City Trees: New Geographies of Urban Livability

2013 Urban Forestry Institute

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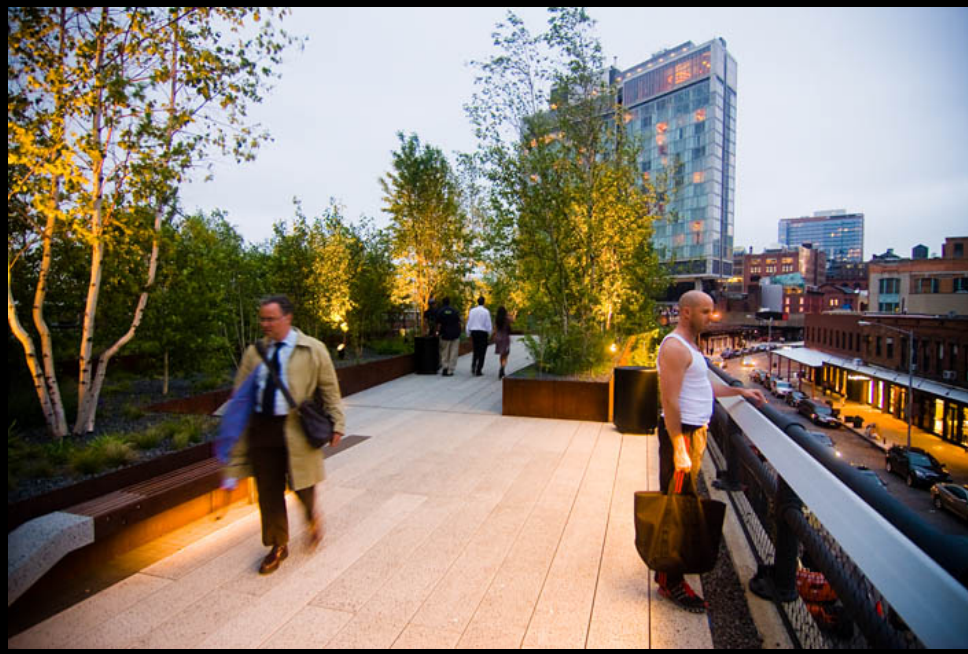
University of Arkansas Community Design Center

The Green City is a model
for the world today…

…as retrofit of metropolitan infrastructure



…in new urban garden formats

…as architectural cladding systems, or skins

…as vertical gardens

…as sky lobbies

…as roof gardens

…as town-making fabrics

A6
Amsterdam
Schiphol
Almere Floriade
P Floriade
Almere Haven

“Ecology as a science is based on the negation of all things natural. It makes nature into a constituent element of an interrelationship with urban production. This marks the end of nature as an indeterminate field on its own. Now it has to be translated in terms of resources and their exploitation, and ecology…”

Frederic Migayrou

Therefore...the greatest ongoing challenge to planning is design within human-dominated ecosystems.

Key functions of trees in city making:

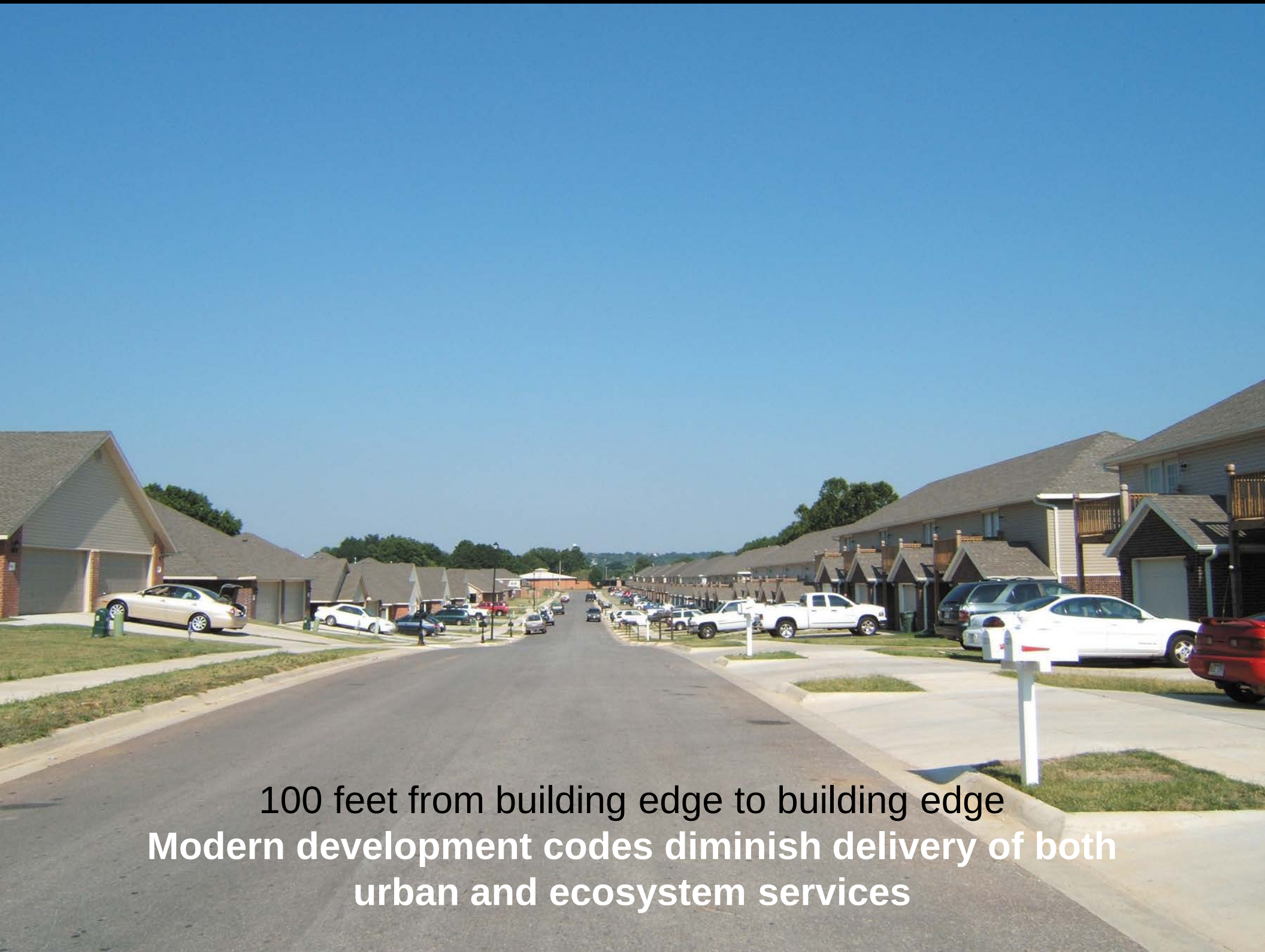
- Complete Streets
- low impact development
- edible civic landscapes

Complete Streets

- Tree longevity
- Non-traffic social functions
- Urban livability

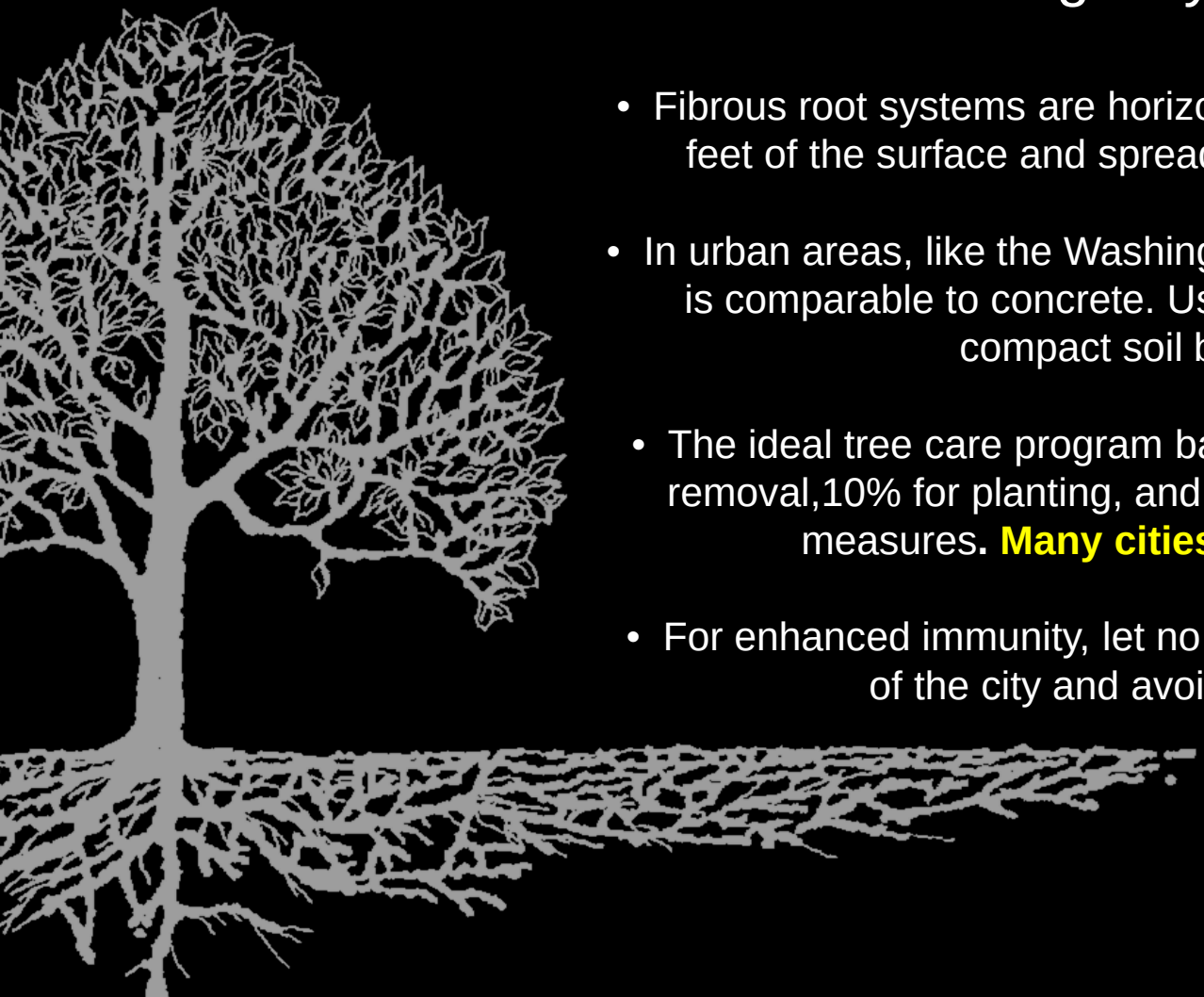
150 feet from building edge to building edge

The average life span of a contemporary urban tree is 13 years.



100 feet from building edge to building edge

Modern development codes diminish delivery of both urban and ecosystem services



For longevity, consider that:

- Fibrous root systems are horizontal as 90% of roots are within three feet of the surface and spread 2-4 times the height of the tree.

- In urban areas, like the Washington DC Mall for instance, soil density is comparable to concrete. Use geotextile cloth to limit need to compact soil beneath sidewalk.

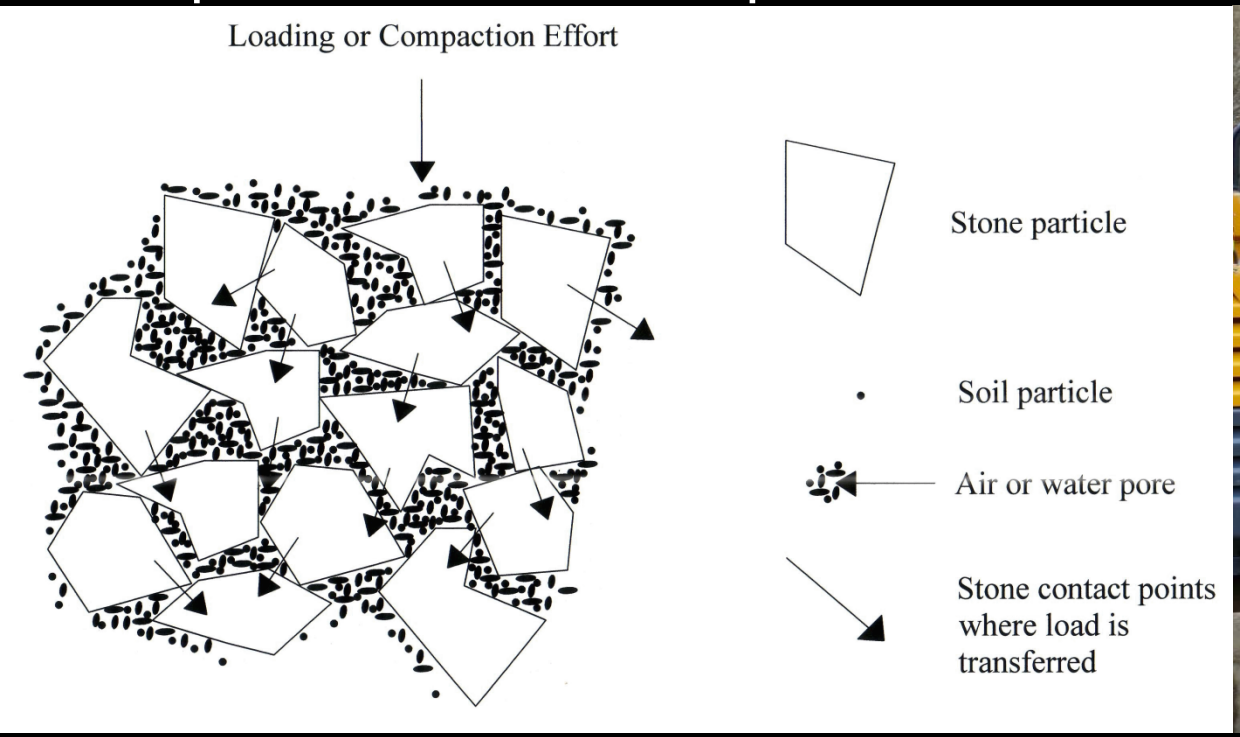
- The ideal tree care program balance is: 40% for trimming, 14% for removal,10% for planting, and remainder for other maintenance measures**. Many cities spend 80% on removal.**

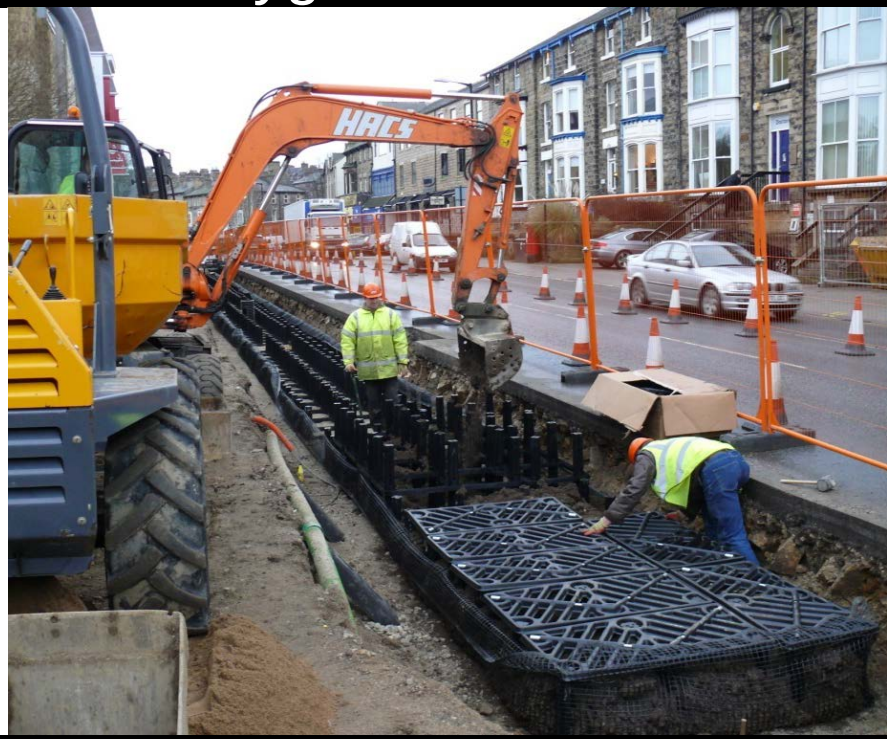
- For enhanced immunity, let no one species occupy more than 10% of the city and avoid monolithic tree rows.

In Portland, trees and stormwater management have priority as constituent elements in the city's development regulations.

