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— L'eau dans la ville | Urban water

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L'eau dans la ville | Urban water

Pédogenèse des milieux de biorétention dans les bassins versants urbains du Midwest, É-U: Comprendre l'évolution des sols pour guider l'entretien

Pedogenesis of bioretention media in Midwest, USA urban watersheds: Understanding soil evolution to guide maintenance

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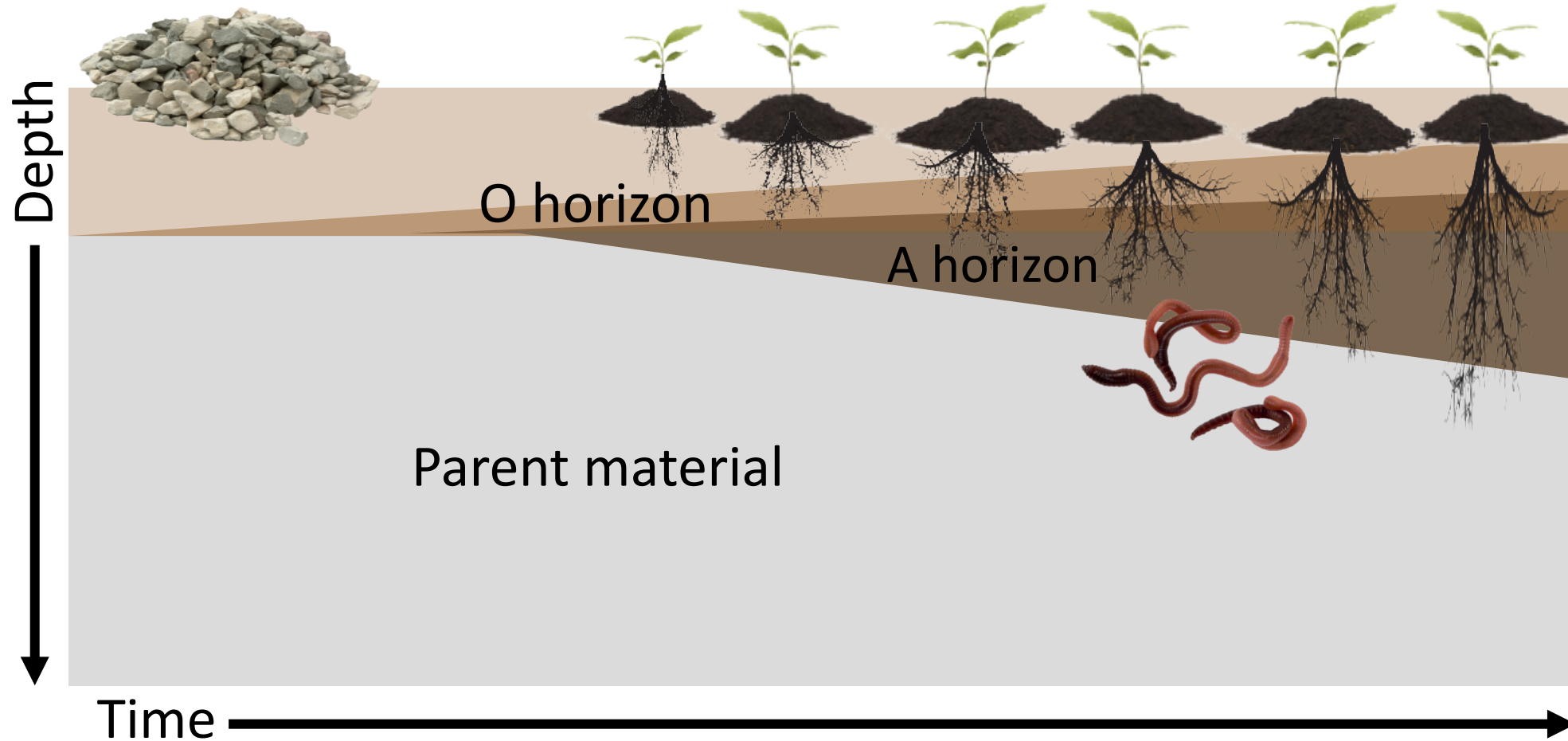


THE OHIO STATE UNIVERSITY
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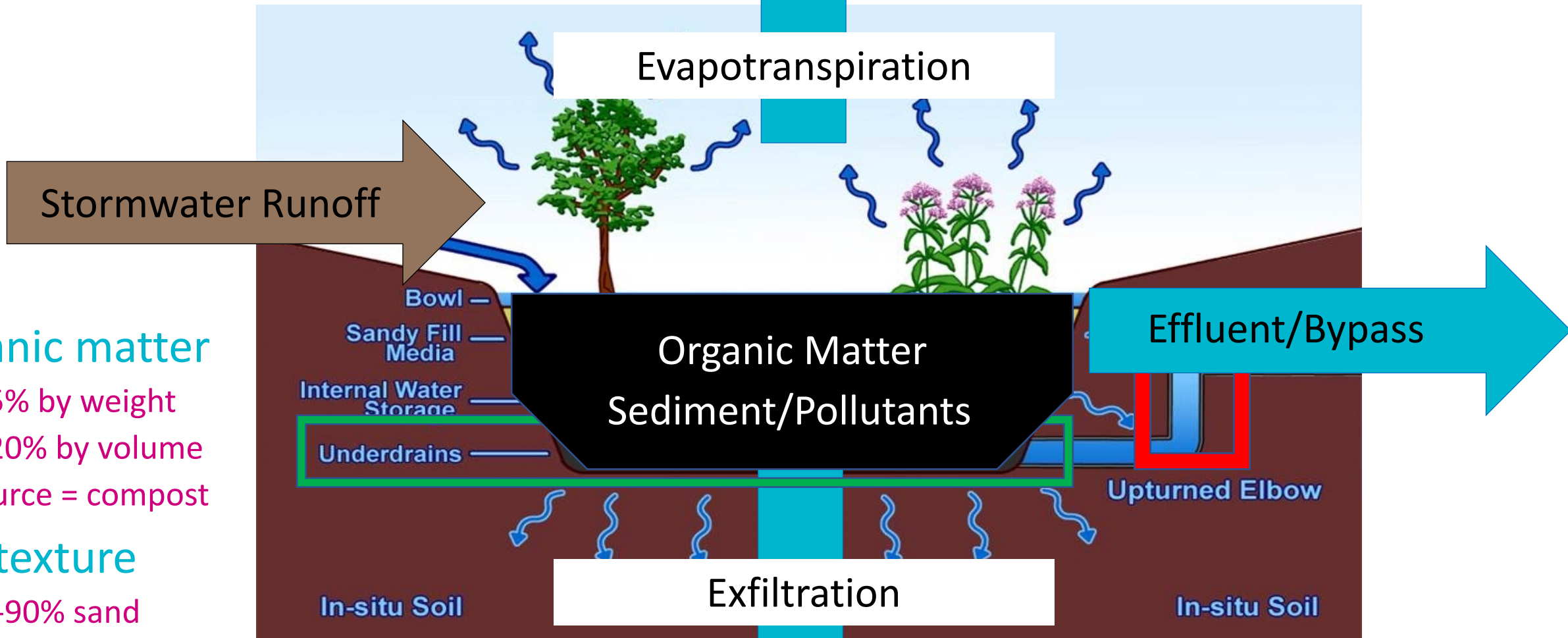
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Introduction

