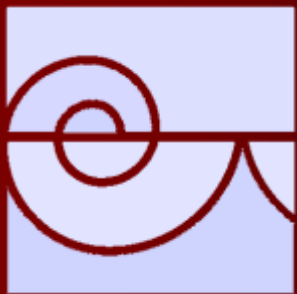


# Urban Soils & Water Quality

*Rebuilding Brown Infrastructure*



Cuyahoga  
Soil and Water  
**Conservation**  
District

*excellence in conservation*

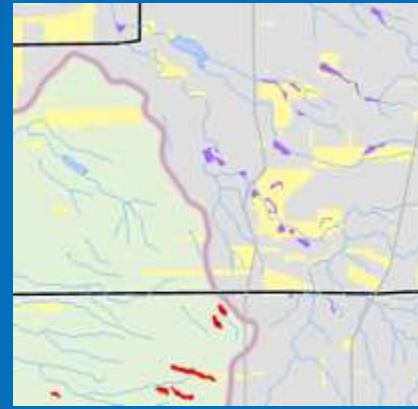
Todd A. Houser, CPESC, CPSSc  
Storm Water Program Manager



# What is Brown Infrastructure?



# Gray



# Blue



# Green





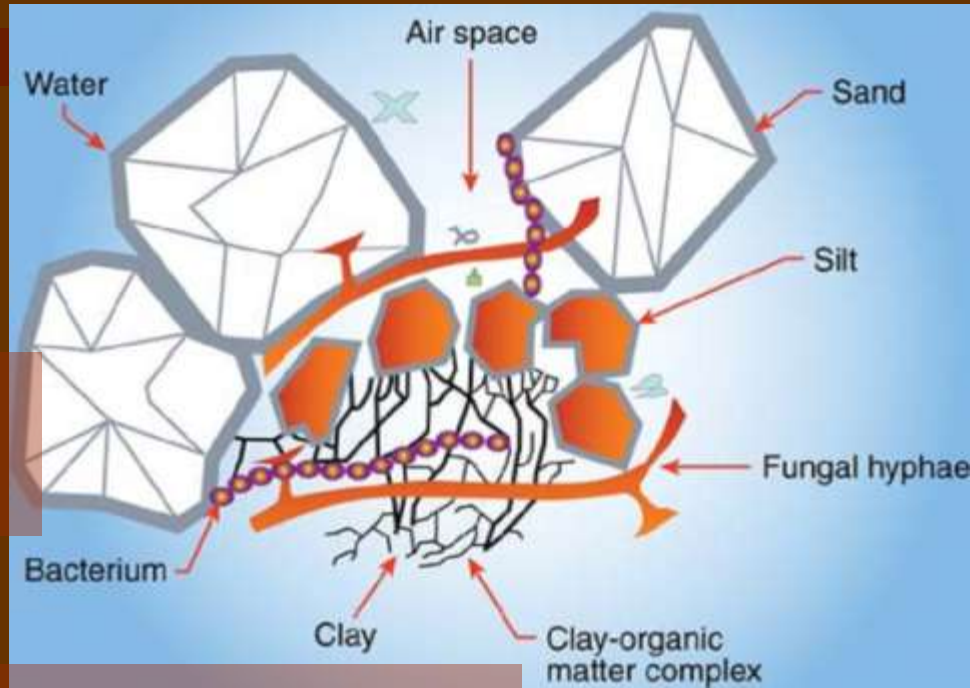
# Brown

## soil survey of **Cuyahoga**

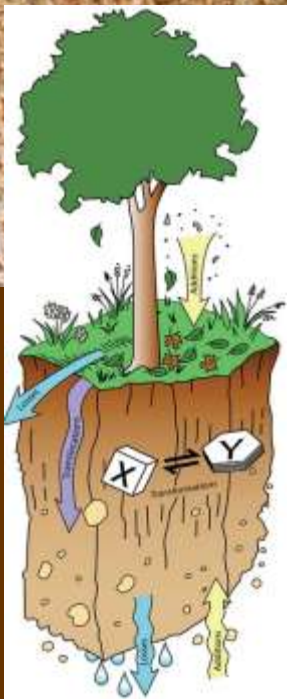
United States Department of Agriculture  
Soil Conservation Service  
In cooperation with  
Ohio Department of Natural Resources  
Division of Lands and Soil  
and  
Ohio Agricultural Research and Development Center



# Soil defined...



A dynamic natural body composed of mineral, organic materials and living organisms in which plants grow. (Brady et al.)