While street trees were always important to Portland, the old model lacked best installation practices to sustain their longevity.

the problem of soil compaction and lack of soil oxygen and nutrients





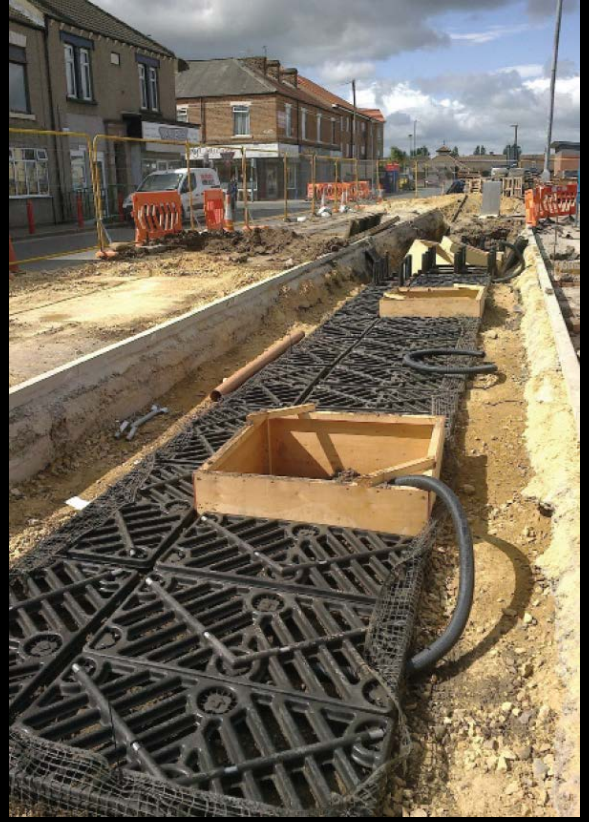
Structural Soil—CU Specification

Provide minimum 40% porosity beneath hard surfaces with light or stationary loading.

Structural Cells

For applications beneath hard surfaces with heavy and moving traffic.

premier-meats.
" A Different Class



Since rail transit requires walkable neighborhoods, transit malls incorporate trees.

Main streets, which typically lacked landscaping to maximize shopping productivity, have been retrofitted as Complete Streets with trees in their revitalization.

16th Street Mall: Denver

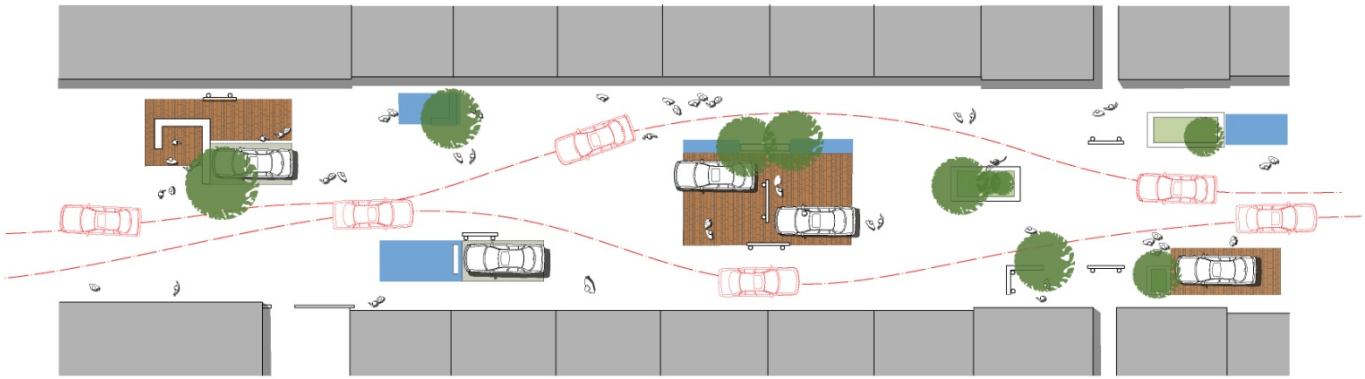
Trees set the stage for social life in streets, so that streets, once again, may deliver non-traffic services.

Strategic use of street trees to define private, semi-private, and public territories in dense, urban contexts. Green streets are essential to urban neighborhood reinvestment.

The Dutch shared street is designed first as a series of pedestrian gardens, privileging the social dimension of the street over trafficking.

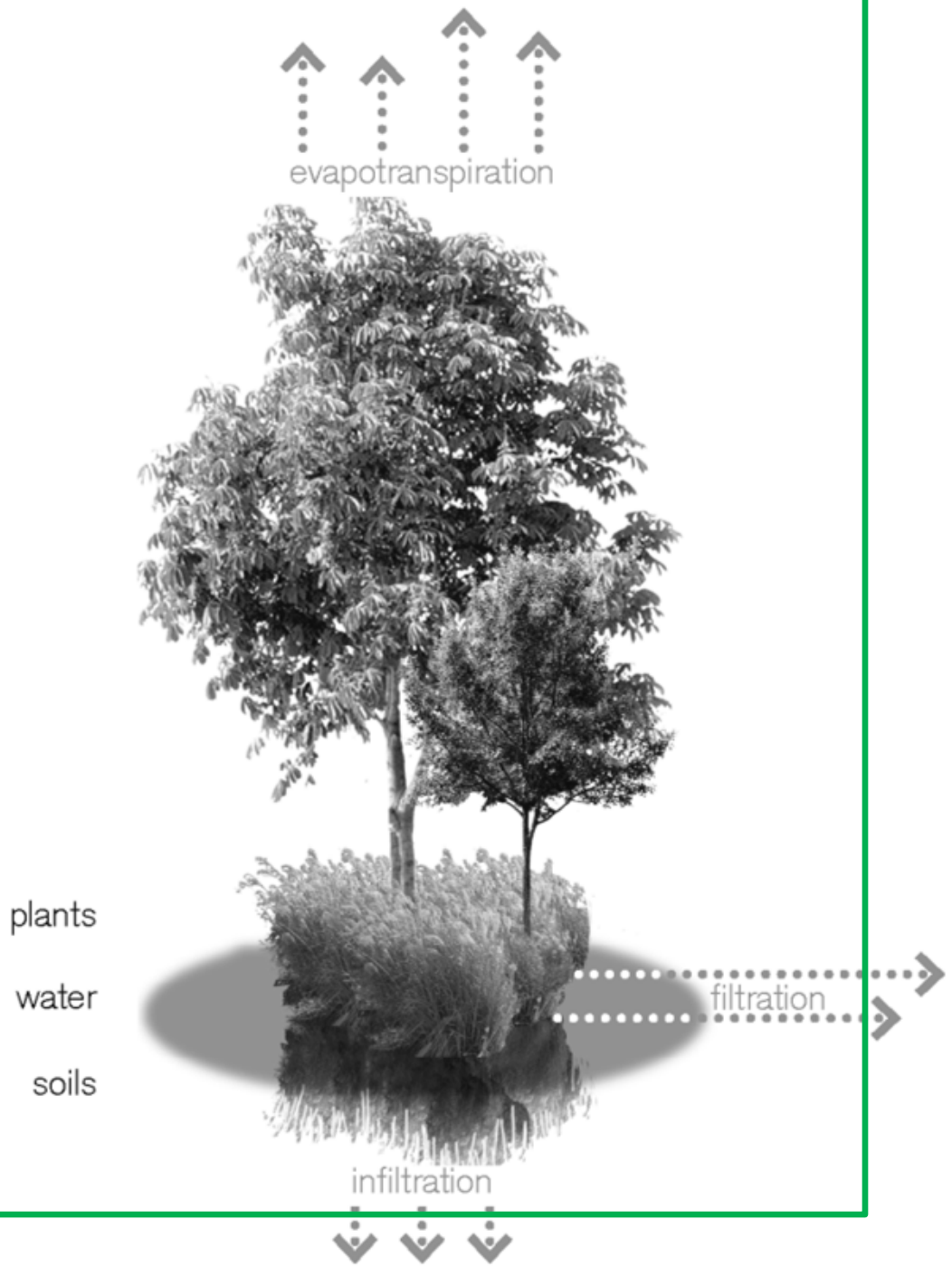
GREEN AND SHARED STREET DESIGN

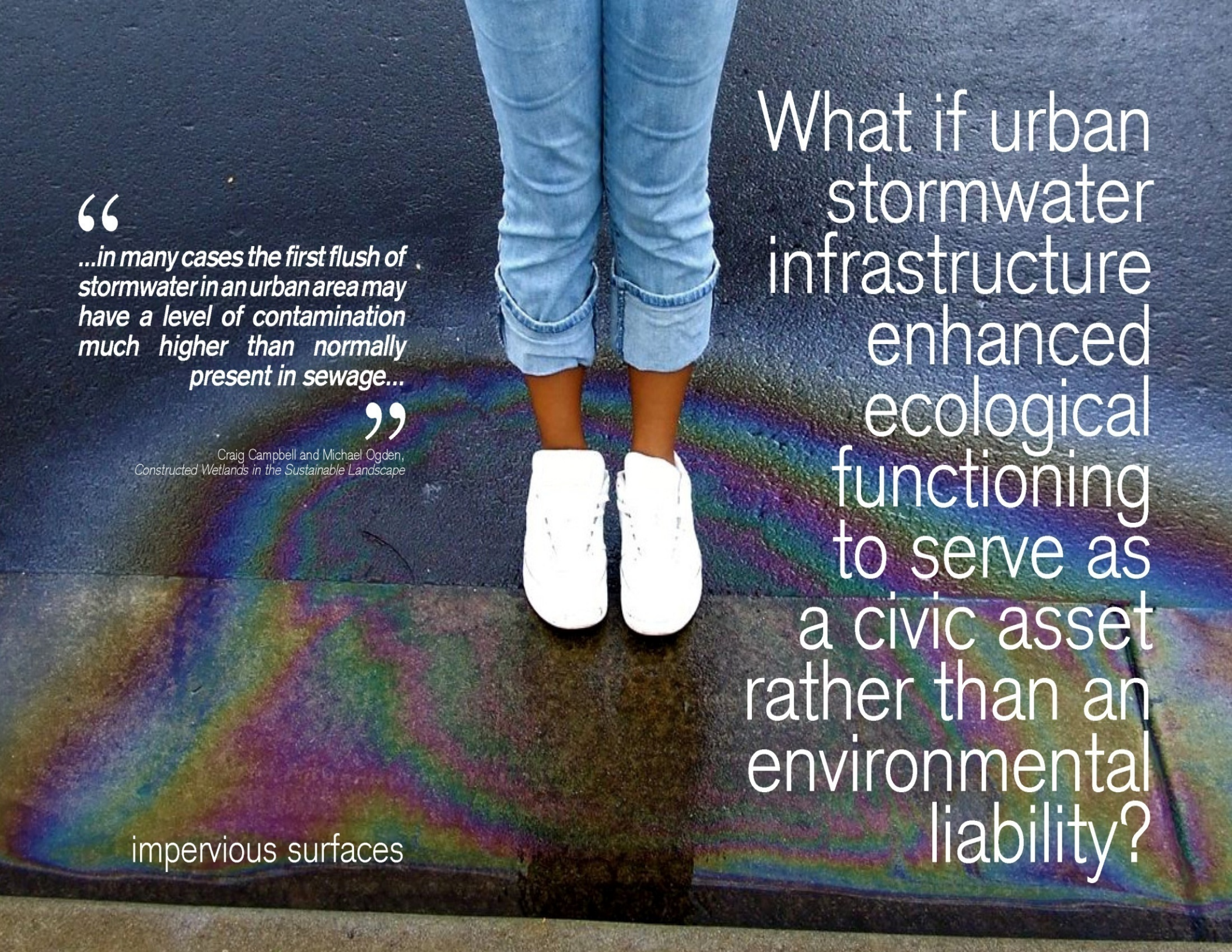
Green streets and shared streets are streets designed as gardens that balance the needs of pedestrians, transit, and stormwater management.



Low Impact Development

- Ecological services
  - Parks, not pipes!
  - Phytoremediation



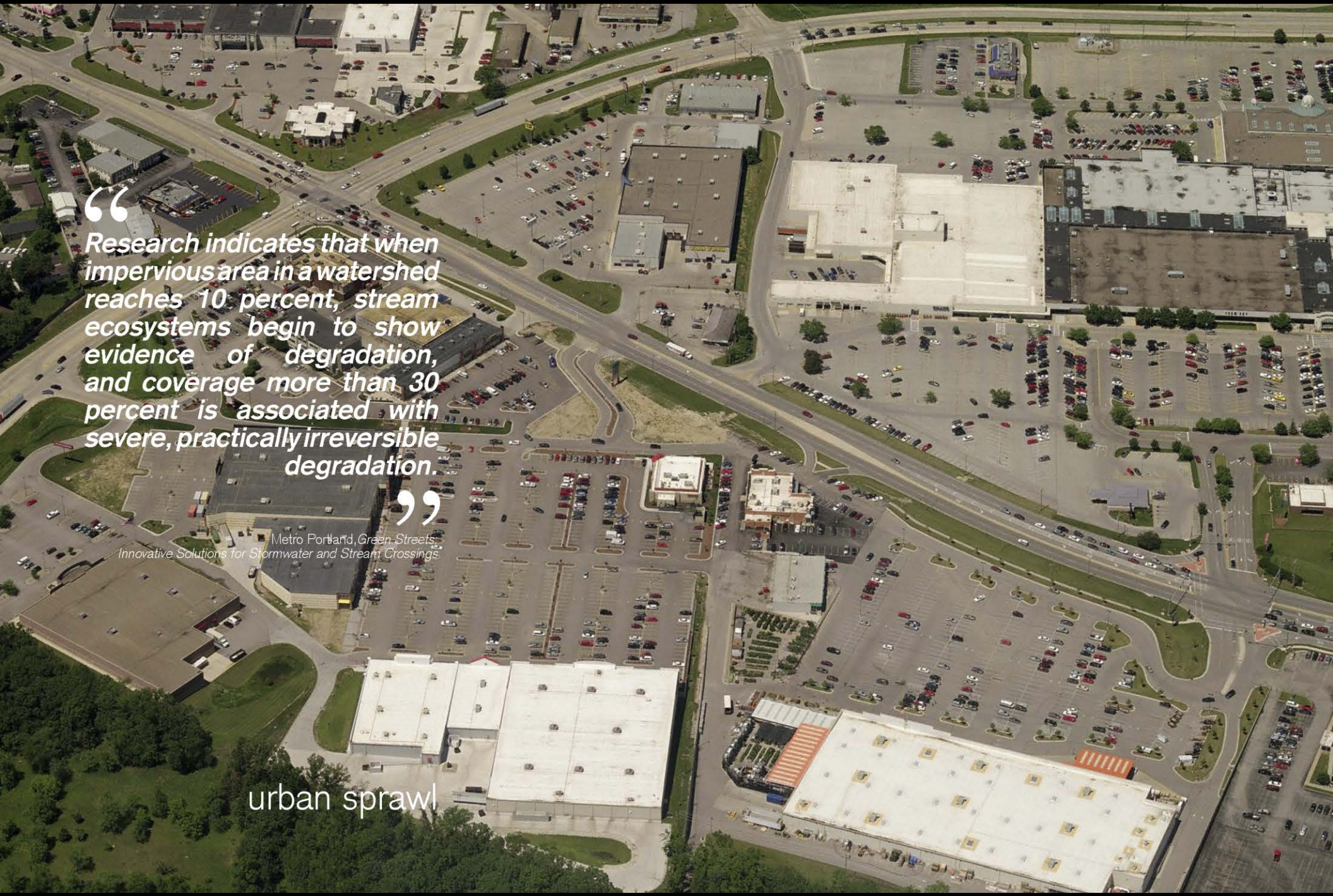


“...in many cases the first flush of stormwater in an urban area may have a level of contamination much higher than normally present in sewage...”

Craig Campbell and Michael Ogden,
Constructed Wetlands in the Sustainable Landscape

impervious surfaces

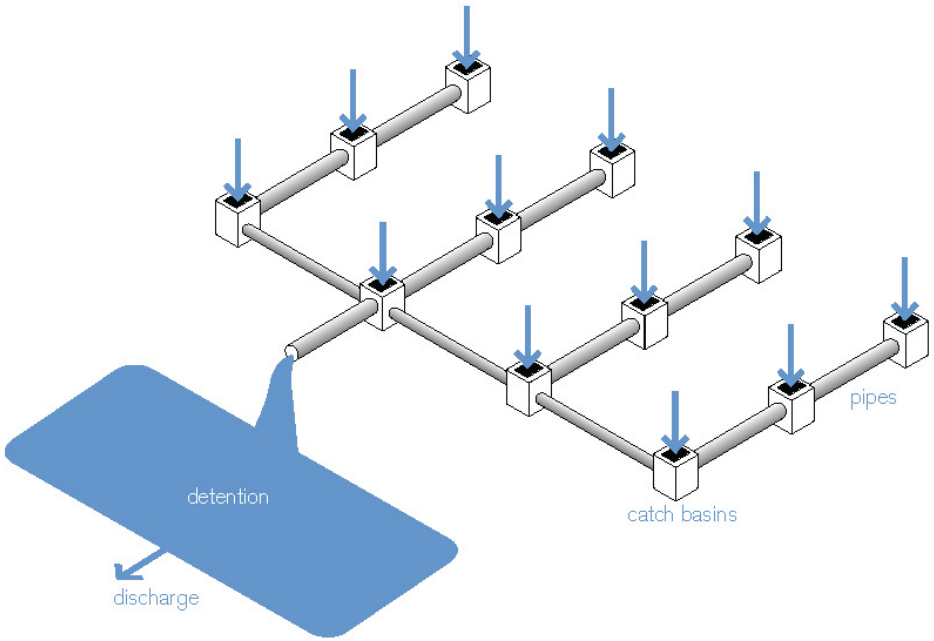
What if urban stormwater infrastructure enhanced ecological functioning to serve as a civic asset rather than an environmental liability?


