# SOIL COMPACTION & URBAN TREES

**Lunch & Learn Webinar on 11/30/16**
**TREE Fund, Utah DNR, Division of Forestry, Fire & State Lands & Utah State University Forestry Extension**

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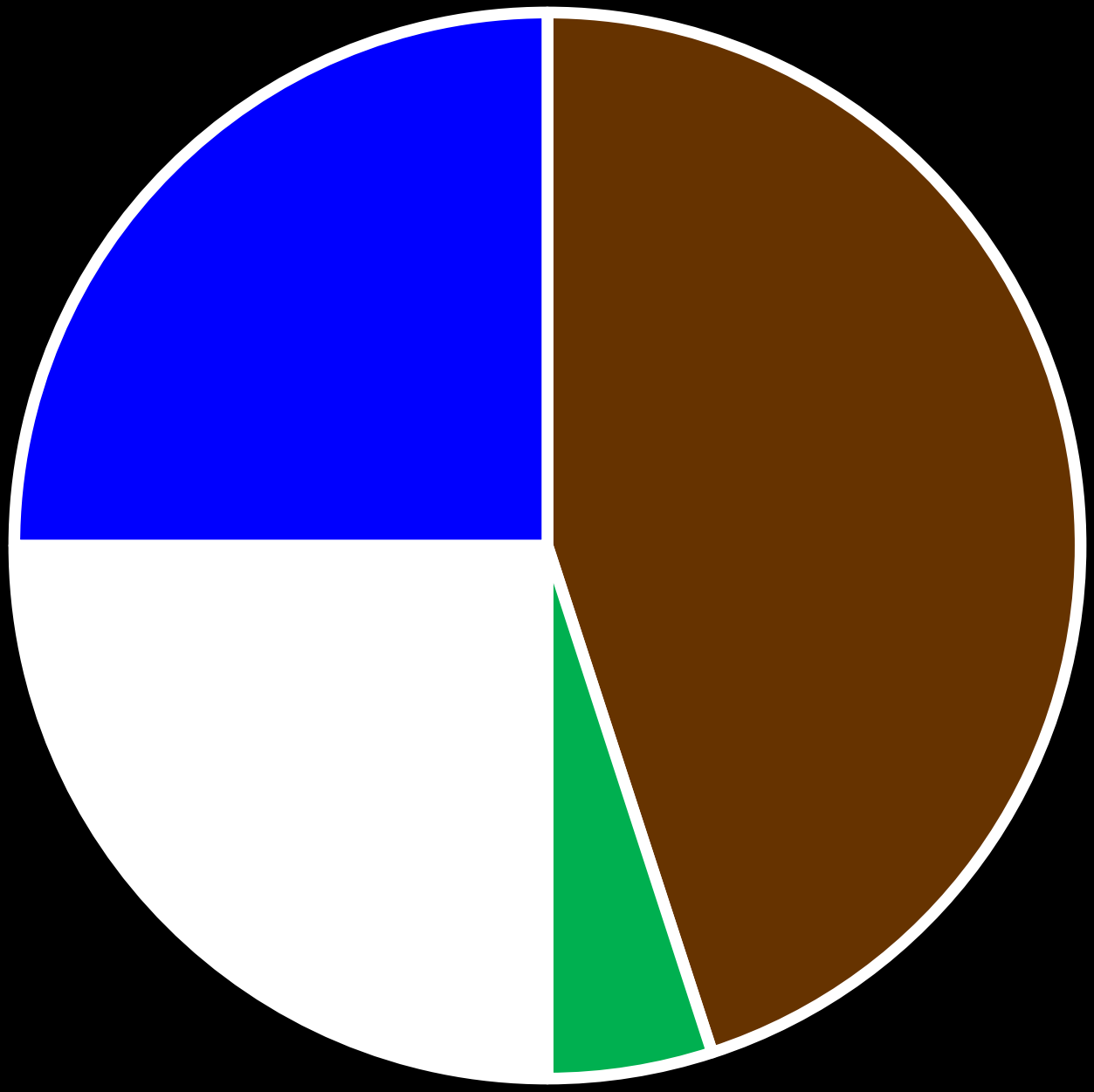
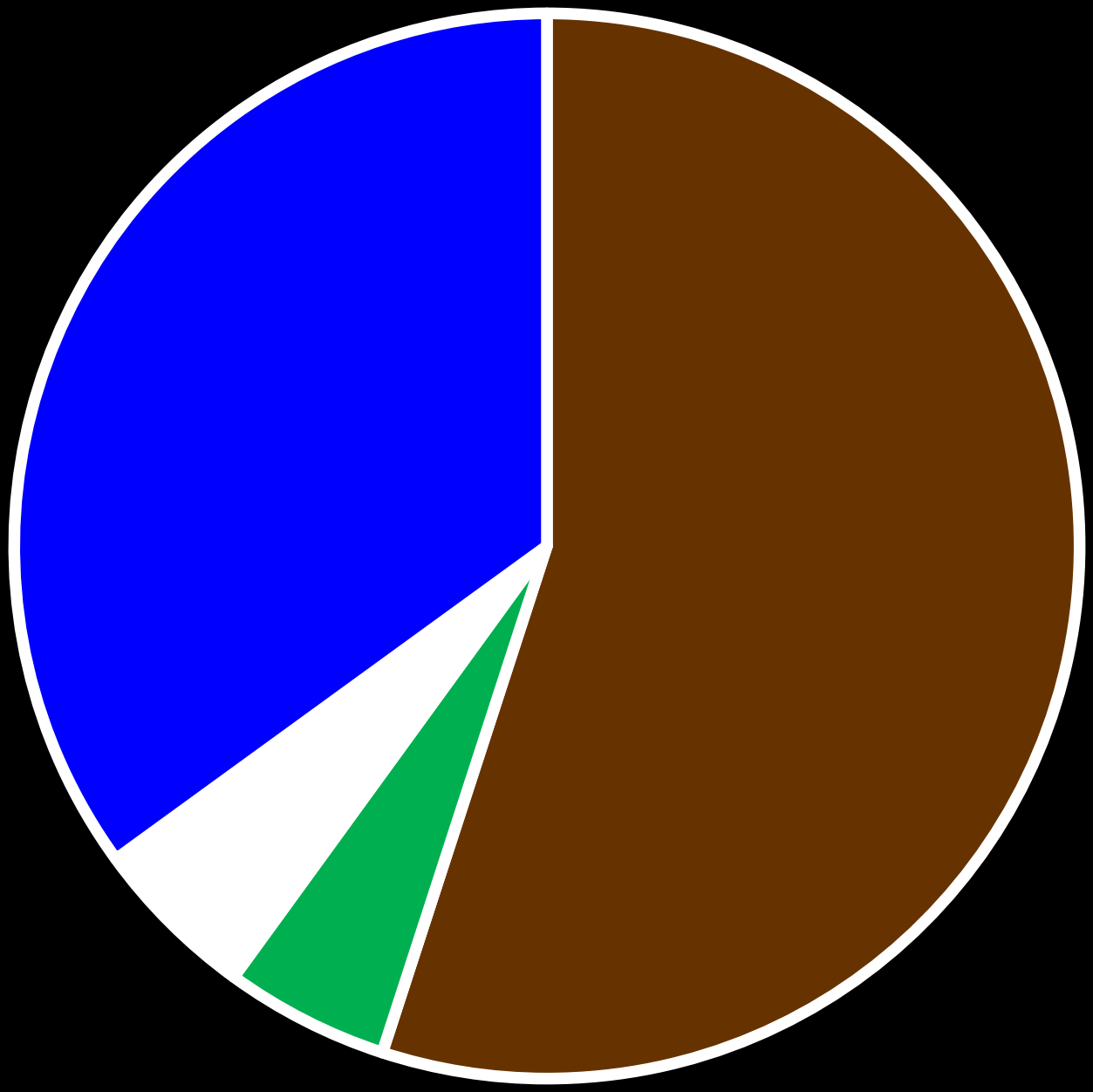
**The Morton Arboretum**
**University of Wisconsin – Stevens Point**