# Urban soils...

- High variability
- Mostly *carbon starved*
- Mostly *compacted*
  - massive or degraded soil structure
- Nutrient and pH imbalanced (can be phytotoxic)
- Profile may be buried, removed or mixed
- Low microbial biomass



# Urban Soil Functions


- Pollutant sorption & degradation
- Waste and nutrient recycling
- Urban landscaping & wildlife habitat
- Soil carbon sequestration
- High-intensity urban agriculture
- Heat and storm water volume reduction



# Soil Quality

- The capacity of a soil to function within an ecosystem to sustain biological productivity, maintain environmental quality, and promote plant and animal health (Soil. Sci. Soc. Am., 1996).





Most urban soils have  
degraded quality...



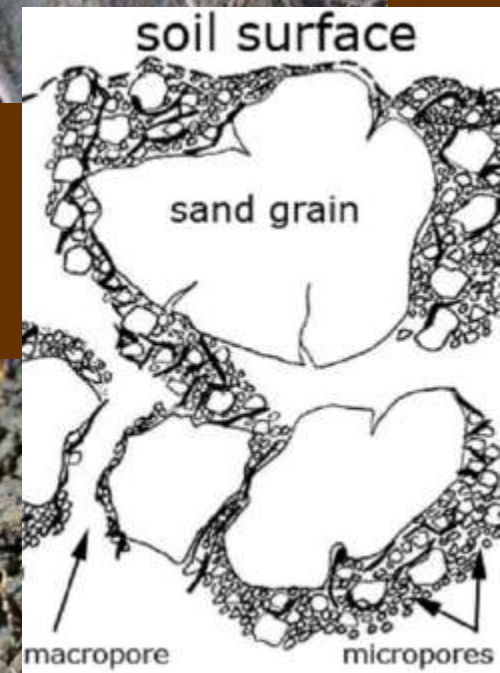
How do we rebuild  
*brown infrastructure?*



...Begin with evaluation of soil quality indicators.

# Soil Quality Indicators

- Total organic carbon
- Bulk density (compaction)
- Available water capacity
- Aggregate stability
- Respiration
- Electrical conductivity & pH
- Soil structure and macro-pores
- Infiltration
- Earthworms