“Research indicates that when impervious area in a watershed reaches 10 percent, stream ecosystems begin to show evidence of degradation, and coverage more than 30 percent is associated with severe, practically irreversible degradation.”
Metro Portland, *Green Streets: Innovative Solutions for Stormwater and Stream Crossings*
urban sprawl

“Lawns use more equipment, labor, fuel, and agricultural toxins than industrial farming, making lawns the largest agricultural sector in the United States.”
Richard Burdick, “The Biology of Lawns”, *Discover*, July 2003
industrial landscapes

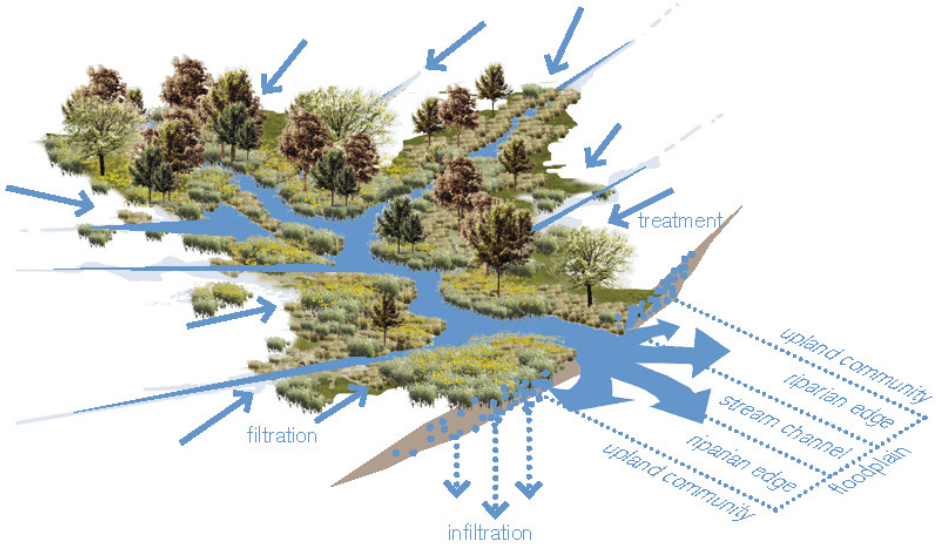
What Low Impact Development (LID) does is make hard engineering...
work more like soft engineering.
offering the 17 ecosystem services
1. atmospheric regulation
2. climate regulation
3. disturbance regulation
4. water regulation
5. water supply
6. erosion control and sediment retention
7. soil formation
8. nutrient cycling
9. waste treatment
10. pollination
11. species control
12. refugia/habitat
13. food production
14. raw material production
15. genetic resources
16. recreation
17. cultural enrichment

hard engineering
...just transfers pollution to another site



conventional management: "pipe-and-pond" infrastructure
drain, direct, dispatch

soft engineering
...metabolizes pollutants on site—parks, not pipes!



low impact management: watershed approach
slow, spread, soak

hard engineering

A catch basin is a part of the stormwater management system that is designed to trap debris and sediment so it cannot enter the drainage pipes.

catch basin

polluted runoff

polluted runoff

pollutants:
bacteria
oil
sediment
heavy metals
fertilizer

output

input

soft engineering

phytoremediation

Phytoremediation is the treatment of polluted soil, water, or air using the properties or processes of plants to breakdown or remove contaminants.

absorbed as nutrients

phytovolatization:
Phytovolatization is the release of organic compounds into the air after conaminants have been broken down.

polluted runoff

uptake

phytoextraction:
Phytoextraction is the uptake of contaminants from the environment into plant roots and movement from the roots to the plant.

root storage

biochemical breakdown

phytodegradation:
Phytodegradation is the metabolic process within a plant that breaks down and removes contaminants from the environment.

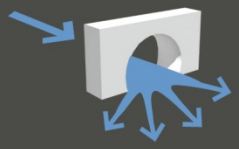
phytostabilization:
Phytostabilization is the immobilization of contaminants in the soil through adsorption and accumulation in roots.

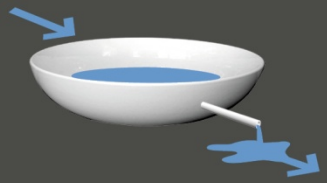
integrating hard engineering...

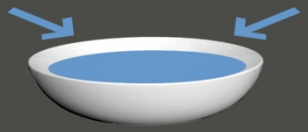
and soft engineering
toward a LID approach

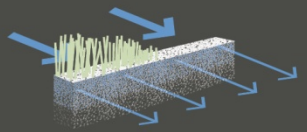
mechanical

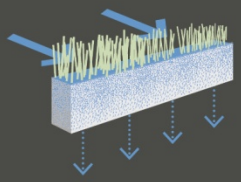
biological

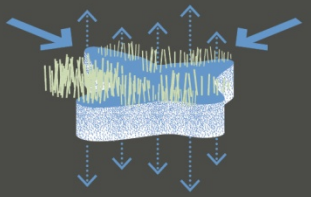

flow control


detention


retention


filtration


infiltration


treatment

slow → spread → soak

flow control: devices used to regulate concentrated water loads, attenuating energy flow and volume.

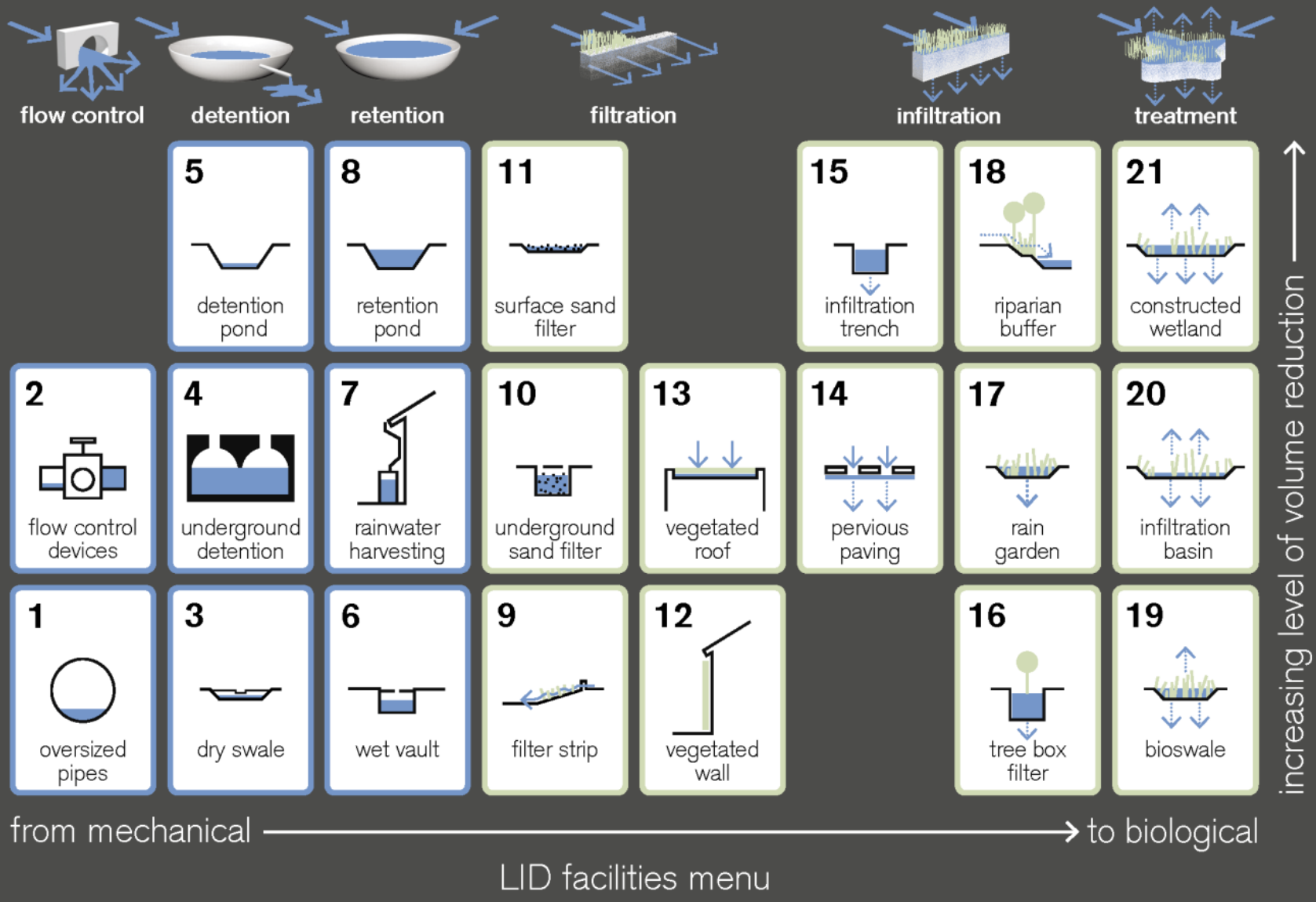
detention: facilities designed to intercept a volume of stormwater runoff and temporarily hold the water for gradual release, within a 24 hour period.

retention: facilities that retain a permanent pool of water, allowing for minor water quality improvement through the settling out of sediment.

filtration: processes that remove solids from stormwater through a porous media, such as sand, vegetation, or a man-made filter.

infiltration: processes in which surface water moves through soil, recharging groundwater and aquifers.

treatment: processes that metabolize pollutants from stormwater runoff.


flow control
detention
retention
filtration
infiltration
treatment
1
oversized pipes
2
flow control devices
3
dry swale
4
underground detention
5
detention pond
6
wet vault
7
rainwater harvesting
8
retention pond
9
filter strip
10
underground sand filter
11
surface sand filter
12
vegetated wall
13
vegetated roof
14
pervious paving
15
infiltration trench
16
tree box filter
17
rain garden
18
riparian buffer
19
bioswale
20
infiltration basin
21
constructed wetland
increasing level of volume reduction
from mechanical
to biological
LID facilities menu

optimal level of service
filtration or infiltration
(depends on which system is used)

location in LID network
upstream of major treatment systems,
and in place of street trees
(not in swales or other filter devices)

scale
a single tree box to a
large urban tree box network

management regime
occasional removal of trash and raking
of surface to maintain permeability;
replacement of tree after seven years

16

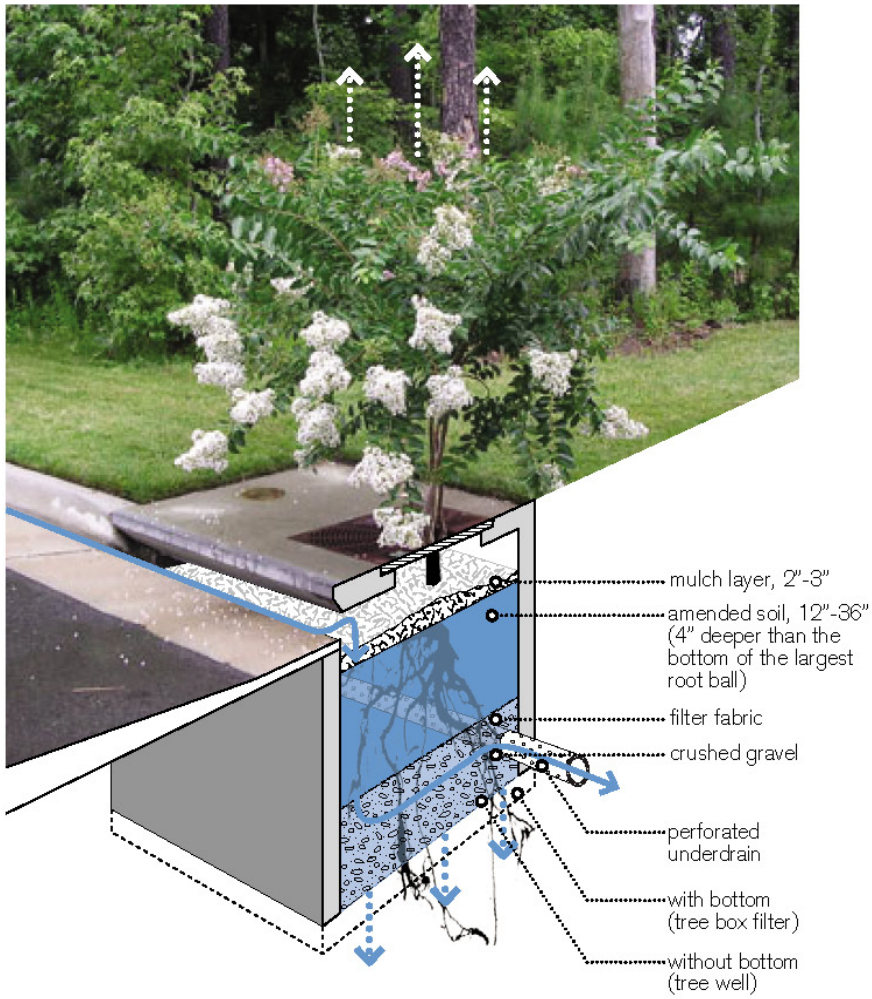
tree box
filter

Tree Box Filter

A tree box filter or well consists of a container filled with amended soil and planted with a tree, underlain by crushed gravel media.

Tree root systems treat and uptake stormwater runoff captured from the street into the box filter. An underdrain carries treated runoff to either a surface discharge location or a larger retention system for secondary treatment. The life of the tree is short as trees will need to be replaced every five to ten years. The unit can also be planted with hardy shrubs and herbaceous plants tolerant of inundations.

Tree box filters and wells can be incorporated into urban retrofits with the added benefits of water quality improvement and reduction of the urban heat island effect. As with other filtration devices, tree box filters require occasional inspection to remove large debris and/or trash.



References:
Low Impact Development Manual for Michigan
Urban Design Tools-Low Impact Development
Minnesota Urban Small Sites BMP Manual

optimal level of service
filtration/infiltration/treatment

location in LID network
downstream of filtration components, but upstream of larger detention, retention, or treatment facilities

scale
2'-8' wide with 2"-4" optimal water depth

management regime
occasional removal of trash and pruning of vegetation

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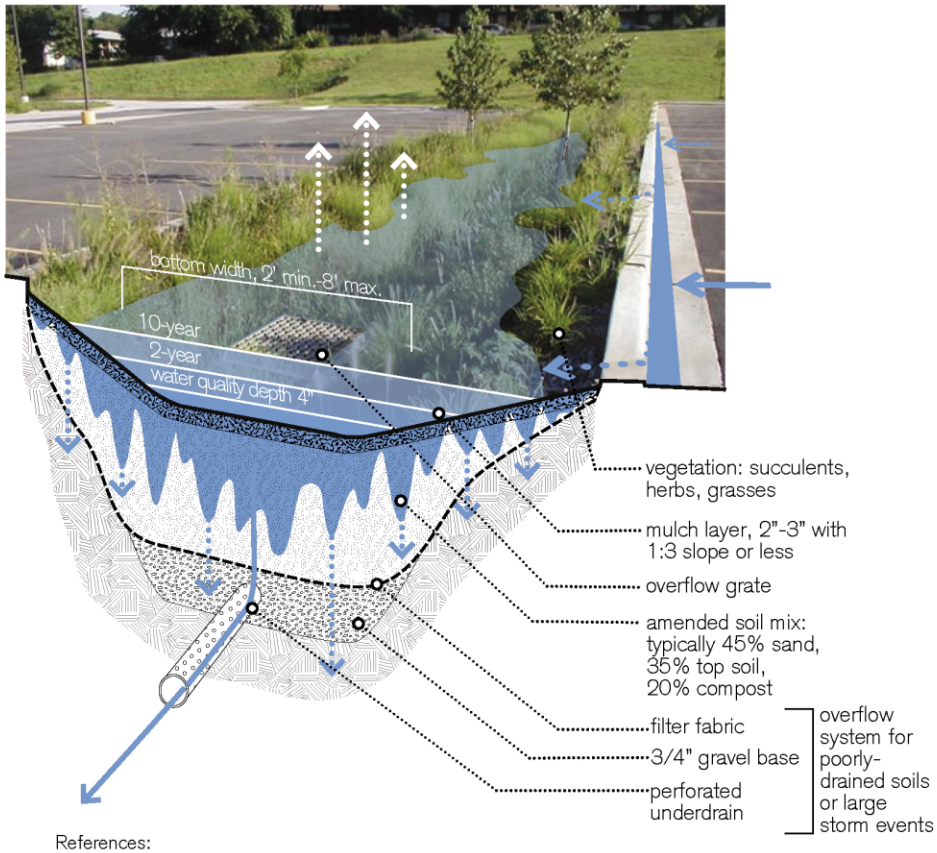
bioswale

Bioswale

A bioswale is an open, gently sloped, vegetated channel designed for treatment and conveyance of stormwater runoff.

