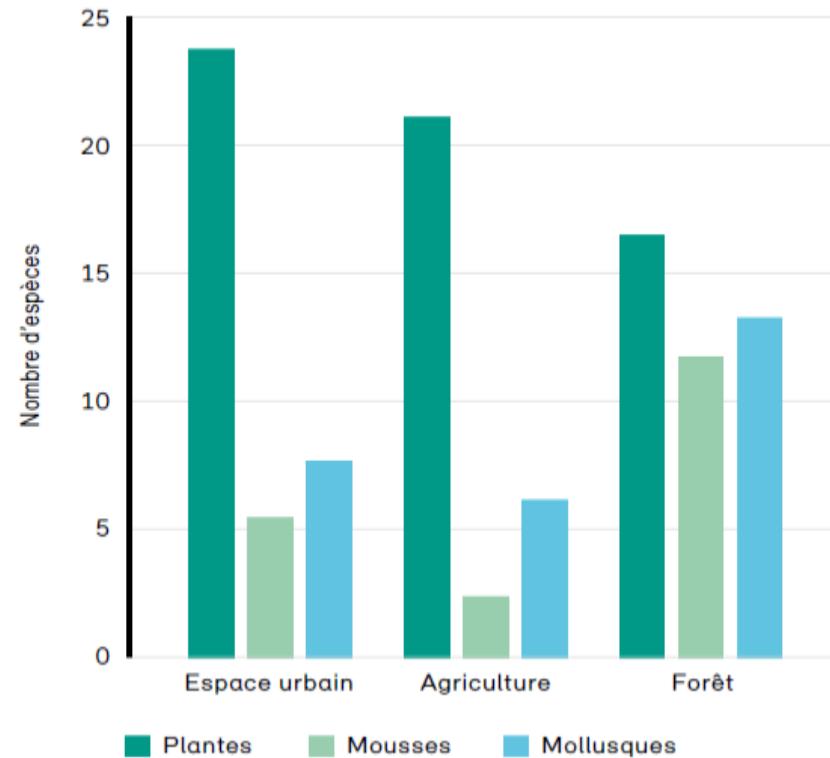
Study of urban biodiversity [S=10ha]
(Clergeau, 2020, p.39)
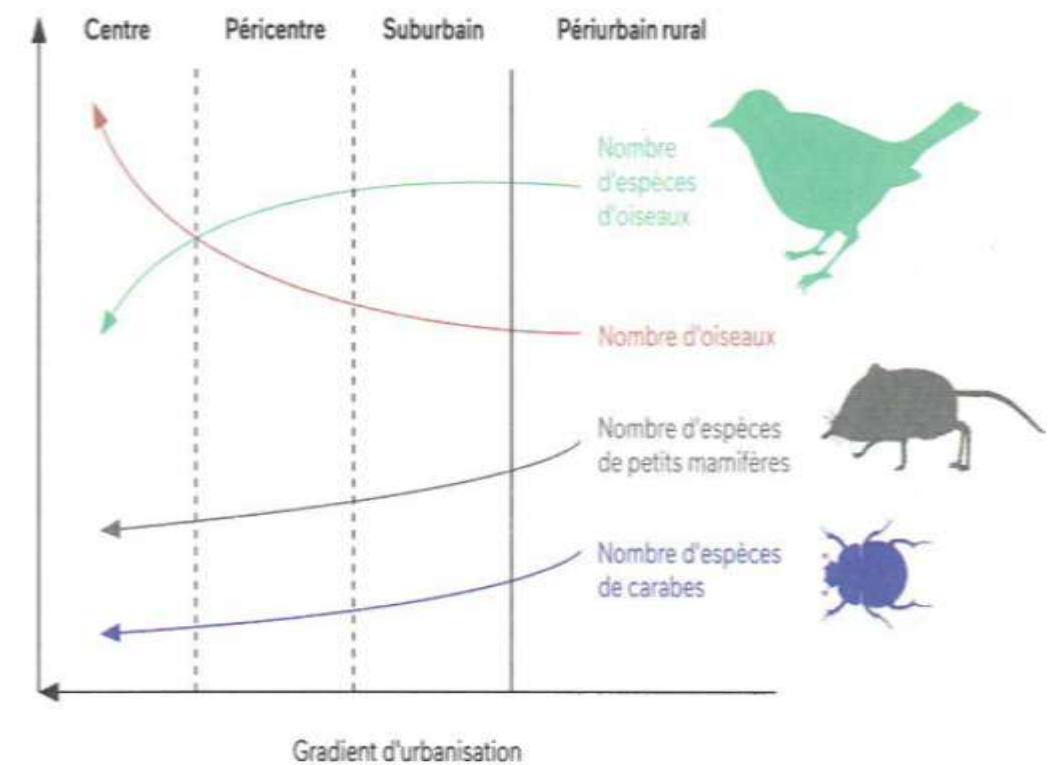
# Influence of Urban Development on Nature, Landscape and Biodiversity (2)

