

# High Performance Urban Ecosystems



In a world where **six million** people are being added **each month**, every site matters



Over 50% of the global population – **80%** in the U.S. and Europe – now **live in urban areas**

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in revenue, profits**



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# Census: Austin fastest-growing metro in Texas, third-fastest in nation

Mar 26, 2015, 8:00am CDT Updated Mar 26, 2015, 12:47pm CDT

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Pacific Cannery Lofts, Miller Company Landscape Architects

**Our interactions with nature** and the benefits it provides most often occur in **developed landscapes**



Lopez Common Ground, Mithun

**Our interactions with nature and the benefits it provides most often occur in developed landscapes**



Ackermannbogen Neighborhood Parkland, Zaharias landschaftsarchitekten

**Our interactions with nature** and the benefits it provides most often occur in **developed landscapes**



Taylor 28, Mithun

In our quest for sustainability, we **habitually neglect** the **potential of urban landscapes**



**Why not demand more?**





**Lawn irrigation consumes 30% of municipal freshwater in the eastern United States and up to 60% in the west**

US EPA



Purple loosestrife, *Lythrum salicaria*

**85% of the invasive woody plant species in the U.S. were introduced for landscape or ornamental use, and approximately 5,000 species have escaped into natural systems.**

Recihard, S.H. and White, P., "Horticulture as a Pathway of Invasive Introductions in the United States," *BioScience* 51: 103-13

# City of Austin

## Invasive Species Management Plan





**Stormwater runoff** from developed land is the **leading cause of water pollution** in urban areas

Loizeaux-Bennet 1999



**Stormwater runoff** from developed land is the **leading cause of water pollution** in urban areas

Loizeaux-Bennet 1999



**Think broadly about our developed landscapes and recognize their untapped potential**

Global Climate  
Regulation

Local Climate  
Regulation

Water Supply and  
Regulation

Erosion and  
Sediment Control

Hazard Mitigation

Pollination

Habitat Functions

Waste  
Decomposition  
and Treatment

Human Health  
and Well-being  
Benefits

Food and  
Renewable Non  
Food Products

Cultural Benefits

**Ecosystem services** *n.* - goods and services provided by ecosystems that **sustain and fulfill human life.**

The provision of ecosystem services is a **key attribute of sustainable design.**

\$16 - \$54 trillion per year. **Twice the global GNP**











# Global and local climate regulation





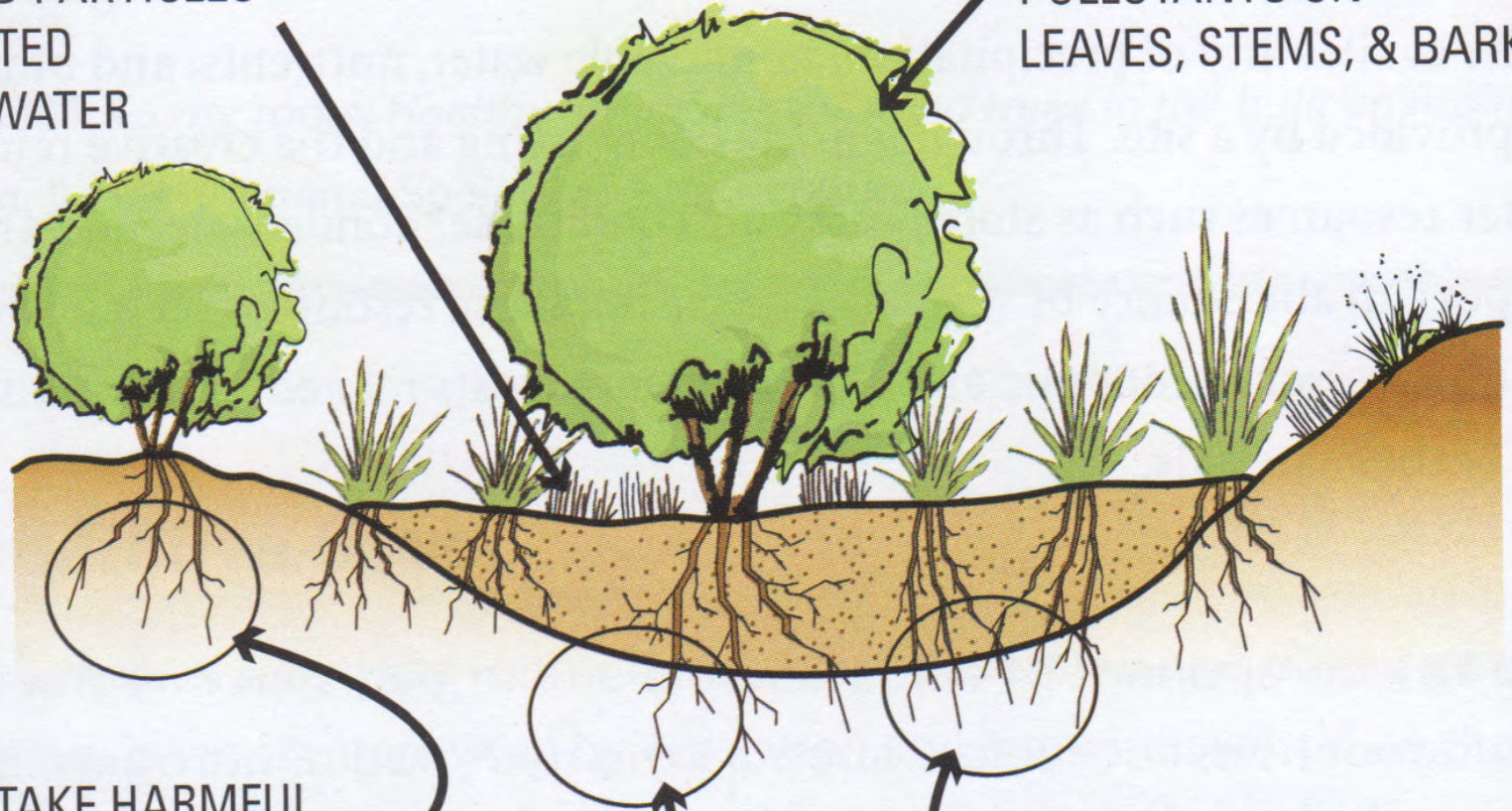
**Micro-climate: Urban heat island - A single tree: 9°F reduction in surface air temp. Green façade: up to 30°F reduction in building wall temp during summer months. 50% tree canopy over roads: reduce road surface temps by 28°F**

# Cleanse and store water



CAPTURE SEDIMENT & OTHER  
SUSPENDED PARTICLES  
TRANSPORTED  
BY STORMWATER

CAPTURE AIRBORNE  
POLLUTANTS ON  
LEAVES, STEMS, & BARK



ROOTS UPTAKE HARMFUL  
SUBSTANCES ALONG WITH  
WATER & NUTRIENTS

ROOTS BIND  
CONTAMINATED  
SOILS IN PLACE

ROOTS EXCRETE  
COMPOUNDS THAT  
ARE A FOOD SOURCE  
FOR MICROORGANISMS,  
WHICH BREAK DOWN &  
IMMOBILIZE POLLUTANTS

what's underneath

*healthy* soil has amazing water-retention capacity.