Bioswales are a type of bioretention device in which the primary pollutant removal mechanisms are filtration by grass blades and other facultative vegetation that enhance sedimentation through adhesion of pollutants to the grass and thatch. Bioswales combine treatment and conveyance functions, reducing development costs by eliminating the need for separate conveyance systems. Their main function is to treat stormwater runoff, while the main function of rain gardens is to infiltrate runoff. Bioswales are usually located along roads, drives, or parking lots where the contributing acreage is less than five acres.

Bioswales require curb cuts, gutters or other devices that direct flow to them. They may require an underdrain where soil permeability is limited, as well as an overflow grate for larger storm events.



References:
Low Impact Development Design Strategies–An Integrated Design Approach
Low Impact Development Manual for Michigan
Low Impact Development Technical Guidance Manual for Puget Sound
United States Department of Housing and Urban Development
Minnesota Urban Small Sites BMP Manual

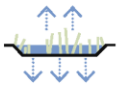
optimal level of service
retention/filtration/infiltration/treatment

location in LID network
end-of-line facility, upstream of overflow basins or receiving waterbodies

scale
from pocket wetlands managing up to 10 acres of watershed runoff to shallow marshes managing more than 25 acres of watershed runoff

management regime
system requires removal of trash and sediment between two and ten years, and semiannually during first three years

21



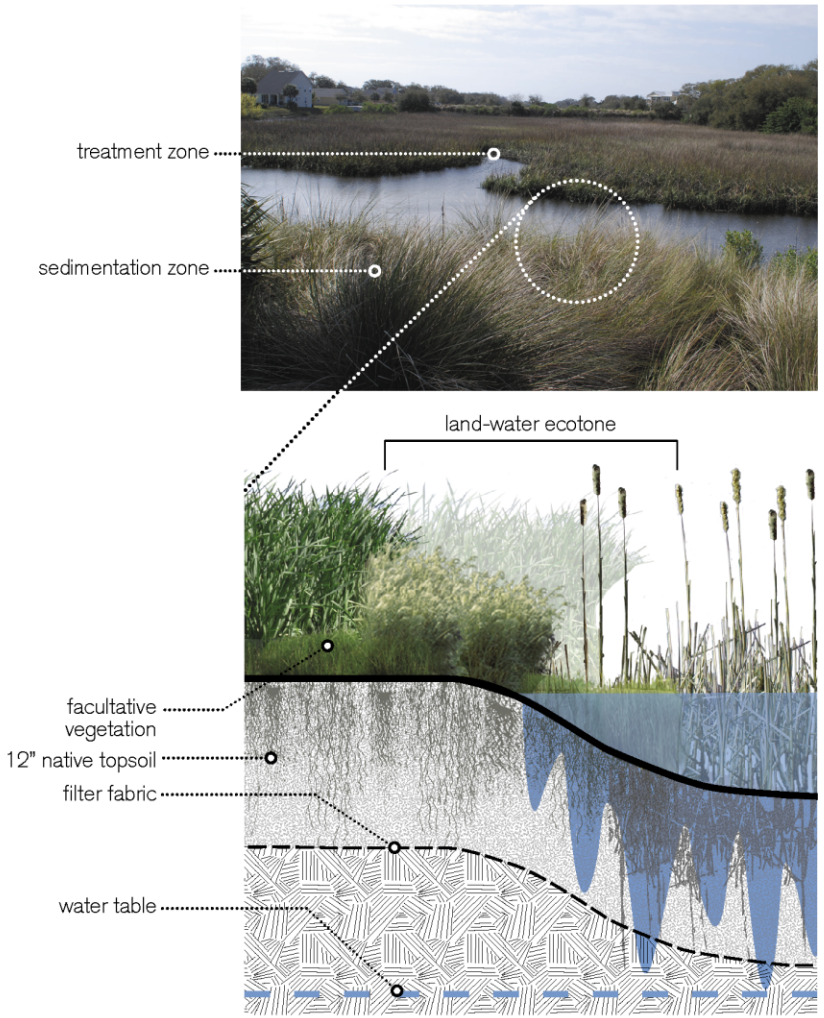
constructed wetland

Constructed Wetland

Constructed wetlands have a permanent pool of water designed to treat polluted stormwater through microbial breakdown of pollutants, phytoremediation, retention, settling, and adsorption (surface assimilation).

Considered to be a comprehensive treatment system, constructed wetlands can be re-established in historically drained wetland areas or low areas of a site. Plants and wetland geometry reduce stormwater velocity, allowing sediment to settle out. As with other infiltration systems, pre-treatment systems upstream help to remove sediment that may clog a wetland system, resulting in eutrophication or an oxygen deprived system.

Constructed wetlands are land rich facilities and differ from retention ponds in their shallower depths and greater vegetation coverage. They require relatively large contributing drainage areas to maintain a shallow permanent pool. Minimum contributing watershed runoff area should be at least 10 acres, although pocket wetlands may be appropriate for smaller sites if sufficient water flow is available.



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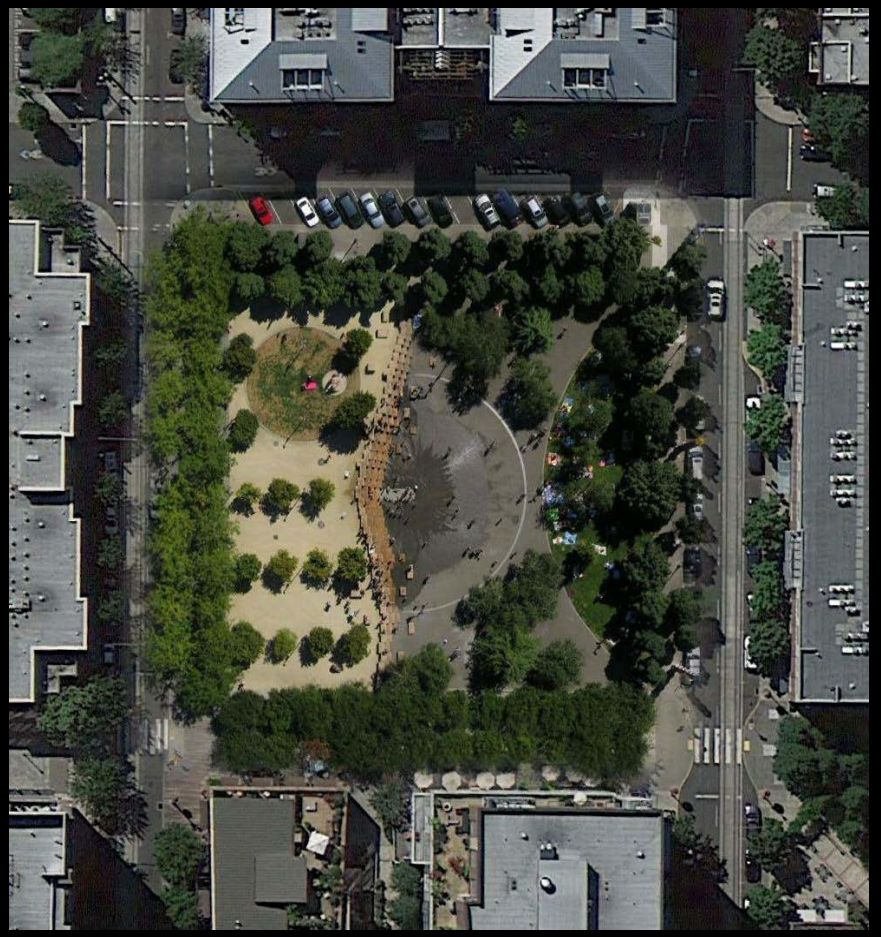


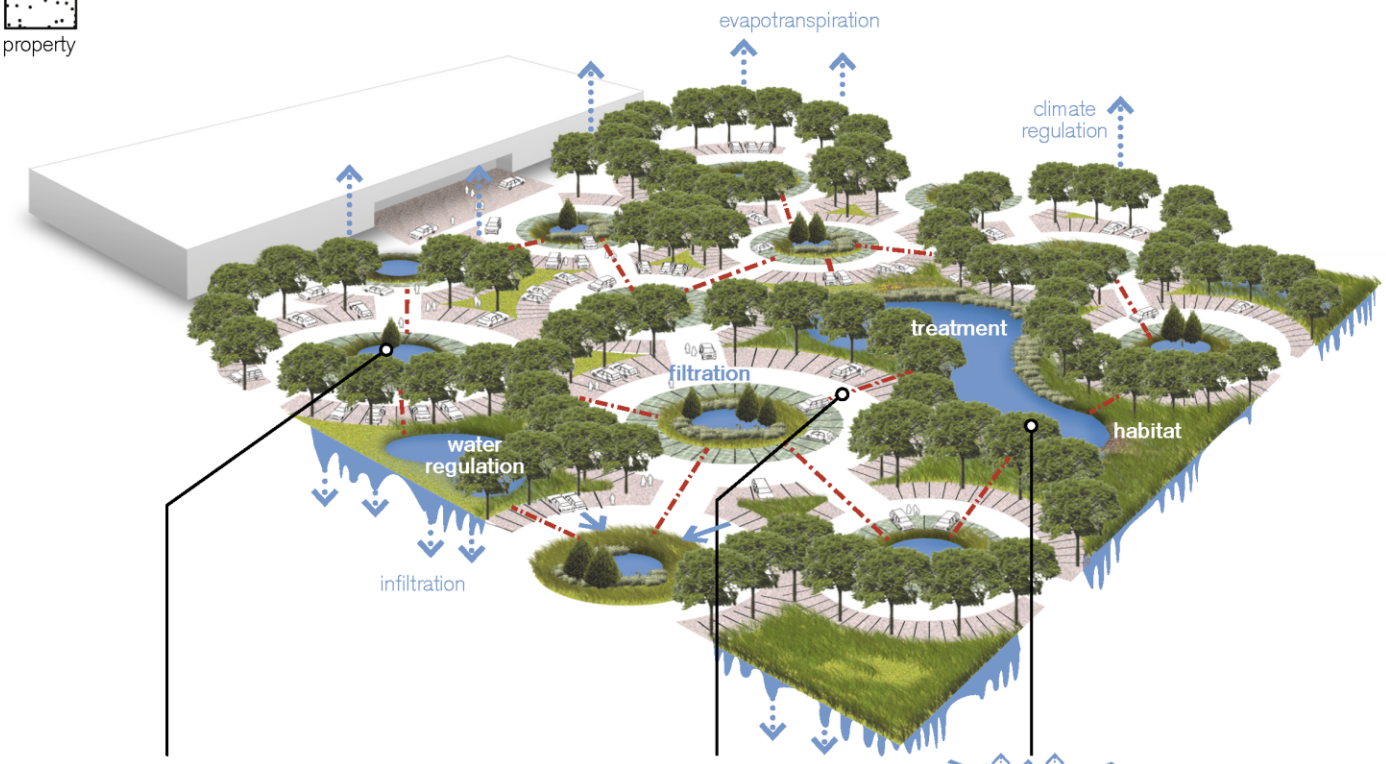
Jamison Square: Portland, OR

Public plaza that doubles as a water management and recharge facility

Parking Gardens

property

Reconfigure conventional parking lot models to serve the hydrology of the site, where cars sit in their own treatment basins.



Slow

Construct rain gardens in center of parking modules to treat first flush and infiltrate most contaminated runoff during **one to ten-year storm events.** *Rain Garden* pp. 178-179

Spread

Convey water through oversized perforated pipes from rain gardens to treatment facilities during **10 to 50-year storm events.** *Oversized Pipes* pp.146-147

Soak

Use residual spaces as large treatment meadows that eliminate runoff contaminants as infiltration occurs. *Infiltration Basin* pp. 184-185