Pedogenesis = gradual changes in a soil that occur naturally over time



Midwest, USA (Ohio)



Organic matter

- 3-5% by weight
- 8-20% by volume
- source = compost

Soil texture

- 80-90% sand
- <10% clay

15-60 mg/kg P

“Organics and small sized particles reduce bioretention flow properties” (Vijayaraghvan, 2016)

Research Objectives

- Describe how bioretention soil media evolves over time
- Determine variables that soil media evolution in bioretention
- Relate bioretention pedogenesis to flow properties and a wider context



“Bioretention media needs more than two years to settle” (Spraaakman et al., 2020)

Field Sites

The USA



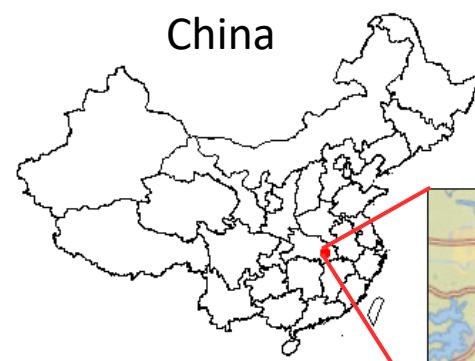
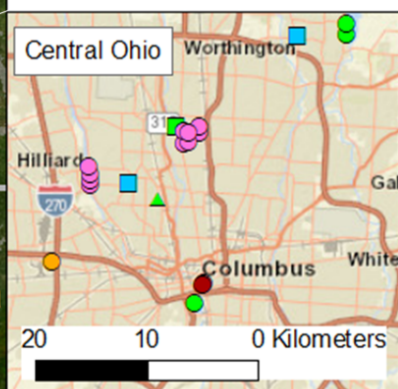
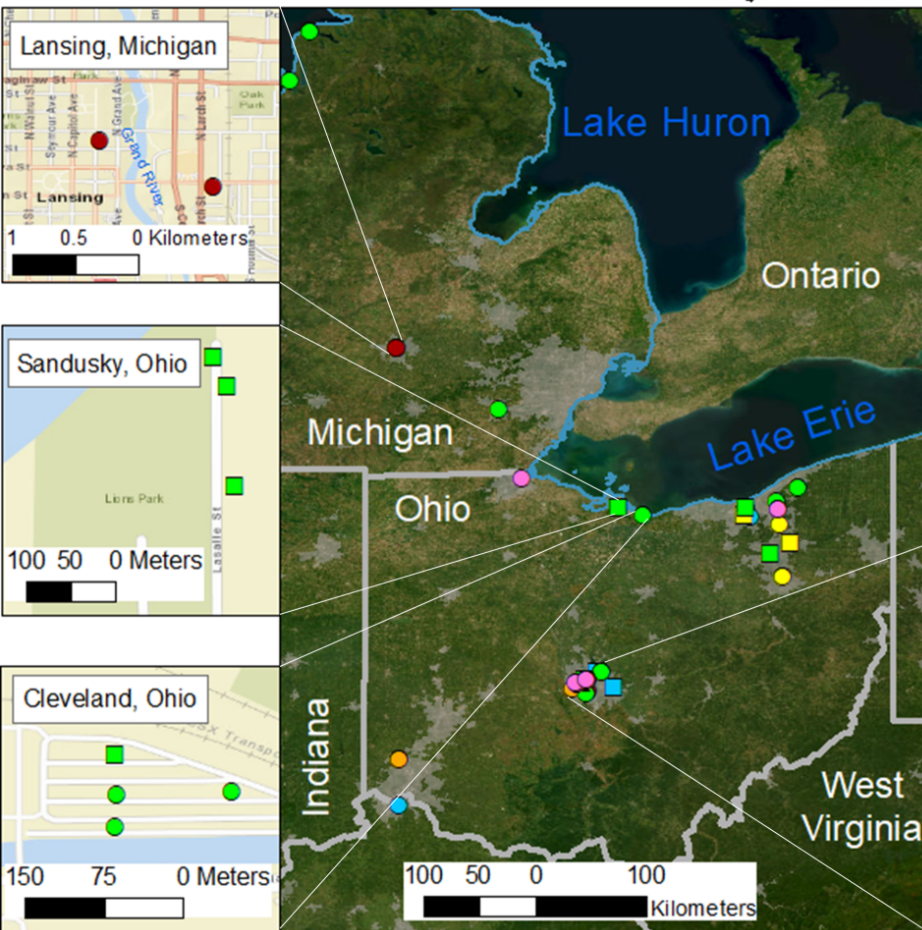
Number of Visits

- 1 visit
- 2 visits
- ▲ 3 visits

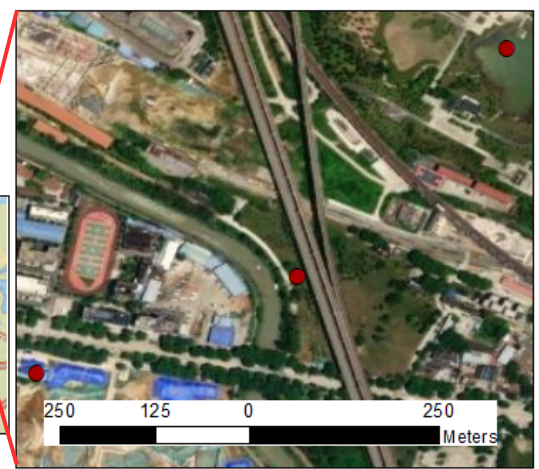
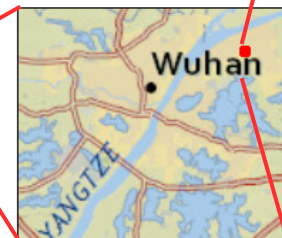
Land Use