Every

**1%**

increase in organic matter results in as much as



**25,000**

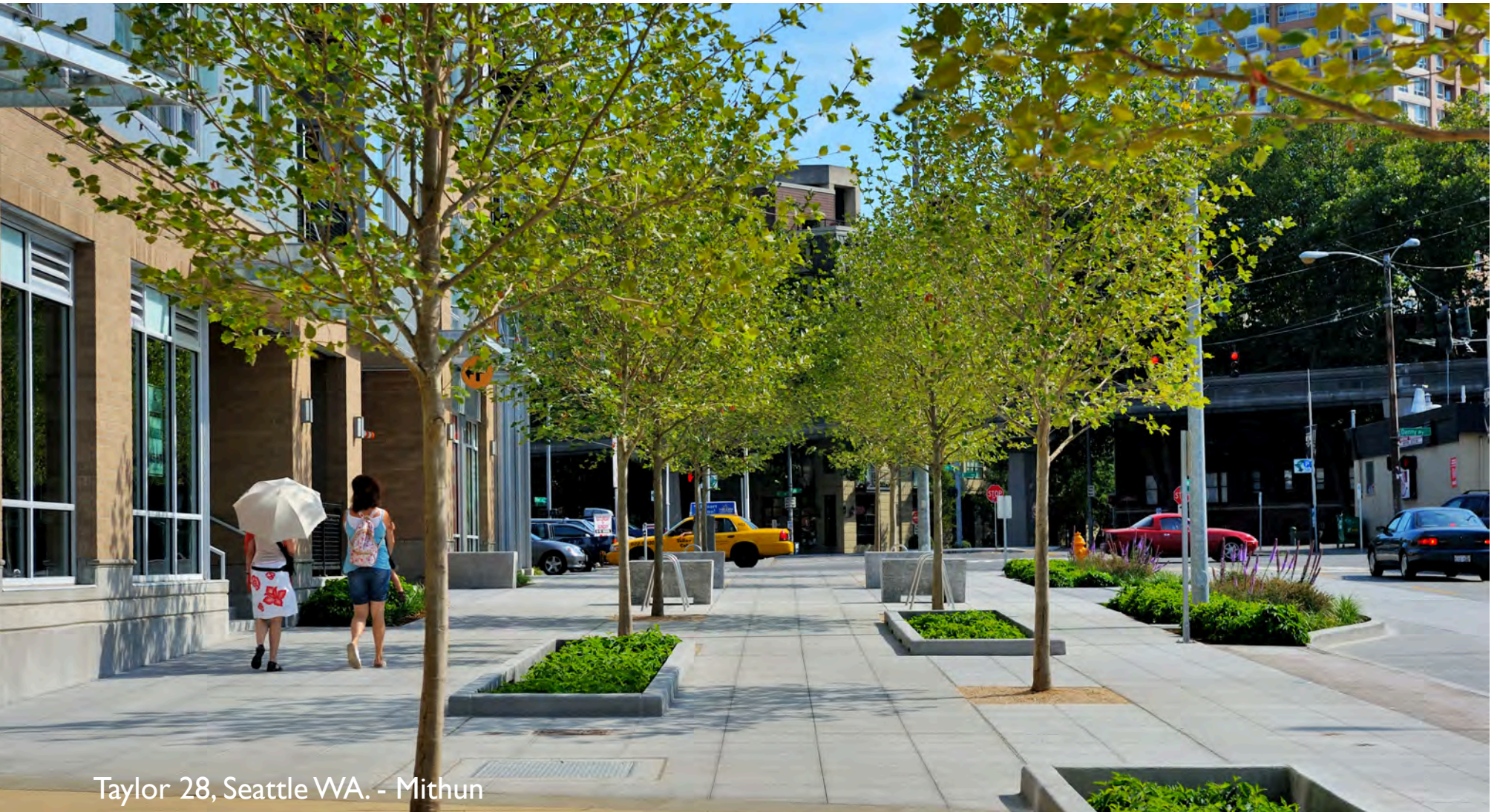
gal of available soil water per acre.

*Source: Kansas State Extension Agronomy e-Updates, Number 357, July 6, 2012*



Want more soil secrets?  
Check out [www.nrcs.usda.gov](http://www.nrcs.usda.gov)





