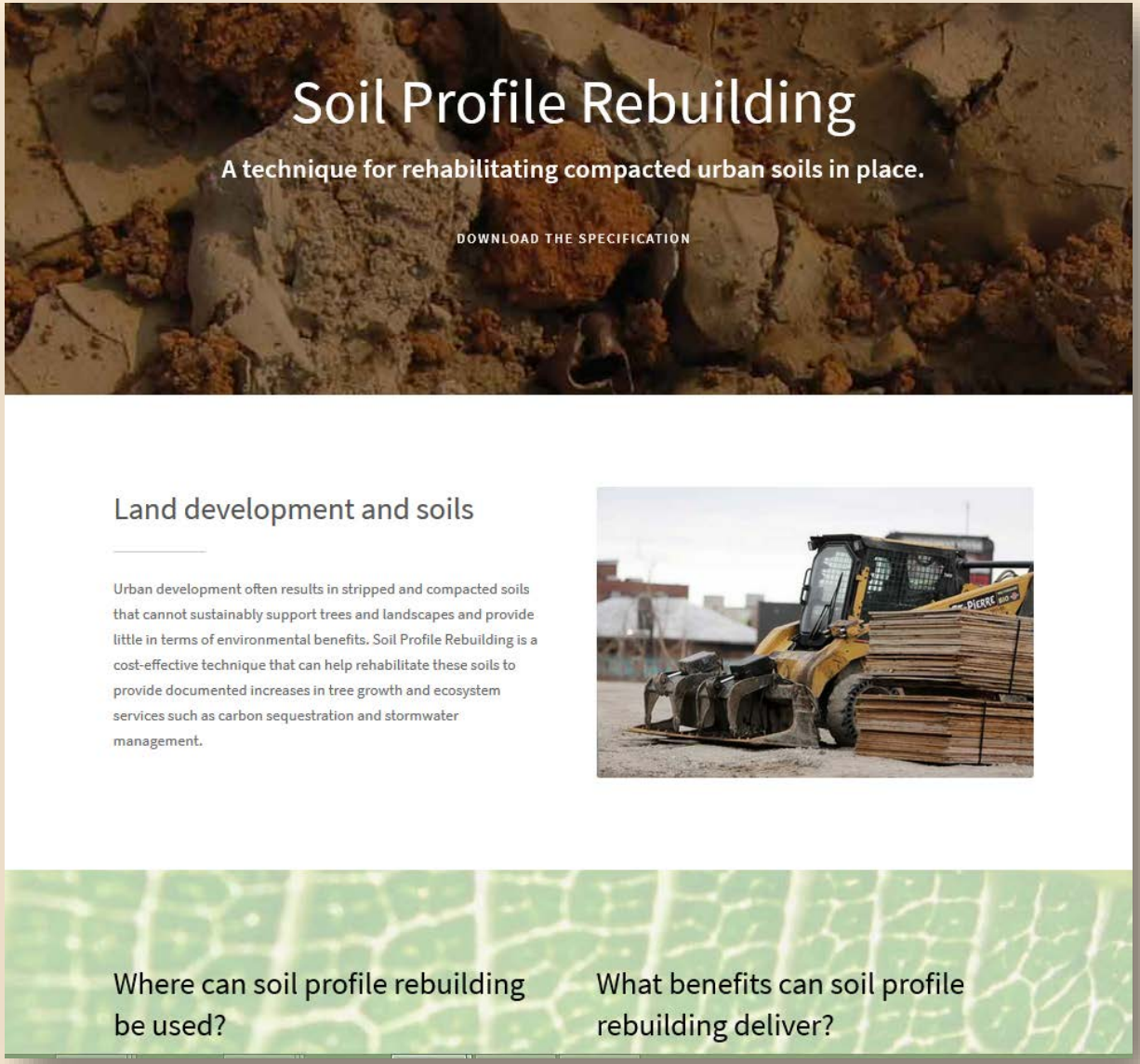
Soil Profile Rebuilding: Rehabilitating Compacted Soils

Dr. Susan D. Day
Forest Resources & Environmental Conservation, Virginia Tech

Brief Agenda

- Soil Profile Rebuilding—What is it?
- So you have “Compacted Soil Syndrome”
- When do you act?
- SPR—a long-term strategy
  - Where SPR is appropriate
  - How you carry out SPR
  - What you get
- Q & A

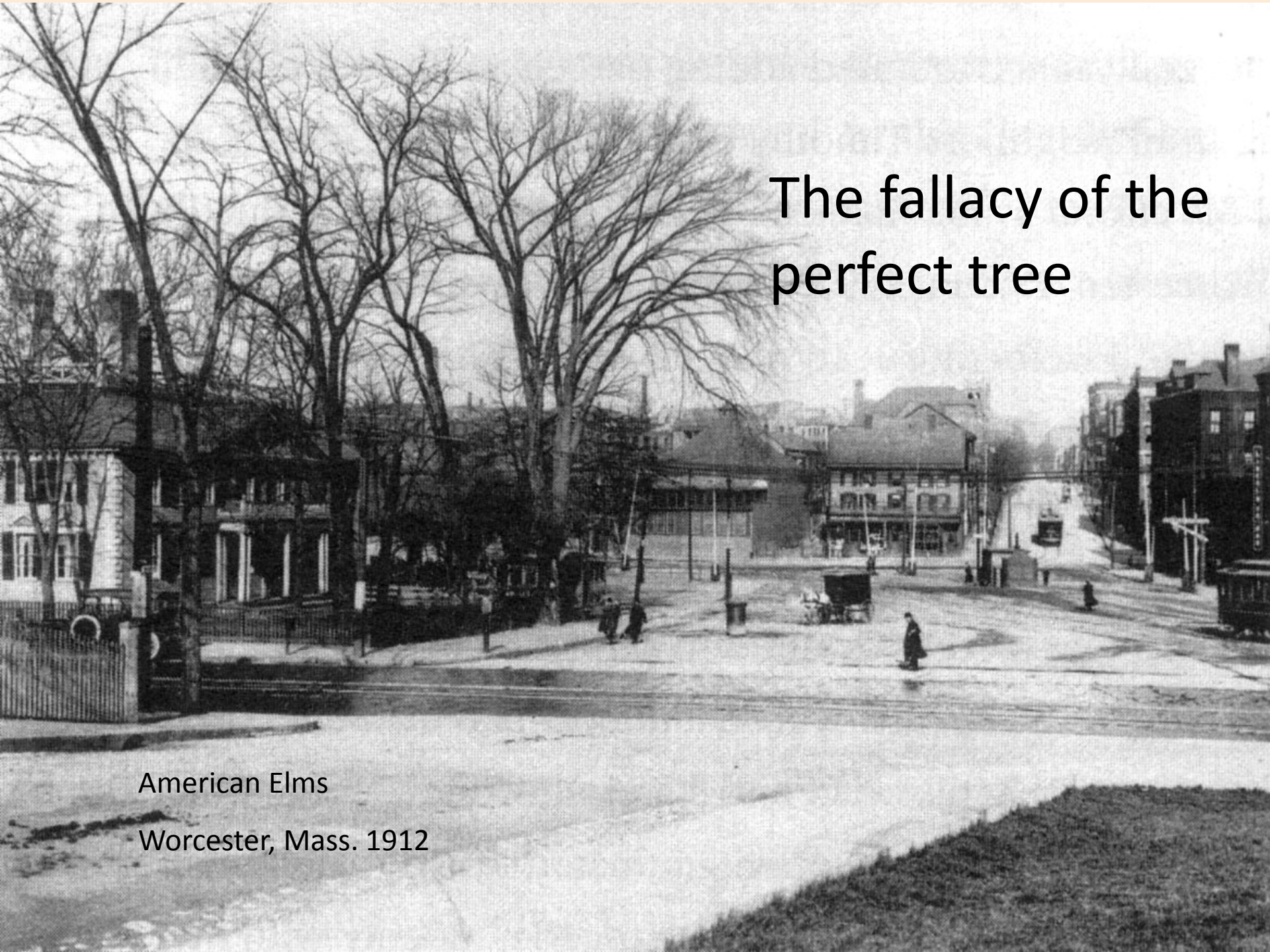
Look familiar?