- Urban Areas
- Commercial
- Downtown Urban
- Fueling Station
- Industrial
- Parking/Roads
- Residential

- 57 sites, 70 unique visits
- 3 states in Midwest, USA
- 3 sites Wuhan, China
- 657 soil samples
- 172 infiltration tests



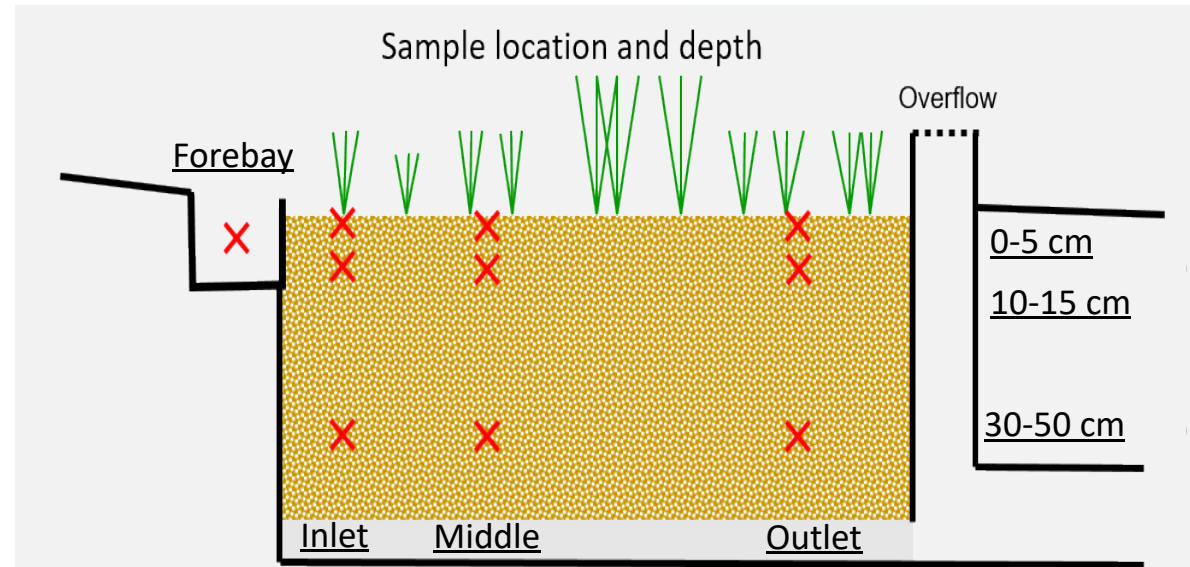
Hubei Province



Field and Analysis Methods



“Surface infiltration rate”

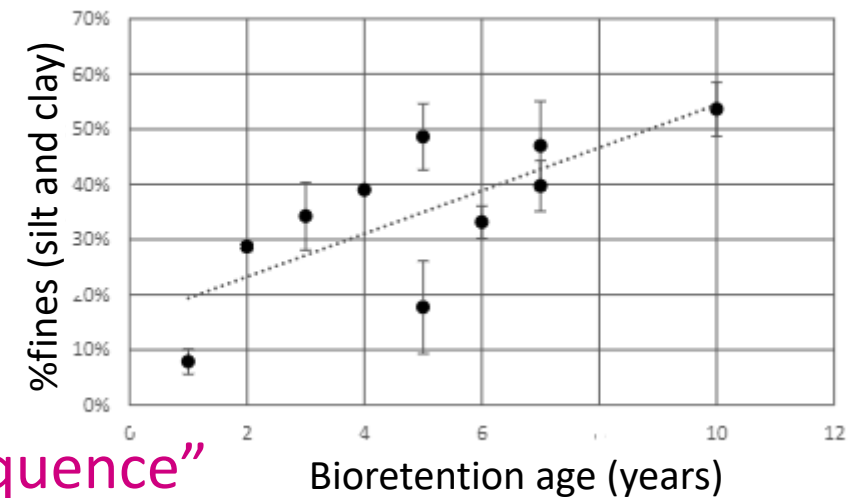


Soil samples with depth and location

| | |
|---|--|
| Date Observed: | 11/9/21 |
| Rain Garden Name | SHEETZ KENT #452 |
| Location / Nearest Address | 600 N. MARTIN ST KENT, OH 44270 |
| Installation Year | |
| Photo taken? | Y |
| Built Design Details | Y |
| Type of Rain Garden (on/offline) | ON |
| Number of Downspout Connections | 6 |
| Number of Curb cuts | 6 |
| Overflow Structure Height above Mulch (in) | 6, 5, 4.5, 6.5 |
| Inflow Diffuse/Concentrated | Conc towards Sheetz, diffuse towards n |
| Description of drainage area (impervious, pervious, etc.) | parking lot |
| Visible Erosion | |
| Inlet Path Erosion (Y/N) | N, but some more traffic |
| Downspout Connection Erosion (Y/N) | N |
| Other Visible Erosion Areas | N |
| Sinkholes present (Y/N) | N |
| Presence of Trash/Debris | |
| Trash Present at Inlet/Forebay (Y/N) | Y |
| Trash/leaves blocking Inlet (Y/N) | Y, but not block-y |
| Trash Present Throughout Basin (Y/N) | Y |
| Street sediment present near inlet (Y/N) | Y |