Taylor 28, Seattle WA. - Mithun

**Water quality and quantity – Green infrastructure neighborhoods can decrease storm flow by 42%.**

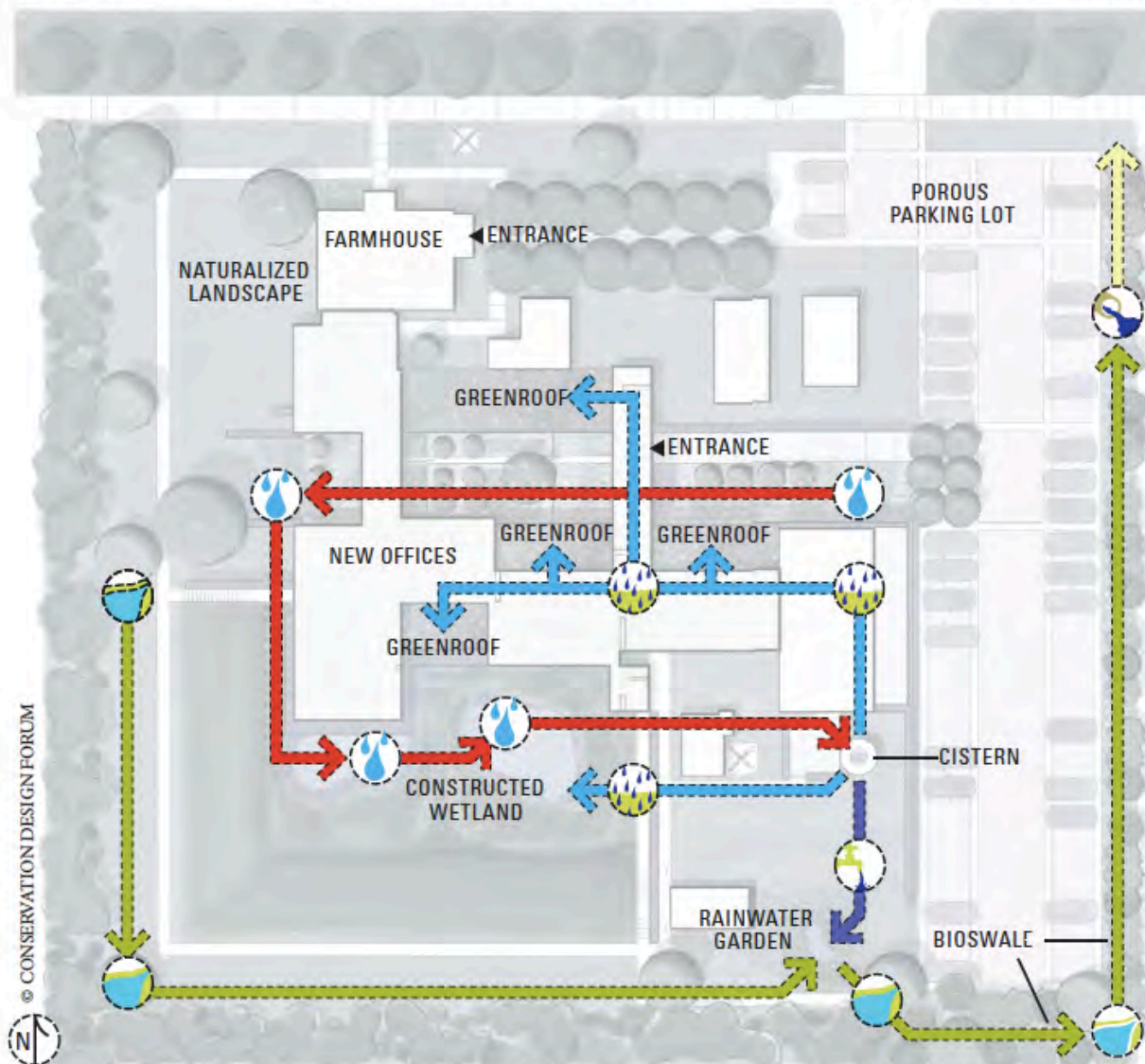


**2000 sq. ft. bioretention garden and outdoor classroom at Mt. Tabor Middle School in Portland manages runoff from 30,000 sq. ft. of impervious surface. Saved the City over \$100,000 in upgraded infrastructure costs.**

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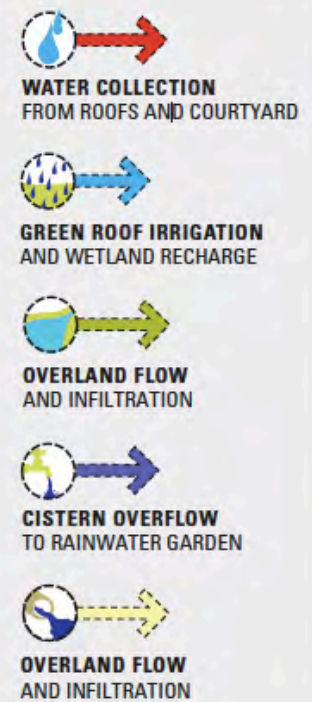


KRESGE FOUNDATION HEADQUARTERS RAINWATER DIAGRAM



■ **FIGURE 5.23**

Kresge Foundation headquarters stormwater management diagram.



# Pollination and habitat





**Diverse habitats - Wildlife refugia - ‘Stepping stones’ for habitat connectivity. Lincoln Park – 20 million human visitors and 158 bird species reported by citizen scientists.**



**‘Bottom-up’ influences on biodiversity – Groups of yards working together can potentially double native bird species richness.**

# Physical and mental health







Chicago Community Climate Action Tool Kit

Physical activity – ‘Green exercise’ – Food gardens –  
**Neighborhoods with more vegetation** near homes  
more likely to **engage in frequent physical activity.**  
**40% less likely to be obese**



**Mental health and well-being – visual and physical access to nature has been linked to restored concentration, positive attitudes and improved productivity.**

# Design Solutions

How do we design spaces that improve ecosystem function and build natural capital?





Taylor 28, Mithun

Plants are **essential** to the provision of ecosystem services

## Potential Annual Benefits of a Tree

Absorb 48 lbs of air pollutants

Produce 260 lbs of oxygen

Reduce cooling costs by up to 13%

Increase property value by 15%

Habitat for over 500 insect species

Intercept 4000 gallons of stormwater





Turtle Creek Pump House, MESA

A site's vegetative biomass can indicate its productivity, with **more plant layers** typically providing **greater benefits**.

Ecosystem  
Service Benefits

Triple bottom  
line costs

Supporting Services

Provisioning  
Services

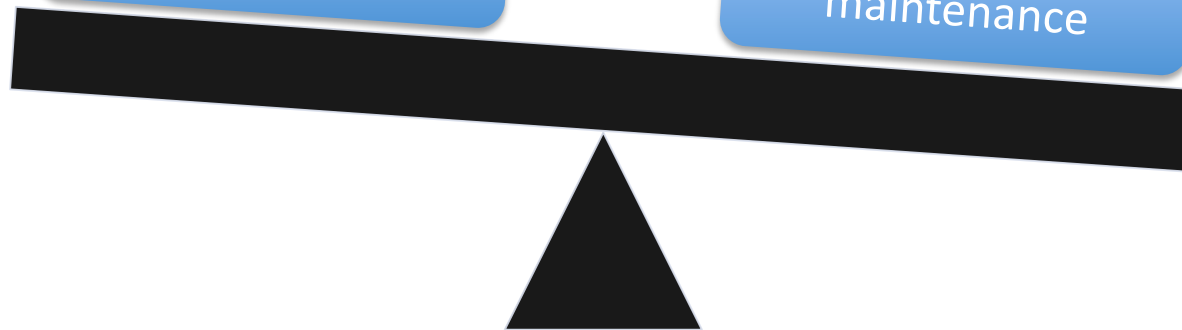
Regulating Services

Site Clearing

Plant production/  
transportation

Establishment

On-going  
maintenance



remove

increases environmental  
and economic costs

rebuild

replace





**Incorporate** existing appropriate vegetation into the design.



**Bur Oak 5" dbh**

Intercepts 331 gallons of  
stormwater

Annually sequesters 86 lbs  
CO<sub>2</sub>

**Bur Oak 25" dbh**

Intercepts 7,996 gallons of  
stormwater

Annually sequesters 877  
lbs of CO<sub>2</sub>





Redstone Canyon Garden, Plant Driven Design

**Eliminate potable water use after plant establishment**



In the US, **52,620,000 metric tons** of  $\text{CO}_2$  – the **equivalent to the amount generated by 10 million cars** – is released each year by **water treatment facilities** (US EPA 2010).

# Water Balance



Water needs  
of the  
landscape

The diagram consists of two blue circles connected by an equals sign. The left circle contains the text 'Water needs of the landscape'. The right circle contains the text 'Precipitation and on-site alternative water resources'. The equals sign is formed by two horizontal bars.