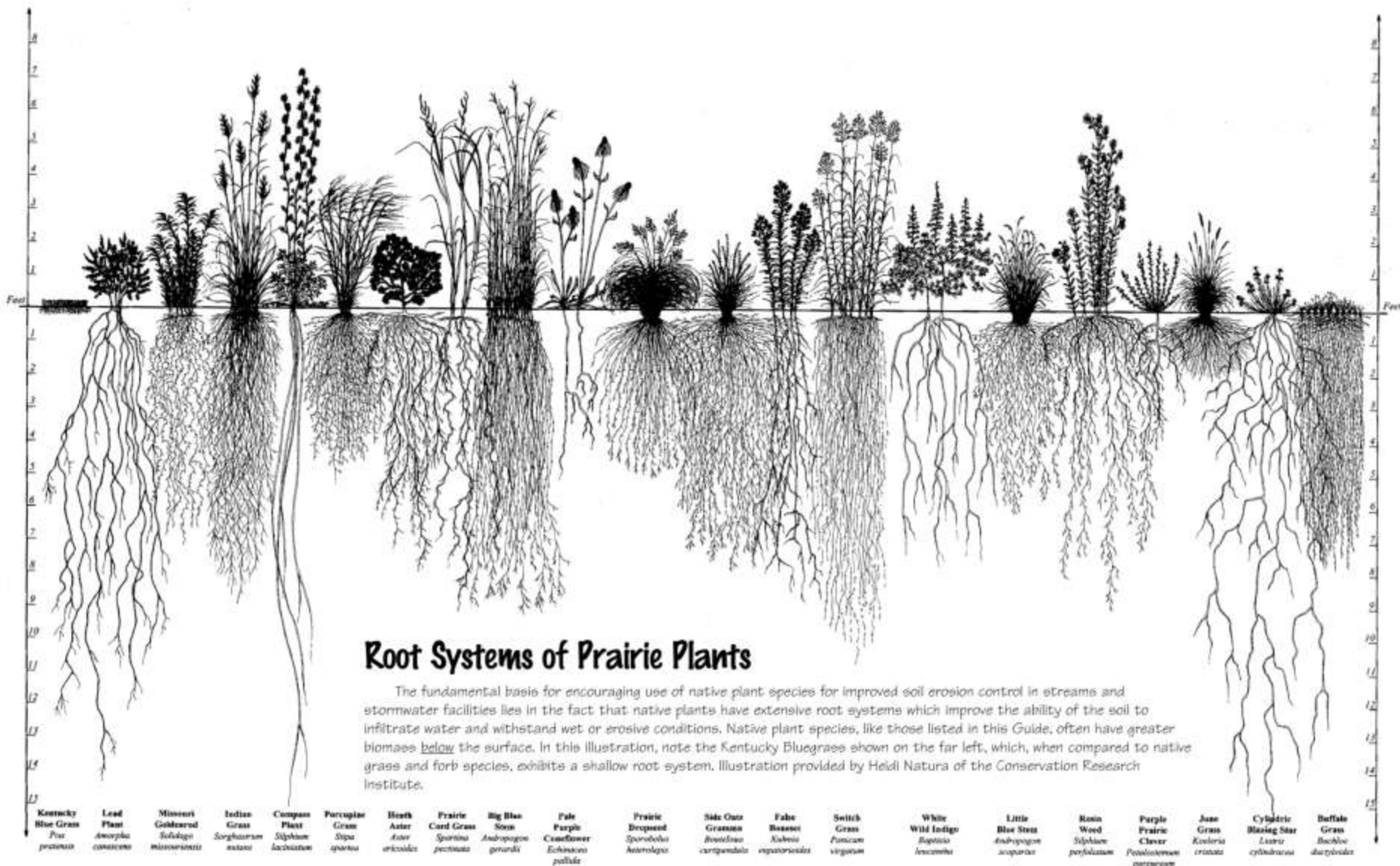


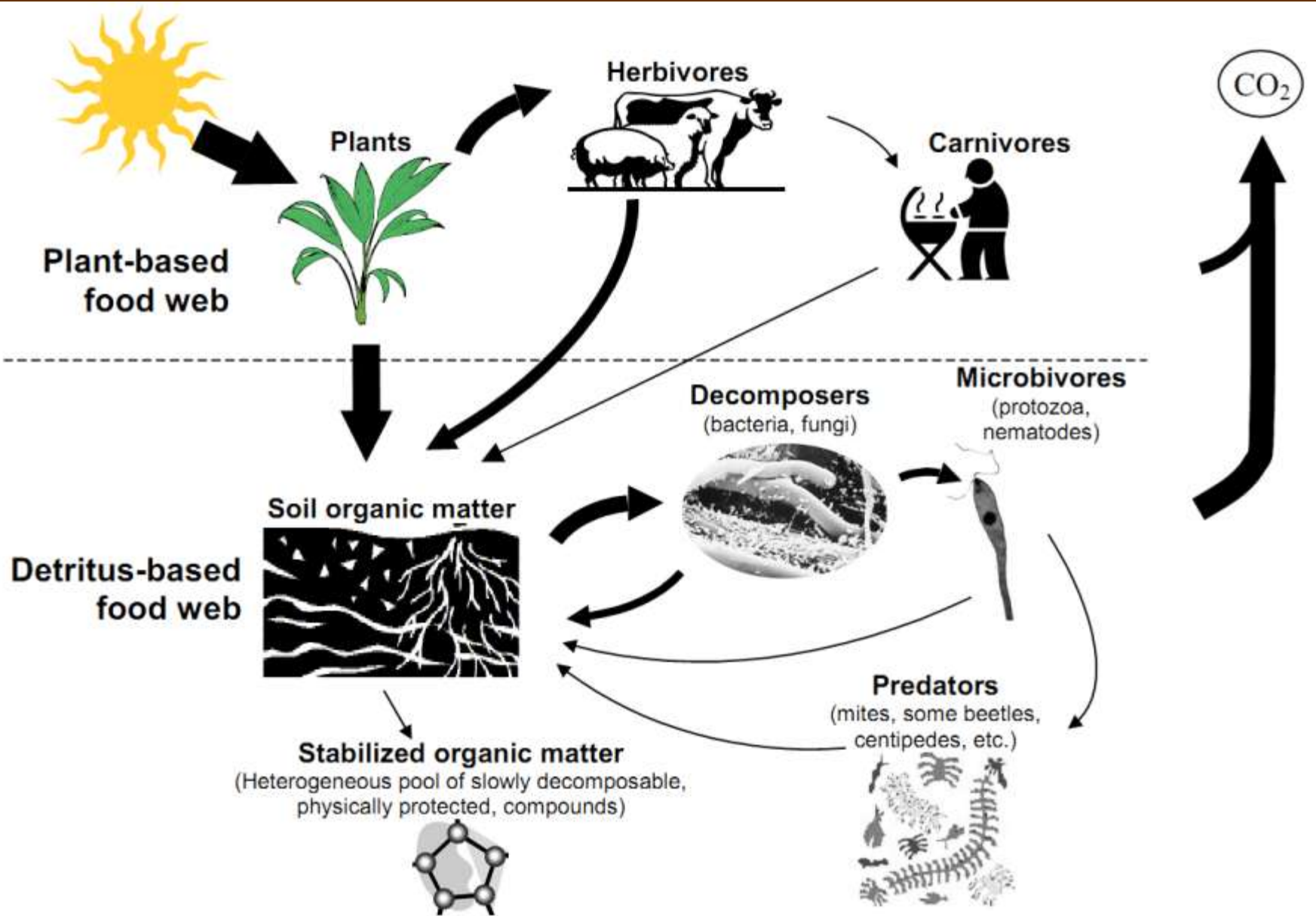
Then, implement  
the right practices...

# Soil Rehabilitation

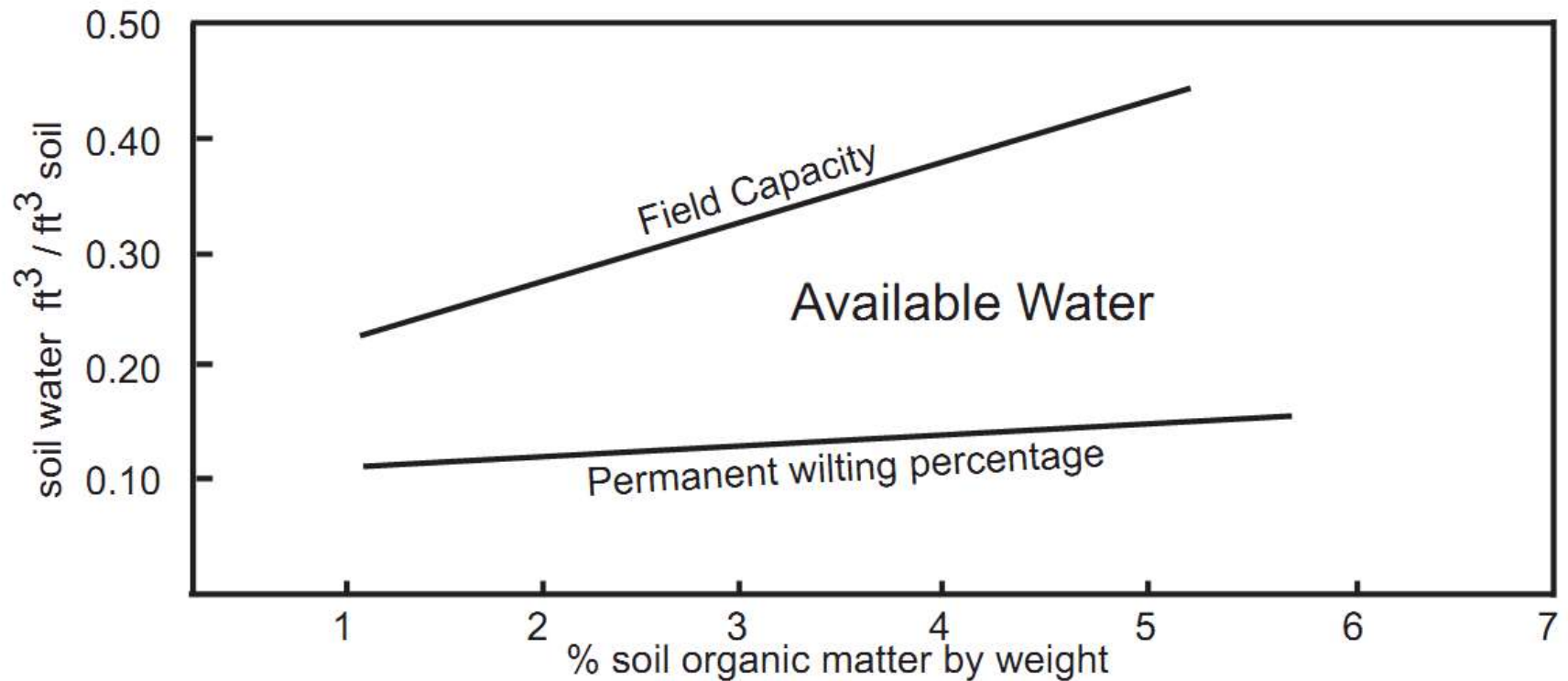
- Reduce impervious surfaces
- Loosen compacted soils
- Reduce luxury fertilization
- Reduce over-liming
- Use compost-filled trenches & vertical mulching
- Plant deep-rooted, herbaceous vegetative treatments & cover crops