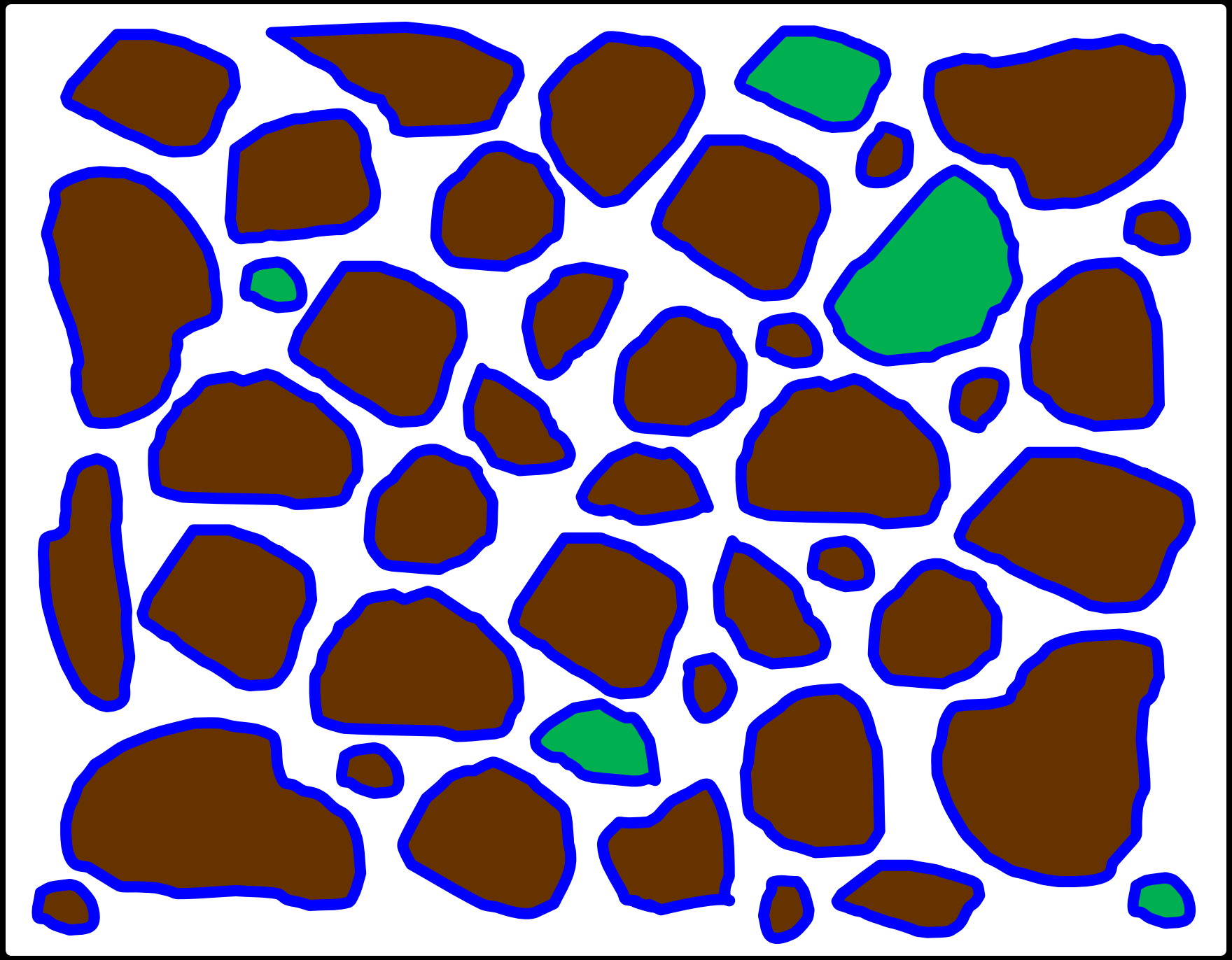
# Outline

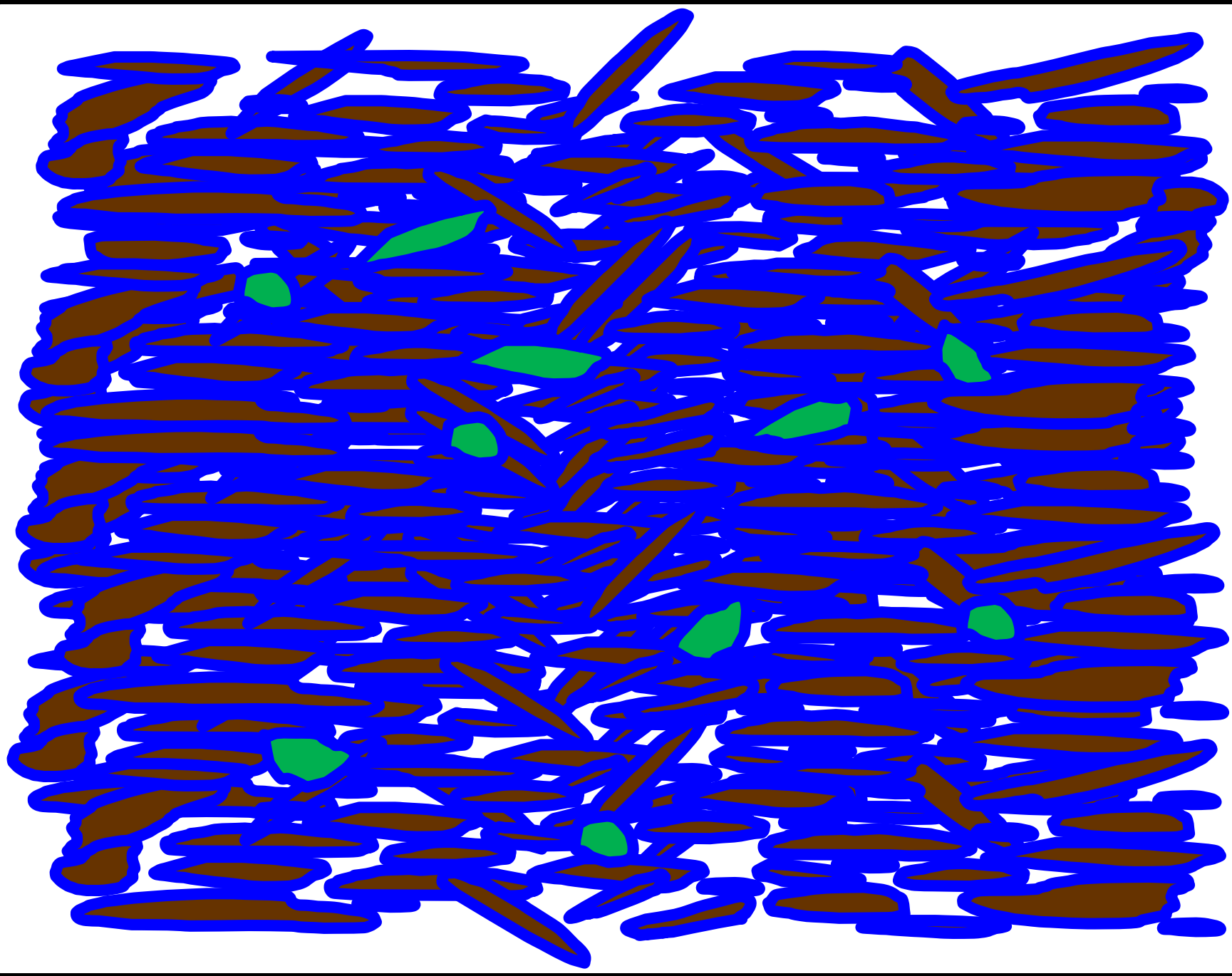
- What is soil compaction?
- How does soil compaction occur?
- What are the problems associated with urban soil compaction?
- What management actions can and should we undertake to deal with soil compaction?
  - Protect-Assess-Manipulate-Monitor

# What is soil compaction?


mineral
organic
air
water


mineral
organic
air
water

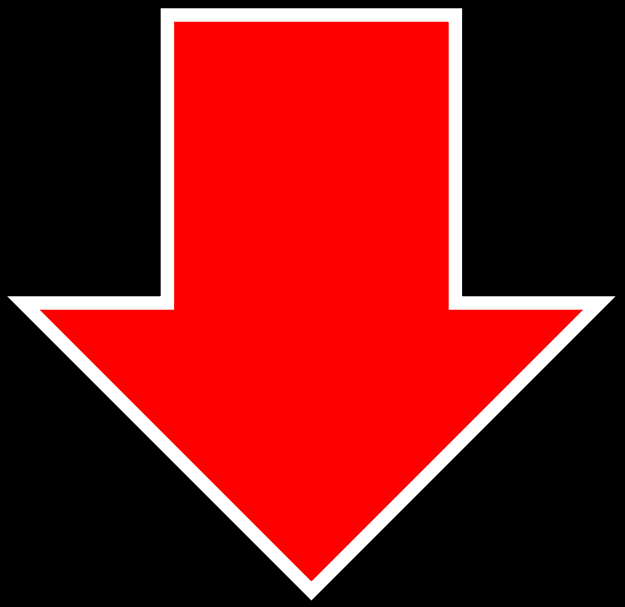




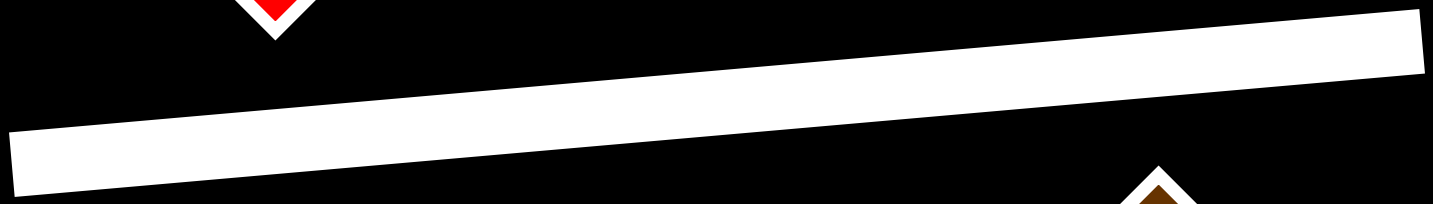
Granular structure and organic matter (Scharenbroch)


Angular blocky structure in compacted soil at TMA in Lisle, IL (Scharenbroch)

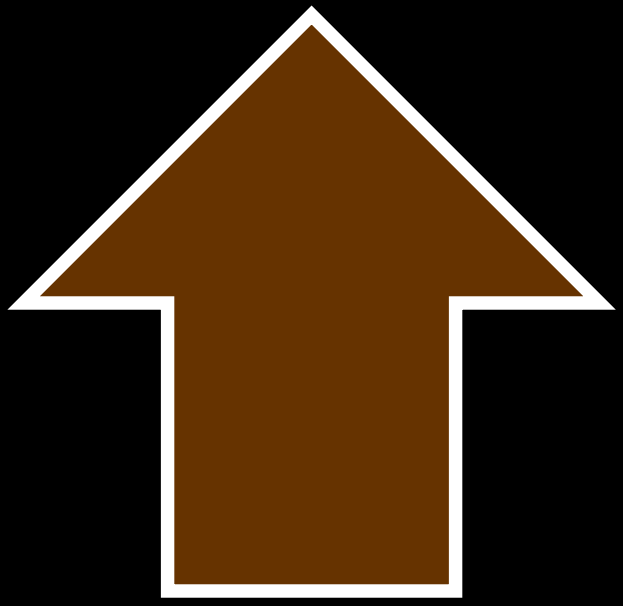
# How does soil compaction occur?



Force



Resistance



Residential development in Moscow, ID (Scharenbroch)


Top-soil and soil compaction on research plot at TMA in Lisle, IL (Scharenbroch)

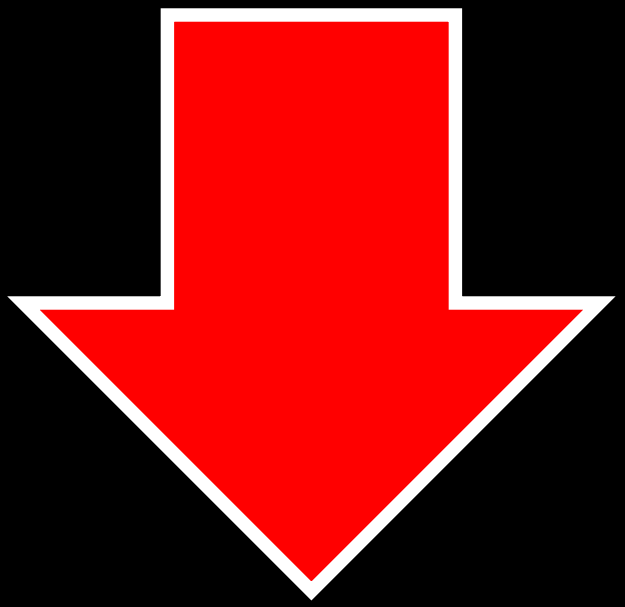
Soil compaction by foot traffic on UWSP campus, Stevens Point, WI (Scharenbroch)


**Fragipan in Grantsburg silt loam, fine-silty, mixed, active, mesic Oxyaquic Fragiudalfs in southern Illinois (Scharenbroch)**

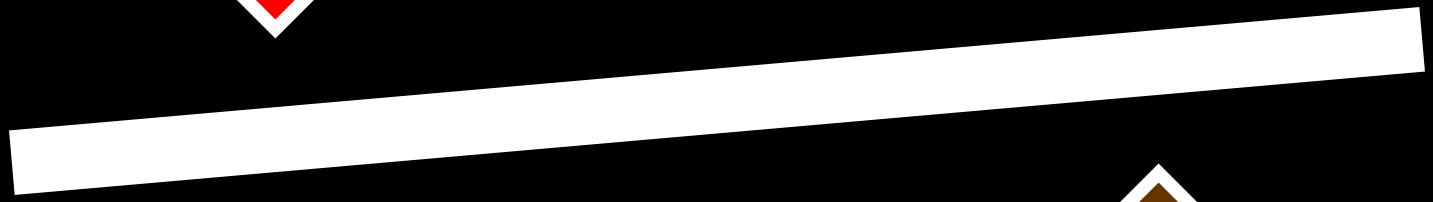


UWSP students digging soil hardpans (pun intended) (Scharenbroch)

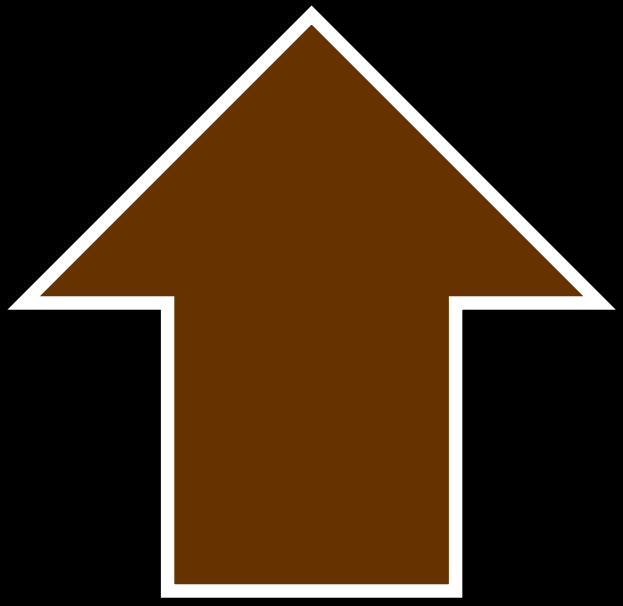
Petrocalcic layers in alluvial soil near Phoenix, AZ (Scharenbroch)