Precipitation  
and on-site  
alternative  
water  
resources

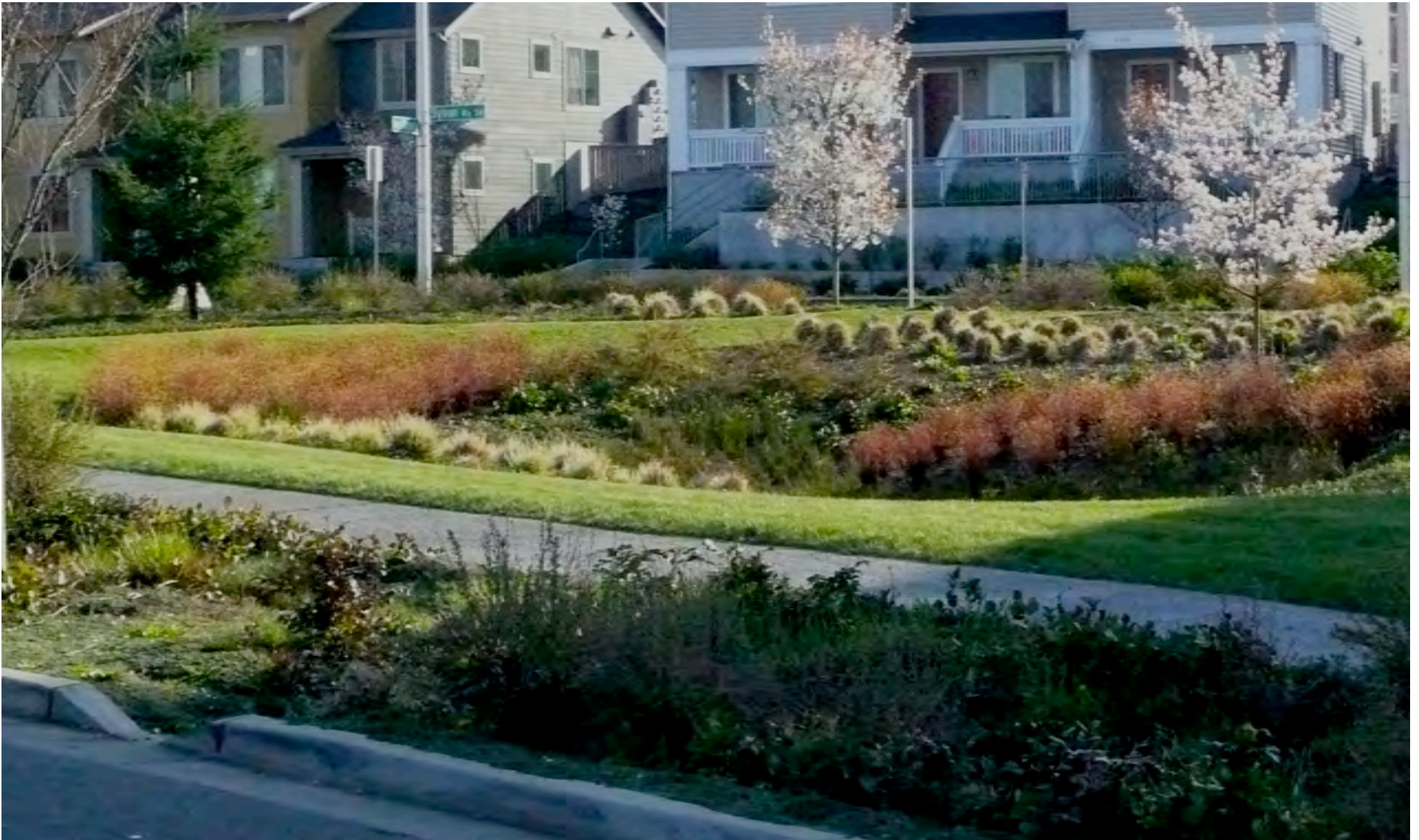
# Active Rainwater Harvesting

catchment area (ft<sup>2</sup>) x rainfall (ft) x 7.48 gal/ft x runoff coefficient = net runoff (gal)



# Passive Rainwater Harvesting

catchment area (ft<sup>2</sup>) x rainfall (ft) x 7.48 gal/ft x runoff coefficient = net runoff (gal)





# Air Conditioner Condensate

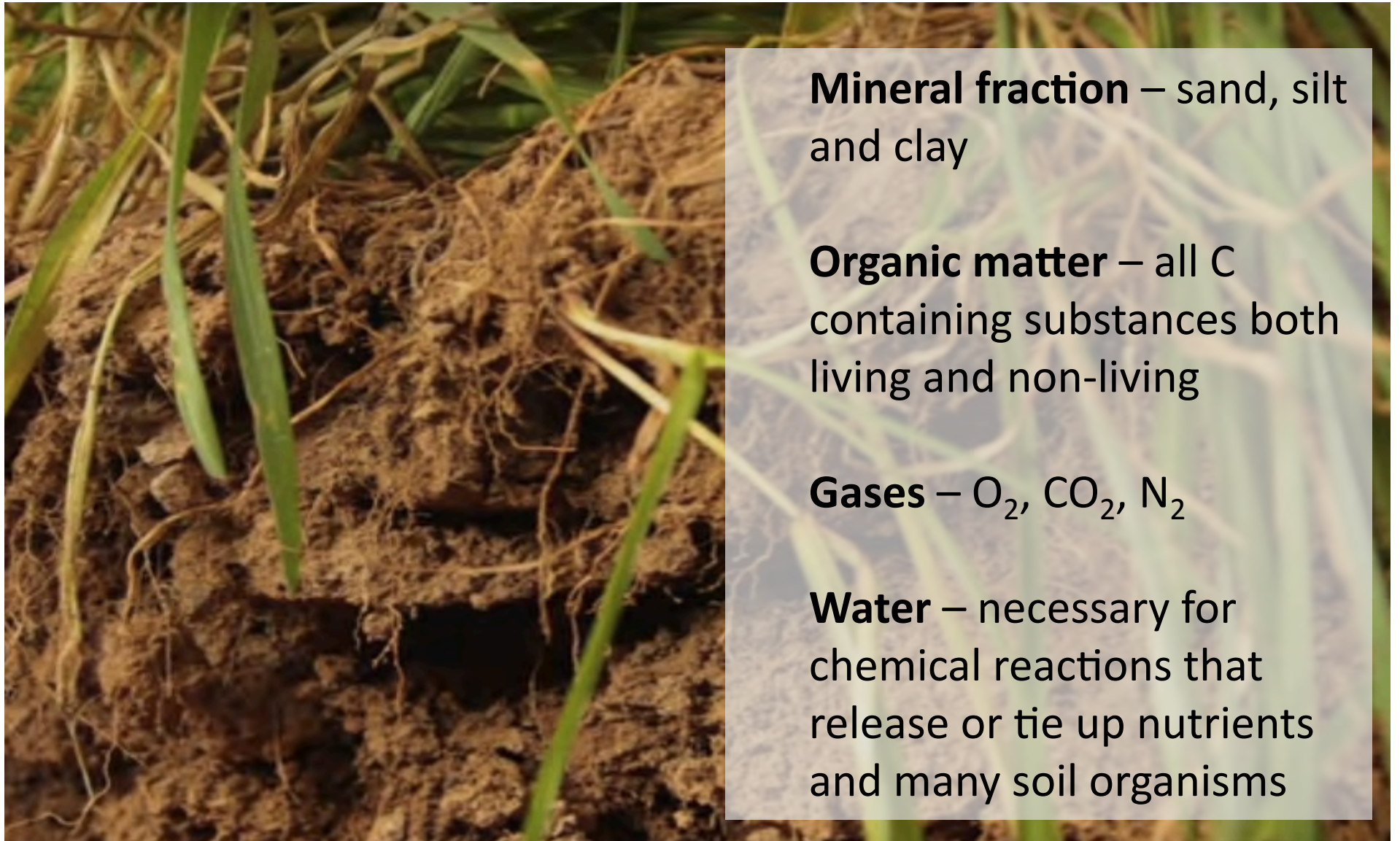
- The average single-family home produces 5 to 10 gallons/per day
- Connect to rainwater system or store separately