Parking Lot Design

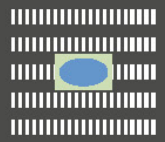
center

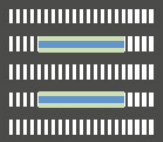
bands

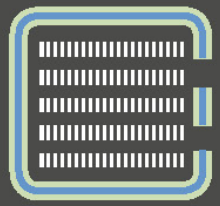
edges

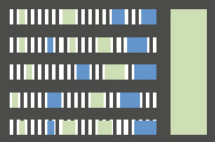
pixels

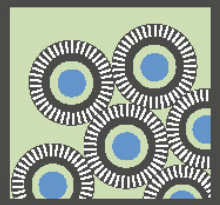
parking gardens



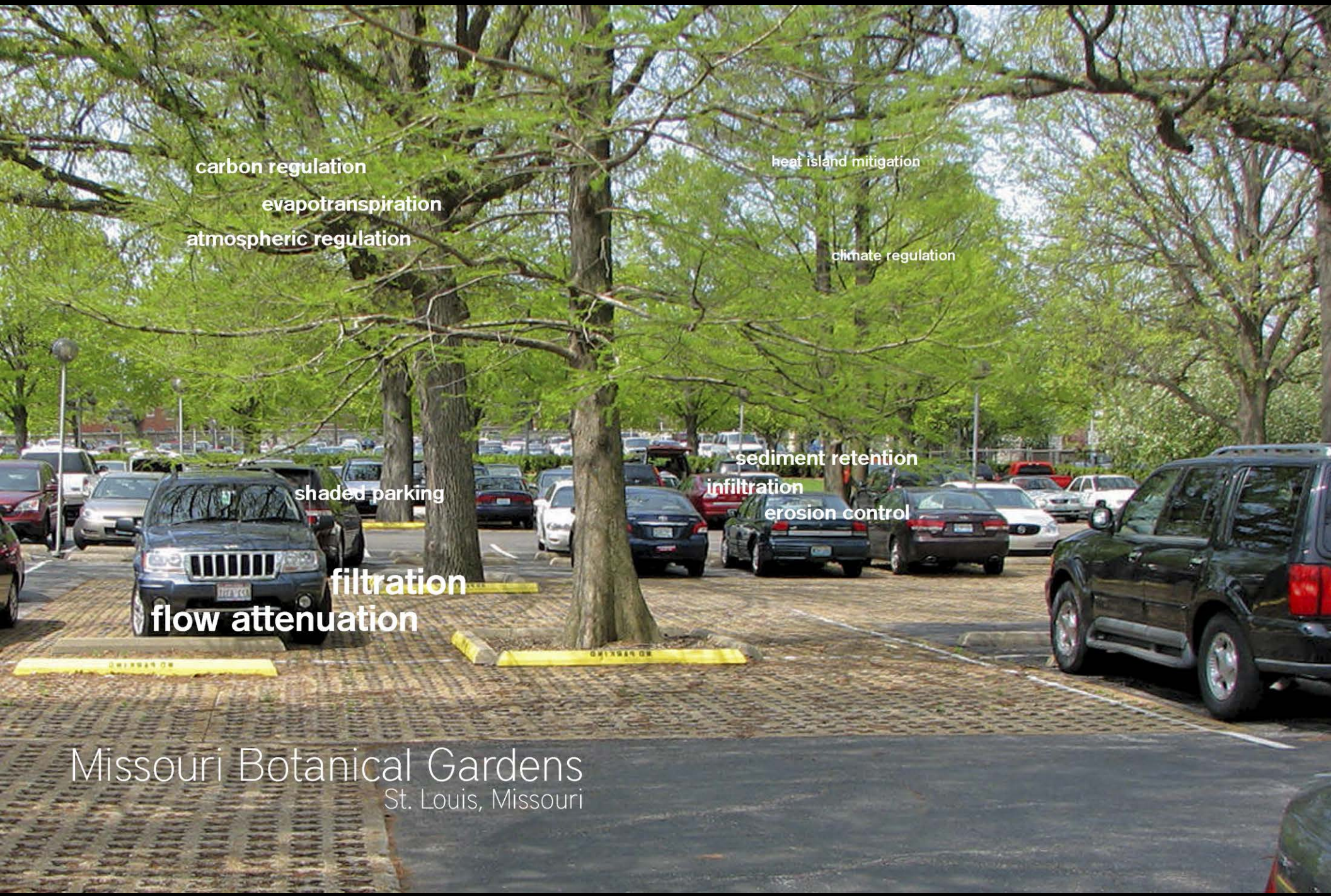








minimum level of ecological service → maximum level of ecological service



Missouri Botanical Gardens

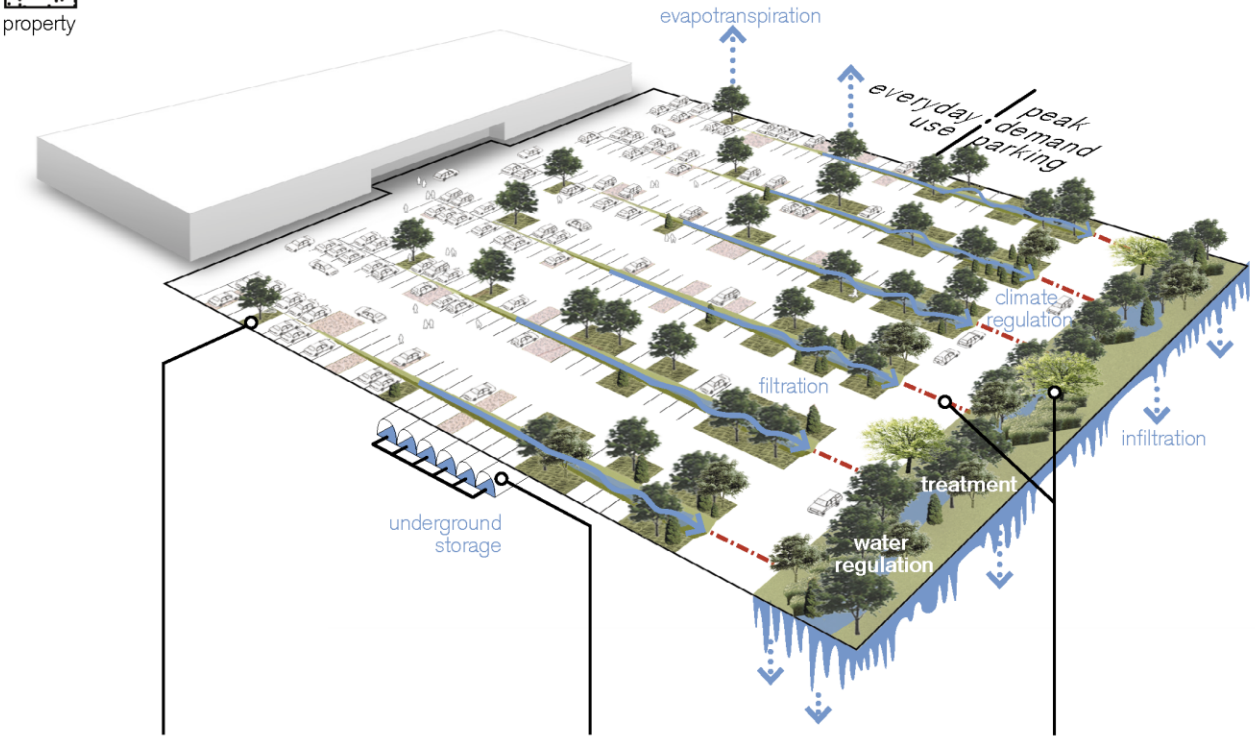
St. Louis, Missouri

atmospheric regulation
flow attenuation
soil formation
infiltration
erosion control
climate regulation
filtration
sediment retention
flow attenuation
Heifer International
Little Rock, Arkansas

Pixelated Parking

property

Reduce impervious surfaces by pixelating the parking surface with LID paving and landscapes.



Slow

Remove curbs and sink tree islands in parking stalls to receive and filter stormwater from **one to ten-year storm events** as it enters treatment landscapes. *Bioswale* pp. 182-183

Spread

For **10 to 25-year storm events**, use underground storage if soils are poorly drained or land area is limited. *Underground Detention* pp. 152-153 and *Wet Vault* pp. 156-157

Soak

Use oversized pipes to connect bioswales to an infiltration basin or a retention pond, which retain and infiltrate runoff during **25 to 50-year storm events**. *Retention Pond* pp. 160-161

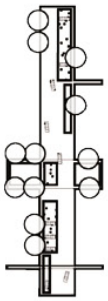
tree location affects behavior and use patterns in the lot

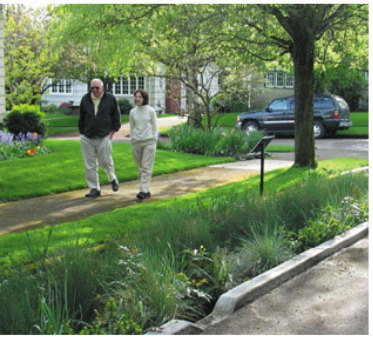
parking around nodes

parking in rooms

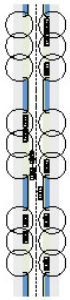
…parking lots to can be designed to sponsor more complex socio-environmental ecologies.

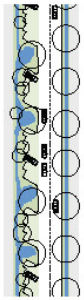
Street Types

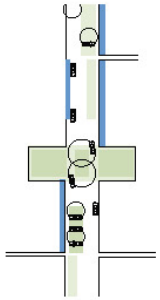


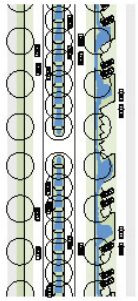


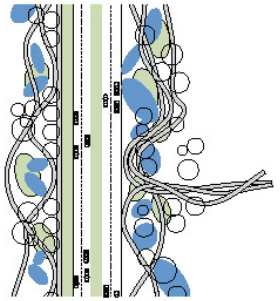
skinny streets | green streets | shared streets | eco-boulevards | parkways











from local streets → to arterial streets

Skinny Streets

For LID applications, select trees from the bottomlands, like sycamore, pin oaks, silver maples, willows and other phreatophytes—long-rooted trees that transpire significant amounts of water for hydraulic control.

Green Streets

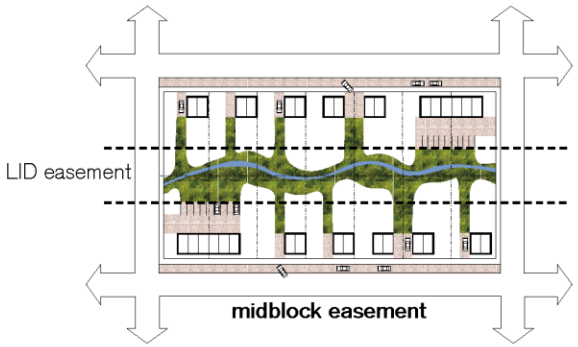
Shared Streets

heat island mitigation
atmospheric regulation
rain garden
central arterial
shared local street
shaded sidewalk
Octavia Boulevard
San Francisco, California
pervious paving

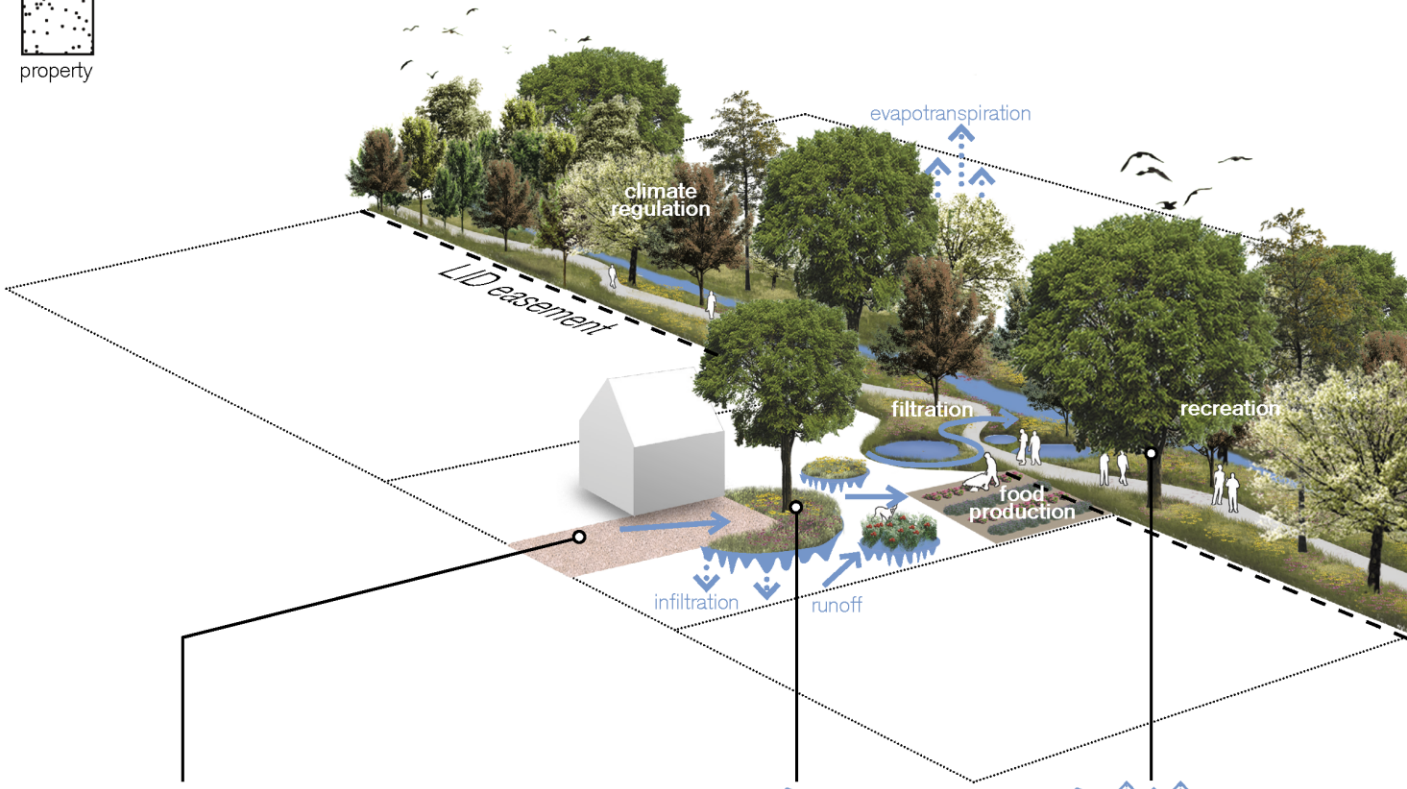
Boulevards

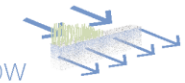
Block Design

Incorporate shared conservation areas into LID neighborhood fabrics by connecting property to easements.



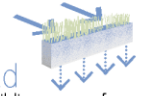
property





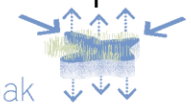
Slow

Filter stormwater through the use of pervious paving on driveways. *Pervious Paving* pp. 172-173



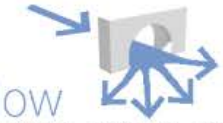
Spread

Locate buildings away from critical areas and create a series of rain gardens for attenuation and filtration of stormwater runoff from **one to ten-year storm events**. *Rain Garden* pp. 178-179



Soak

Plant and maintain vegetation in the riparian corridor. This is especially important in upstream developments. *Riparian Buffer* pp. 180-181

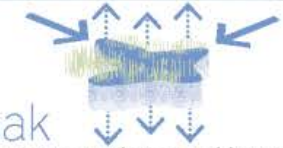


Slow

Use flush curbs to allow water to be distributed evenly over treatment facilities. *Flow Control Devices* pp. 148-149

Spread

Reduce impervious surfaces to filter and attenuate stormwater from the street. *Pervious Paving* pp. 172-173

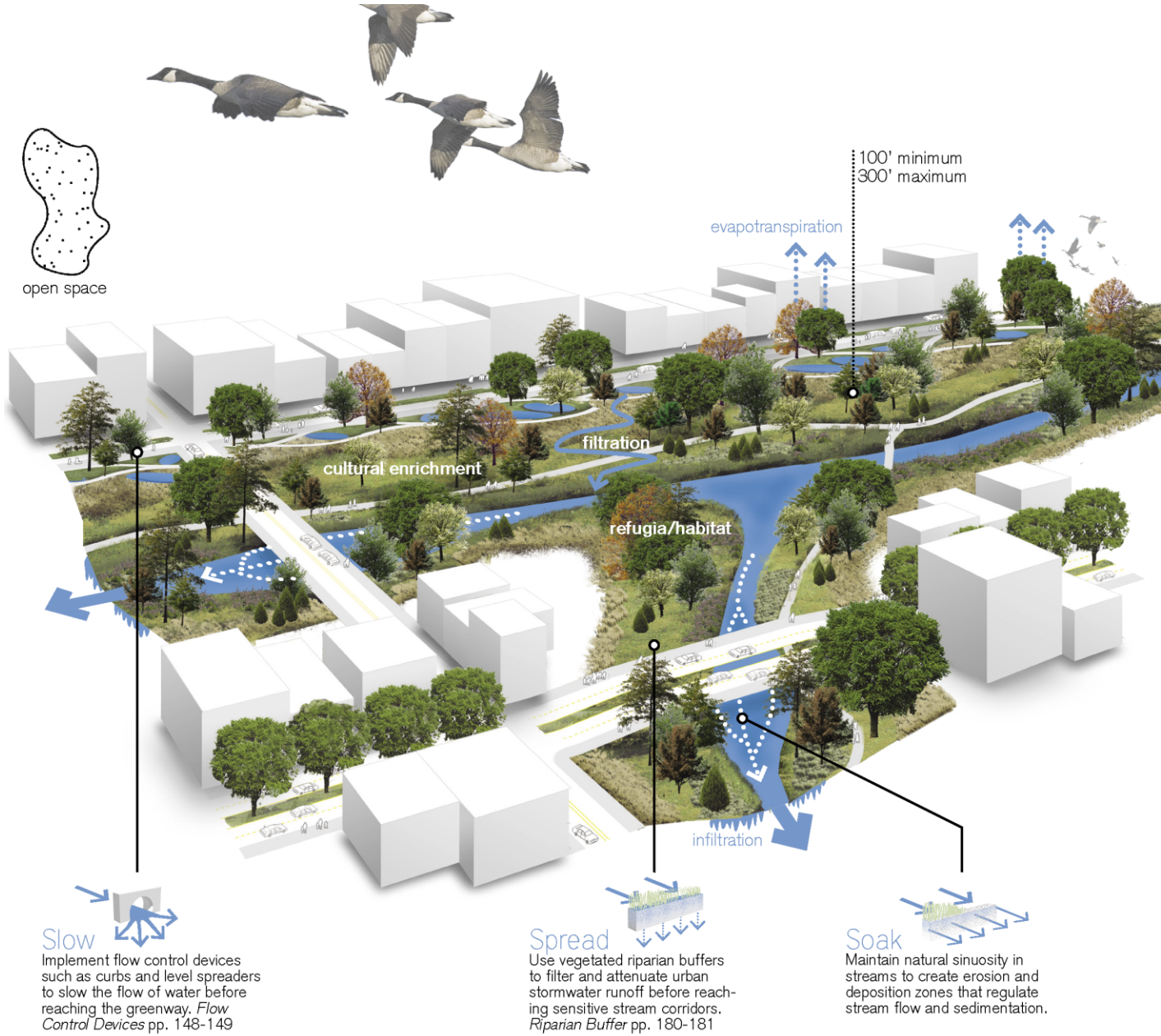


Soak

Apply rain gardens and bioswales in the easement for treatment during **one to ten-year storm events**. These facilities must be connected to secondary facilities to handle 10 to 50-year storm events. *Bioswale* pp. 182-183

Greenways

Connect open spaces to create an urban greenway that maintains nutrient, natural resource, and habitat flows through the city.