- A technique for rehabilitating compacted urban soils developed at Virginia Tech
- Addresses subsurface compaction typical of building sites
- Simple and cost-effective
- Specifications are available for download and can be adapted as desired

Excerpt from Soil Profile Rebuilding website: http://urbanforestry.frec.vt.edu/SRES

Compacted Soil Syndrome



The fallacy of the perfect tree

American Elms

Worcester, Mass. 1912

Photo: P. Eric Wiseman

Photo: Robert Llewellyn—Magnolia acuminata (Cucumber Tree)
The Remarkable Trees of Virginia

Sustainable Land Development?

Prime farmland soil was graded down 3 ft to redirect stormwater to bioinfiltration swale

At “peak” time of year (May) 3 years later, tree dieback, thin turf, thin canopies, nutrient deficiencies

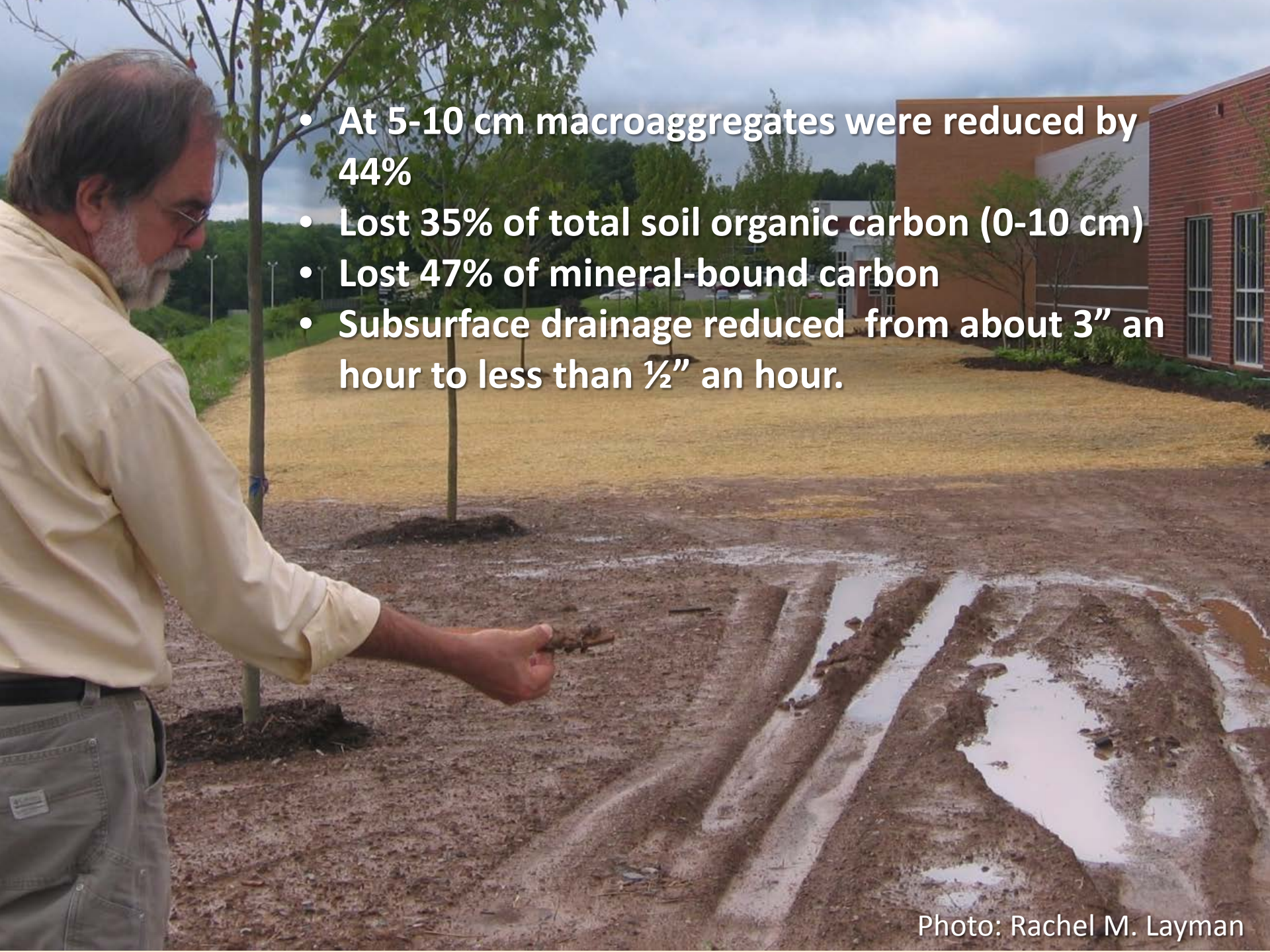

• At 5-10 cm macroaggregates were reduced by 44%
• Lost 35% of total soil organic carbon (0-10 cm)
• Lost 47% of mineral-bound carbon
• Subsurface drainage reduced from about 3” an hour to less than ½” an hour.
Photo: Rachel M. Layman

Photo: Jeannette E. Spaghetti (CC)

When do you act?