# Greywater

- Wastewater from the shower, sink and washing machine
- Approximately 50% to 80% of residential wastewater
- Average U.S. household generates 35 gallons per person/day





**Mineral fraction** – sand, silt and clay

**Organic matter** – all C containing substances both living and non-living

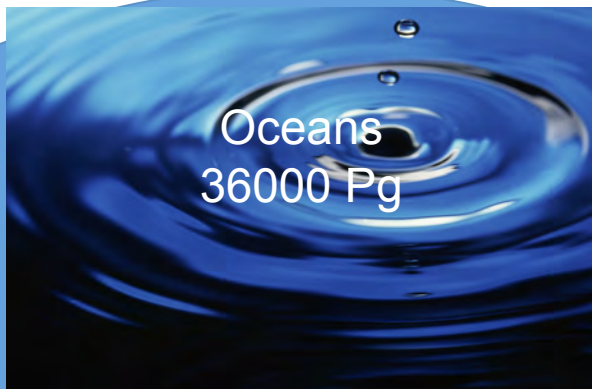
**Gases** –  $O_2$ ,  $CO_2$ ,  $N_2$

**Water** – necessary for chemical reactions that release or tie up nutrients and many soil organisms

**Protect and restore ecosystem services provided by soils.**

# **Ecosystem services provided by soils**

- **Absorbs rainfall and mitigates flooding**
- **Removes pollutants and cleanses water**
- **Stores water for plants, wildlife and people**
- **Provides nutrients**
- **Stores atmospheric carbon**
- **Provides habitat for millions of microbes, insects, plants and animals**



Oceans  
36000 Pg

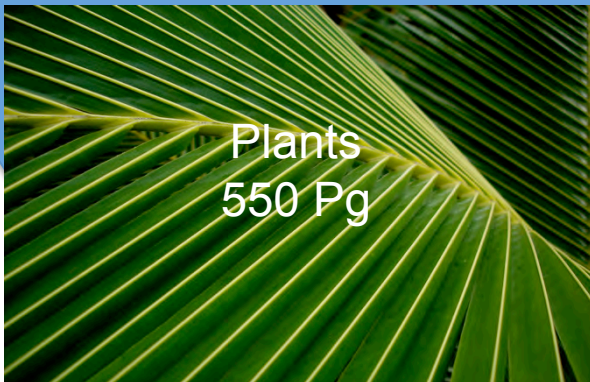


Soil  
1500 Pg



Fossil Fuel  
5000 Pg

# CO<sub>2</sub> Pools



Plants  
550 Pg

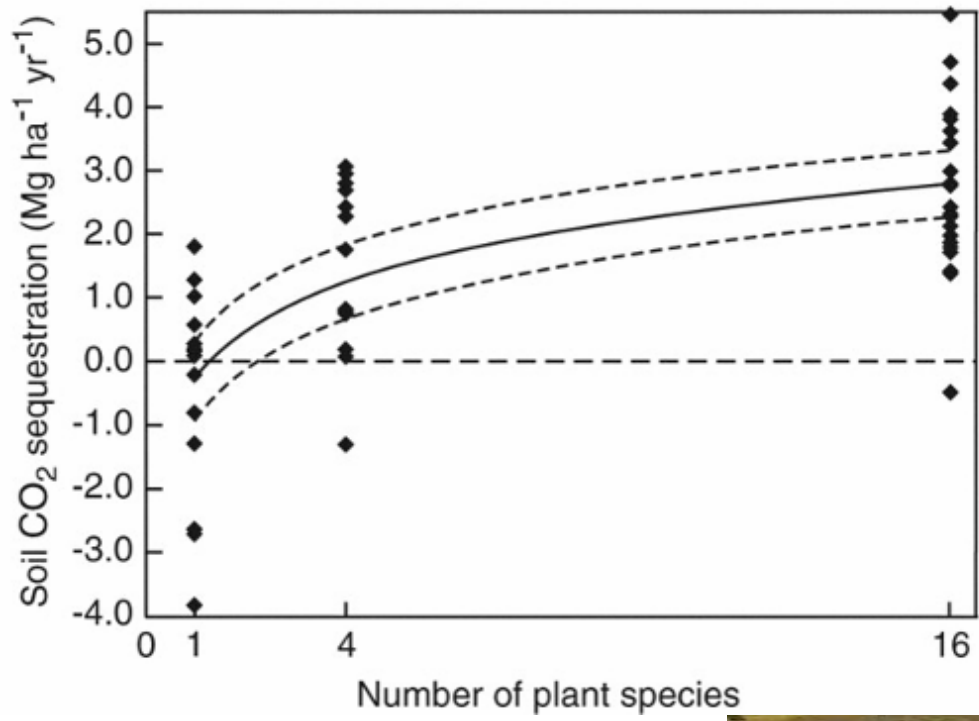


Atmosphere  
750 Pg

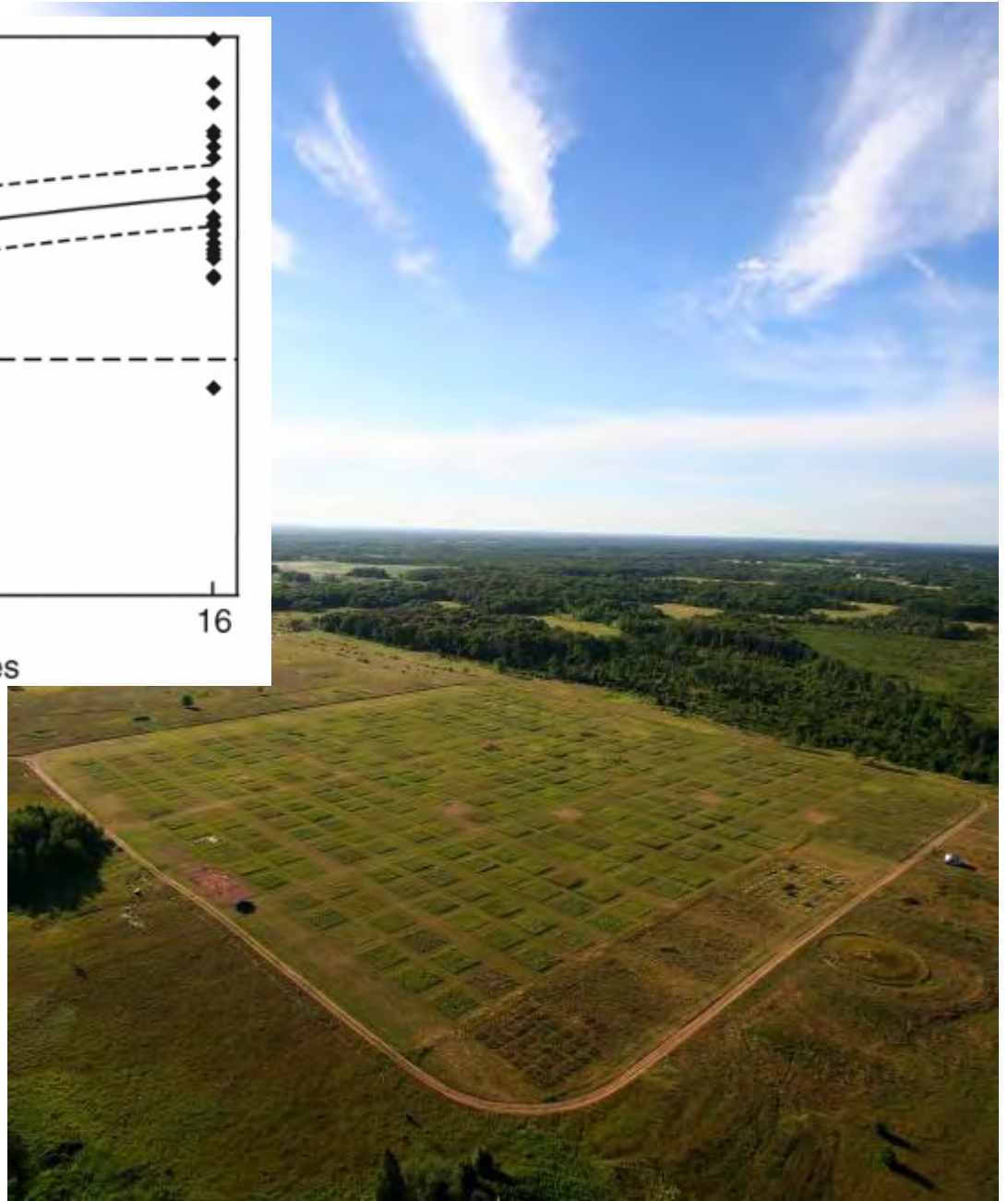
Pg = petagrams =  $10^{15}$  grams = 1 billion tonnes