Checklist

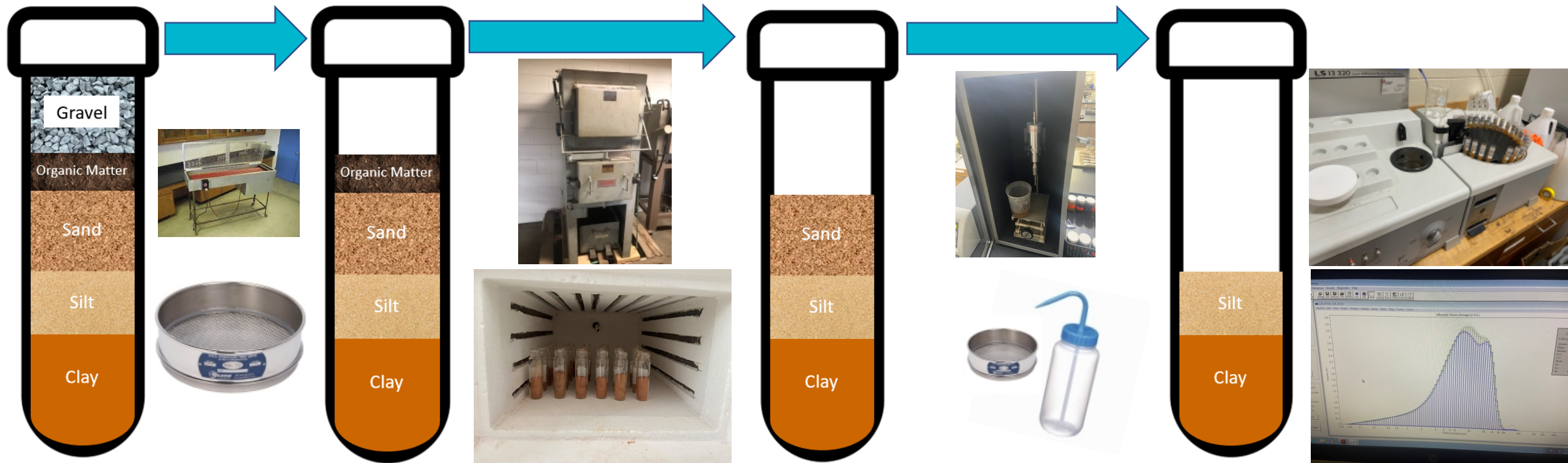
Response variables {
 Organic matter
 Soil texture
 Surface infiltration rate



“Chronosequence”

Laboratory Methods

- Loss on ignition organic matter analysis (ASTM-D2974)
- Laser diffraction particle size analysis (Faé et al., 2019)



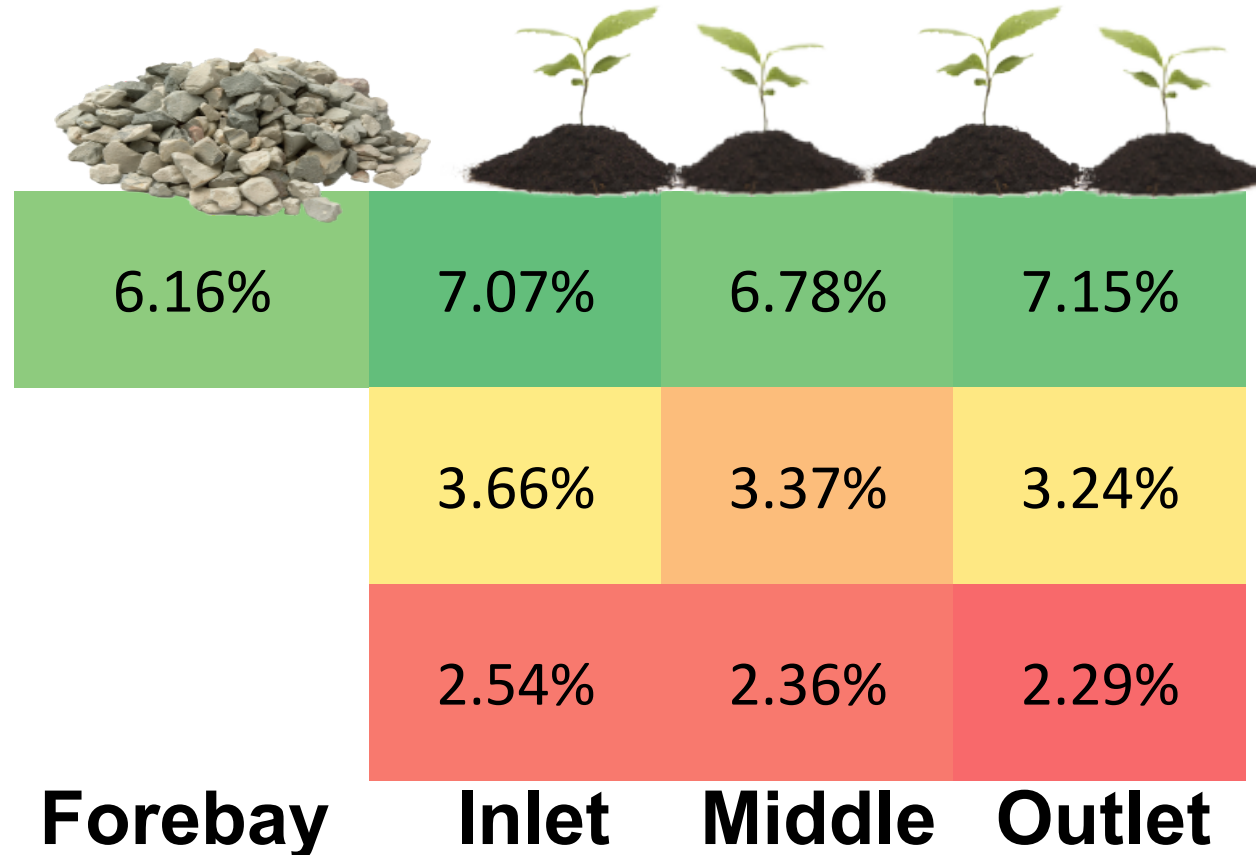
Organic Matter

explained by age, land use, and depth

Commercial = Downtown Urban = Fueling Station = Residential > Parking/Roads > Industrial