You can’t interpret soil bulk density without soil texture

Bulk density = 1.4 $g \cdot cm^{-3}$

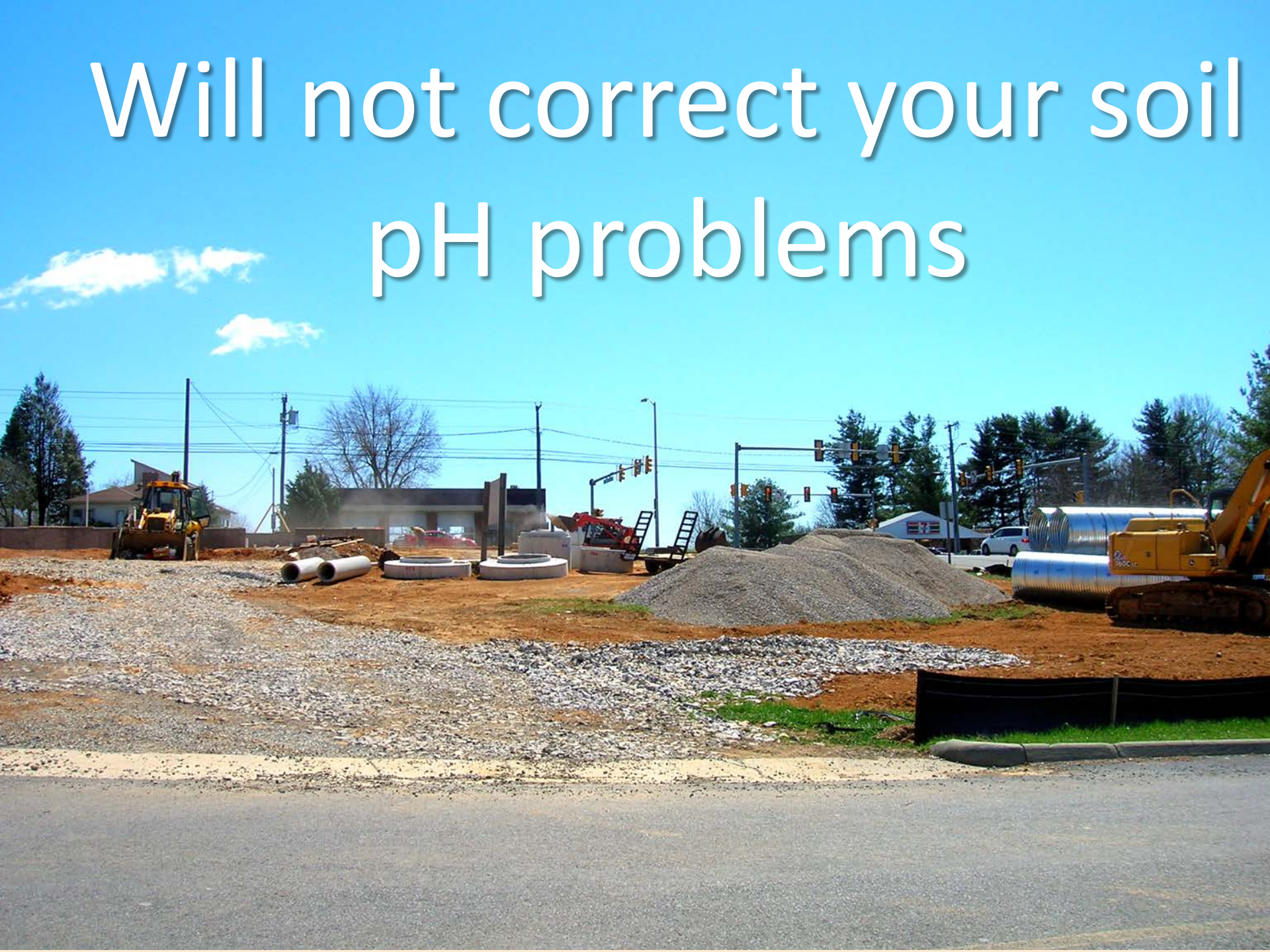
sandy loam—no worries

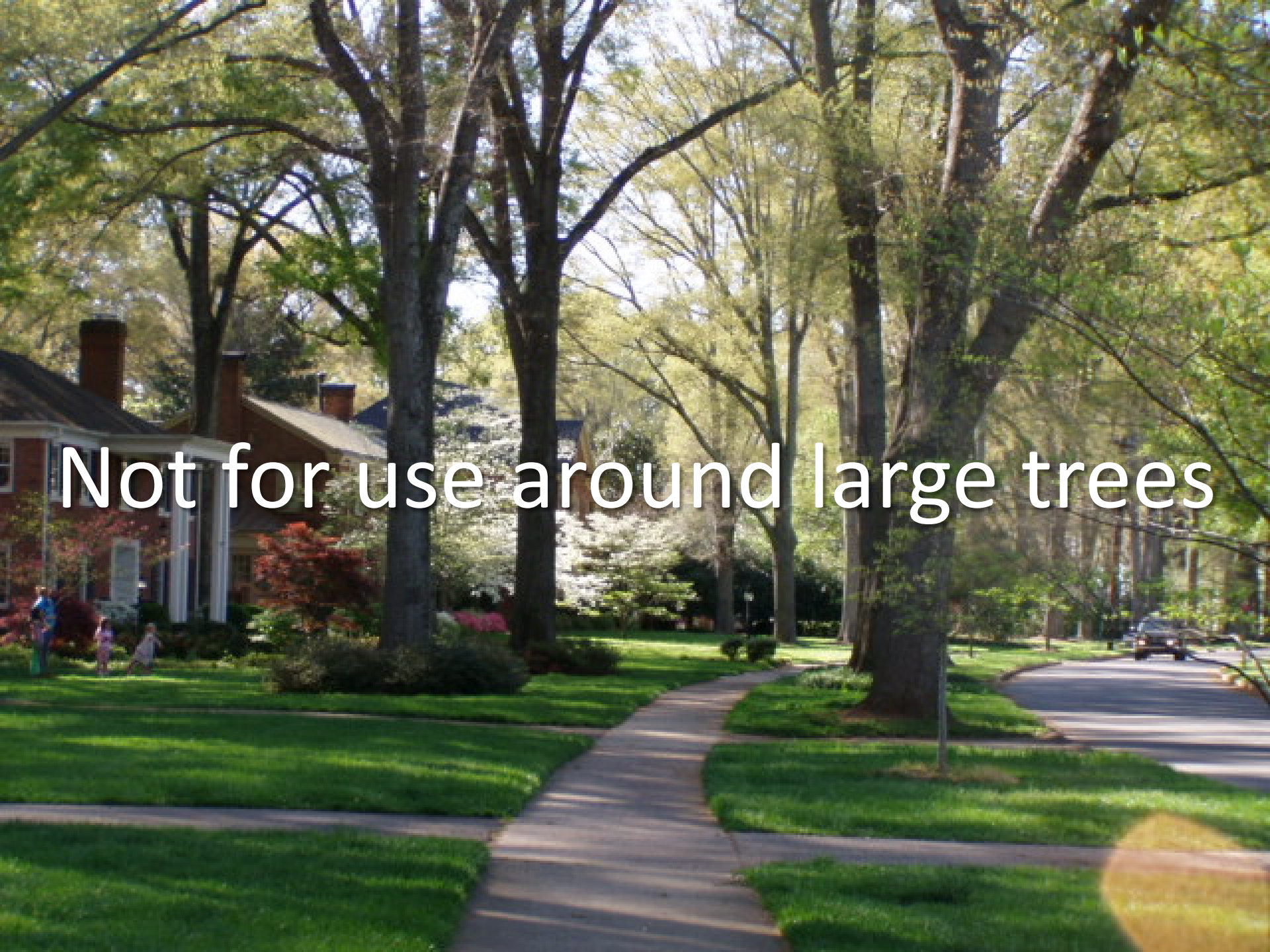
silty clay loam—watch out

Photo: Jeannette E. Spaghetti (CC)