**Once lost, soil carbon pools can take decades or centuries to rebuild. Plants can slowly restore carbon pools but thoughtful plant selection and maintenance is required to ensure the site remains a net carbon sink.**



Tilman, Hill and Lehman. Science (2006)







**Q:**

What is the most common constraint with urban soils in regards to ecosystem function?

**A:**

1. Compaction
2. pH
3. Soil microbes

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**A:**

1. Compaction

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3. Soil microbes

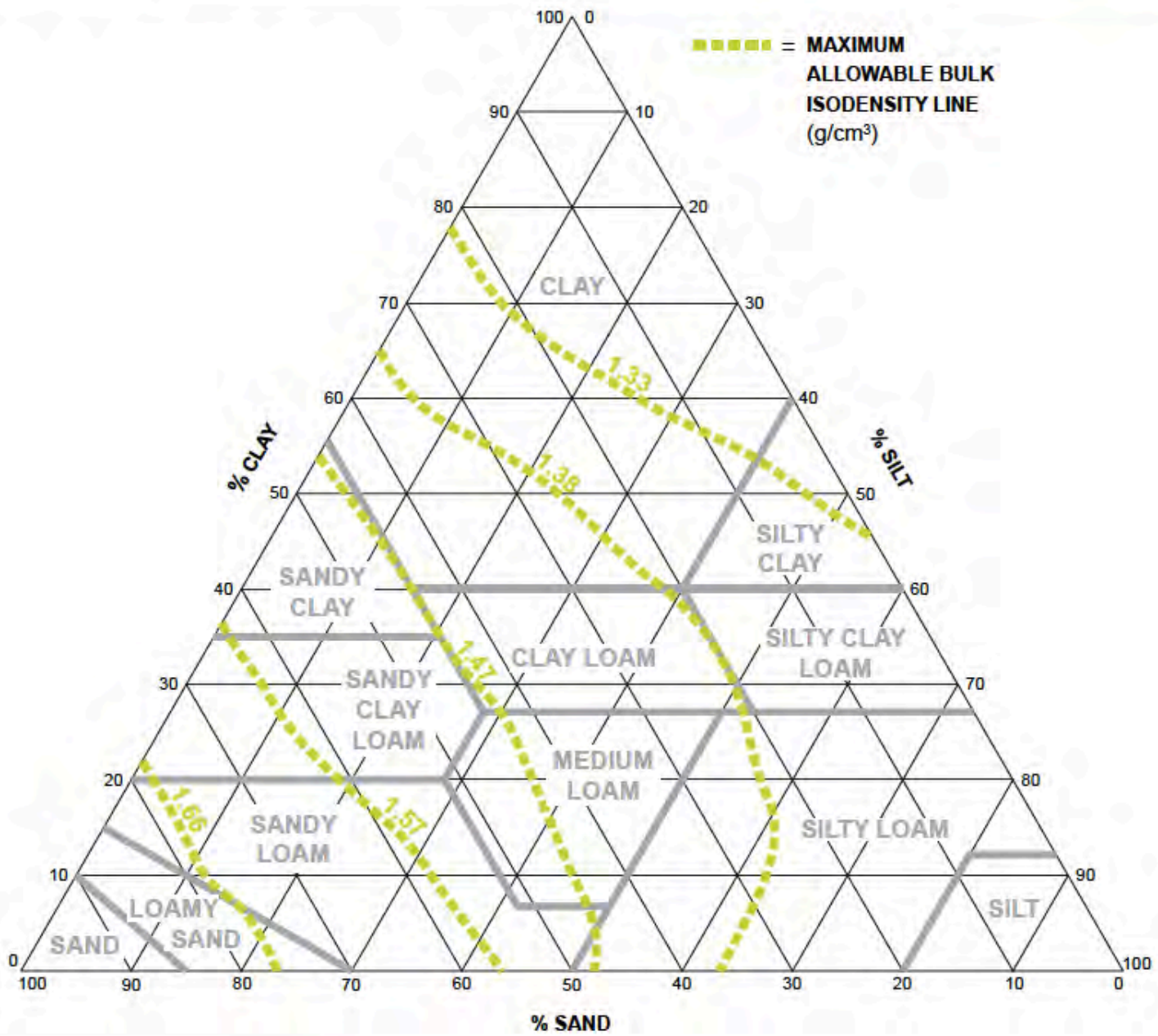
# Soil Compaction

Weight from a single intense force or small repeated forces pushes soil particles together causing them to compact .