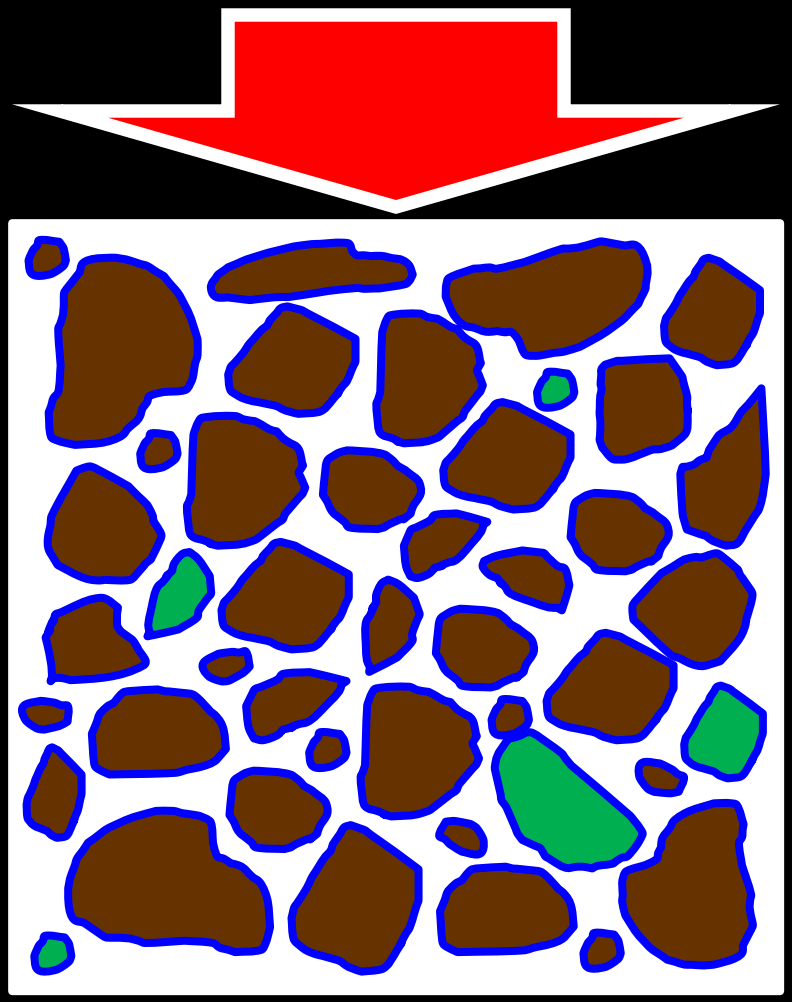
Force



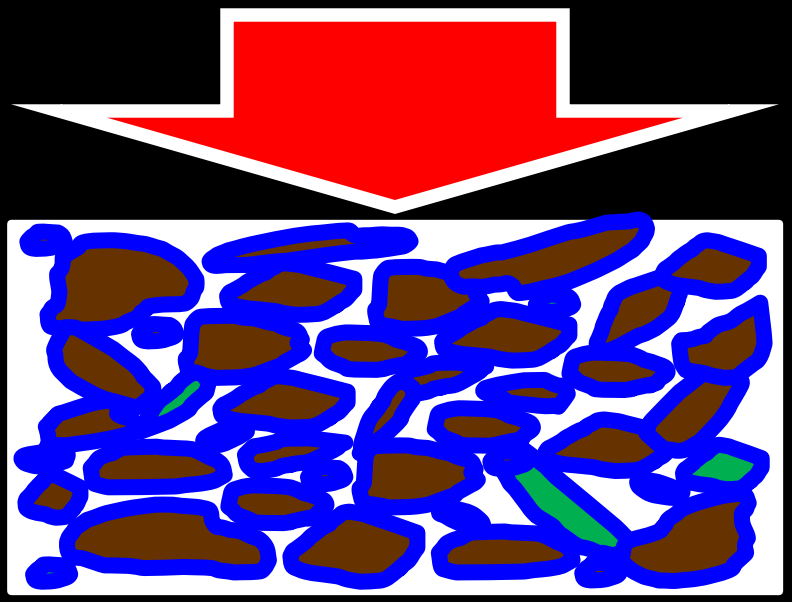
Resistance



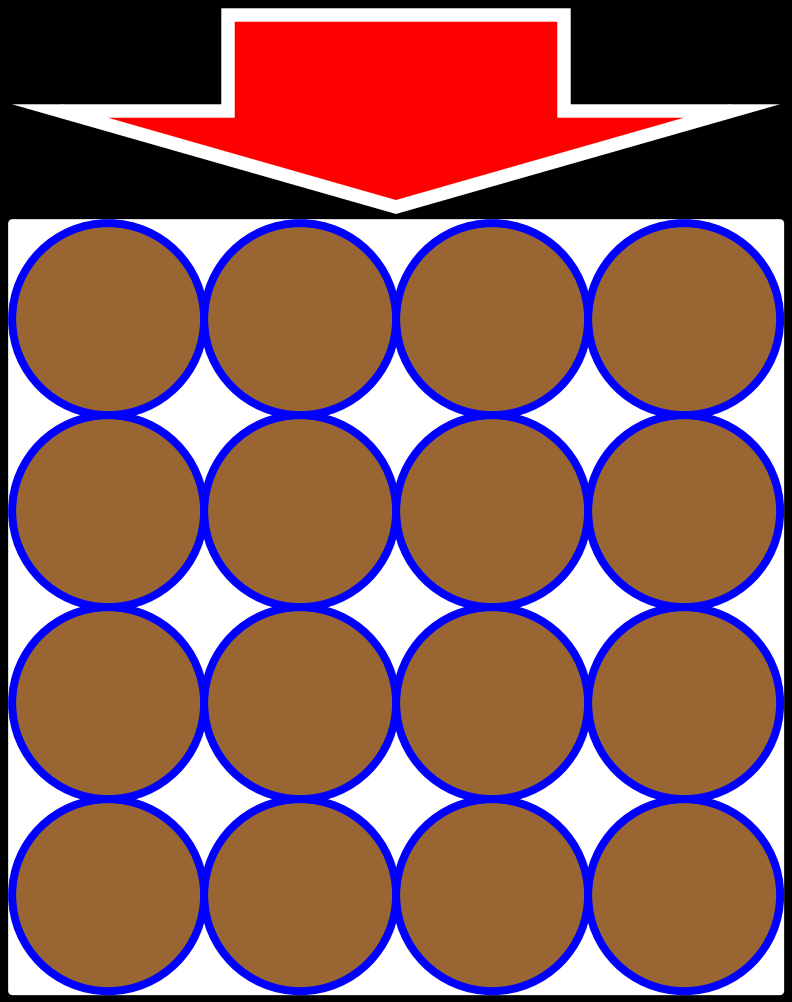
Well-structured soil



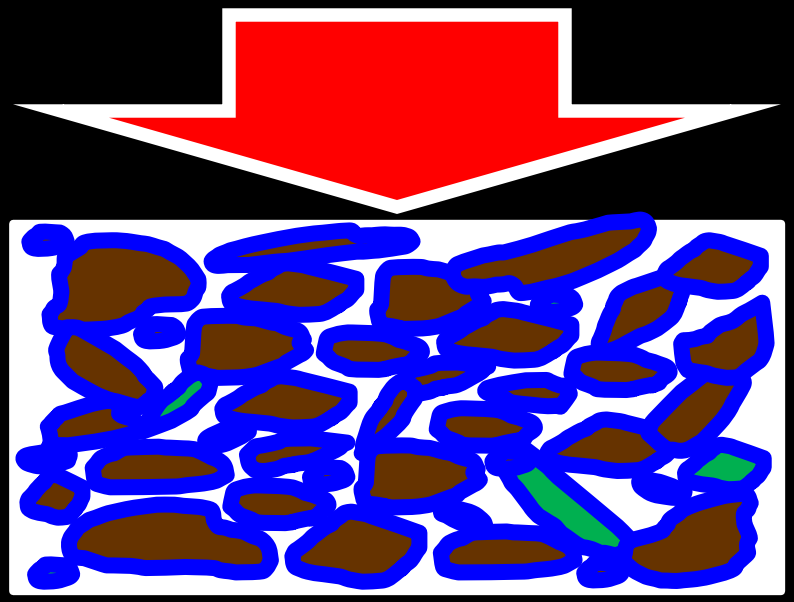
Poorly-structured soil

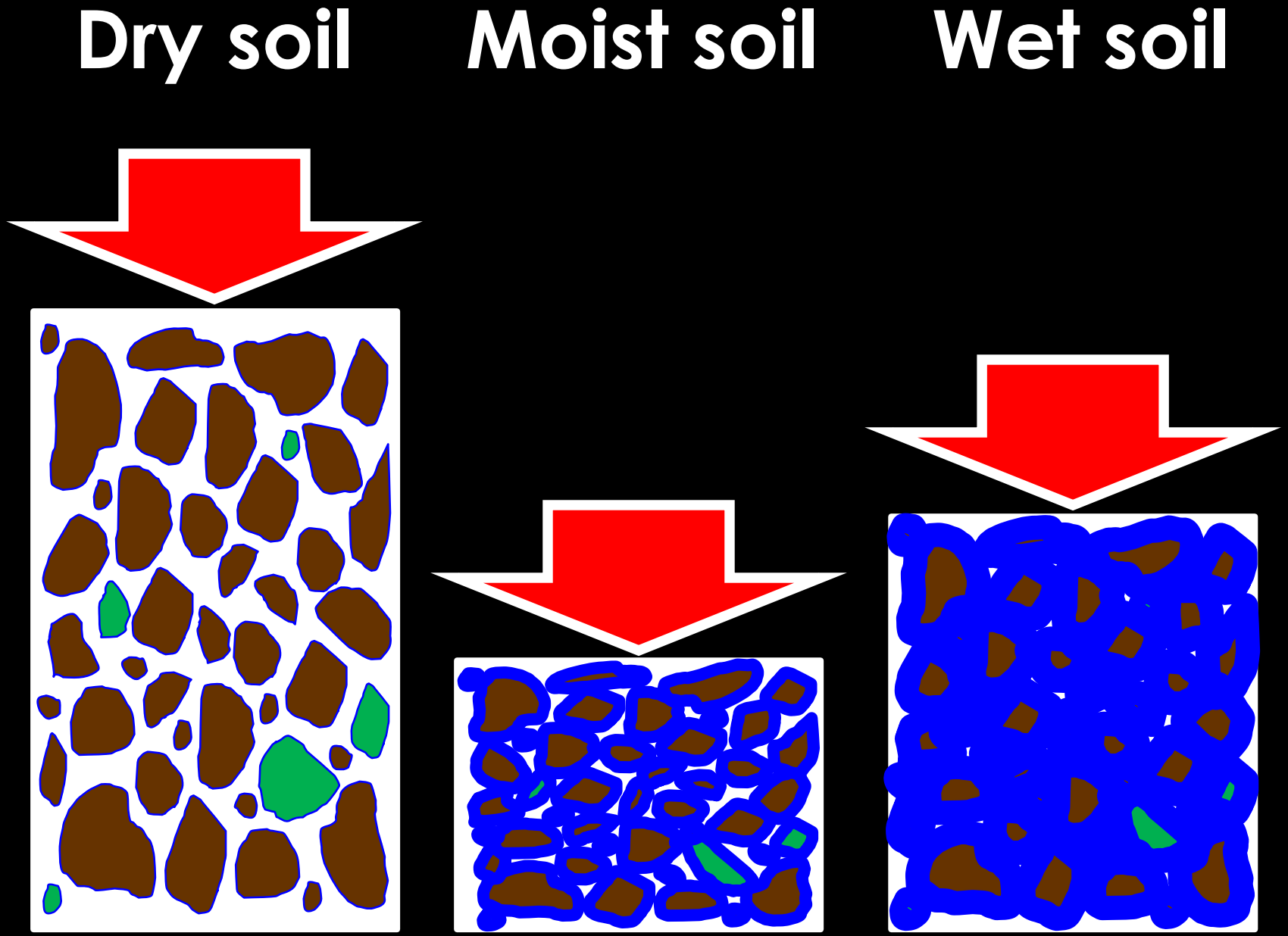


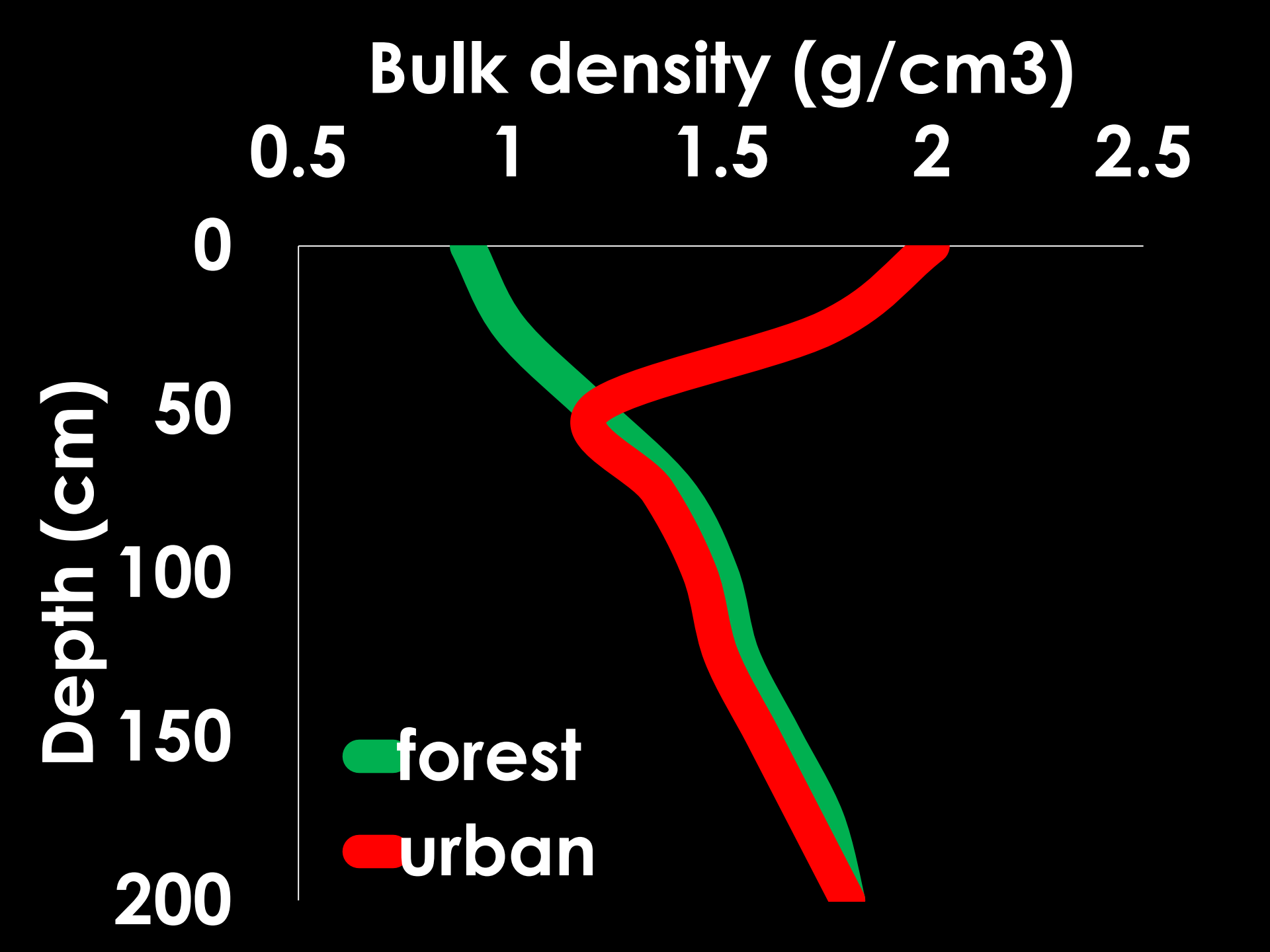
Coarse, poorly-graded soil



Fine, well-graded soil




Dry soil
Moist soil
Wet soil


Bulk density (g/cm3)
0.5
1
1.5
2
2.5
0
50
100
150
200
Depth (cm)
forest
urban

# What are the problems associated with urban soil compaction?

**Massive structure in compacted soil (Scharenbroch)**

*Acer* root system grown in a compacted soil (Scharenbroch)