Average % Organic Matter by Depth



Design standard

- 3-5% by weight
- 8-20% by volume
- source = compost

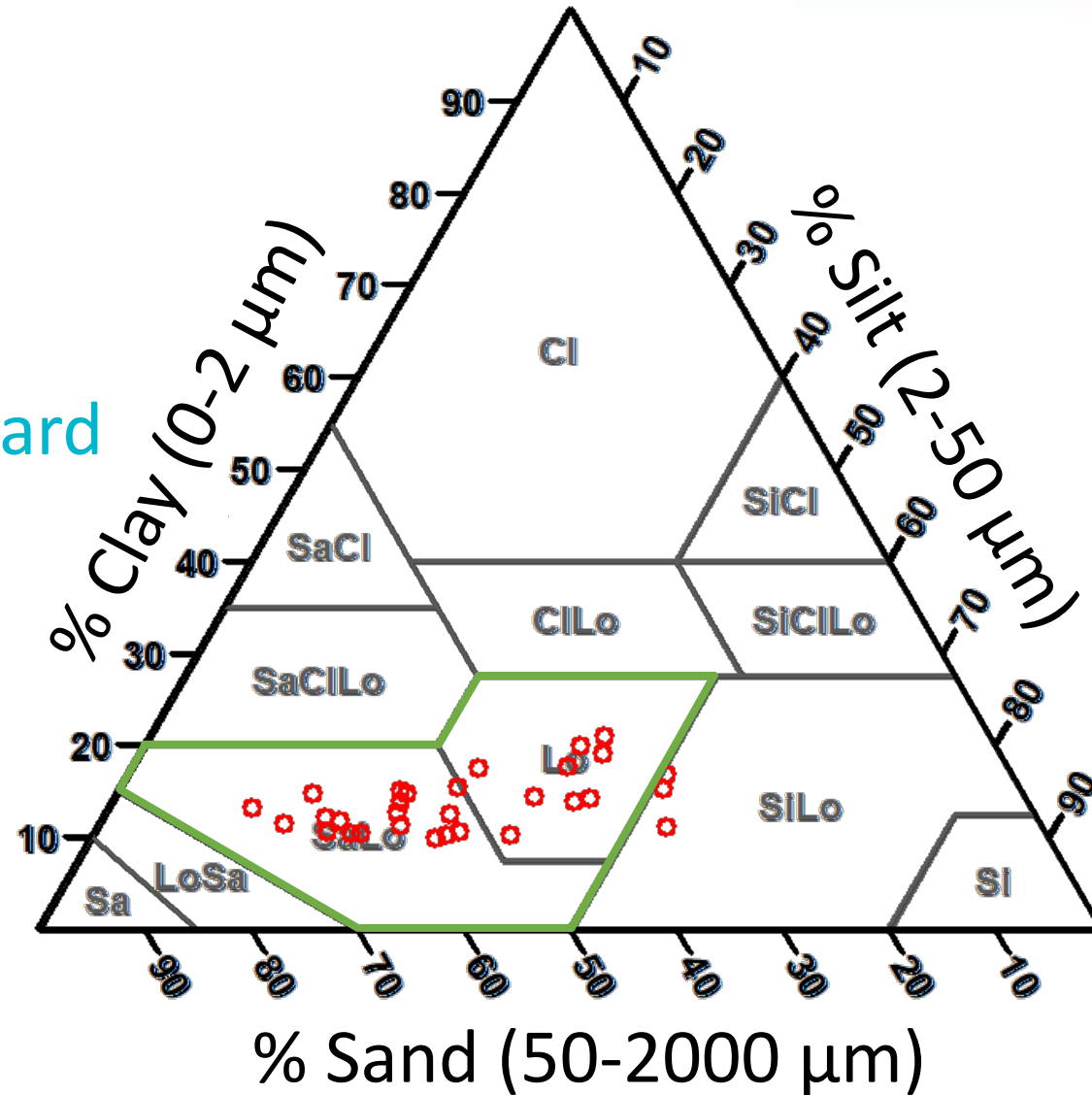
Key message:

Organic matter accumulates at the surface over time (mulch, detritus, wash-off)