## Compacted soils:

- **Contribute to erosion**
- **Restrict plant growth**
- **Limit the soil's ability to absorb water**
- **Decrease the soil's biological activity**





# Common Causes of Soil Compaction

- **Construction and maintenance equipment**
- **Repeated pedestrian and animal traffic**
- **Rainfall on bare soils**
- **Continually removing organic matter such as leaves or lawn clippings from the landscape**
- **Working wet soils**
- **Repeated tillage**



# Design Strategies for Landscapes Under Construction

- Conduct a site analysis before design starts
- Develop a soil preservation plan
- Enforce tight limits of disturbance
- Designate areas for parking and storage



# Design Strategies for Landscapes Under Construction

- Harvest and store topsoil for reuse
- Protect soils with mulch
- Use the lightest equipment possible
- Avoid working soils when wet





**Soil volume** impacts plant size, life span, health and resiliency and irrigation and nutrient requirements. A minimum of **2 cubic feet of soil per 1 square foot of mature tree canopy**



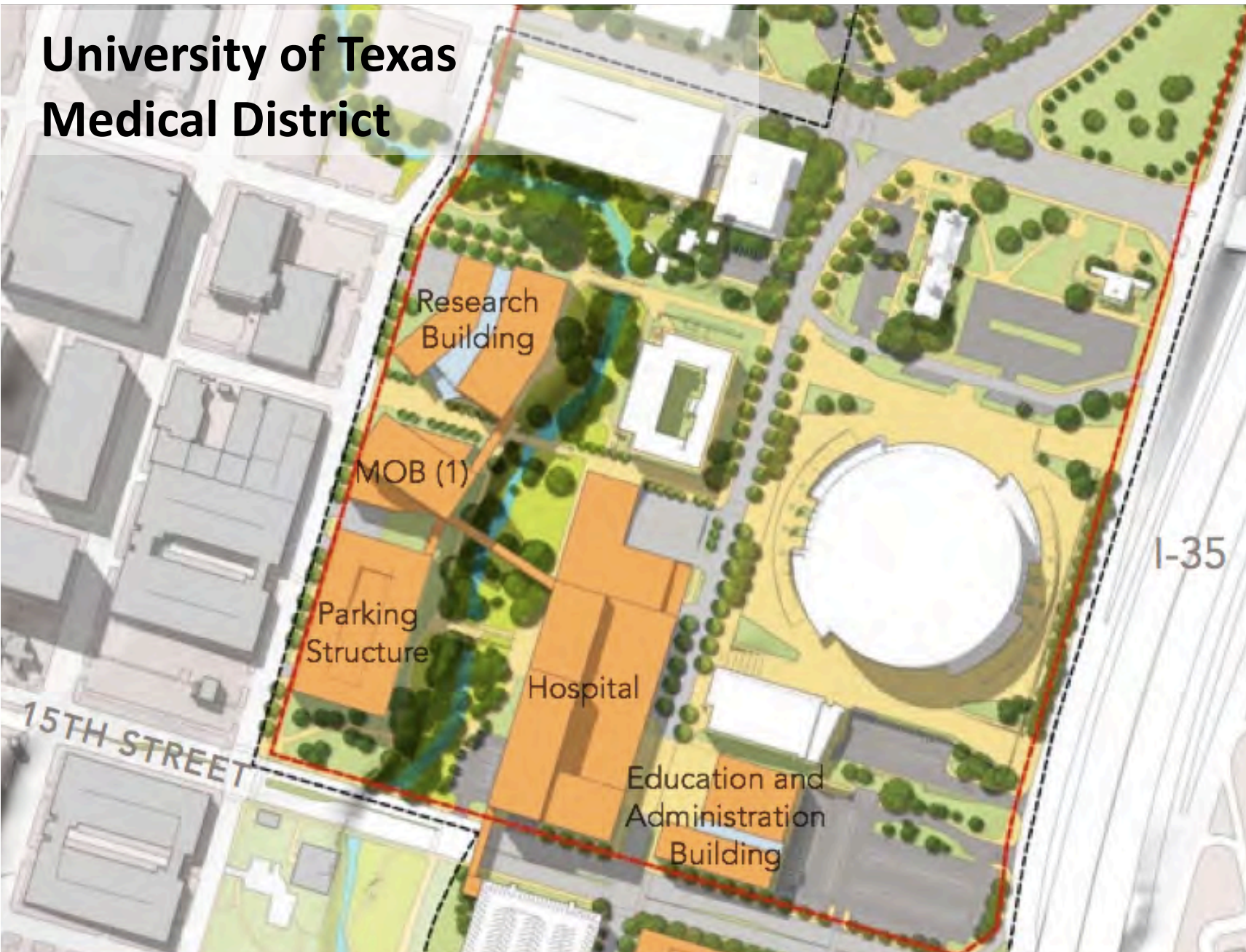


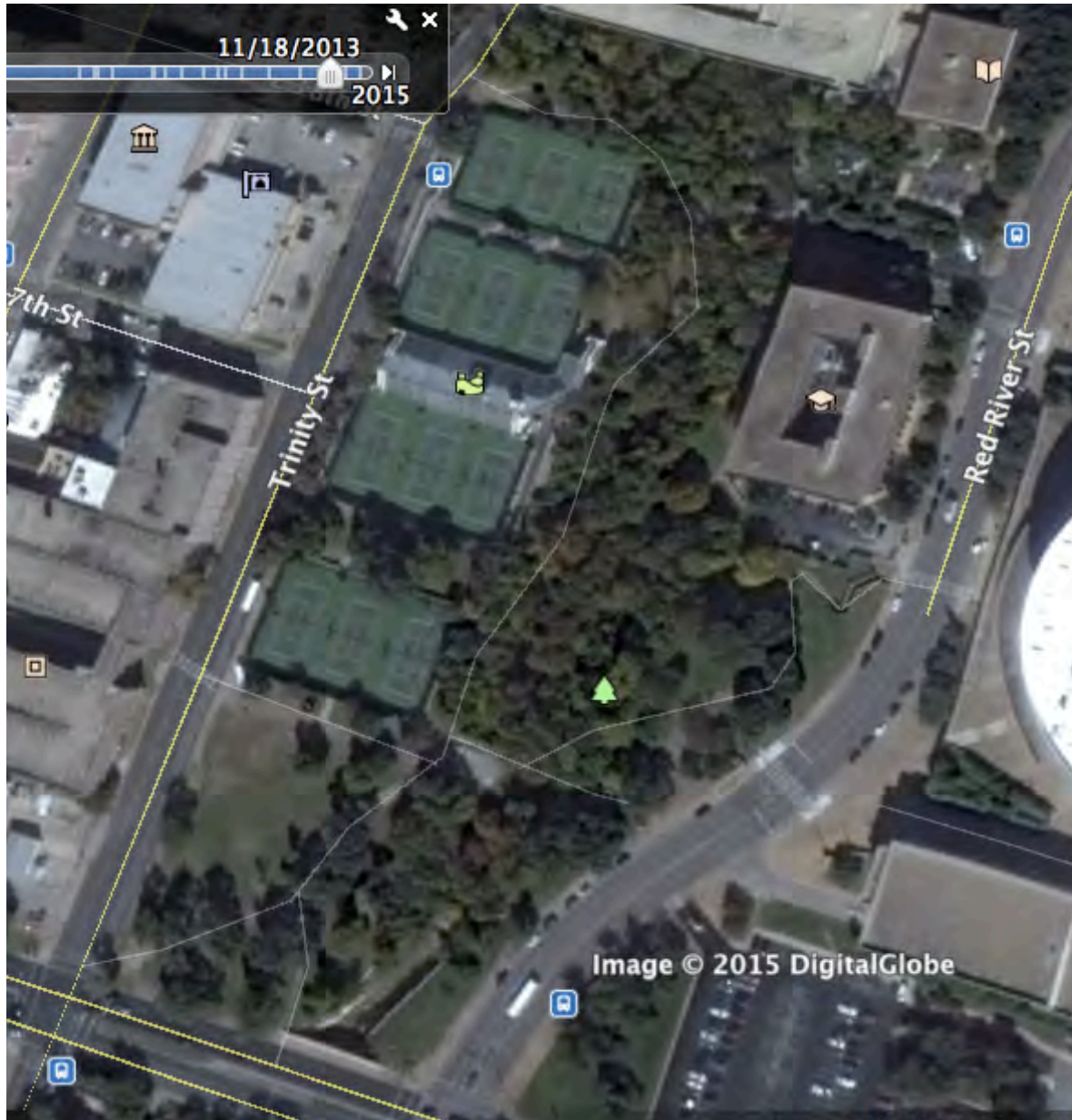
Move from schedule maintenance to **adaptive maintenance** based on **monitoring that guides** the landscape towards **increased performance**