***Figure 2. Effect of increasing organic matter on available water capacity of silt loam soils. Adapted from Hudson, SWCS, 1994.***

# Platy Structure



# Water-Stable Aggregates

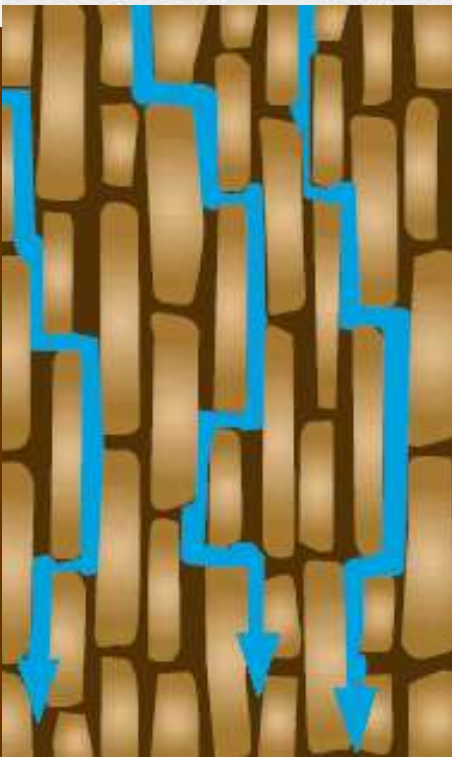
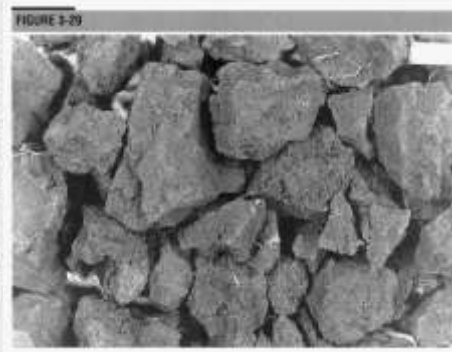
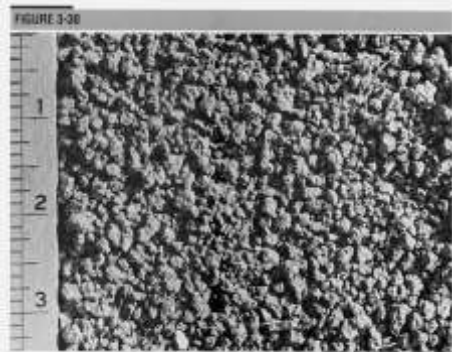