Slow

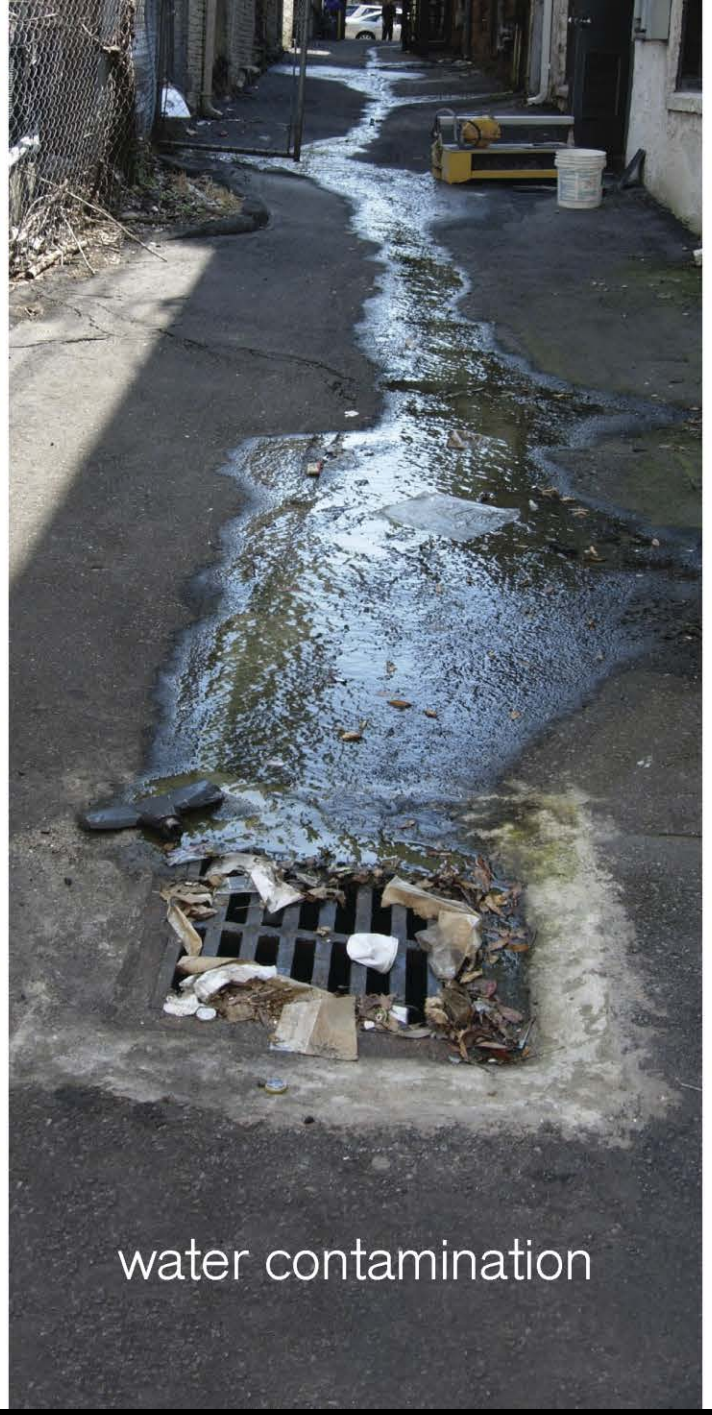
Implement flow control devices such as curbs and level spreaders to slow the flow of water before reaching the greenway. *Flow Control Devices* pp. 148-149

Spread

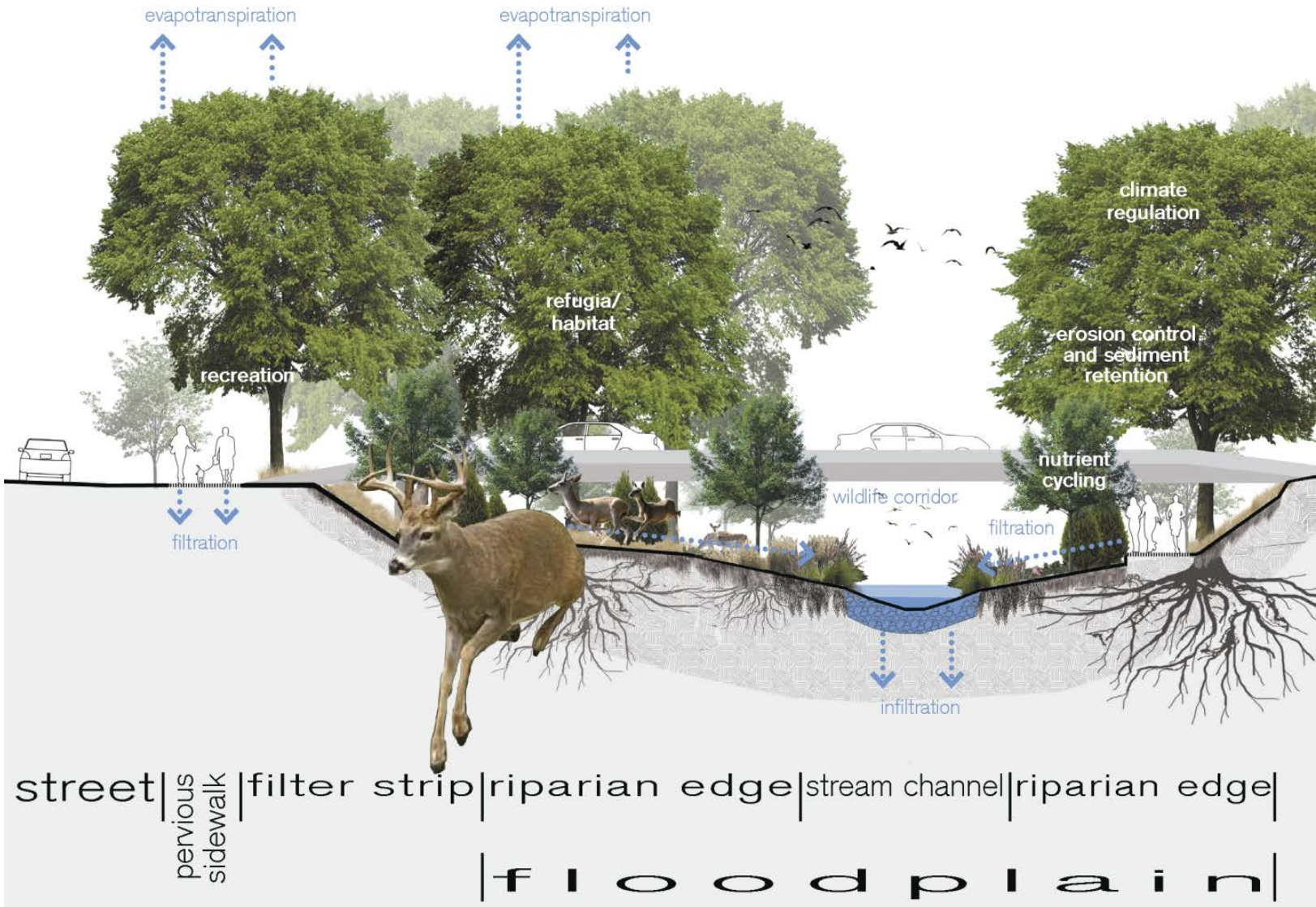
Use vegetated riparian buffers to filter and attenuate urban stormwater runoff before reaching sensitive stream corridors. *Riparian Buffer* pp. 180-181

Soak

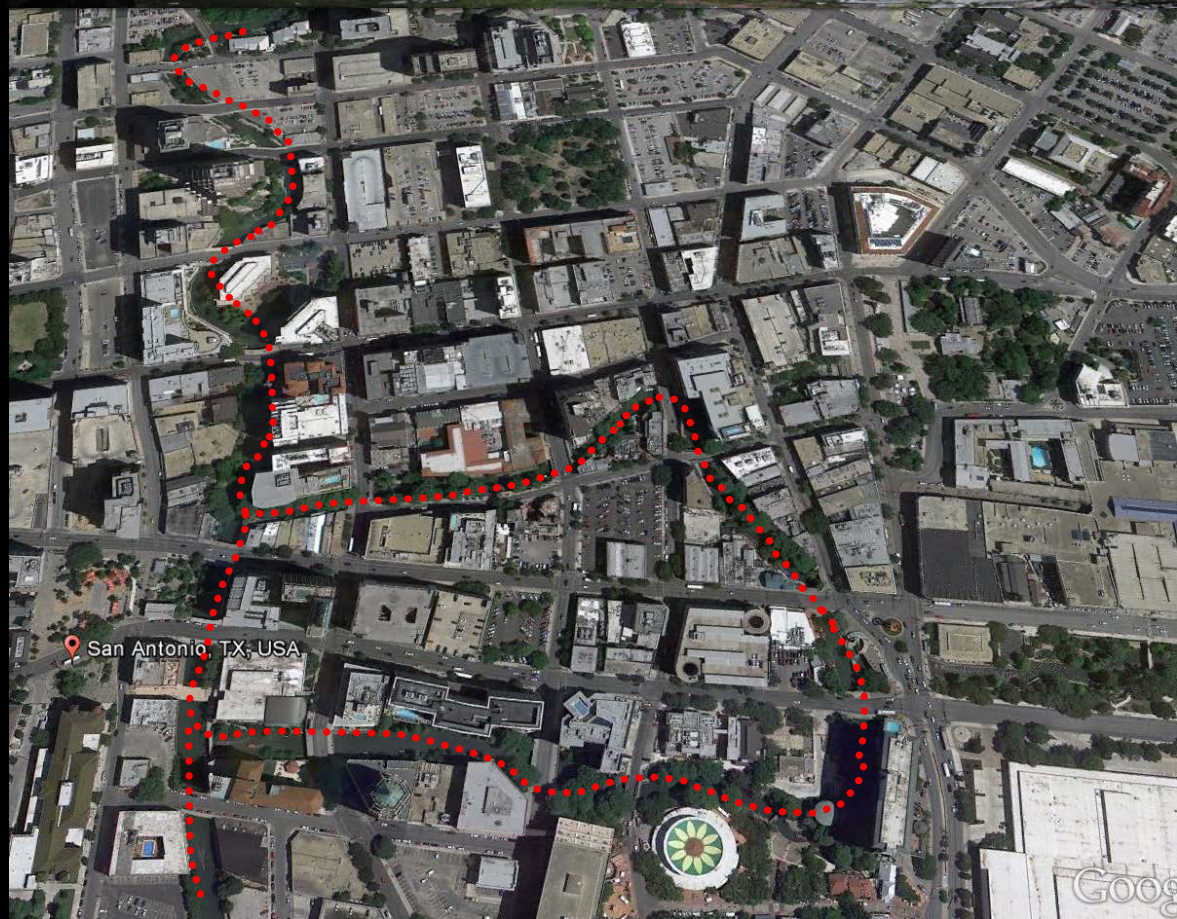
Maintain natural sinuosity in streams to create erosion and deposition zones that regulate stream flow and sedimentation.



Addressing “Urban Stream Syndrome”

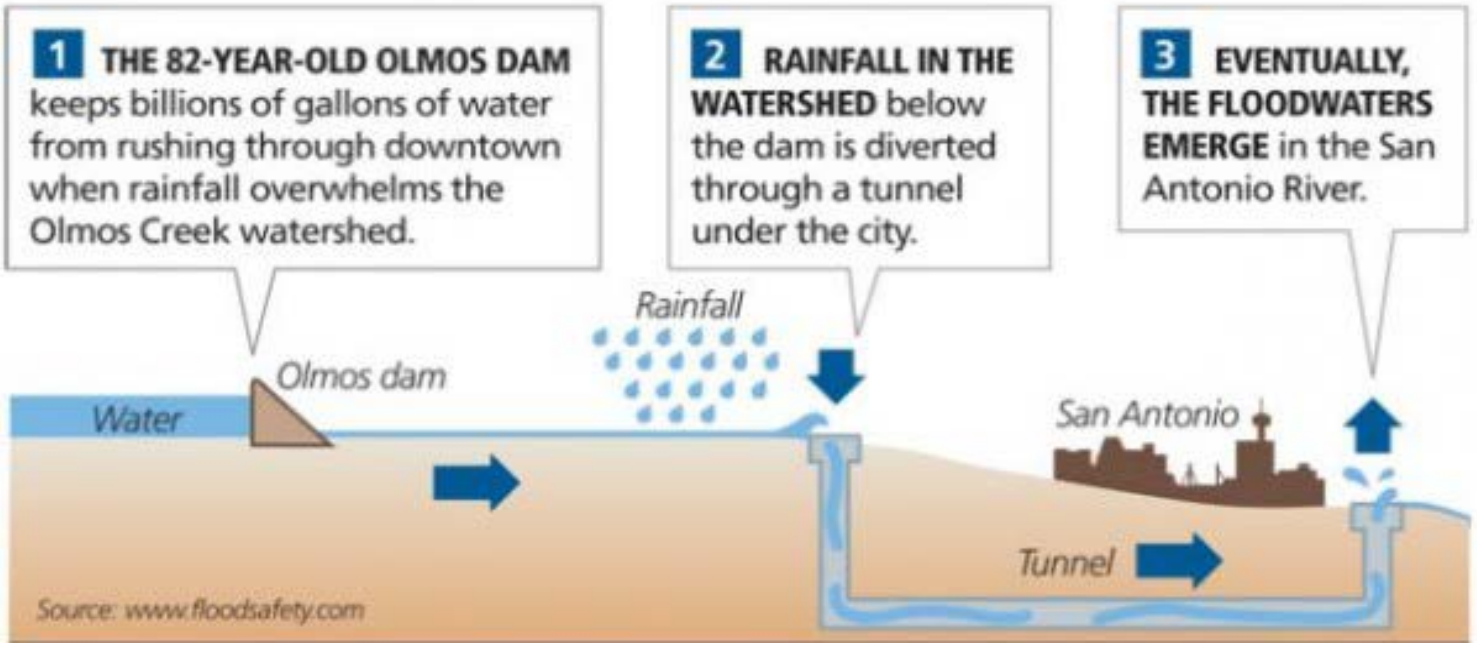

evapotranspiration
evapotranspiration
climate regulation
refugia/ habitat
erosion control and sediment retention
recreation
nutrient cycling
wildlife corridor
filtration
filtration
infiltration
street
pervious sidewalk
filter strip
riparian edge
stream channel
riparian edge
floodplain

Riverwalk: San Antonio, TX



Though an engineered urban ecology, the Riverwalk is one of the country’s most memorable public spaces.

Helping to keep San Antonio from flooding



New reach without trees

Mature reach with trees

Trees are metabolic agents, regulating temperatures to prevent eutrophication of the stream.

Guadalupe River Park: San Jose, CA

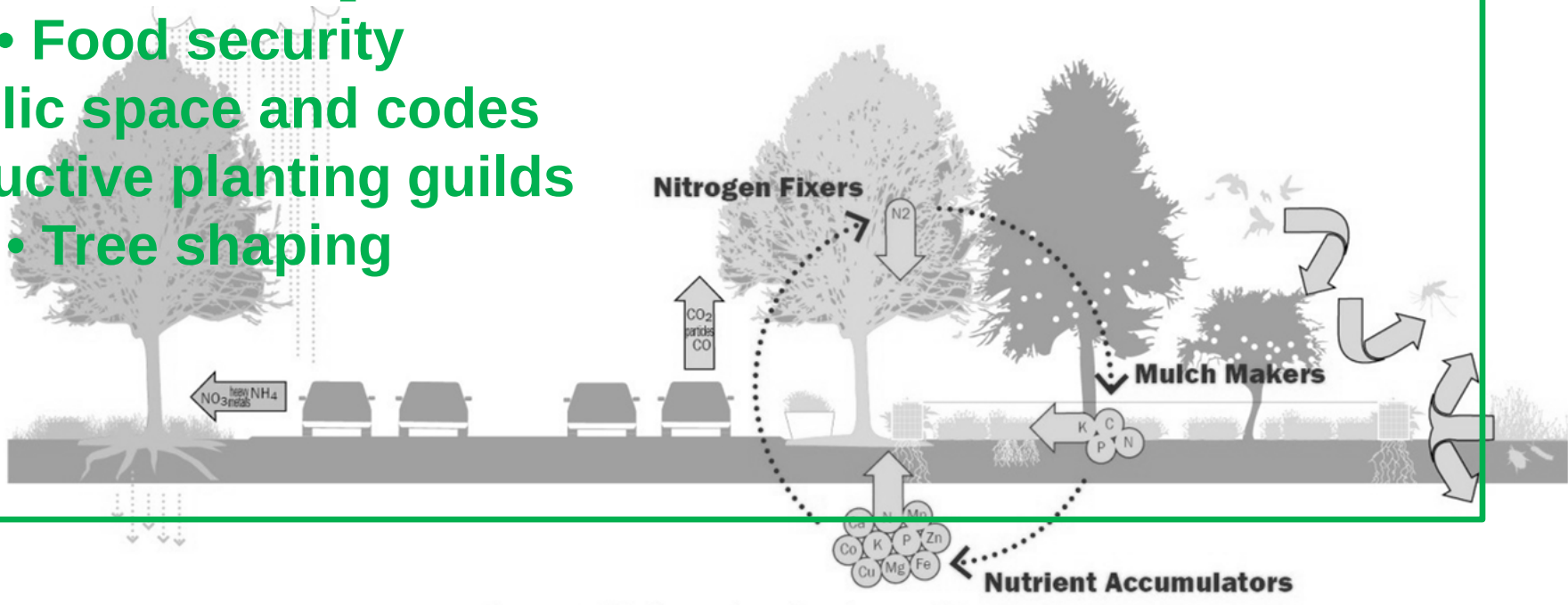
Riparian corridor designed to manage flash flooding and extreme pulse rates. Trees are essential to bank stabilization, sedimentation, and flow attenuation.