Rehabilitating Soil in Place

Will not correct your soil pH problems




Not for use around large trees

Will reduce compaction, increase tree growth, improve permeability, increase soil carbon stores, and set long-term soil formation processes on track

SOIL PROFILE REBUILDING

Remediates Soil Compaction

Sets Soil Formation Processes in Gear

Increases Ksat, soil C, and tree growth

Specs are available online

Peer-reviewed science

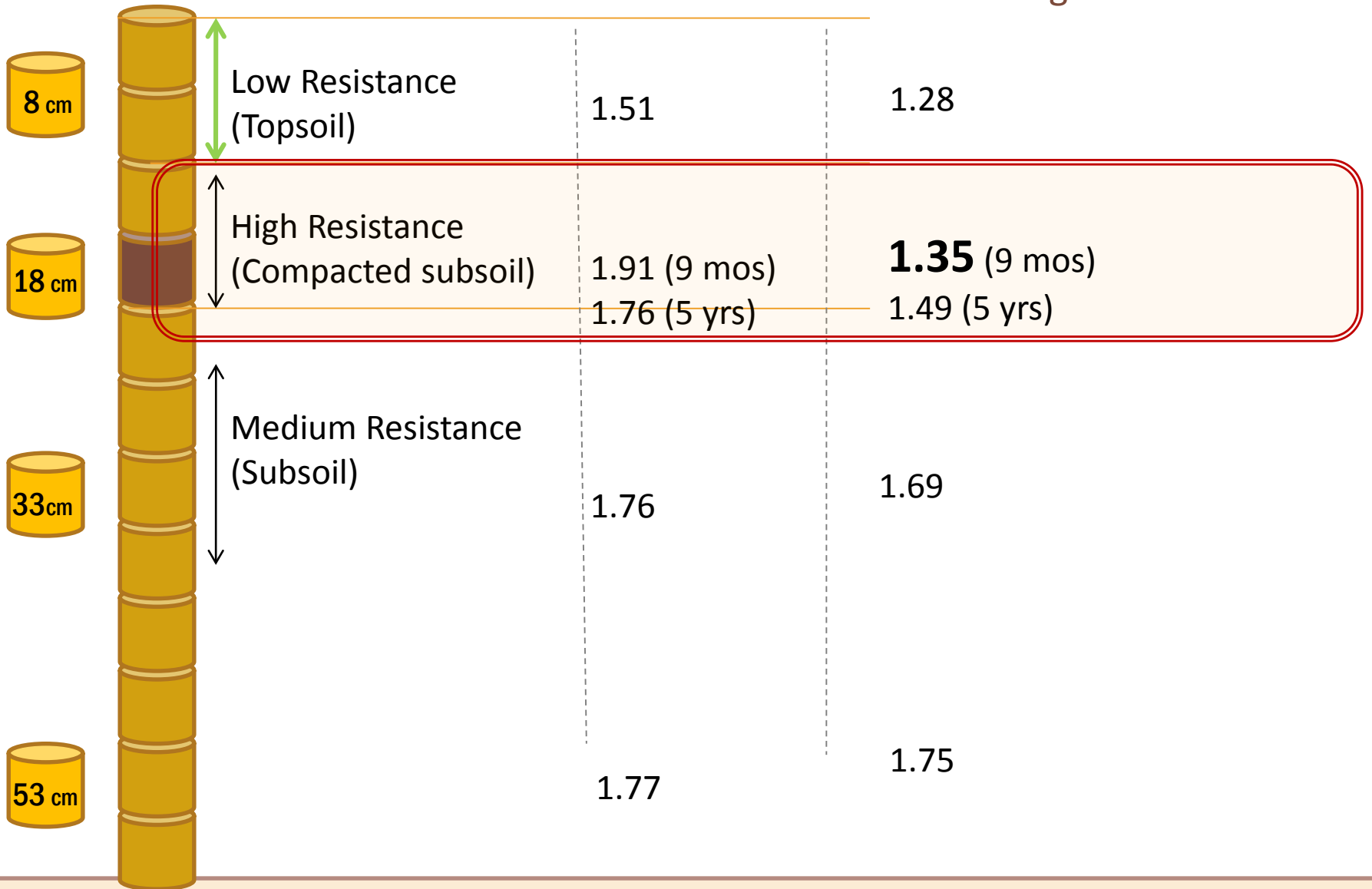
Photo: Jeannette E. Spaghetti (CC)

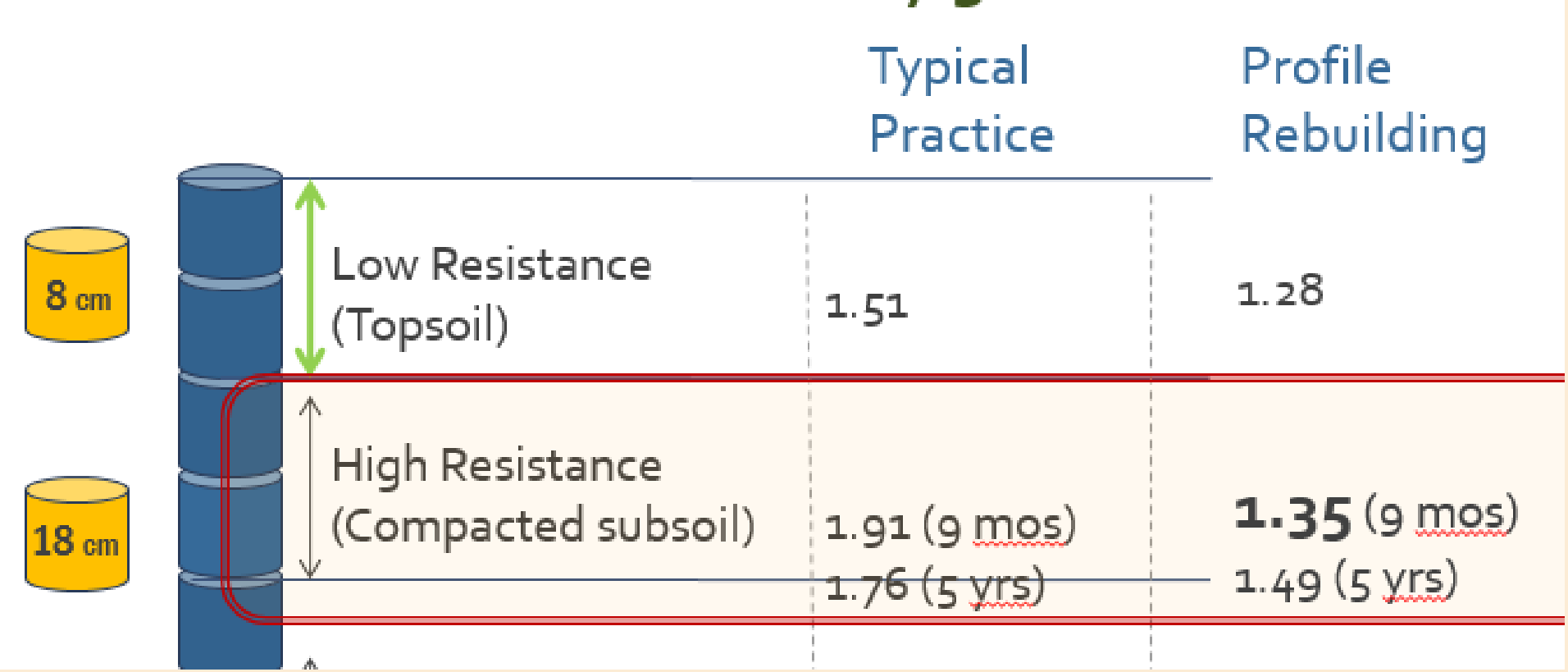
Soil Profile Rebuilding—A rehabilitation technique