Soil Texture - Hubei

China design standard

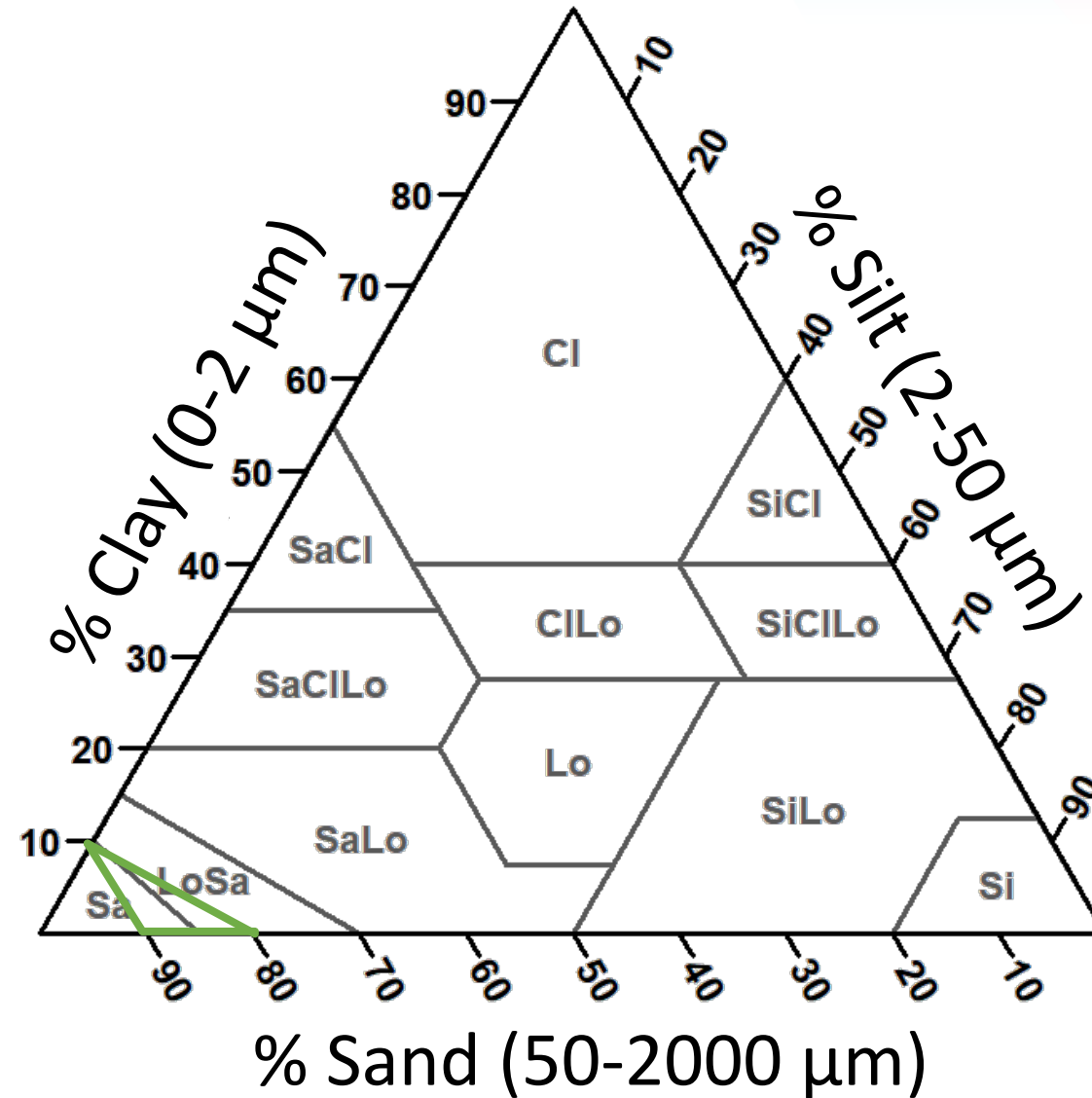
- Sandy loam or
- Loam



10% of samples
are outside of
design range

Of those,
100% were
too fine

Soil Texture - Ohio



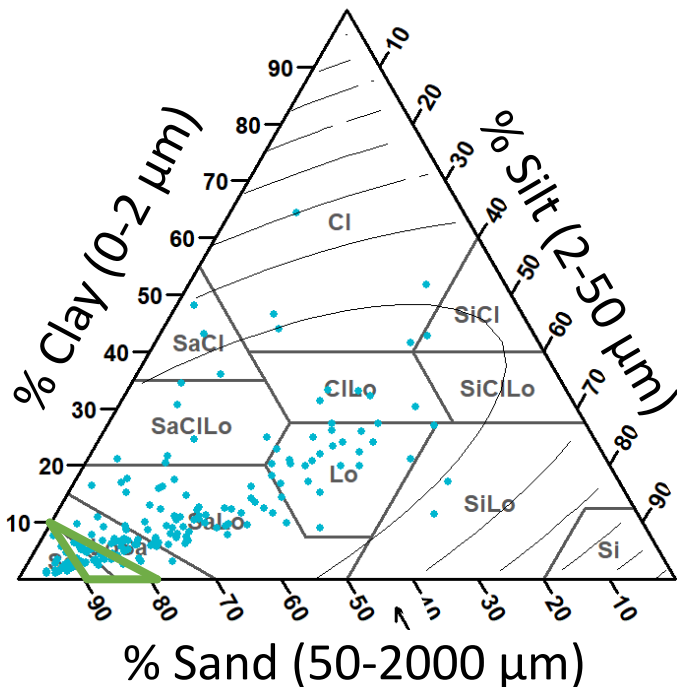
Soil Texture

explained by depth & age

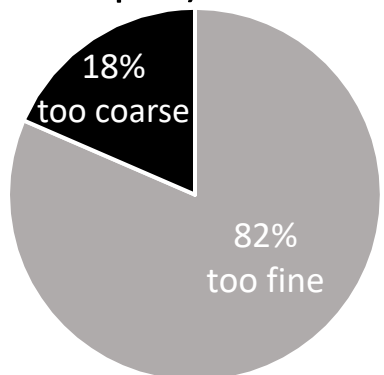
Key message:

>50% of samples were outside the design range, fines accumulate at surface, coarse particles deeper

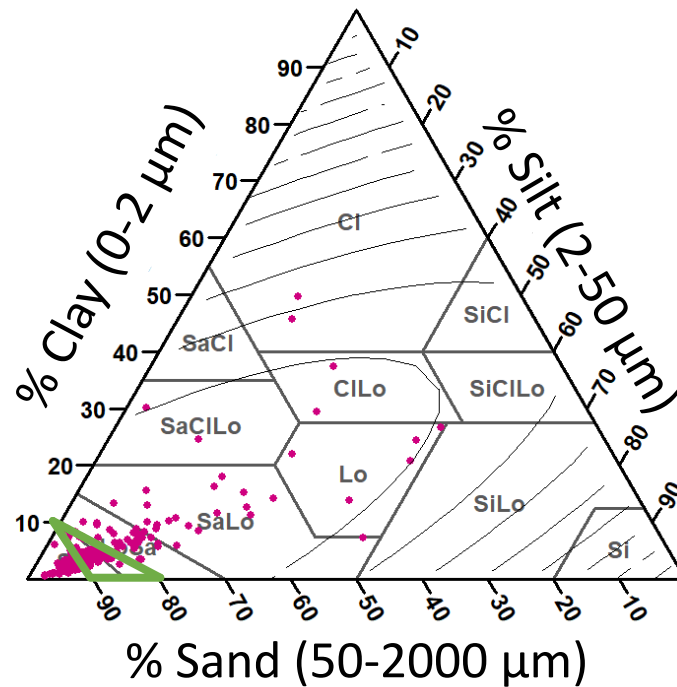
0-5 cm depth



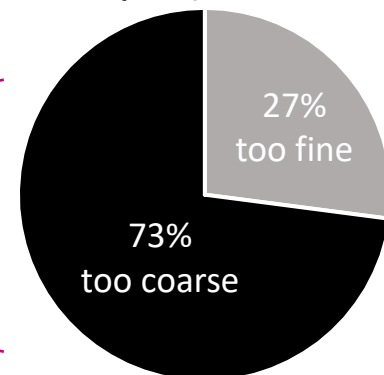
52% of samples are outside of design range