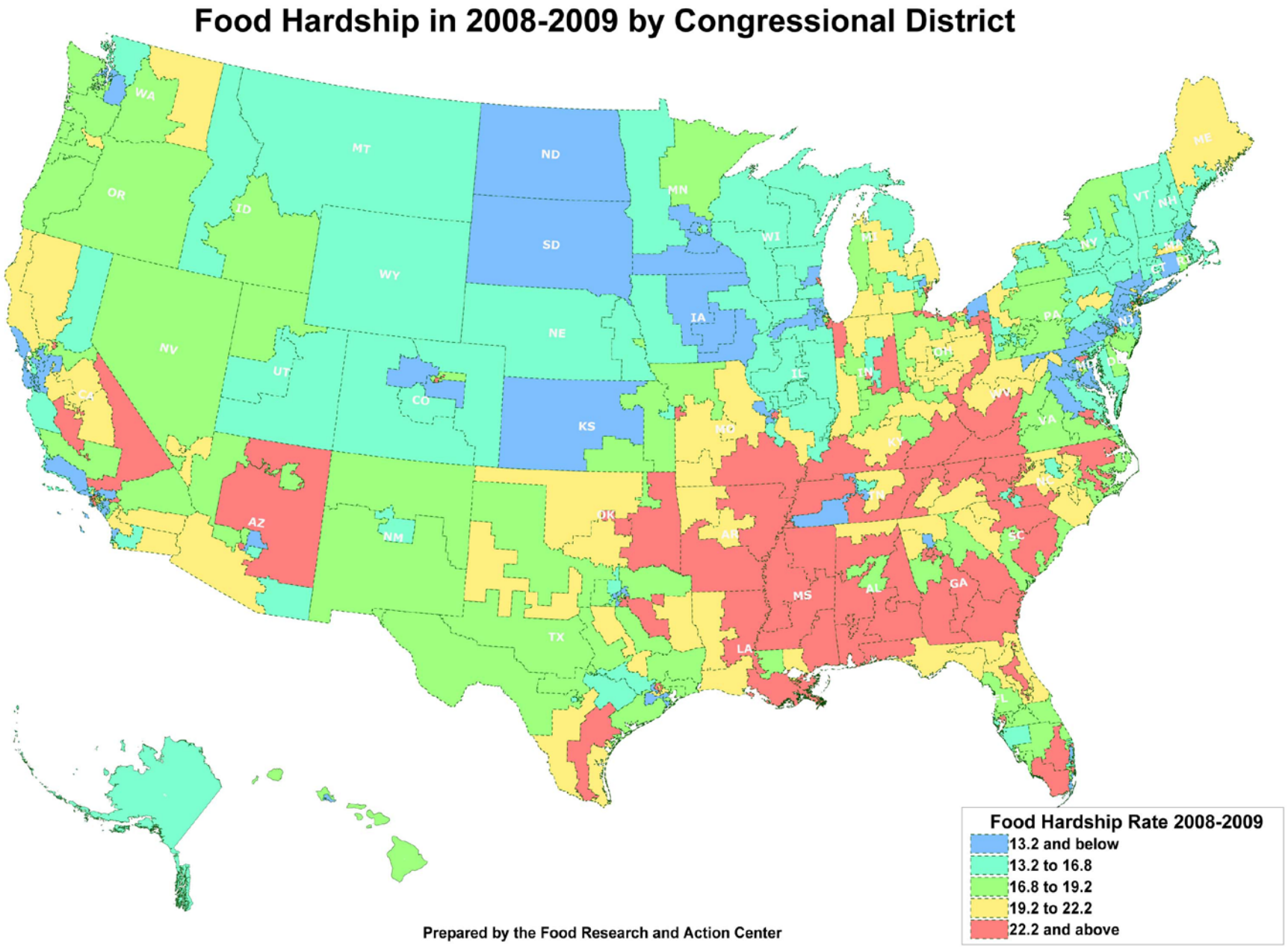
Allegheny River Waterfront:
Pittsburgh, PA

linear terrace civilizes the highway

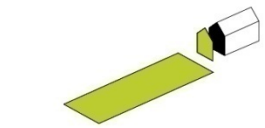
Edible Civic Landscapes

- Food security
- Public space and codes
- Productive planting guilds
- Tree shaping

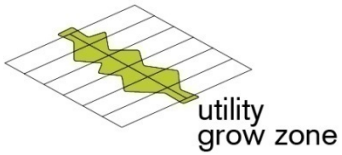




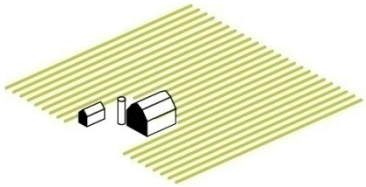
"We are nine meals away from anarchy"



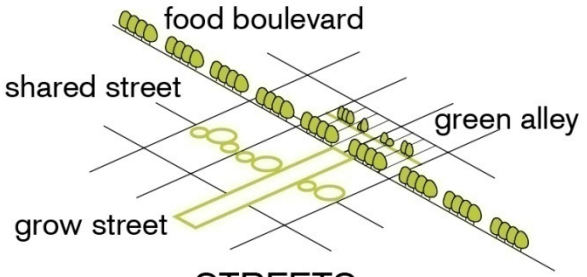
BUILDING/YARD



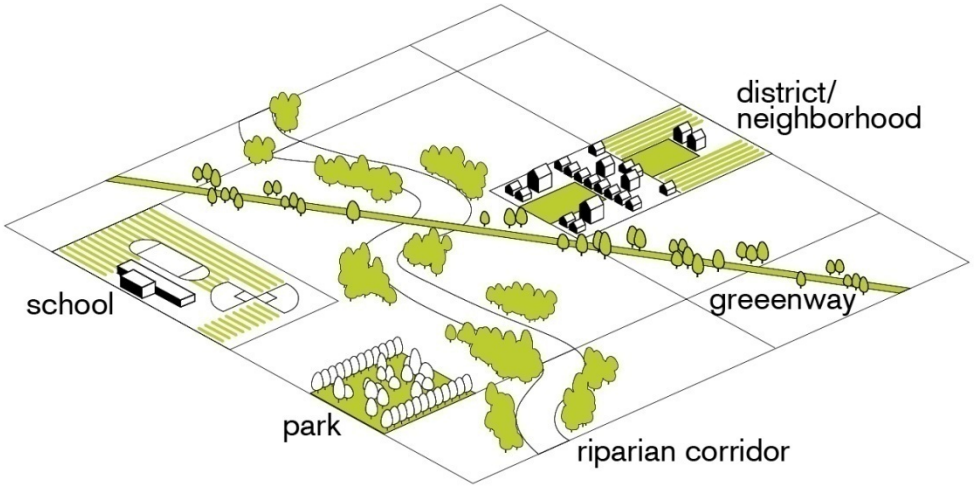
BLOCK



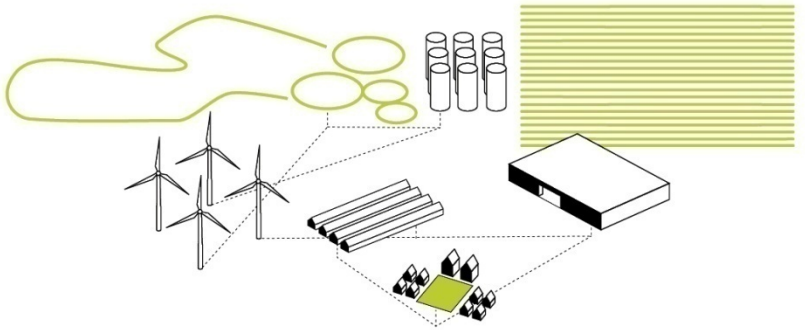
FARM



STREETS

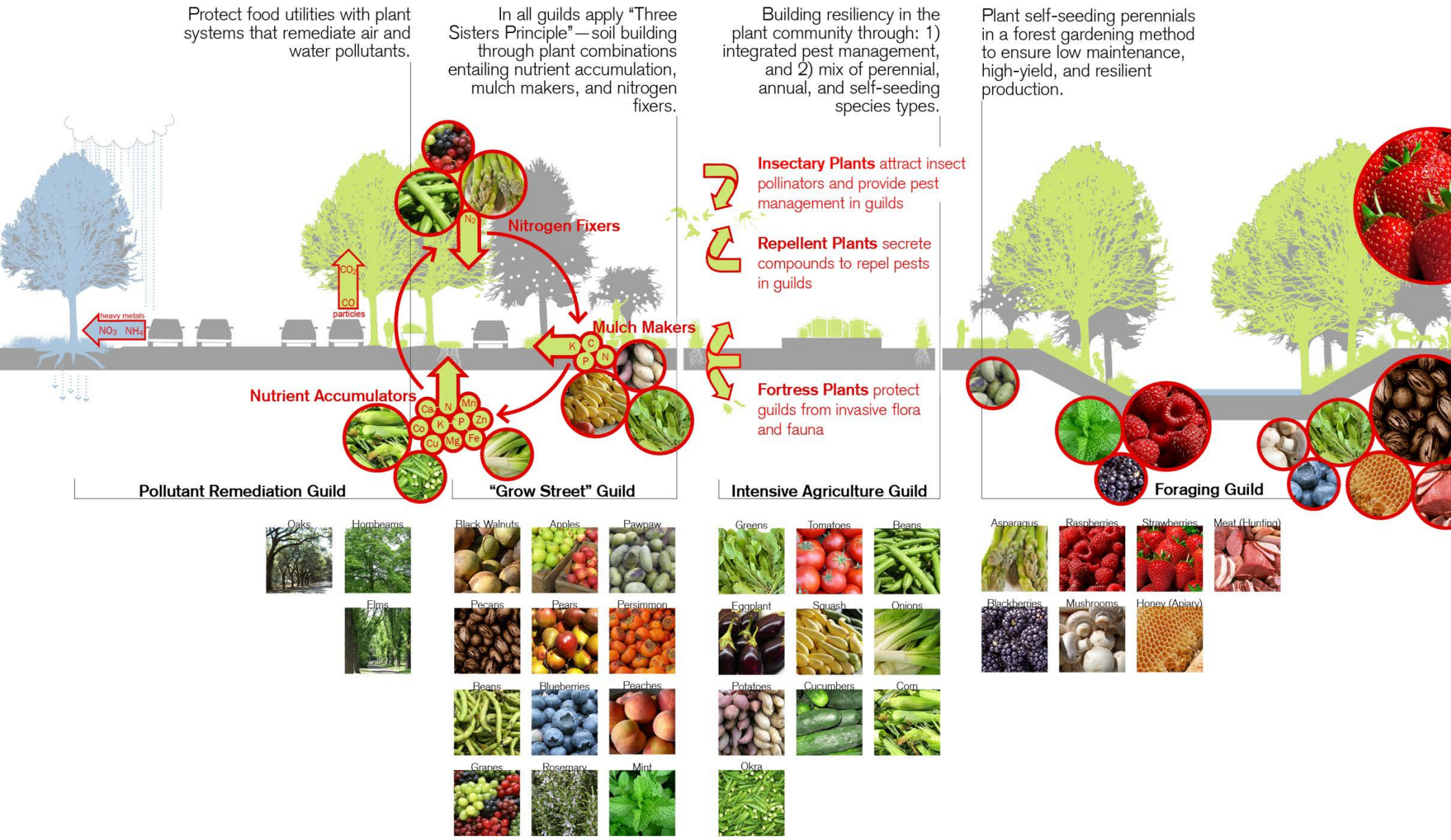


OPEN SPACE



ENERGY DISTRICT

Agricultural Urbanism Opportunities



Agricultural Urbanism Interfaces

State Capitol Grounds:
Sacramento, CA

USUFRUCT:
the legal right to use and enjoy the advantages or profits of another person's property.

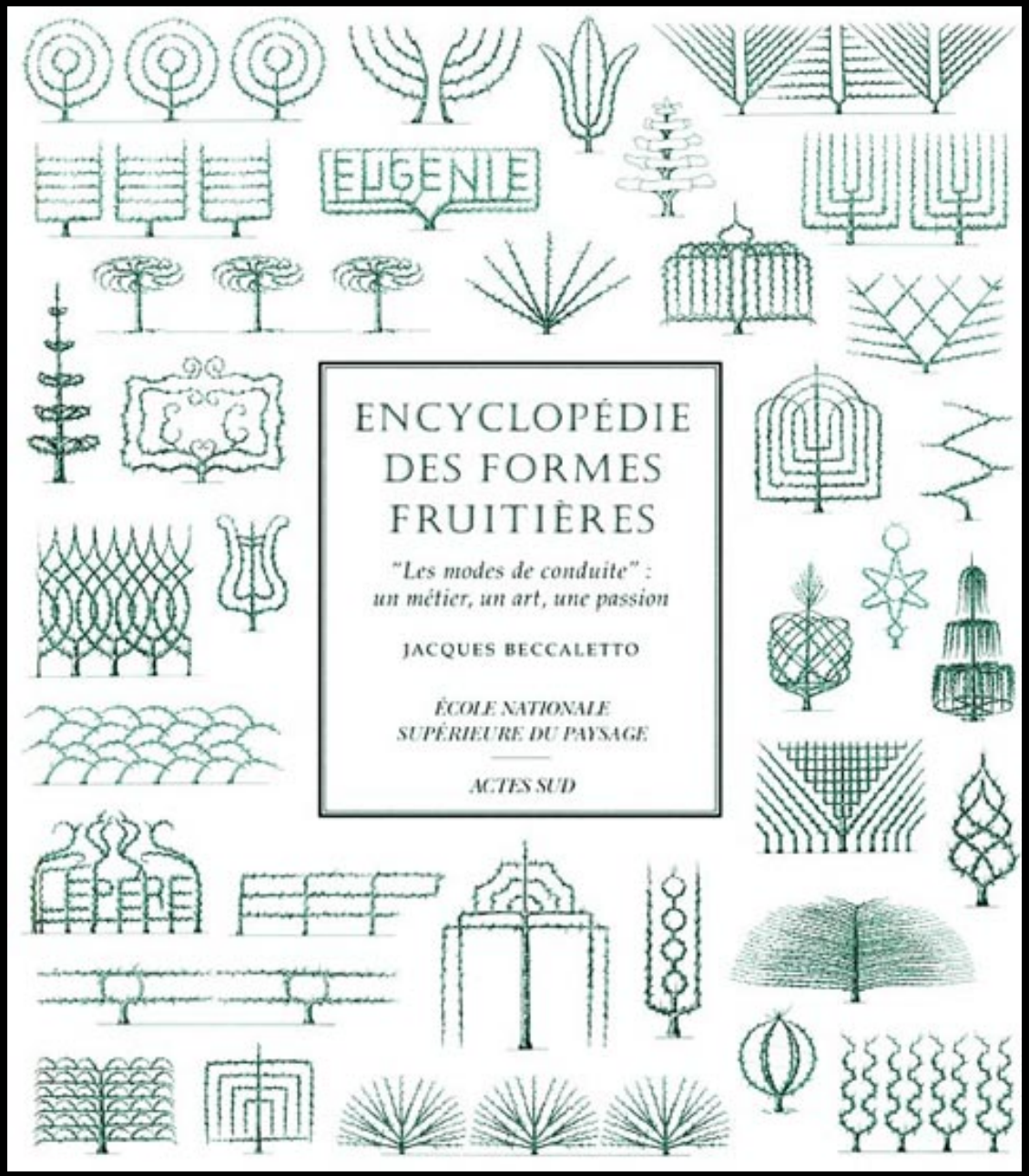
Public orange groves on plazas and streets:
Seville, Spain

Viet-Village Neighborhood Farm:
New Orleans

Public concourse through urban farm

Le Potager du Roi (Kitchen Garden of the King):
Versailles, France

When urban landscapes were shaped for commodity production.



Espalier

Practice of controlling woody plant growth for the production of fruit by pruning and tying branches to a frame so that they grow into a flat plane.

Cordon

The most widely used form of espalier. This technique has the highest yield per unit area of space.

Pollarding

Pruning of upper branches to promote dense foliage head and to maintain predetermined height. Once used to produce new growth for harvesting of wood.

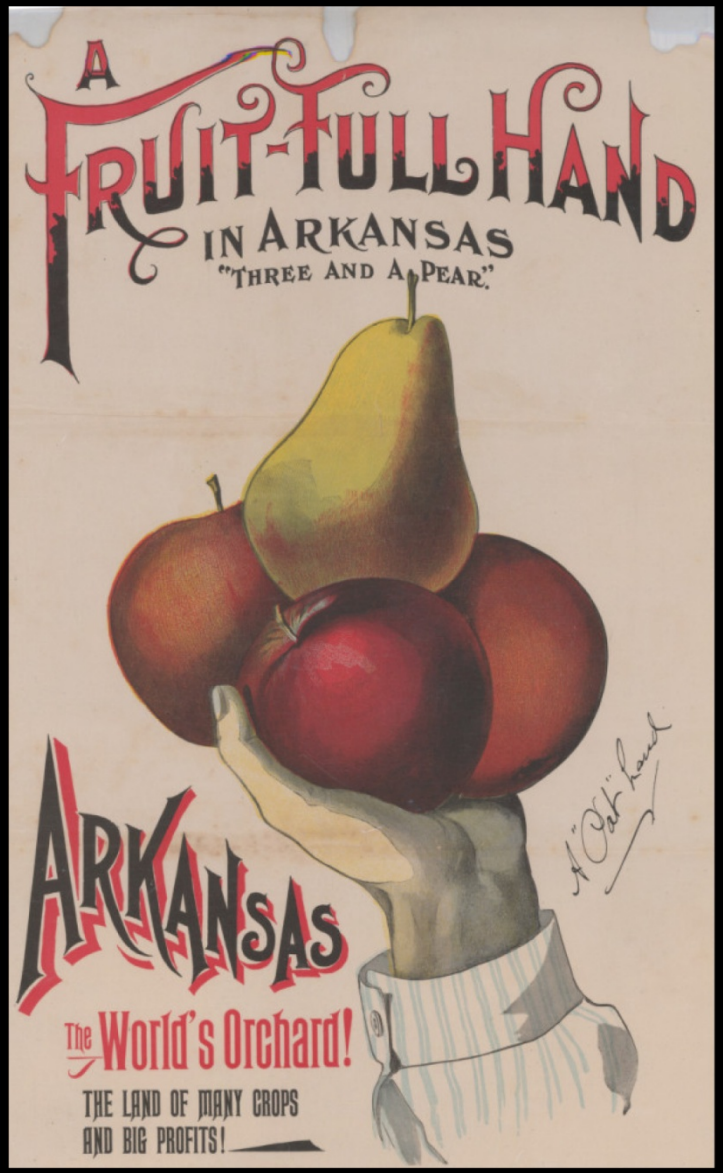
Pleaching

Technique of interweaving branches to create a hedge for stock control, and in modern times to protect fruit against frost.