Backhoe to 2 ft, scoop up and drop to create compost veins to 2 ft.

- Return topsoil as usual (4” min.) and till 8”
- Plant trees or other woody veg
- Treat surface to reduce erosion and maintain infiltration

Loam Soil—Soil Bulk Density g/cm³




Typical Practice
Profile Rebuilding
8 cm
18 cm
Low Resistance (Topsoil)
High Resistance (Compacted subsoil)
1.51
1.28
1.91 (9 mos)
1.76 (5 yrs)
1.35 (9 mos)
1.49 (5 yrs)

Adaptation of Daddow and Warrington, 1983 by Sustainable Sites Initiative

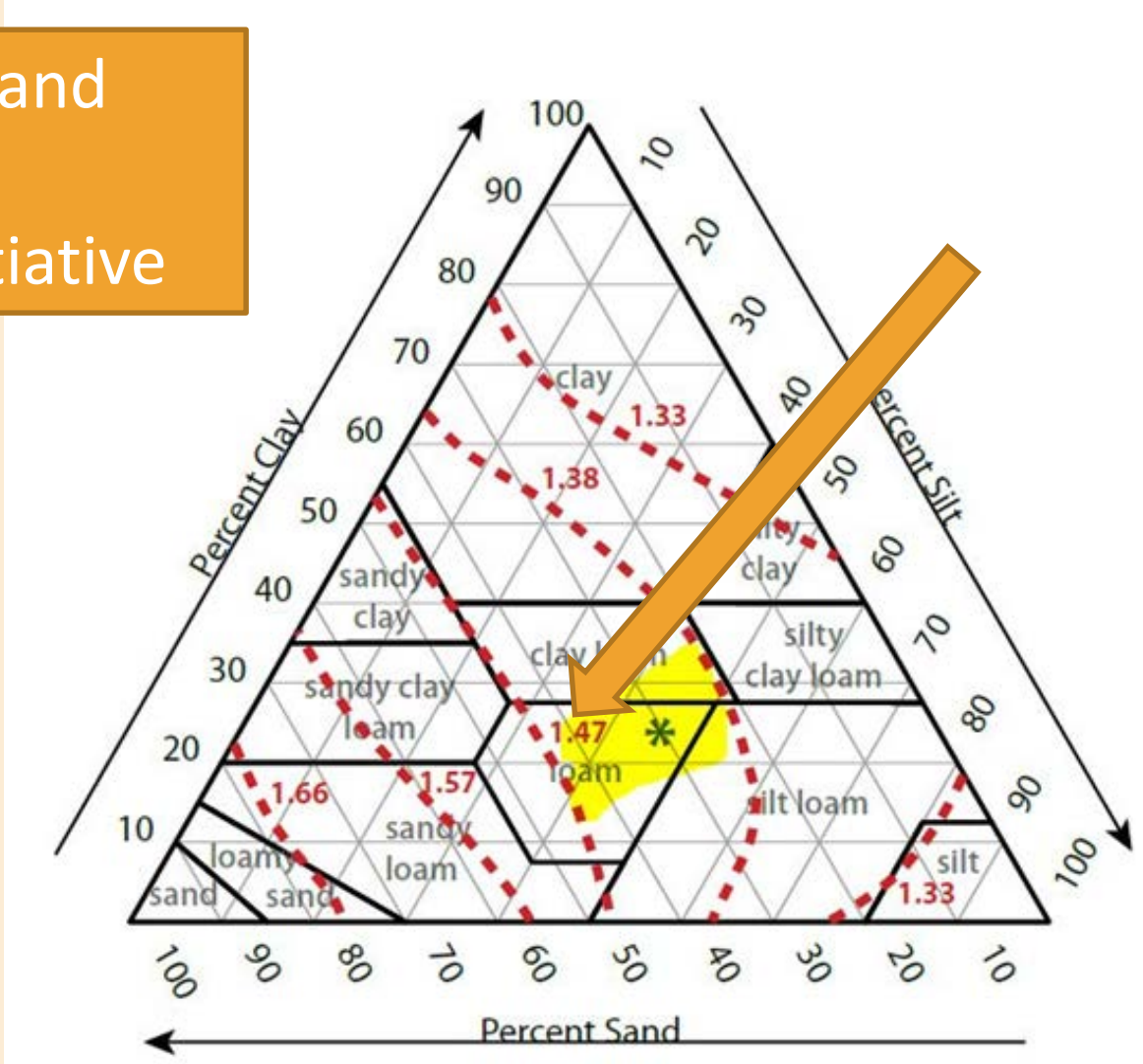
Soil in Tree Root Zone

Without Rehab yr 1 = 1.91 g cm^{-3}

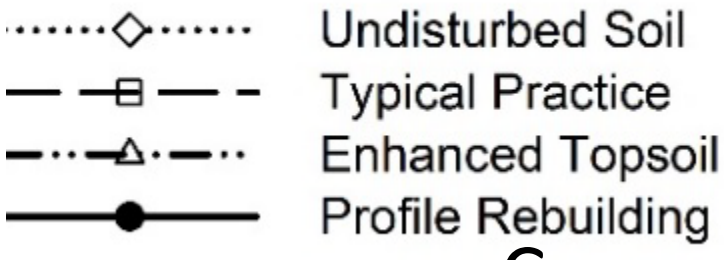
With Rehab yr 1 = 1.35 g cm^{-3}

Without Rehab yr 5 = 1.76 g cm^{-3}

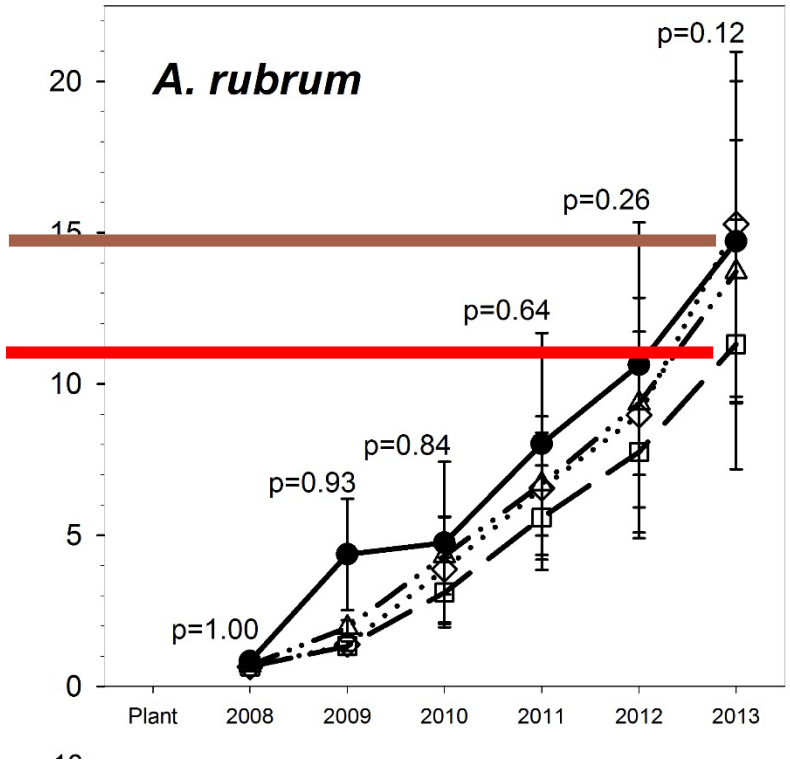
With Rehab yr 5 = 1.49 g cm^{-3}

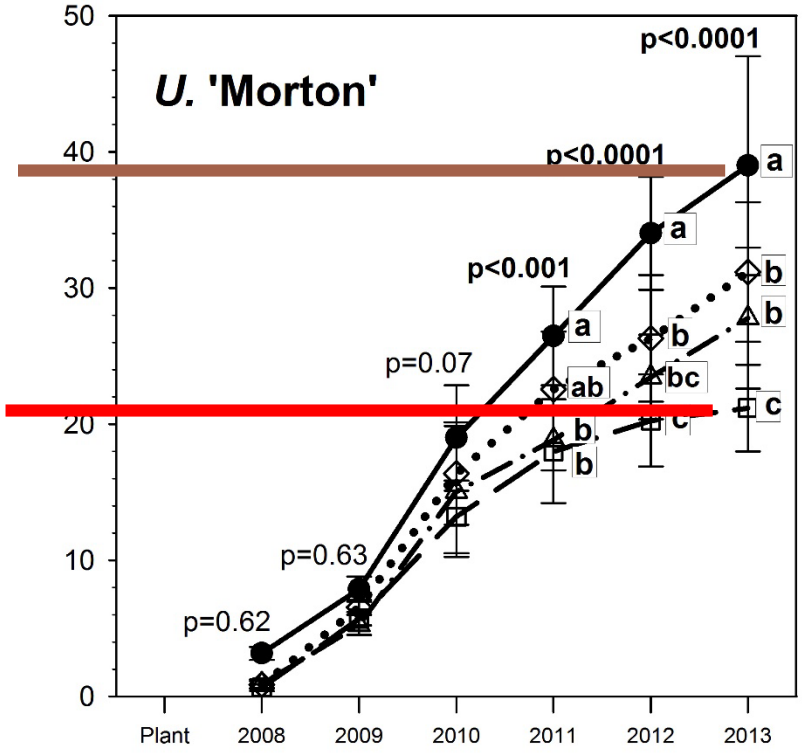


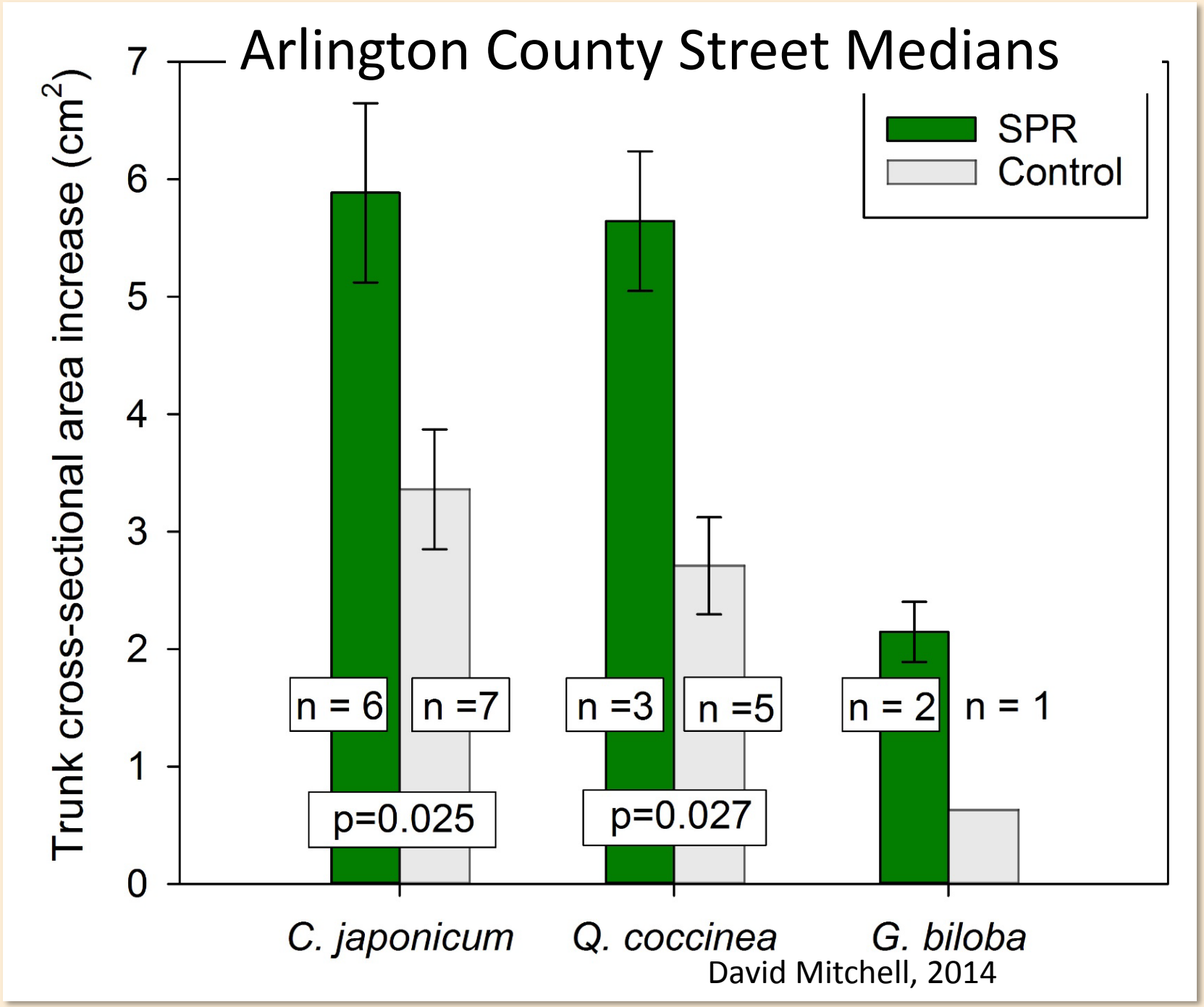
Canopy Area approximately doubled after 7 years in controlled experiments