Poor drainage in compacted soil at TMA in Lisle, IL (Scharenbroch)

Redox features in poorly drained soil near Purdue, IN (Scharenbroch)

Surface crust in compacted soil in Bolingbrook, IL (Scharenbroch)

Surface crust in compacted soil at TMA in Lisle, IL (Scharenbroch)

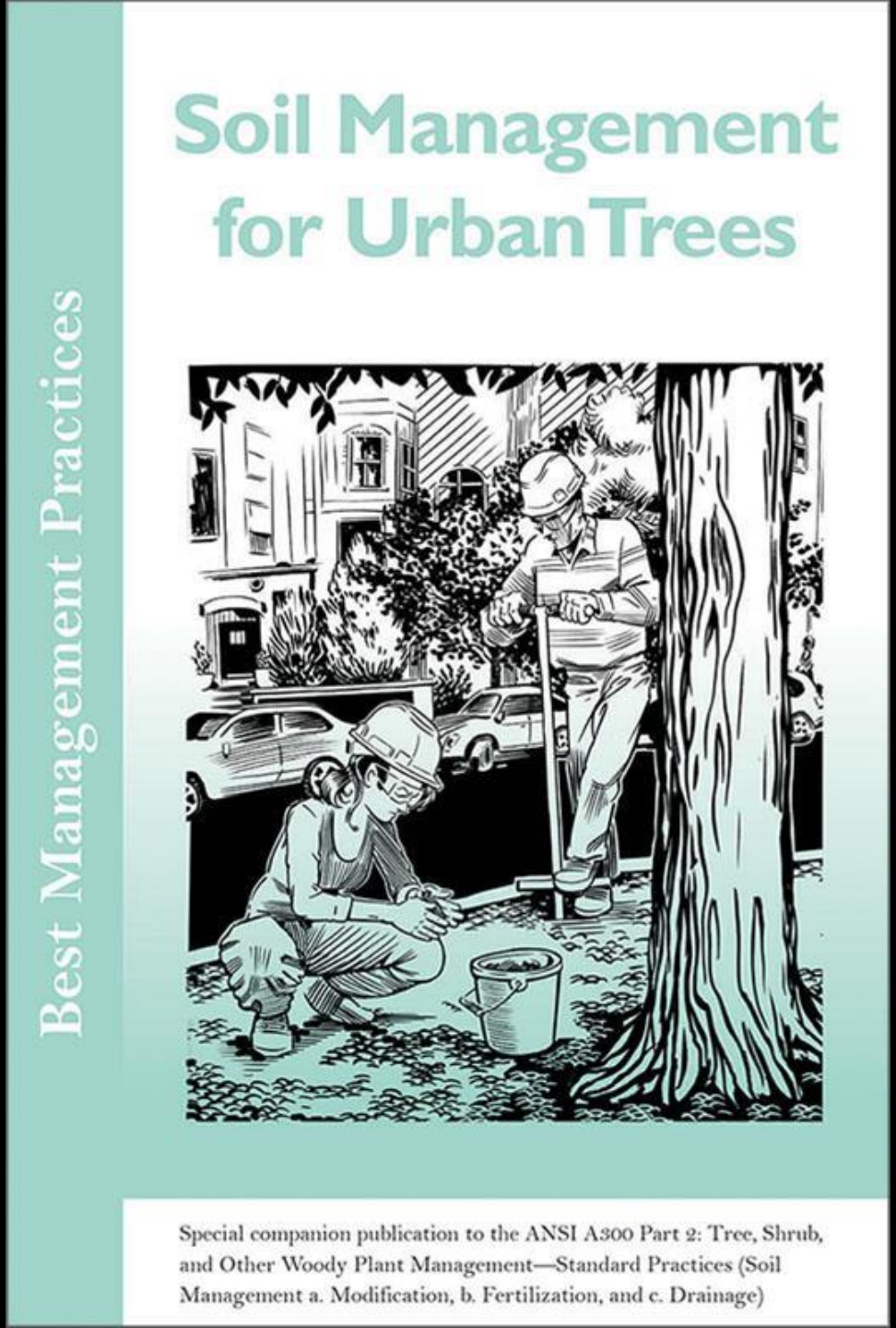
Surface crust in compacted in Lisle, IL (Scharenbroch)


Erosion on residential soil in northern WI (Scharenbroch)

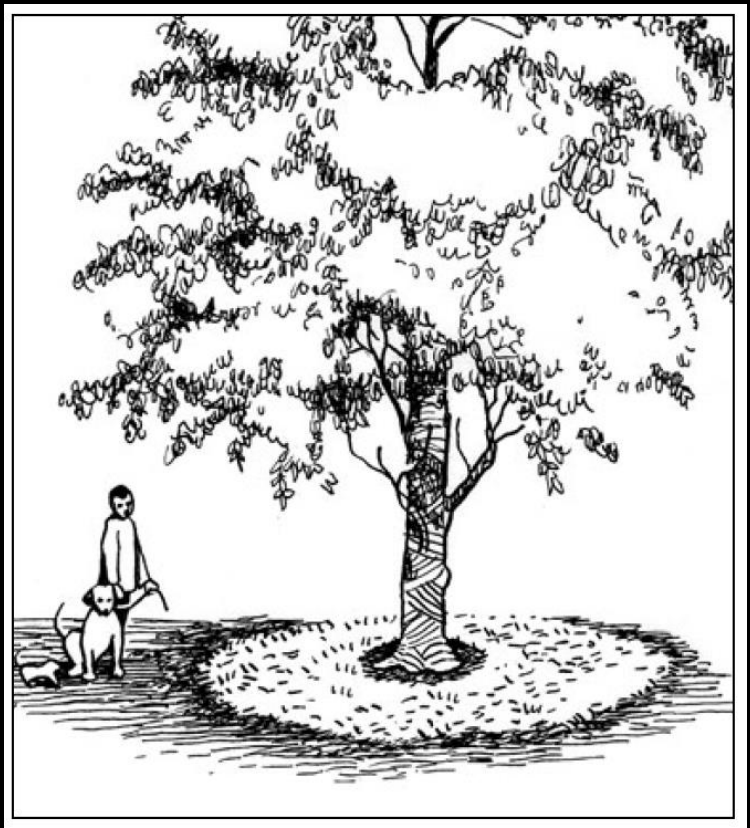
# What management actions can and should we undertake to deal with urban soil compaction?

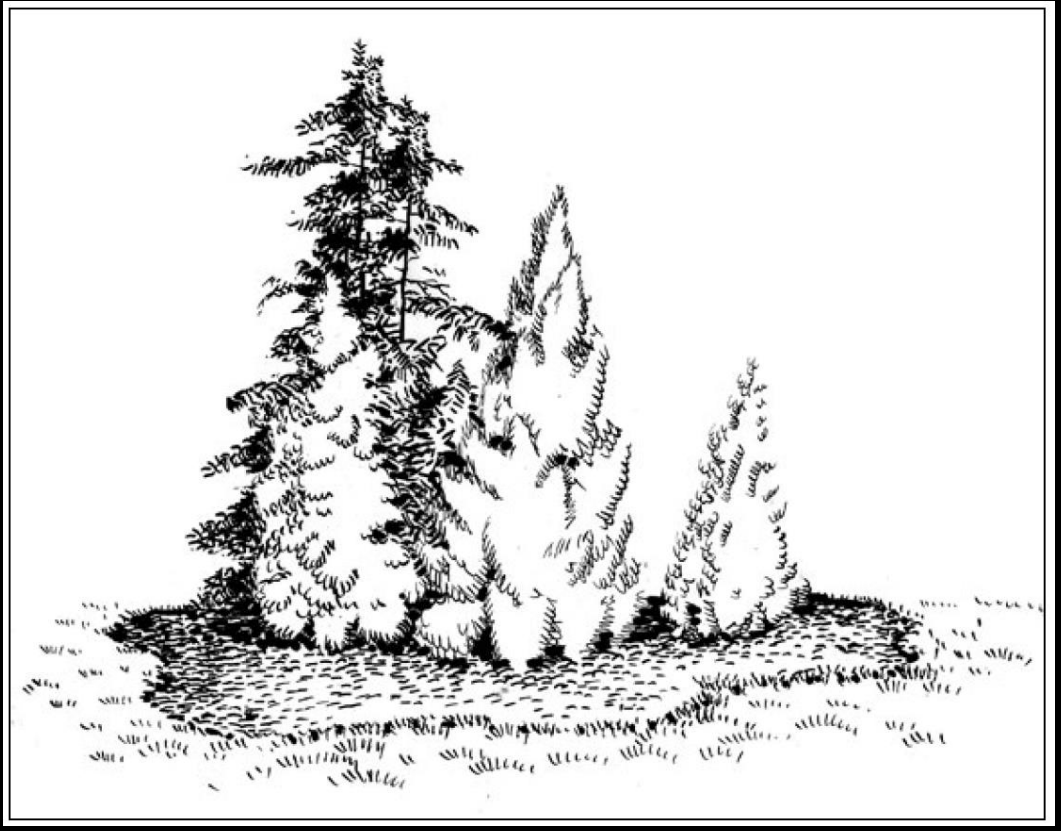
1. Protect
2. Assess
3. Manipulate
4. Monitor

(Scharenbroch et al., 2014)