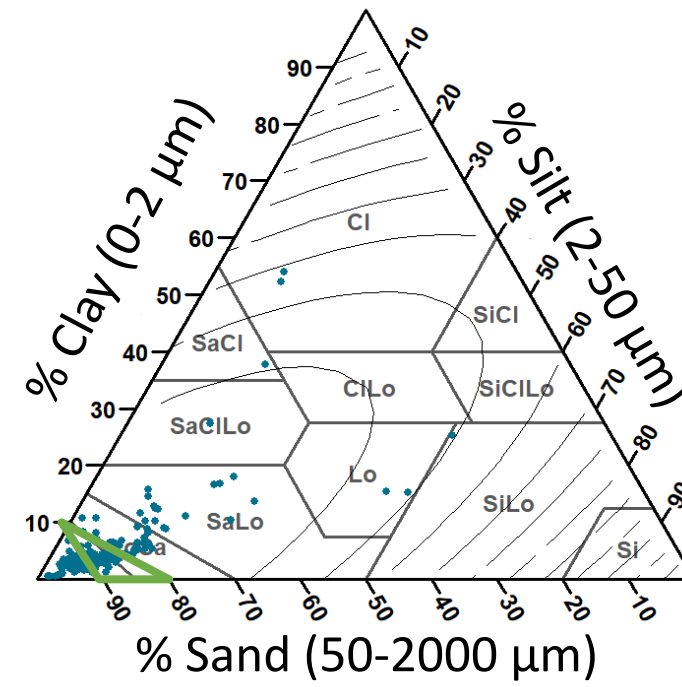
10-15 cm depth



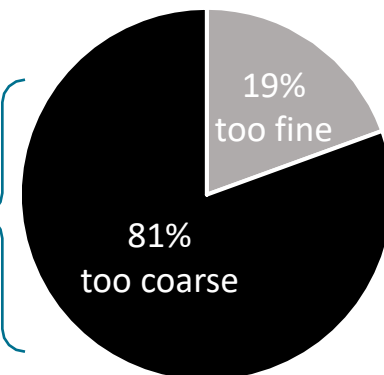
49% of samples are outside of design range