Share of Threatened Habitats (CR, EN, VU) on the Red List by Ecosystem (OFEV, 2023, p. 10)
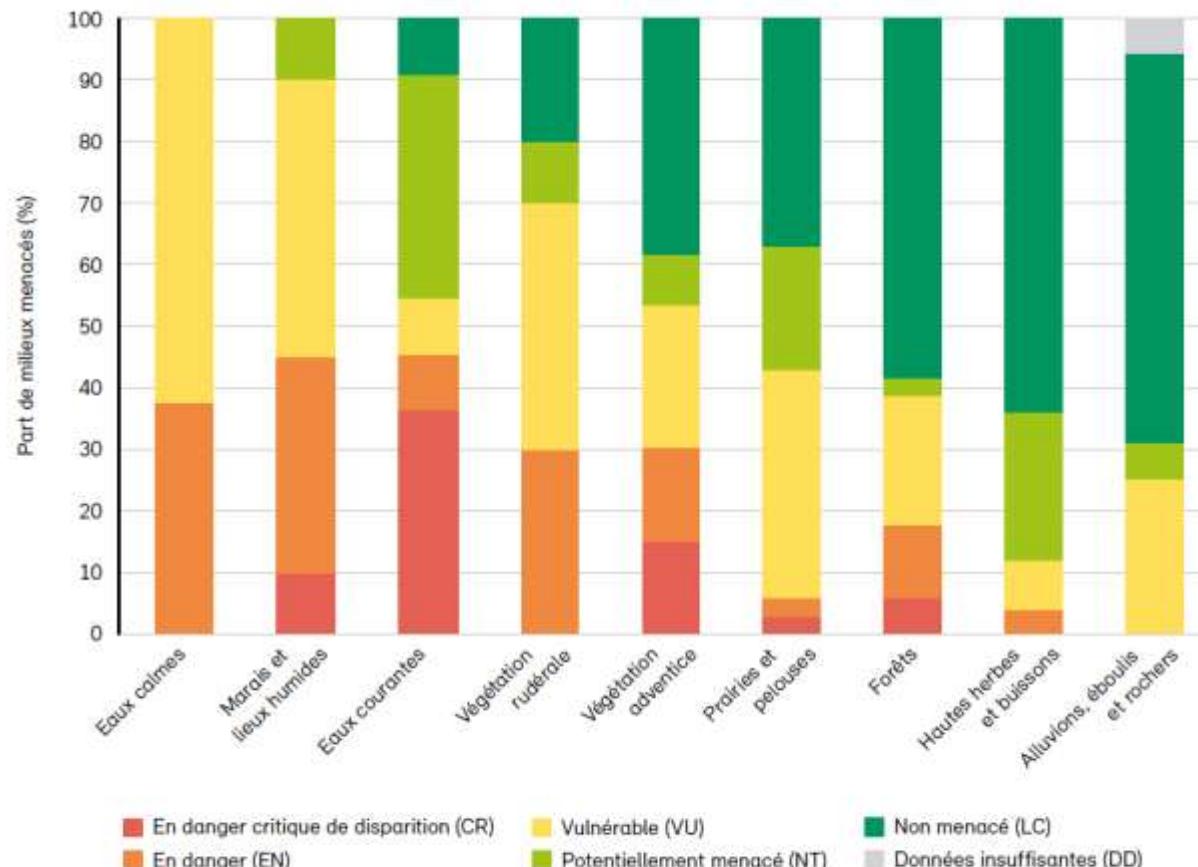
- Reduction of natural and open areas

- Fragmentation/fragmentation of natural environments

- Waterproofing (floors, walls and roofs)

- Intensive maintenance of green/open spaces

- Monotony of landscaping

- Neophytes and invasive species

- Air pollution and light emissions

- etc.

(FOEN 2023)

Conserving - Strengthening - Connecting
Ecological Reservoirs, Corridors & Networks!

Schéma tiré de Cottebrune 2018

Is there still room for nature in the cities of tomorrow?!?