# 1. Protect





**Mulching under urban landscape trees (Scharenbroch et al., 2014)**

Tree “protection” at College of DuPage in Glen Ellyn, IL (Scharenbroch)

Compaction on home construction site in Glen Ellyn, IL (Scharenbroch)

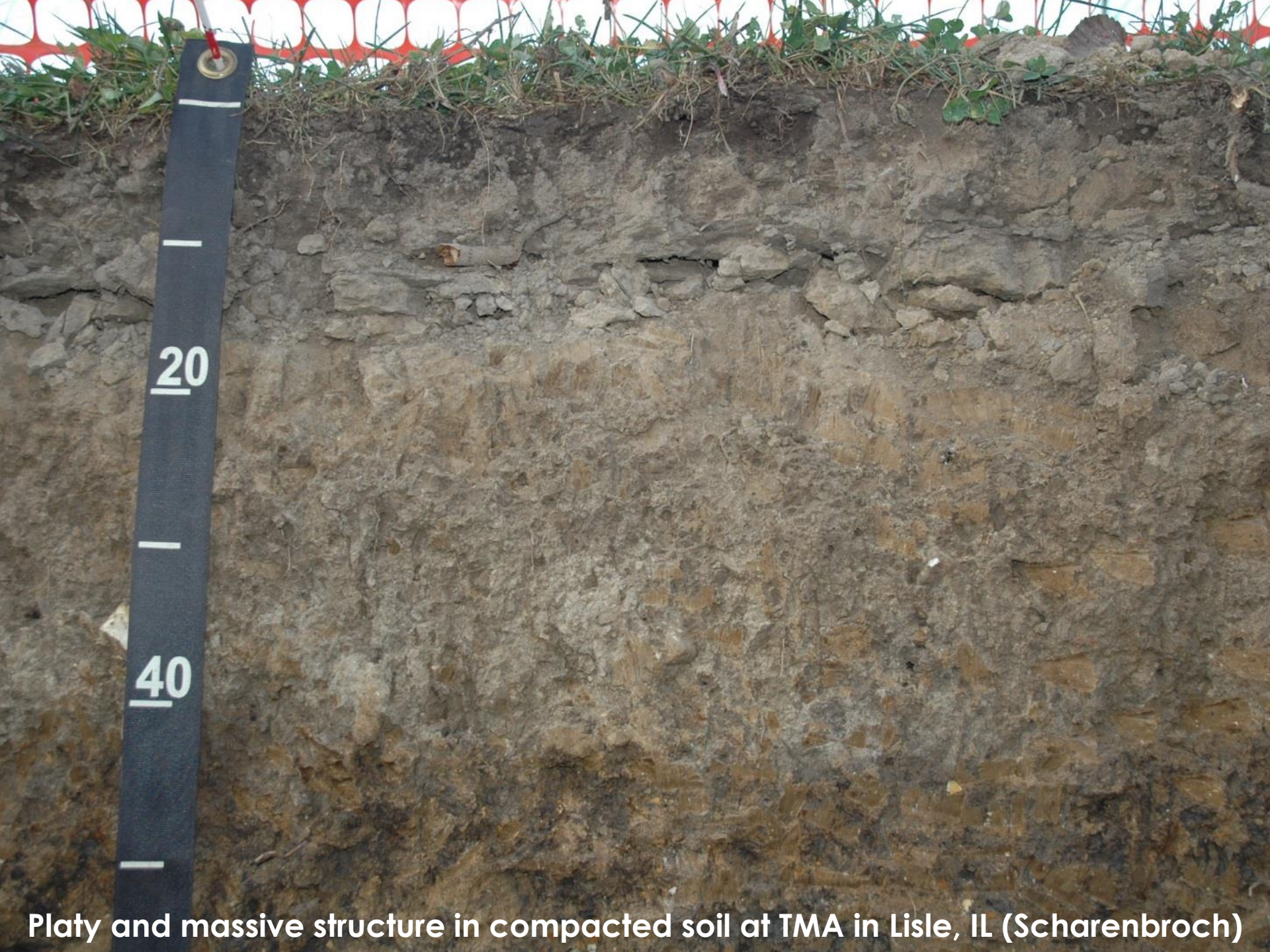

Urban tree planting in structural soil in Chicago, IL (Scharenbroch)

Suspended pavement in Boston, MA (Scharenbroch)


*Quercus* decline in Baker Hill subdivision in Glen Ellyn, IL (Scharenbroch)

# 2. Assess


Collection and assessment of urban soils (Scharenbroch et al., 2014)



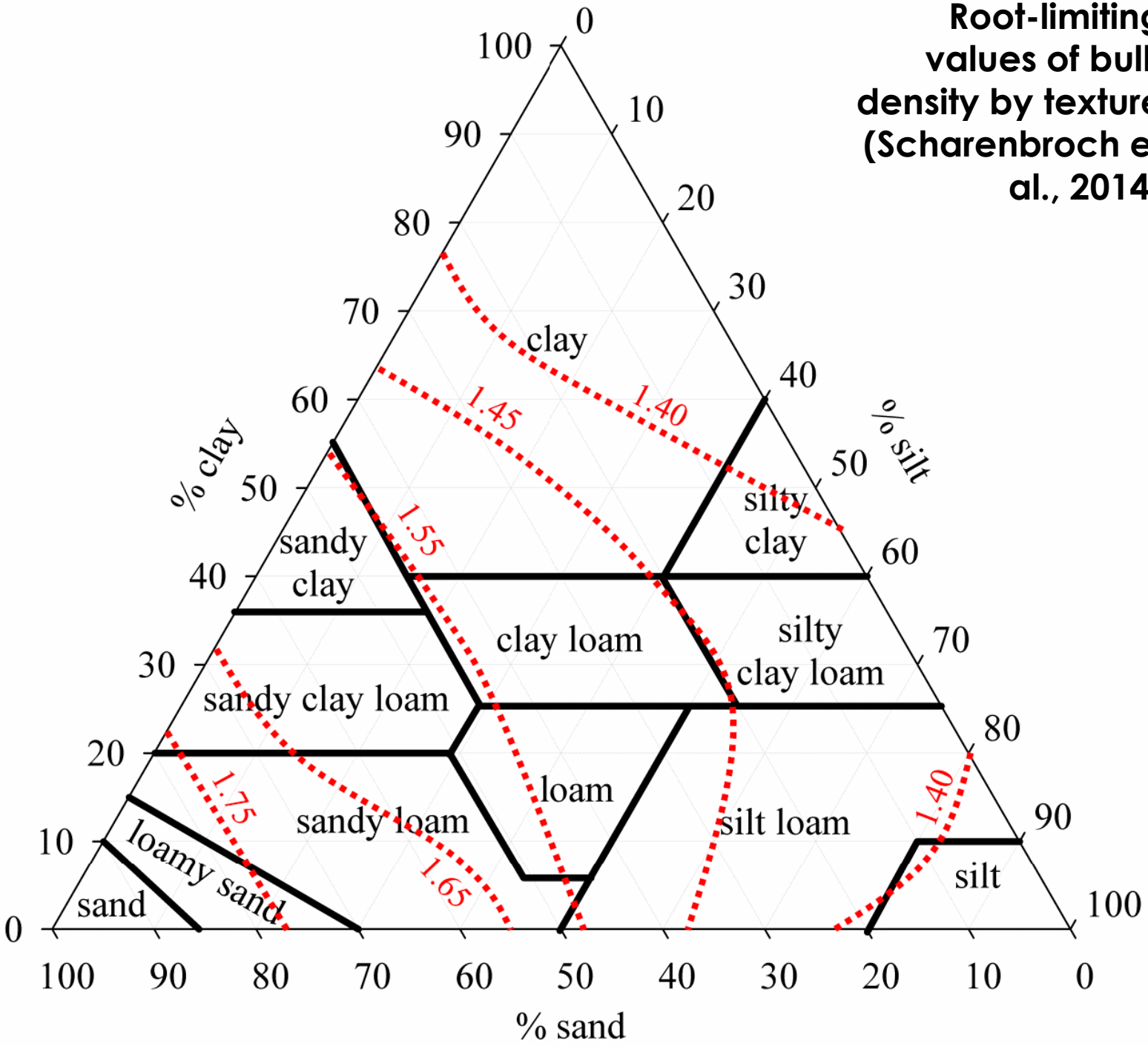

Platy and massive structure in compacted soil at TMA in Lisle, IL (Scharenbroch)


Massive structure in compacted soil at TMA in Lisle, IL (Scharenbroch)

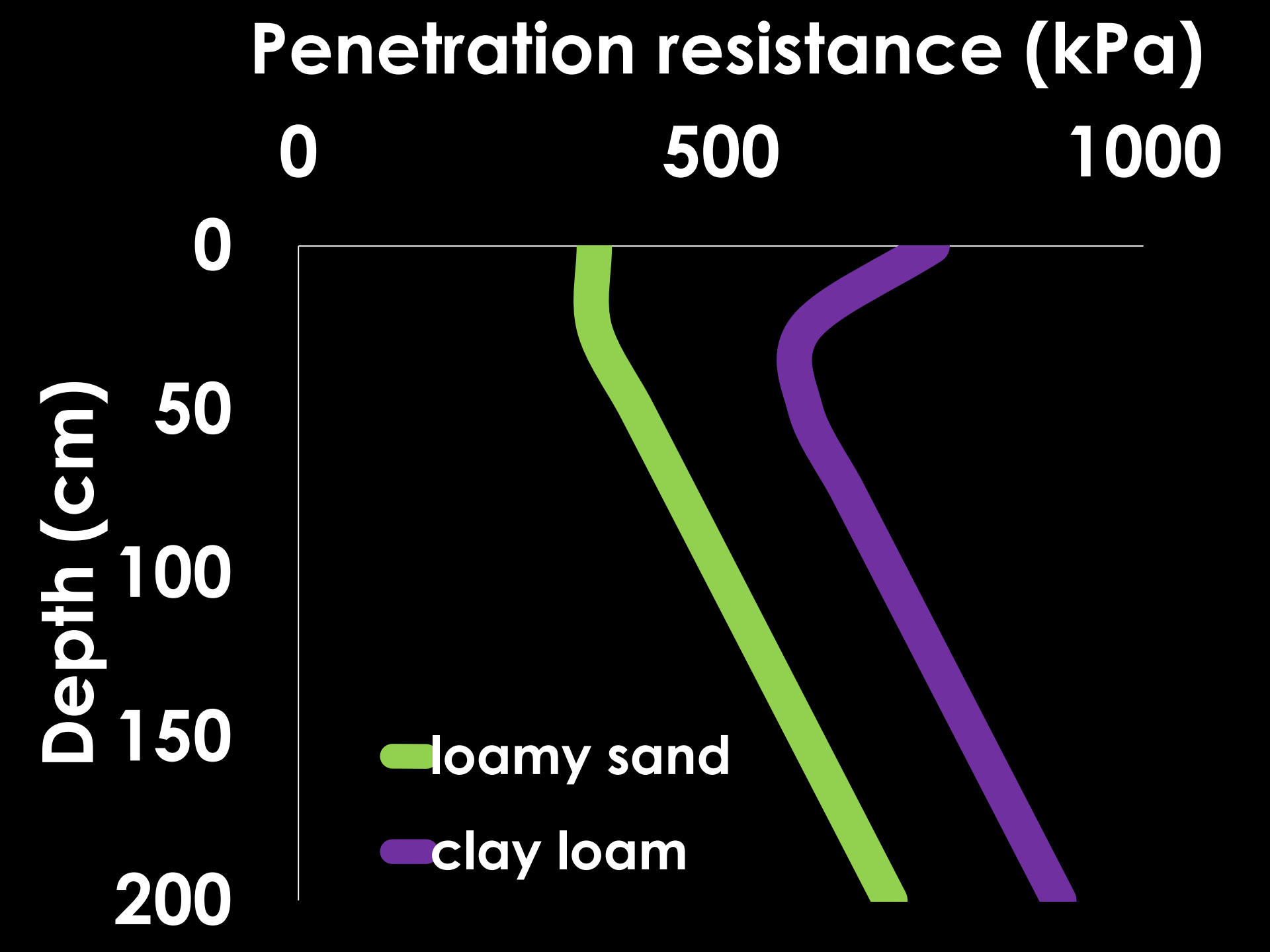

Granular structure in residential soil in Naperville, IL (Scharenbroch)