## Protecting Urban Soil Quality:

### Examples for Landscape Codes and Specifications

Soil texture	Ideal bulk densities (g/cm <sup>3</sup> )	Bulk densities that may affect root growth (g/cm <sup>3</sup> )	Bulk densities that restrict root growth (g/cm <sup>3</sup> )
Sands, loamy sands	<1.60	1.69	>1.80
Sandy loams, loams	<1.40	1.63	>1.80
Sandy clay loams, loams, clay loams	<1.40	1.60	>1.75
Silts, silt loams	<1.30	1.60	>1.75
Silt loams, silty clay loams	<1.10	1.55	>1.65
Sandy clays, silty clays, some clay loams (35-45% clay)	<1.10	1.49	>1.58
Clays (>45% clay)	<1.10	1.39	>1.47

Improved Soil Structure =   $K_{sat}$



Target  $K_{sat}$  of 1.5-2.6 in. hr<sup>-1</sup>  
for planting media

(<http://www.dnr.state.oh.us/tabid/9186/default.aspx>)



Target of penetration resistance  
of <200 psi for planting media

([http://soils.usda.gov/sqi/management/files/protect\\_urban\\_sq.pdf](http://soils.usda.gov/sqi/management/files/protect_urban_sq.pdf))



Compaction limits rooting  
and hydraulic conductivity

# Brown Infrastructure

- Can improve water quality
- Can help minimize long-term costs
- Can improve aesthetics and habitat quality
- Can increase productivity of urban agriculture
- Can help mitigate channel erosion

# Building Soil

## Guidelines and Resources For Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington 2010 Edition

**Summary**

Soil quality is directly related to stormwater detention capacity, and so to the health of streams and aquatic resources in the Pacific Northwest.

Soil quality also determines landscape success, plant survival, growth, disease resistance, and pest control needs.

Soil quality is a key component of site soil testing, reducing the need for costly soil testing to meet BMP requirements.

This guide also includes field inspection techniques, WA suppliers of compost and soil testing laboratories, and specification language in APWA and CSI formats.

For more information, visit [www.buildingsoil.org/tools/Soil\\_BMP\\_Manual.pdf](http://www.buildingsoil.org/tools/Soil_BMP_Manual.pdf).

For more information, visit [soils.usda.gov/sqi/assessment/assessment.html](http://soils.usda.gov/sqi/assessment/assessment.html).

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USDA Natural Resources Conservation Service

Indicator B	Test L	Function D/N
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# Soil Quality Indicators

## Total Organic Carbon

Total organic carbon (TOC) is the carbon (C) stored in soil organic matter (SOM). Organic carbon (OC) enters the soil through the decomposition of plant and animal matter.

also protects SOM from microbial mineralization. Extractable aluminum and allophanes (present in volcanic soils) can form stable compounds with SOM that resist microbial decomposition. Warm temperatures decrease SOC content by increasing decomposition rates, while high



USDA Natural Resources Conservation Service

Indicator P	Test L/O	Function W/S
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# Soil Quality Indicators

## Bulk Density

Bulk density is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles. Bulk density is



USDA Natural Resources Conservation Service

Indicator C	Test F	Function F/N
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# Soil Quality Indicators

## Soil pH

Soil pH generally refers to the degree of soil acidity or alkalinity. Chemically, it is defined as the log<sub>10</sub> hydrogen ions (H<sup>+</sup>) in the soil solution. The pH scale ranges from 0 to 14; a pH of 7 is considered neutral. If pH values are



USDA Natural Resources Conservation Service

Indicator B	Test F	Function D/N
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# Soil Quality Indicators

## Earthworms

Earthworms are native to non-glaciated areas of North America, but non-native species from Europe and Asia also exist here. Earthworms are classified into three groups based on their habitat. Litter-dwellers live in the litter, ingest plant residues, and may be absent in plowed, litter-free soil. Mineral soil-dwellers live in topsoil that is rich in

**Dynamic** - Earthworm abundance and activity trend with the amount and quality of plant residues, which provide food and mulch for habitat. Mulch helps maintain soil moisture and moderates soil microclimate, providing adequate time for earthworms to migrate and escape high or freezing temperatures. No-till and other conservation practices create ideal conditions for earthworms. The population in no-till fields can reach two to three times that