Canopy Area in m^2






Arlington County Street Medians
Trunk cross-sectional area increase (cm2)
0
1
2
3
4
5
6
7
SPR
Control
n = 6
n =7
n =3
n =5
n = 2
n = 1
p=0.025
p=0.027
C. japonicum
Q. coccinea
G. biloba
David Mitchell, 2014

Implications for Stormwater

Site-level Effects Subsurface Permeability 10-40 cm (Ksat)

Agricultural Soil—4 to 5 cm/hr
Compare to HSG B

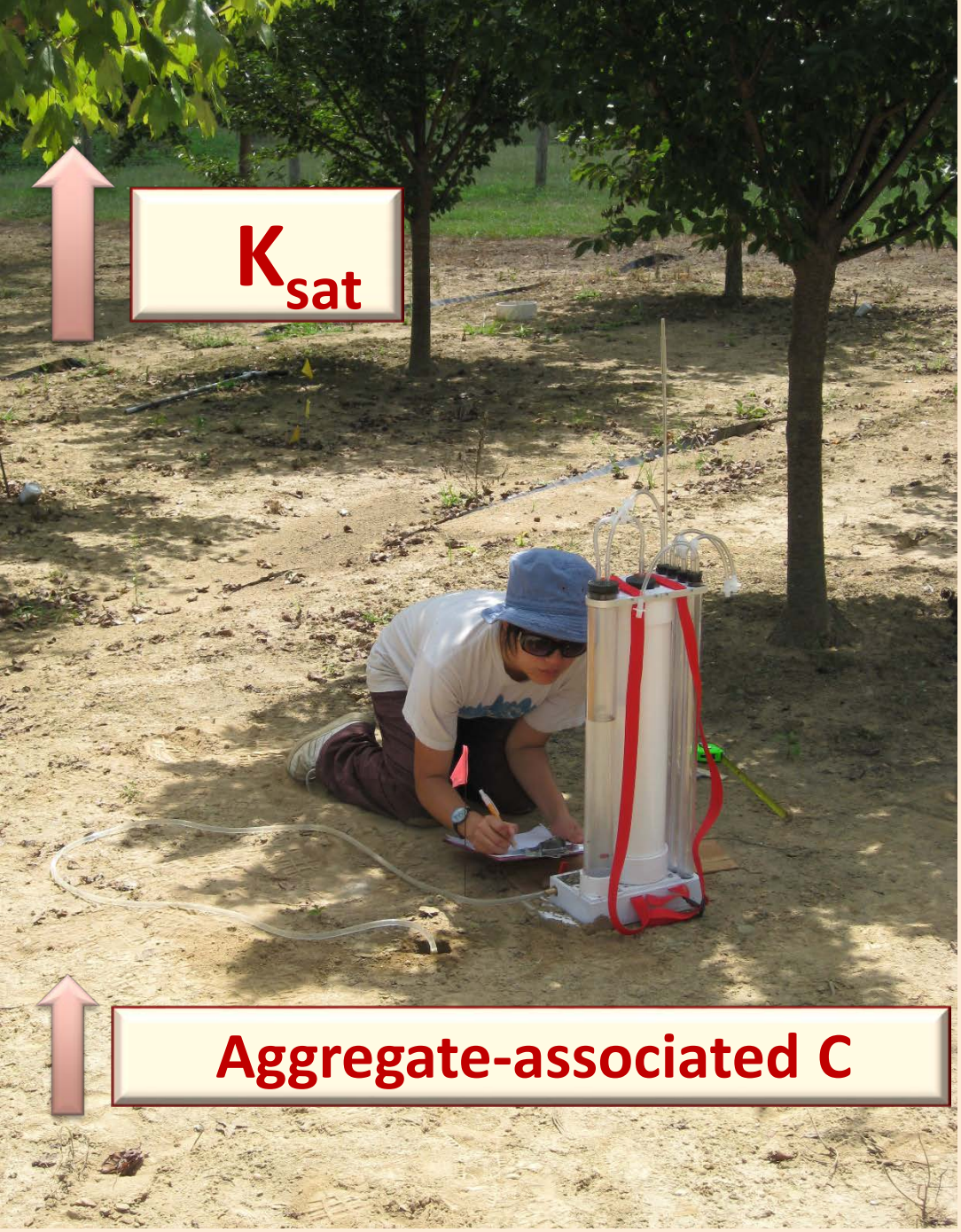
Urban land development

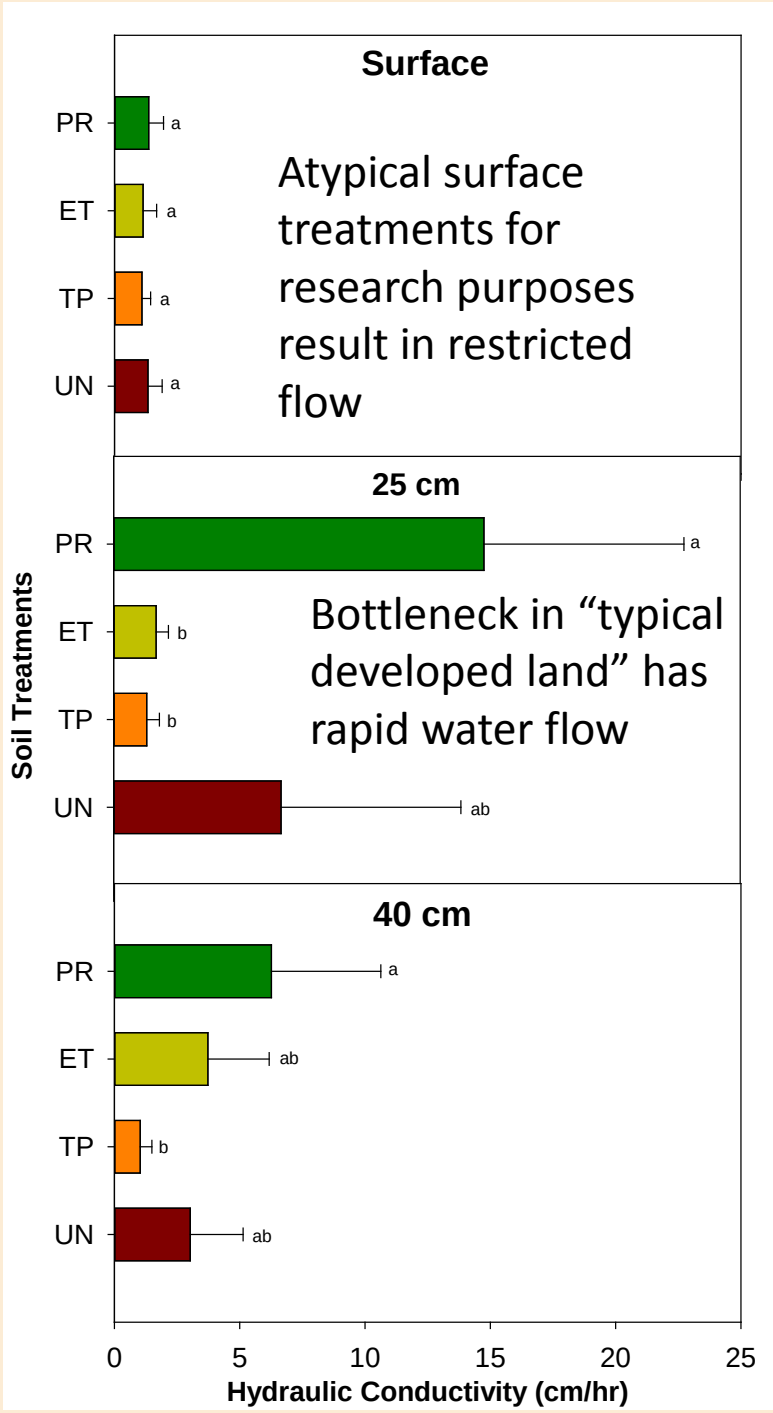
Simple grading, urban land development—1 to 2 cm/hr
Compare to HSG C or D

Soil Management

Rehabilitated soil—10 to 11 cm/hr
Compare to HSG A or B

Chen et al. *Science of the Total Environment* 2014.


K_{sat}
Aggregate-associated C


Surface
PR
ET
TP
UN
a
a
a
a
Atypical surface treatments for research purposes result in restricted flow
25 cm
PR
ET
TP
UN
a
b
b
ab
Bottleneck in "typical developed land" has rapid water flow
40 cm
PR
ET
TP
UN
a
ab
b
ab
Soil Treatments
0
5
10
15
20
25
Hydraulic Conductivity (cm/hr)

The urban forest system

Complexity of the Landscape

VIRGINIA
58-846S
256-VDF

Journal Articles for SPR

Chen, Y., Day, S. D., Shrestha, R. K., Strahm, B. D., Wiseman, P. E., 2014. Influence of urban land development and soil rehabilitation on soil–atmosphere greenhouse gas fluxes. *Geoderma* 226, 348-353.

Chen, Y., Day, S. D., Wick, A. F., McGuire, K. J., 2014. Influence of urban land development and subsequent soil rehabilitation on soil aggregates, carbon, and hydraulic conductivity. *Science of the Total Environment.* 494–495, 329-336.

Chen, Y., Day, S. D., Wick, A. F., Strahm, B. D., Wiseman, P. E., Daniels, W. L., 2013. Changes in soil carbon pools and microbial biomass from urban land development and subsequent post-development soil rehabilitation. *Soil Biology and Biochemistry* 66, 38-44.

Layman, R.M., Day. S.D., Mitchell, D.K., Chen, Y., Harris, J.R., Daniels, W.L. 2015. Below ground matters: Urban soil rehabilitation increases tree canopy and speeds establishment. Under review at *Urban Forestry & Urban Greening*

urbanforestry.frec.vt.edu

Soil Profile Rebuilding: An Alternative to Soil Replacement

by Susan Downing Day, Associate Professor, Depts. of Forest Resources & Environmental Conservation and Horticulture, Virginia Tech

Urban foresters know poor soils can lead to an endless cycle of dieback and tree replacement. Even if trees do establish, growth can be underwhelming and tree health disappointing. Increasingly, project managers have been turning to soil replacement, where existing soils are excavated and removed and replaced with "recycled" or blended soils. These soils present their own challenges, however. For example, many imported blends rely on high sand contents to improve drainage, resulting in low water-holding capacity and drought stress for unirrigated plantings. Resulting sharp transitions in soil texture introduce the possibility of creating a "bath tub" effect in situations where it is impossible to replace all the soil and new soils are confined to the immediate vicinity of individual trees.