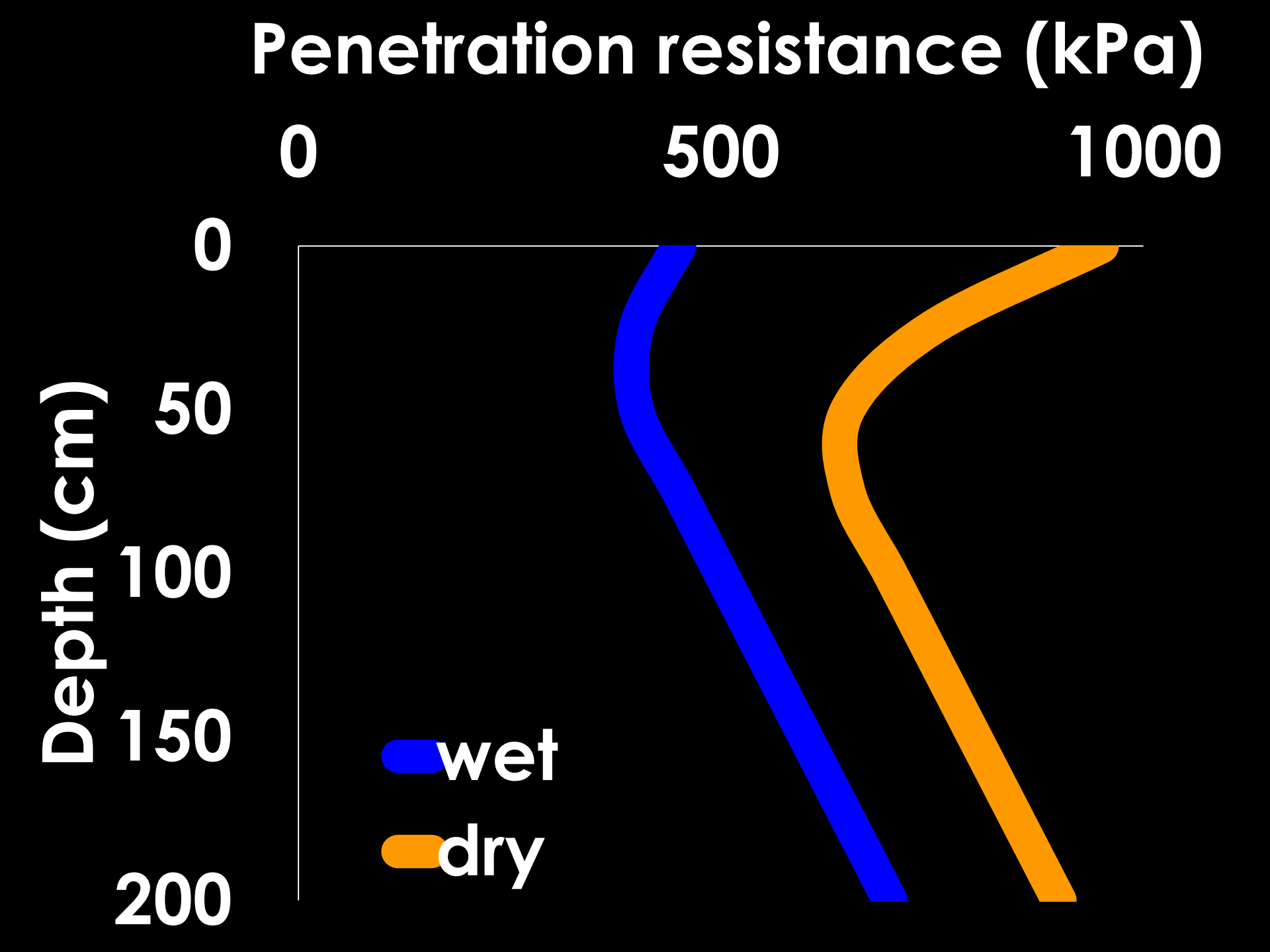

Soil bulk density with an in-tact core (AMS Samplers)

**Root-limiting values of bulk density by texture (Scharenbroch et al., 2014)**




Cone penetrometer (Scharenbroch)


Penetration resistance (kPa)
0
500
1000
Depth (cm)
0
50
100
150
200
loamy sand
clay loam


Penetration resistance (kPa)
0
500
1000
Depth (cm)
0
50
100
150
200
wet
dry

# 3. Manipulate

Air tillage (Scharenbroch et al., 2014)

Moldboard plow (Factory Farmer)

Troy-Bilt rototiller (Van Buren)


Core aeration in Bolingbrook, IL (Scharenbroch)

Subsoiler (NRCS)


Sub-soiling with a backhoe at U. Idaho experimental farm near Moscow, ID (Scharenbroch)


Soil profile rebuilding (Day)


Radial trenching near a *Pinus strobus* in Moscow, ID (Scharenbroch)


Vertical tillage in Bucktown area of Chicago, IL (Scharenbroch)

Air tillage in Bolingbrook, IL (Scharenbroch)


Air tillage in Wheaton, IL (Scharenbroch)

Air-tilled soil in Bolingbrook, IL (Scharenbroch)

Air tillage with biosolids and biochar in Milwaukee, WI (Scharenbroch)

Double-ground hardwood chips (Scharenbroch)

Compost from leaf litter, woody materials and cow manure (Scharenbroch)

Inorganic fertilization (Task Easy)

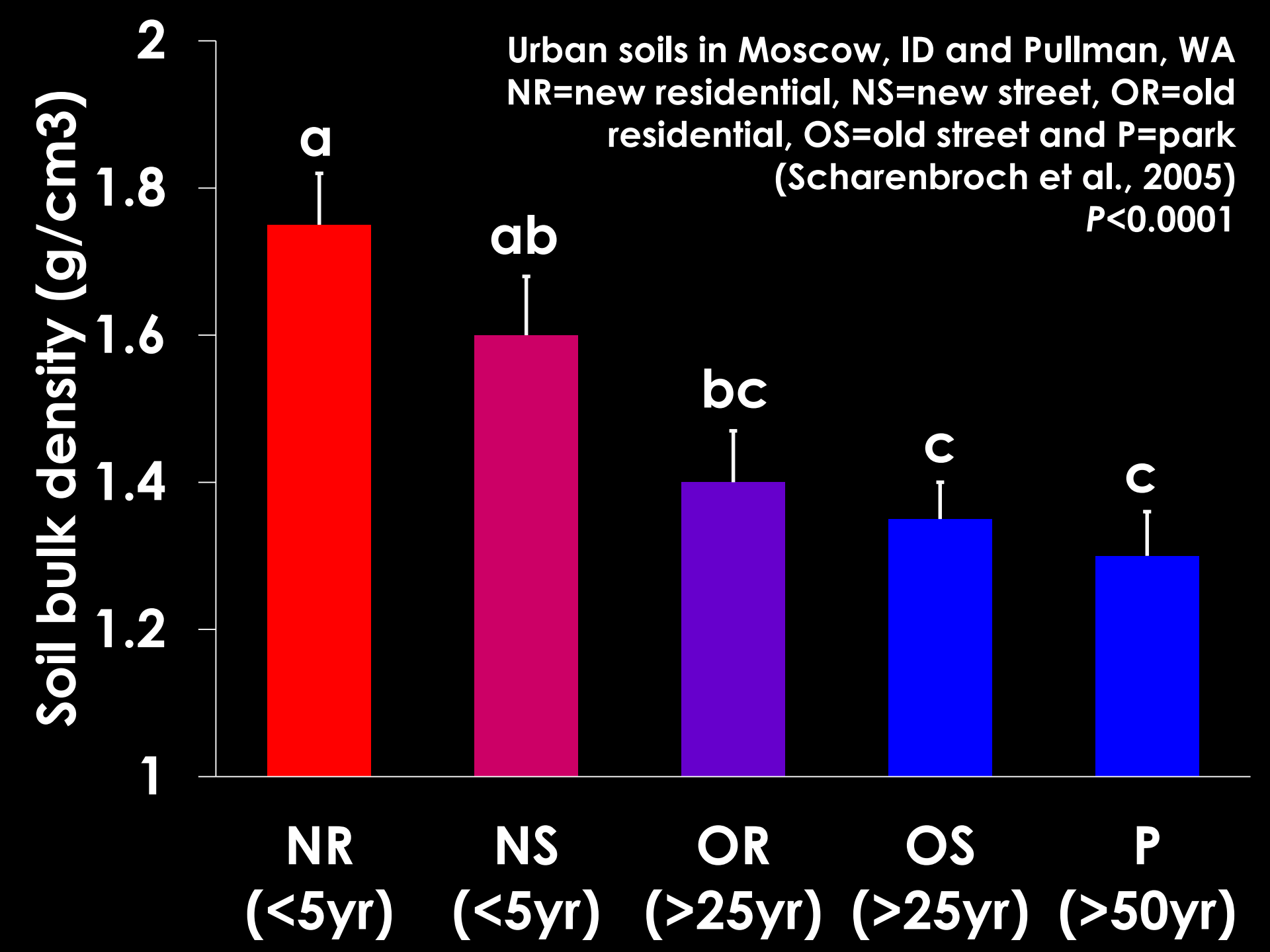
**Expand shale, lightweight aggregate (Scharenbroch)**

# 4. Monitor

Soil sampling for monitoring (Scharenbroch et al., 2014)

| Type | Effect on soil bulk density (g/cm3) | References |
| --- | --- | --- |
| Surface tillage | Minimal, short-lived | Patterson and Bates, 1994; Randrup, 1998 |
| Trenching | None outside of trench | Watson, 1990; Day, 1993 |
| Deep-jetting (high pressure water) | Mixed, short-lived | Smiley et al., 1990; Rolf 1992; Smiley, 2001 |
| Sub-soiling | Minimal, short-lived | Johnson et al., 1987; Rolf, 1998 |

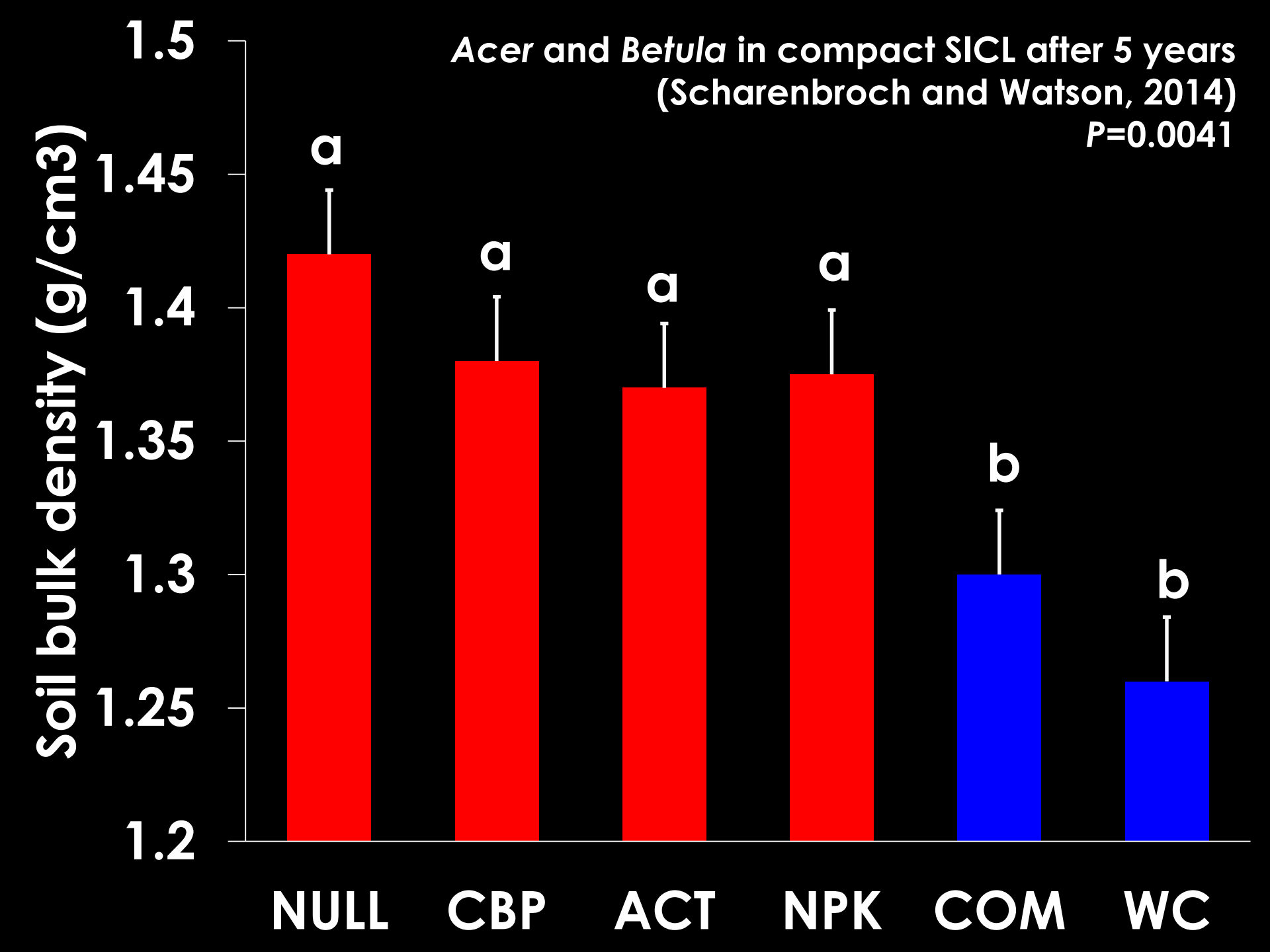
| Type | Effect on soil bulk density (g/cm3) | References |
| --- | --- | --- |
| Inorganic amendments | -0.17 | Patterson and Bates, 1994 |
| Time | -0.20 to -0.35 | Scharenbroch et al., 2005 |
| Organic mulches and amendments | -0.15 to -0.35 | Kolsti et al., 1995; Scharenbroch et al., 2013; Scharenbroch and Watson, 2014 |
| Organic amendments with subsoiling (SPR) | -0.19 to -0.57 | Chen et al., 2014; Layman et al., 2016 |