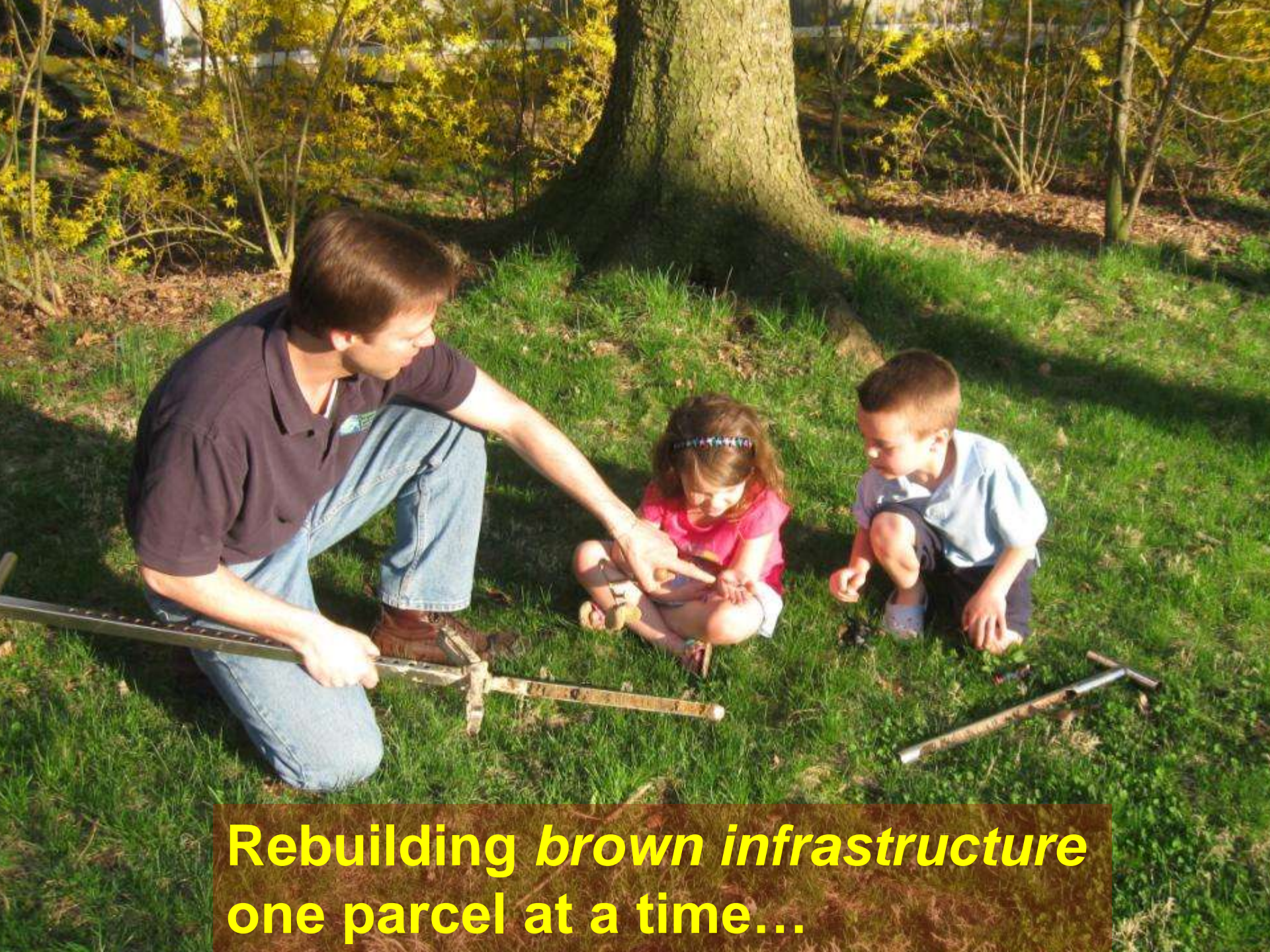
## Photograph Credits

- Cuyahoga SWCD

<http://www.cuyahogaswcd.org>

- Natural Resources Conservation Service,  
USDA

<http://soils.usda.gov/>



**Rebuilding *brown infrastructure*  
one parcel at a time...**