There is an alternative to soil replacement that is especially appropriate where there are extended open soil (unpaved) areas such as in street medians--soil rehabilitation. Soil rehabilitation can help restore important ecosystem functions such as stormwater transmission and vegetation support to existing native soils.

In soil management, urban foresters and designers need confidence that they will get the results they desire and that soil improvements will persist for the long term. Researchers at Virginia Tech developed specifications for **Soil Profile Rebuilding (SPR)**, a soil rehabilitation technique, and have been evaluating performance for nearly a decade. This process can improve tree establishment,

The Theory behind SPR

SPR works by creating veins of compost deep in the soil profile that hold soil channels open for root penetration. The introduction of organic matter coupled with root activity can create conditions that will lead to formation of soil aggregates over time—leading to long-term soil quality enhancement.

This site is a good candidate for SPR because soil is compacted and has an impermeable layer that can likely be broken up by the backhoe subsoiling process. Note limestone gravel mixed in soil indicates pH will be high, which will not be altered by the rehabilitation process. Surface gravel should be removed if possible and underground infrastructure clearly marked. Photo by Susan D. Day

Want more info?

- Recent Article
  City Trees (Sept/Oct)
- Download Specifications
  urbanforestry.frec.vt.edu/SRES
- Details under production

THANK YOU

Collaborators: J. R. Harris, Joseph Dove, Qingfu Xiao, E.G. McPherson, N. Bassuk, Brian Strahm, Abbey Wick, W. Lee Daniels, P. Eric Wiseman, Kevin McGuire, Tess (Wynn) Thompson, and Vincent Verweij

Graduate Students: Rachel Layman, Yujuan Chen, Julia Bartens, and David Mitchell

Soil Profile Rebuilding Specifications available at **urbanforestry.frec.vt.edu/SRES**

Partial support provided by the
USDA-Forest Service National Urban and Community Forestry Advisory Council, Tree Research & Education Fund, the Institute for Critical Technology and Applied Science at Virginia Tech, and the USDA's McIntire-Stennis program

VirginiaTech
Invent the Future

Photo: Peter Nijenhuis (CC)