Urban soils in Moscow, ID and Pullman, WA
NR=new residential, NS=new street, OR=old residential, OS=old street and P=park
(Scharenbroch et al., 2005)
P<0.0001
Soil bulk density (g/cm3)
2
1.8
1.6
1.4
1.2
1
a
ab
bc
c
c
NR (<5yr)
NS (<5yr)
OR (>25yr)
OS (>25yr)
P (>50yr)

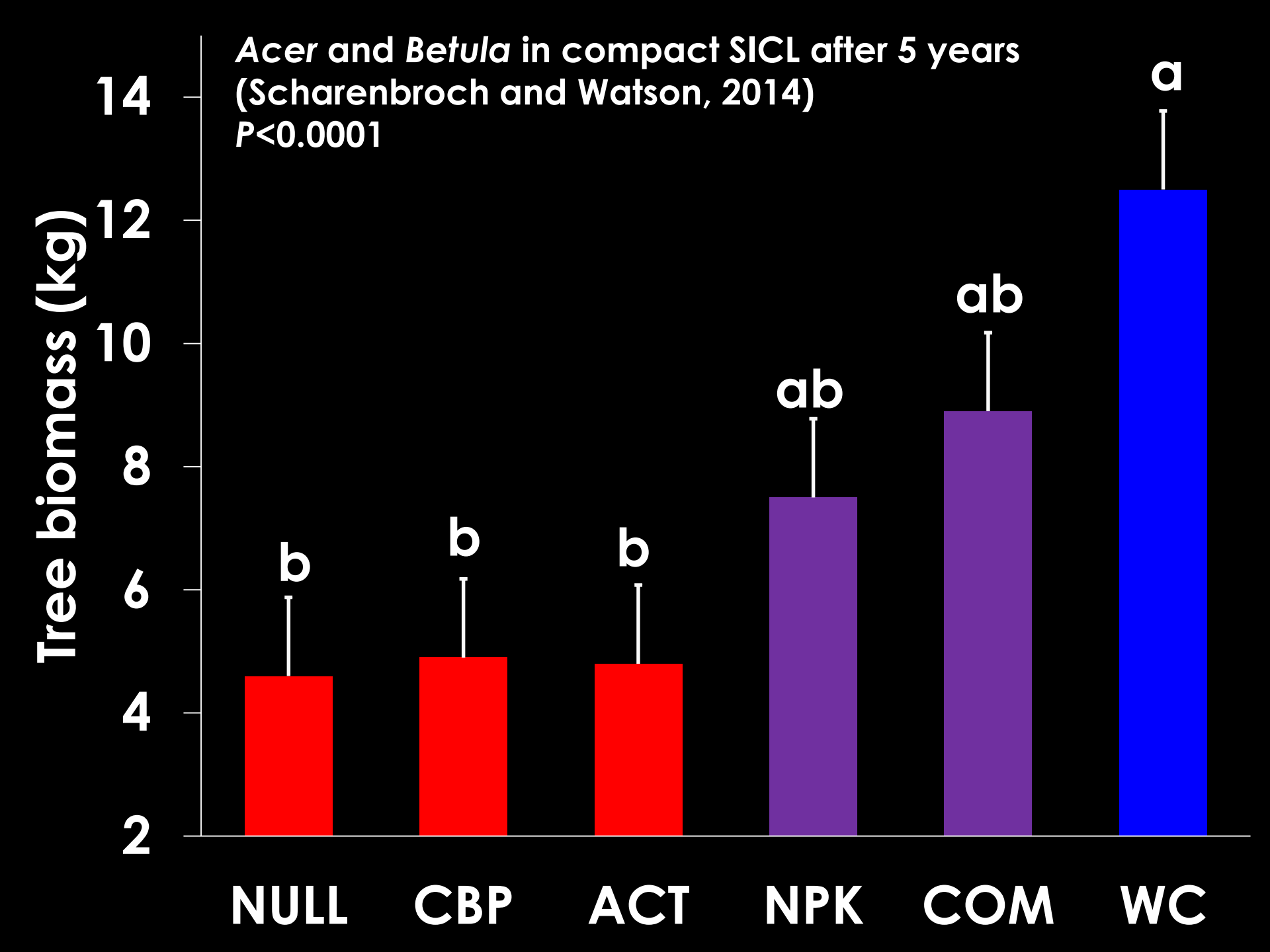

Top-soil removal and compaction on CRUD plot at TMA in Lisle, IL (Scharenbroch)

*Acer* and *Betula* plots on CRUD experiment at TMA in Lisle, IL (Scharenbroch)

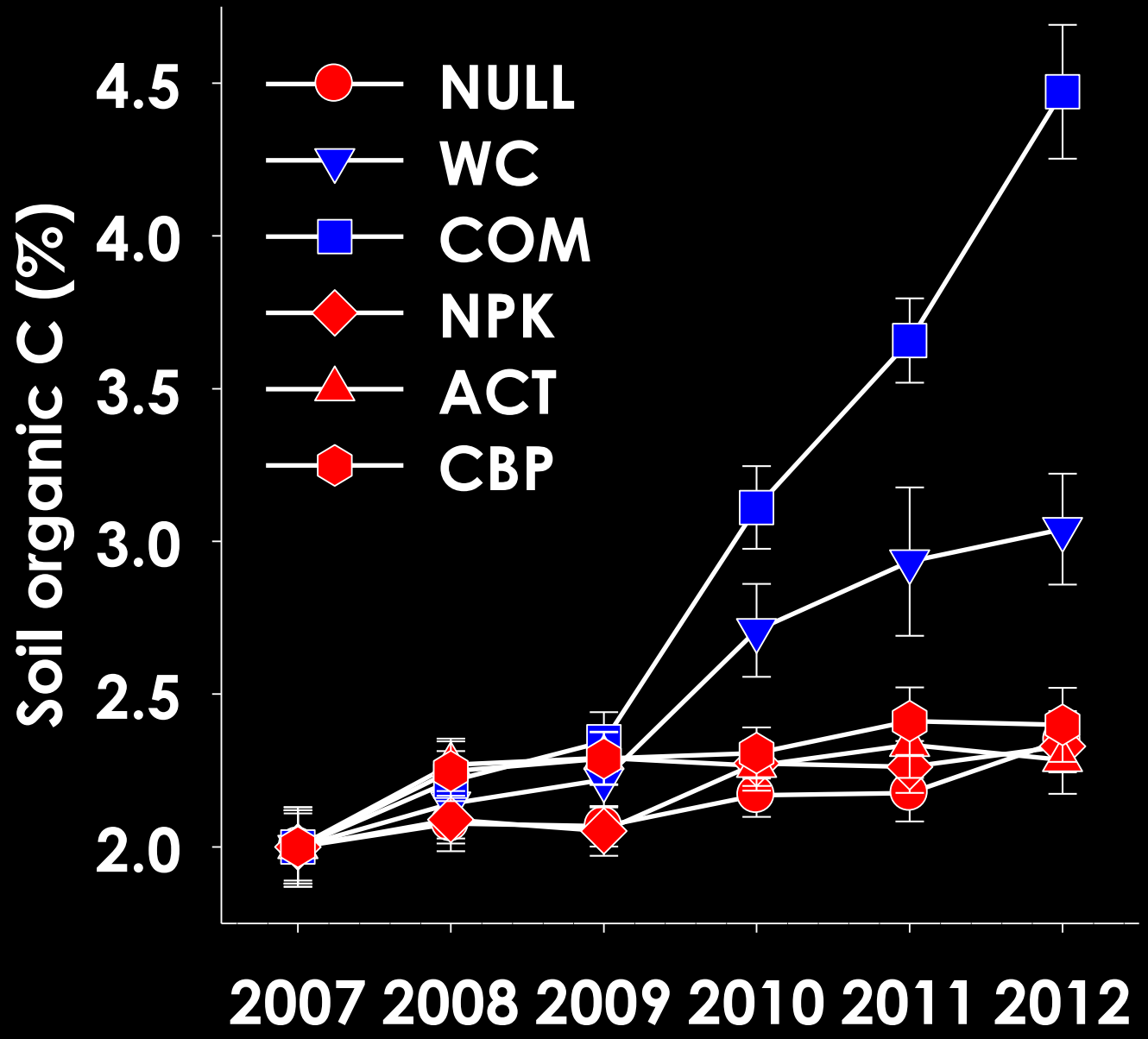
SBK (compost) and ABK-MAS (null) on CRUD plot at TMA in Lisle, IL (Scharenbroch)


*Acer* and *Betula* in compact SICL after 5 years
(Scharenbroch and Watson, 2014)
*P*=0.0041
Soil bulk density (g/cm3)
1.5
1.45
1.4
1.35
1.3
1.25
1.2
a
a
a
a
b
b
NULL
CBP
ACT
NPK
COM
WC

Michelle next to *Betula* plots of mulch (R) and control (L) on CRUD experiment at TMA in Lisle, IL (Scharenbroch)


*Acer* and *Betula* in compact SICL after 5 years
(Scharenbroch and Watson, 2014)
*P*<0.0001
Tree biomass (kg)
14
12
10
8
6
4
2
b
b
b
ab
ab
a
NULL
CBP
ACT
NPK
COM
WC

*Acer* and *Betula* in compact SICL after 5 years
(Scharenbroch and Watson, 2014)
*P*<0.0001