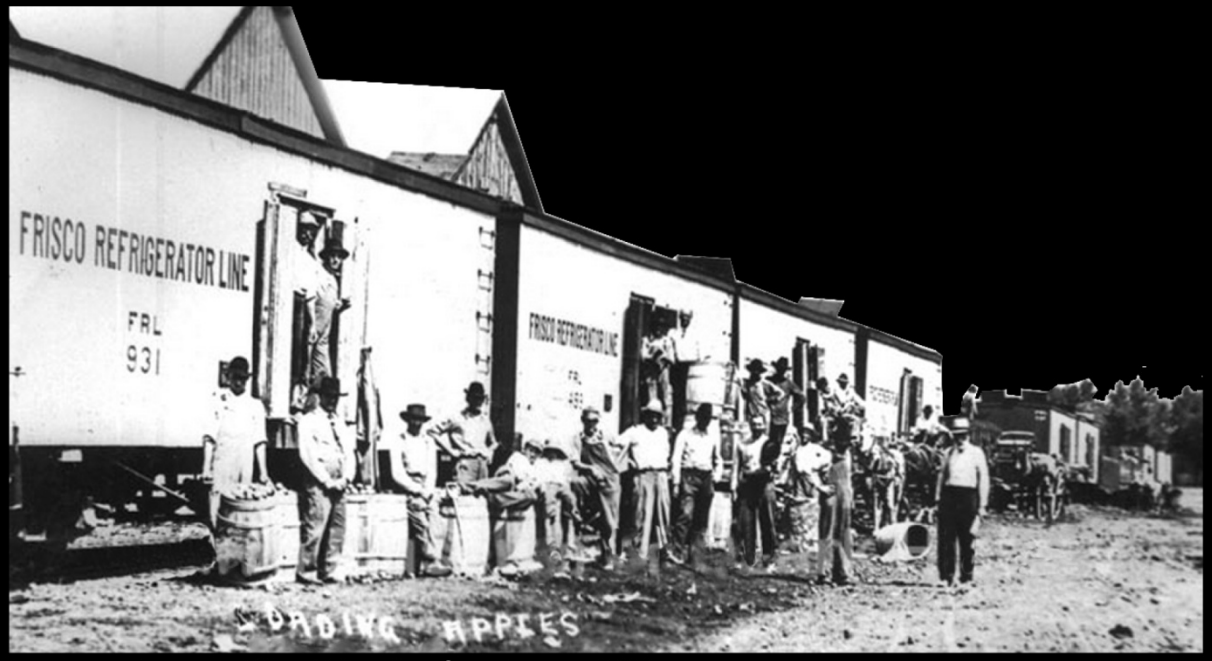
Topiary

Training of evergreen, mostly woody, plants by clipping foliage and twigs to define shapes for ornamental purposes.

TOWNSCAPING AN AUTOMOBILE-ORIENTED FABRIC Farmington, Arkansas



Frisco Railroad Advertisement, 1890.



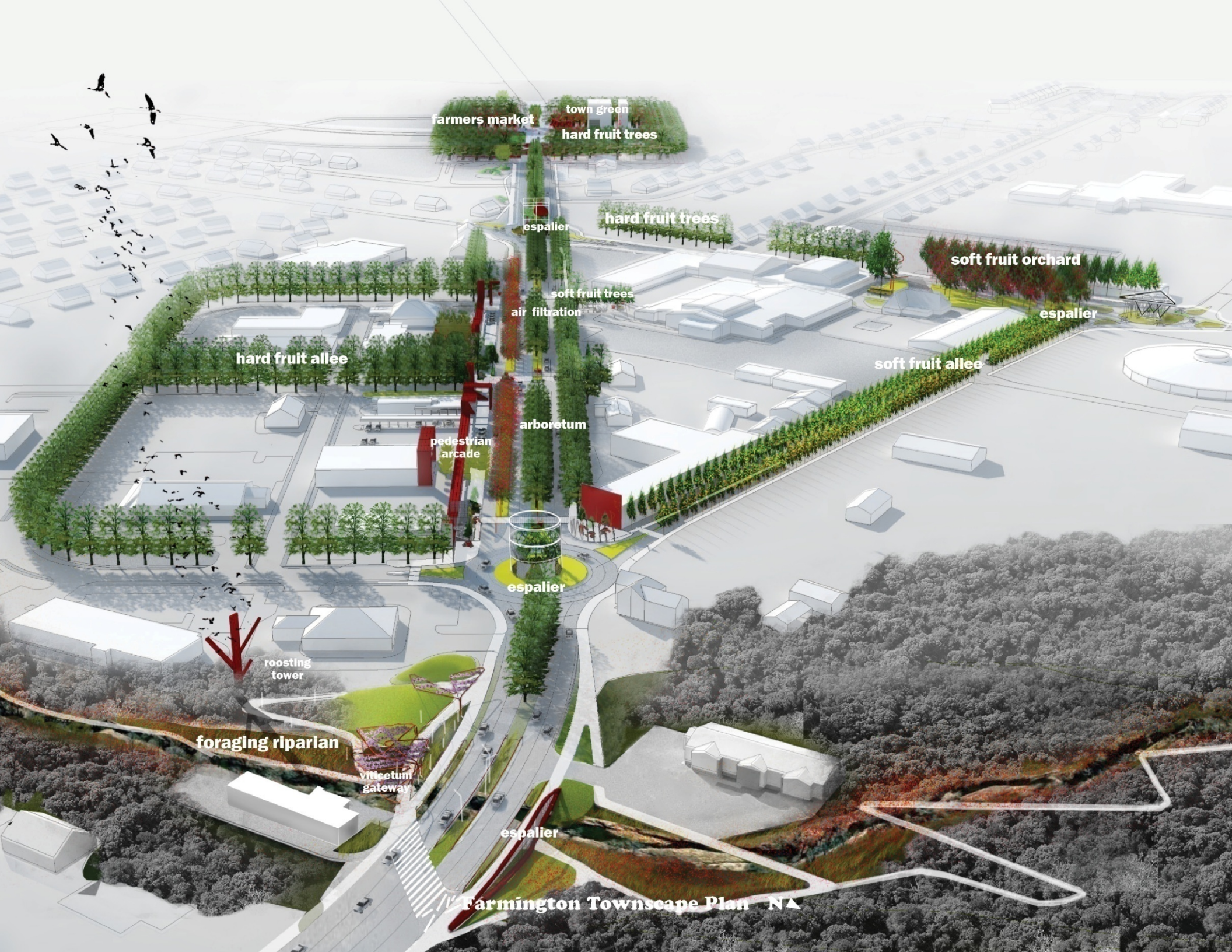
Loading apples on the Frisco Railroad's refrigerator cars, 1910s.

Starke Brothers Orchard near Farmington, 1910.

Regional Apple Fair, 1909.

Farmington was once the World's Orchard

Farmington was once a substantial downtown agricultural processing center in one of the country's largest apple-growing regions. It is estimated that 40 percent of the apples and pears grown at the turn of the 20th century were grown in Northwest Arkansas.


farmers market
town green
hard fruit trees
espalier
hard fruit trees
soft fruit orchard
soft fruit trees
air filtration
espalier
hard fruit allee
soft fruit allee
arboretum
pedestrian arcade
espalier
roosting tower
foraging riparian
viticetum gateway
espalier
Farmington Townscape Plan
N

Green Infrastructure

- Civilizing the city
- Green utilities
- Urban metabolism

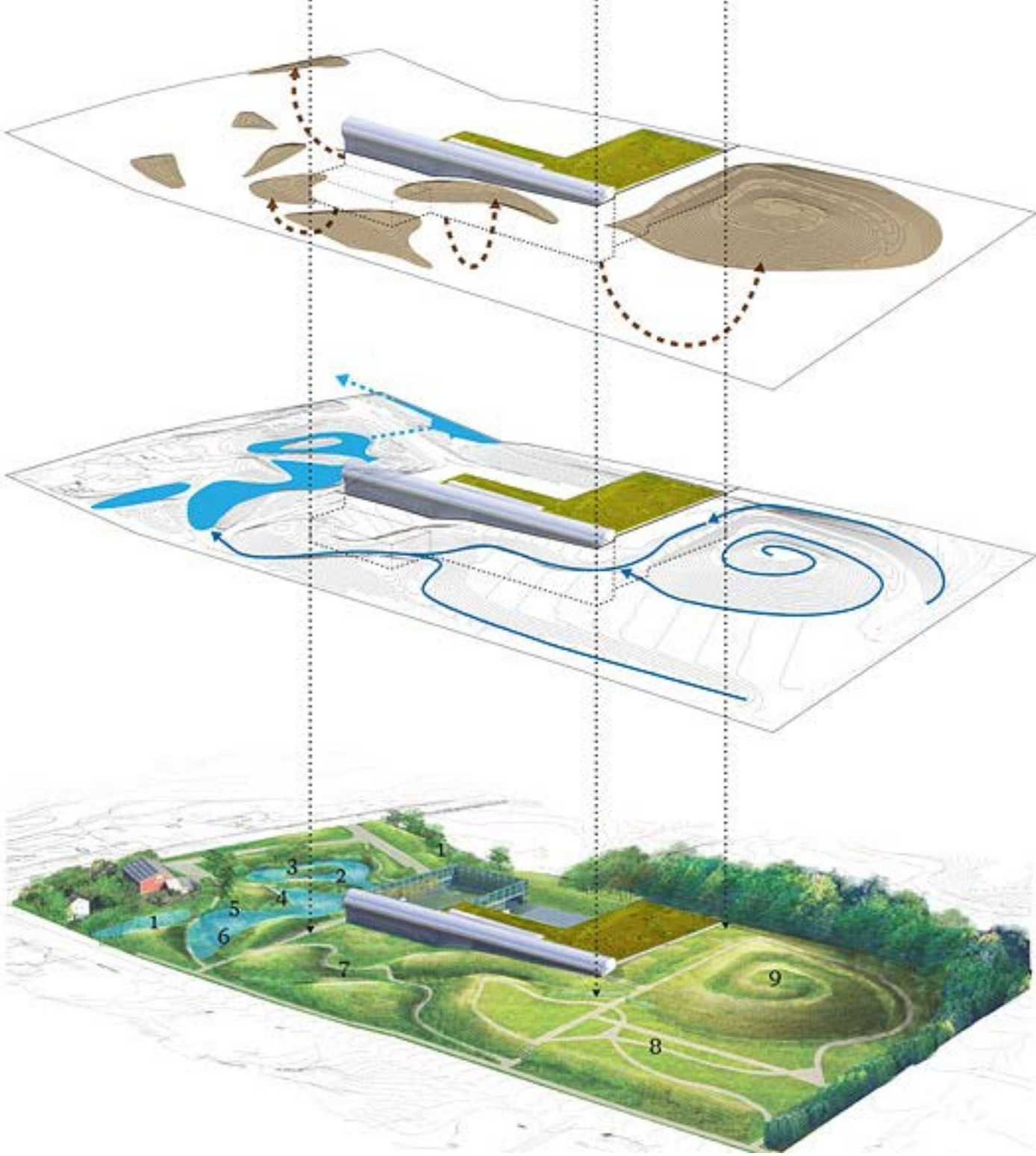
Wastewater Treatment Plant: Hamden, CT

40,000 cubic yards of displaced soil from building excavation creates new topography

Topography harnesses natural hydrological processes to improve water quality

A diverse landscape becomes a neighborhood amenity

1 Pre-existing Wetlands
2 Lake
3 Island
4 Peninsula
5 Beach
6 Gorge
7 Valley & Stream
8 Agricultural Garden
9 Mountain & Intermittent Stream



Trees are components of a wastewater treatment train—polishing phases.

Interstate Park: Seattle

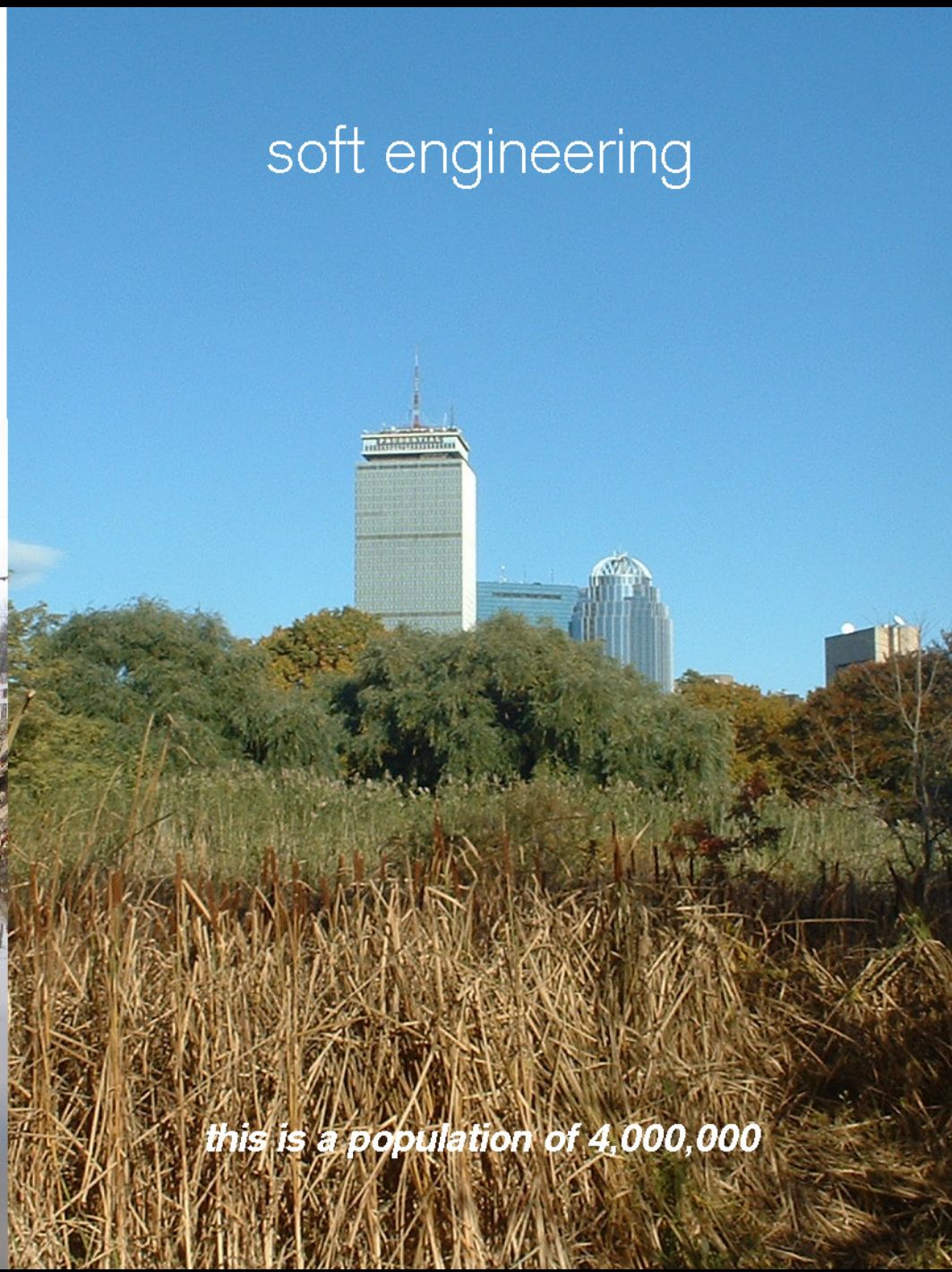
Green infrastructure combines delivery of transportation and ecosystem services within the city.

Wildlife Corridor:
Ontario, Canada

hard engineering

this is a population of 8,000

soft engineering



this is a population of 4,000,000

These are landscapes within a city, involving trees and the creation of Reconciliation Landscapes