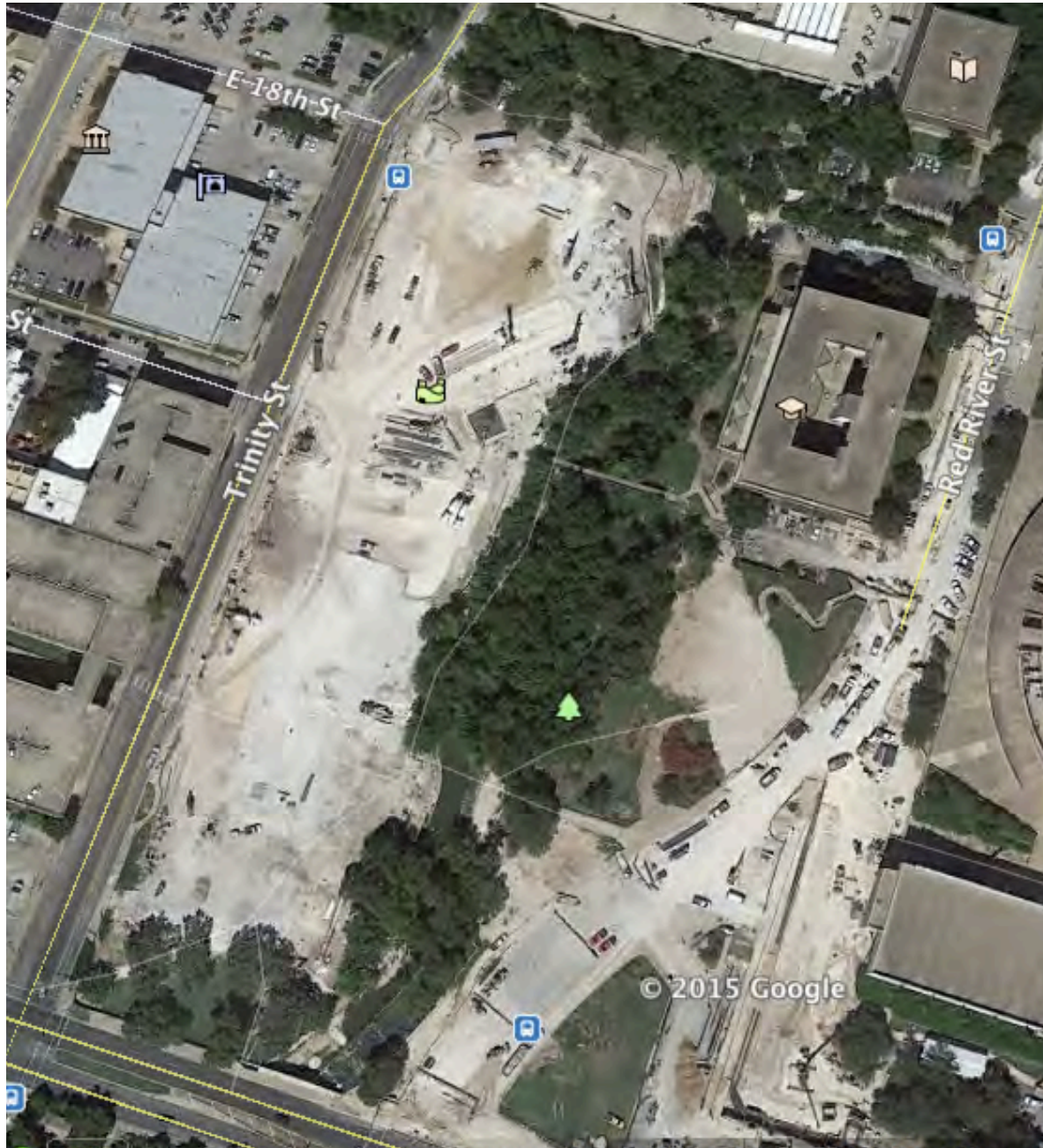


**Continued learning and information feedback loops to improve future work and the industry.**

# University of Texas Medical District









**Evaporate, Infiltrate or Reuse stormwater on-site  
(80<sup>th</sup> percentile)**



**Improve function of Waller Creek**



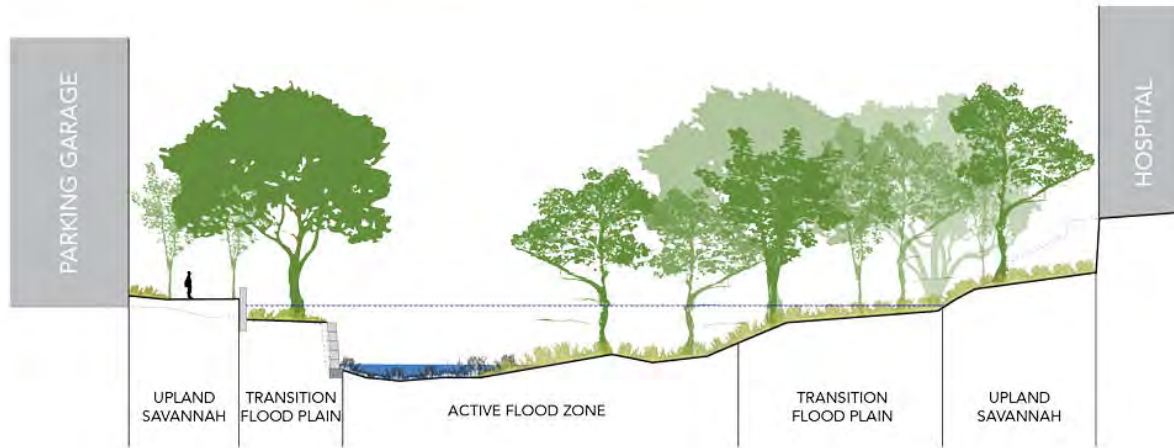


WALLER CREEK IN MEDICAL DISTRICT SECTION A-A'

EXISTING  
CONDITION

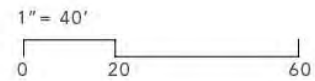


PROPOSED  
CONDITION



LEGEND

- NATIVE PLANT SPECIES
- INVASIVE PLANT SPECIES
- SAVANNAH GRASS SPECIES
- 500-YEAR FLOOD LINE
- 100 YEAR FLOOD LINE





**Restore damaged soils - Increase planting soil volume**



**Increase biodiversity – Reduce maintenance**



**Provide access to nature to a much larger segment of the population**

# High Performance Urban Ecosystems



In a world where **six million** people are being added **each month**, every site matters