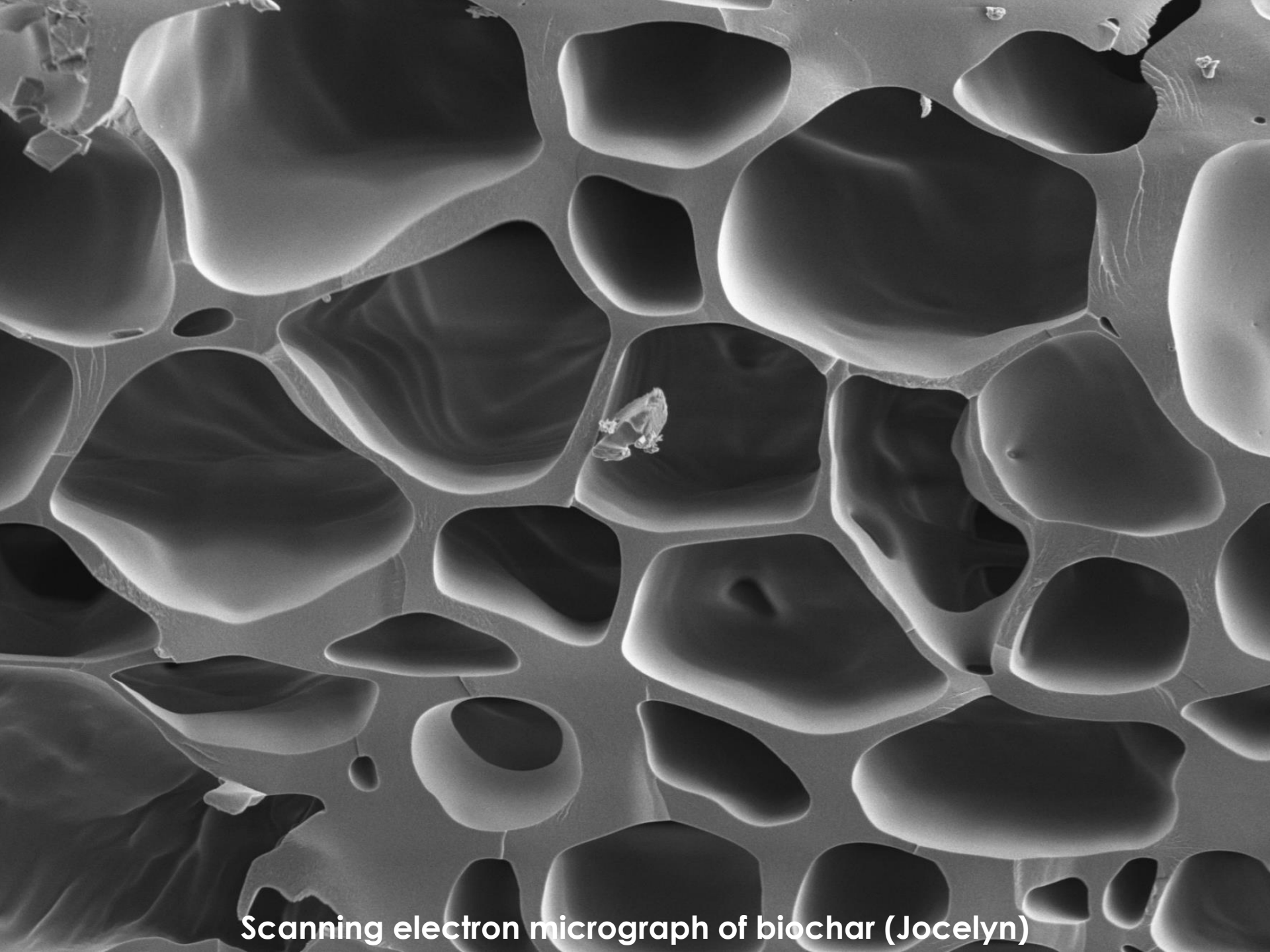


Class A biosolids from Downers Grove, IL (Scharenbroch)

**Biosolids drying beds, Des Plaines River and canal (Chicago MWRD)**

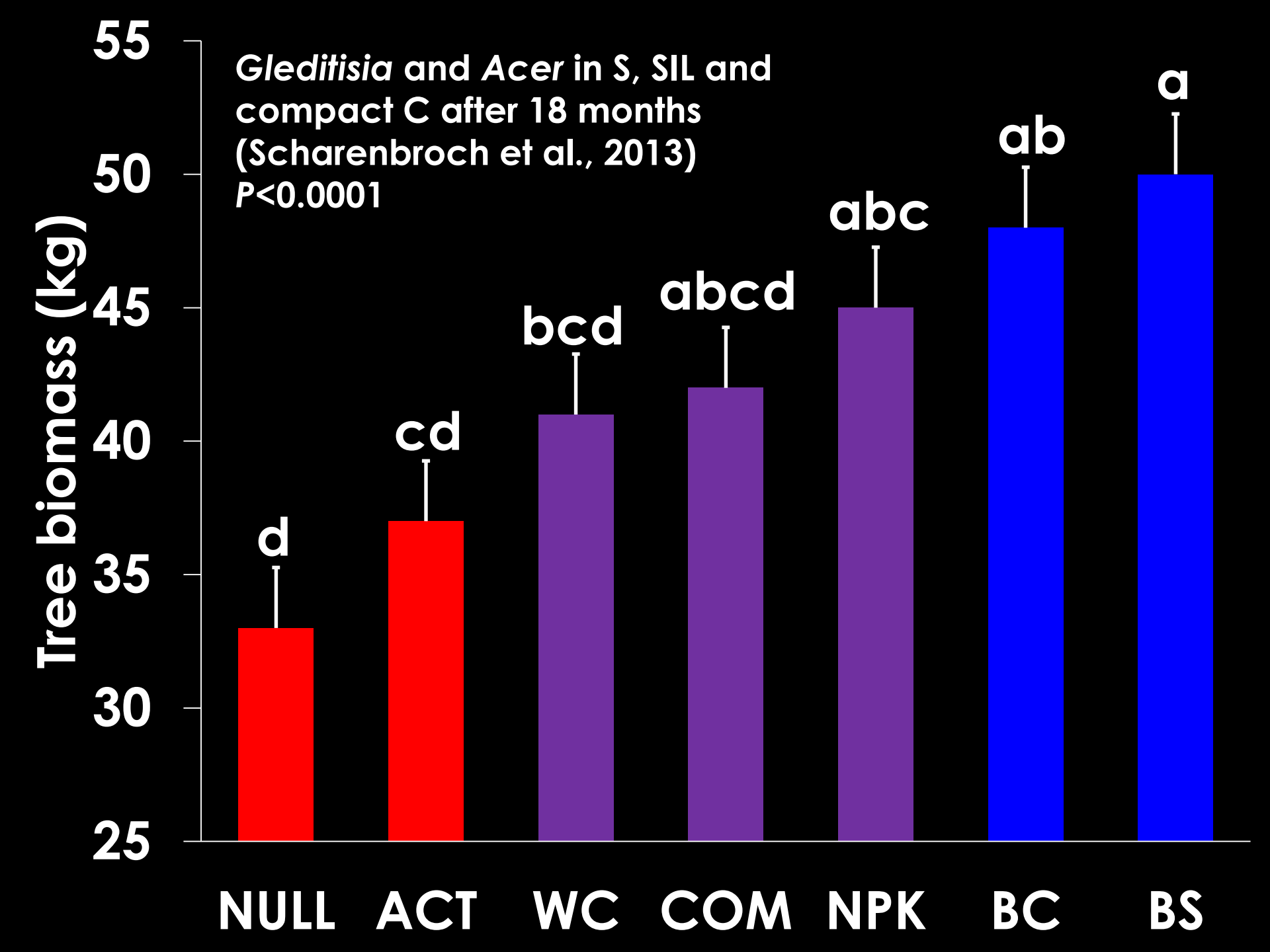
**Biochar from ponderosa pine (L) and wood pellets (R) (Scharenbroch)**

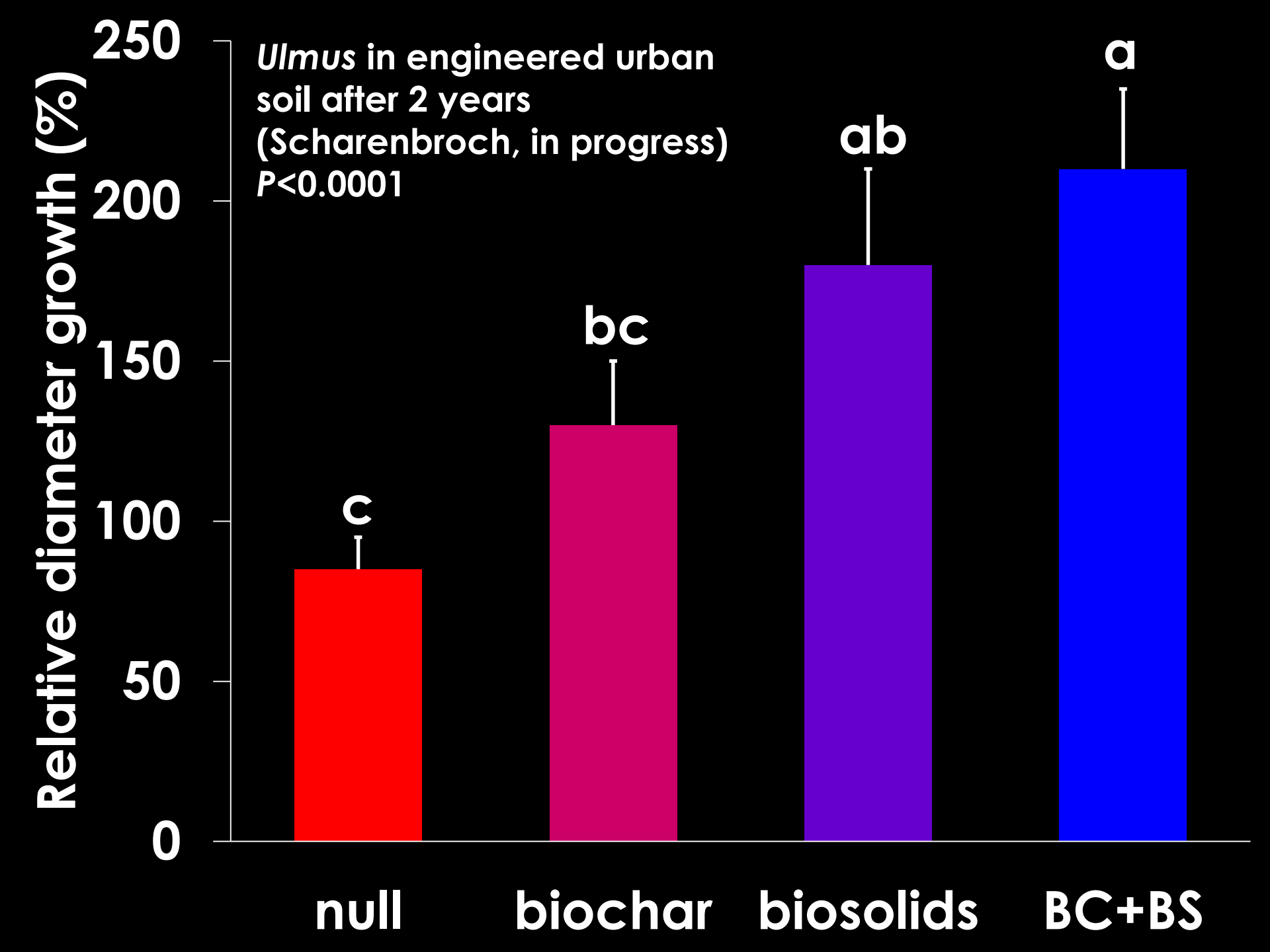
Biochar pyrolysis (500-700°C) under low oxygen conditions (Biochar Now)



Scanning electron micrograph of biochar (Jocelyn)


**Biosolids and biochar microcosm, mesocosm, nursery, Bucktown, Bolingbrook and Milwaukee experiments (Scharenbroch)**


*Gleditisia* and *Acer* in S, SIL and compact C after 18 months (Scharenbroch et al., 2013)
*P*<0.0001
Tree biomass (kg)
55
50
45
40
35
30
25
d
cd
bcd
abcd
abc
ab
a
NULL
ACT
WC
COM
NPK
BC
BS


*Ulmus* in engineered urban soil after 2 years (Scharenbroch, in progress)
*P*<0.0001
Relative diameter growth (%)
250
200
150
100
50
0
c
bc
ab
a
null
biochar
biosolids
BC+BS

# Conclusions

- Compaction is a serious problem for urban soils and trees
- Effective soil management for compaction includes protection, assessment, manipulation and monitoring

# Conclusions

- Organic materials* show promise for improving compacted urban soils
- *Compost and wood chips are effective, but more rapid responses MAY occur with biosolids and biochar

# Thank you









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# Extra slides

| Treatment | Trees | Soils | Environ-ment |
|---|---|---|---|
| Biosolids | ++ | ++ | 0/- |
| Biochar | + | +/- | + |
| Compost | + | + | + |
| Wood chips | + | + | + |
| NPK fertilizer | +/0 | +/0/- | - |

++ is strong positive effect, + is positive effect, 0 is no effect and – is negative effect

| Treatment | Total ($/tr) | Growth (g/tr/yr) | Efficiency ($/g) |
|---|---|---|---|
| Biosolids | 16 | 73 | 0.22 |
| Biochar | 26 | 70 | 0.37 |
| Compost | 19 | 63 | 0.30 |
| Wood chips | 26 | 61 | 0.42 |
| NPK fertilizer | 22 | 39 | 0.55 |