30-50 cm depth



62% of samples are outside of design range



Soil Texture

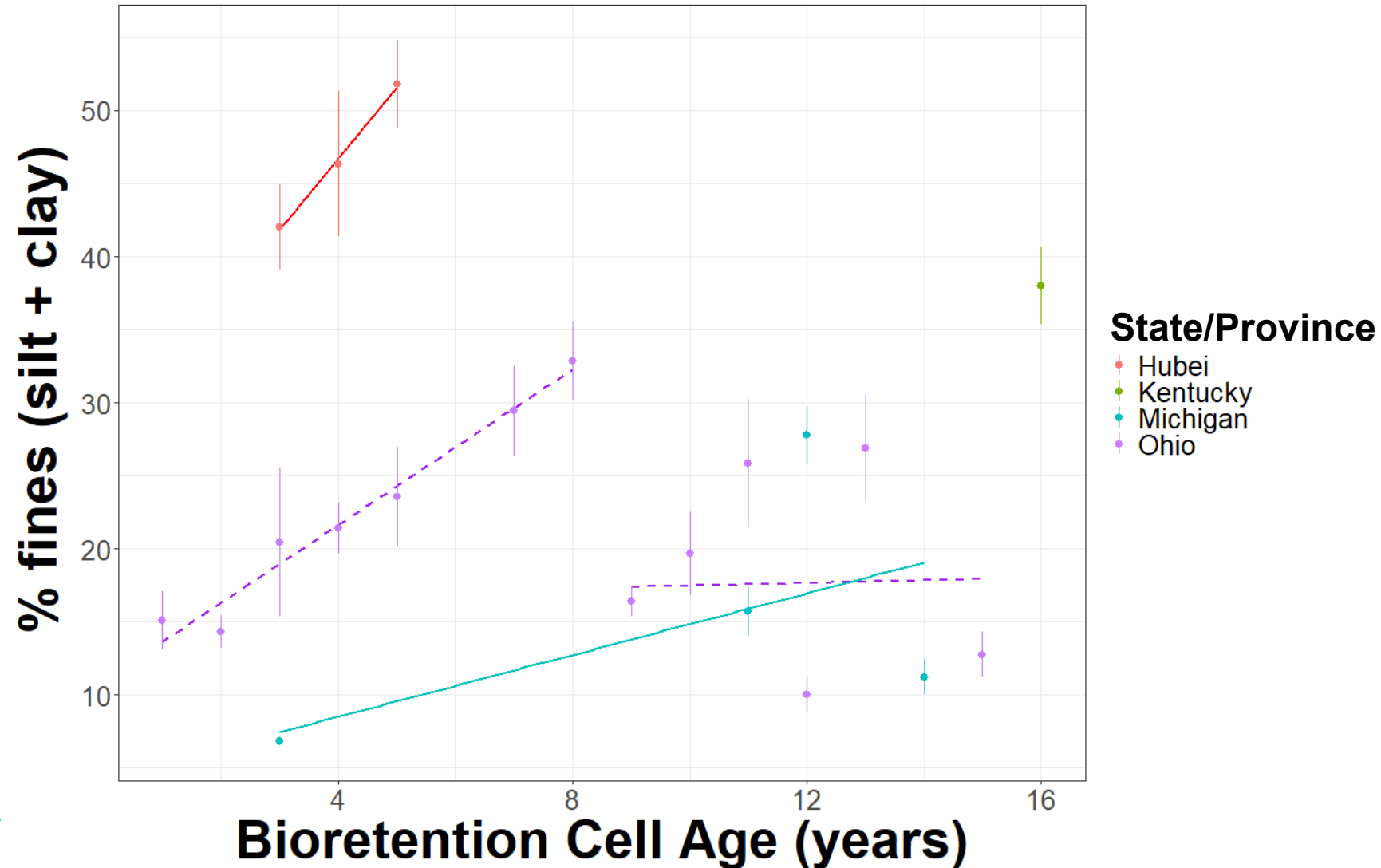
explained by depth & age

Hubei ↑ 4.9% annually

Kentucky 1 data point

Ohio ↑ 2.7% annually

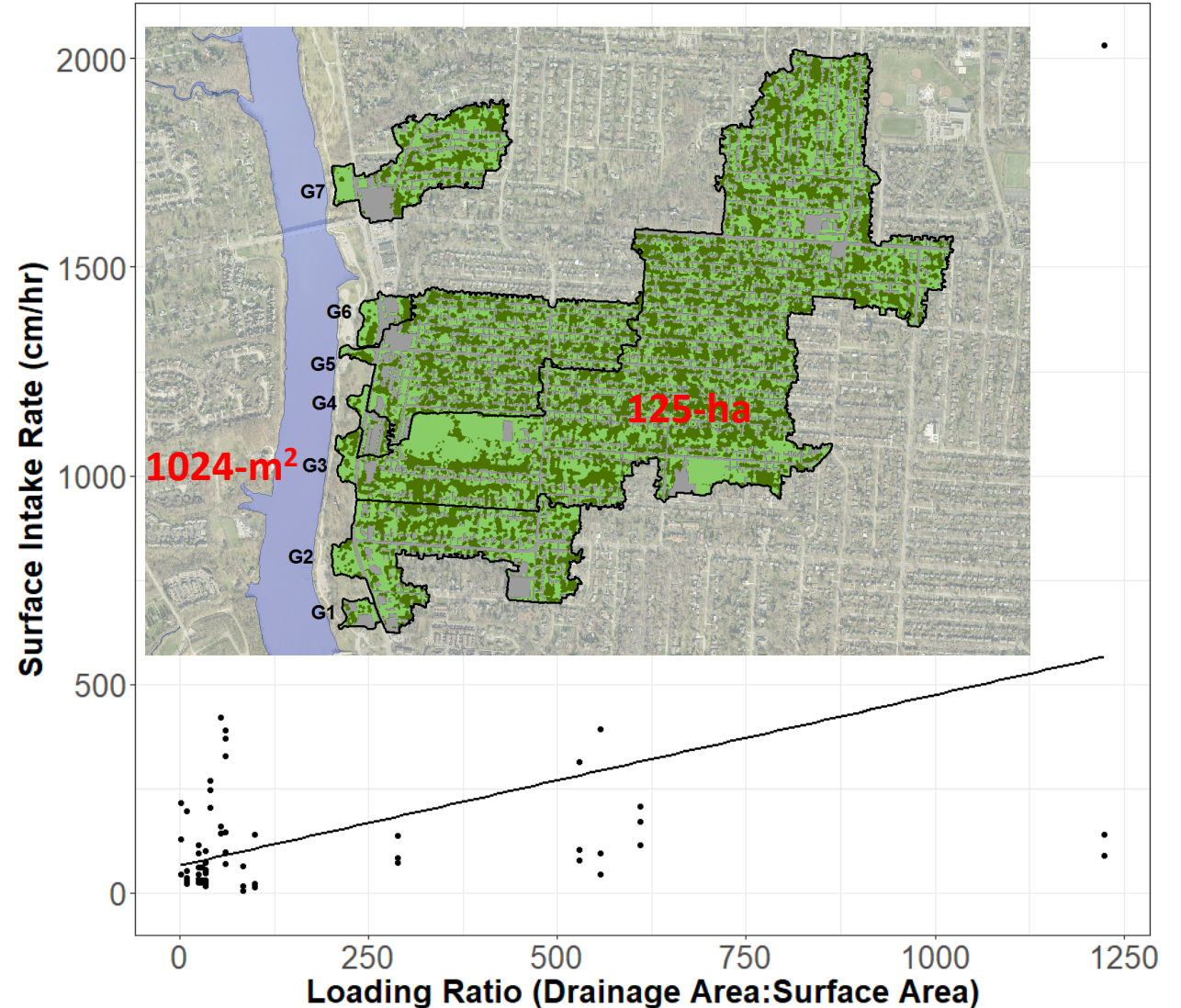
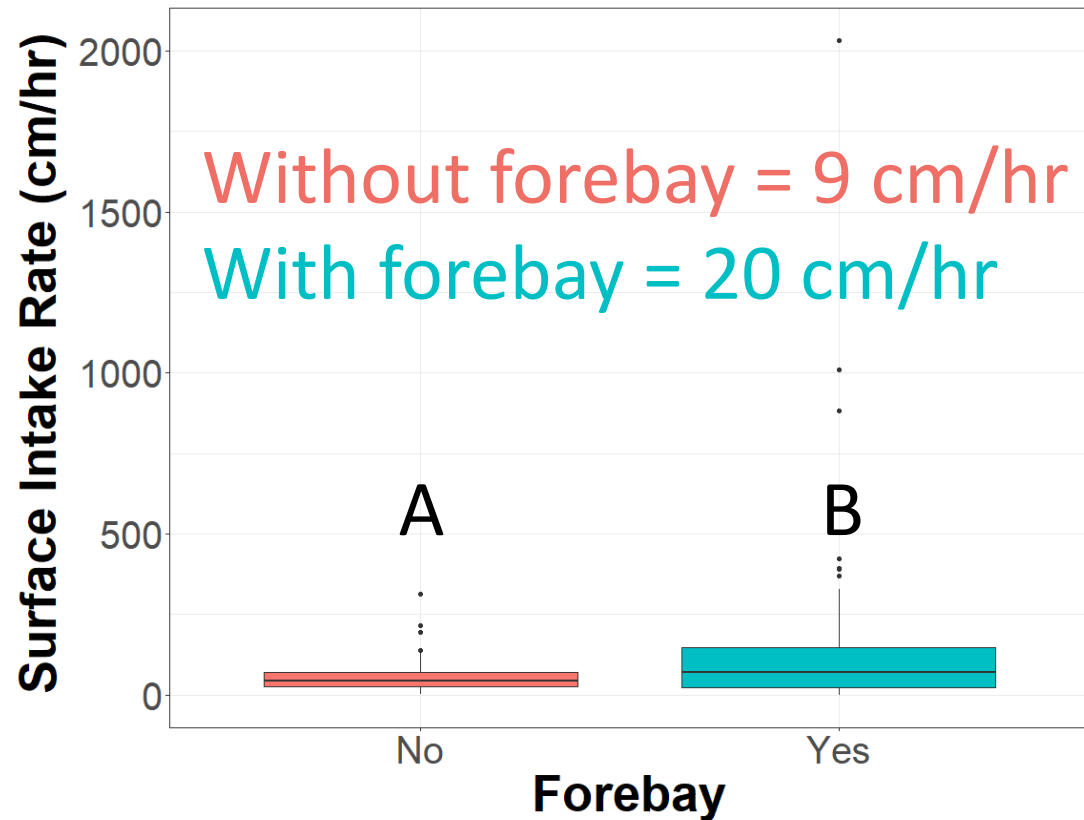
Michigan ↑ 1.1% annually



Surface Intake Rate

explained by age, presence/absence of forebay, and loading ratio

Every year ↓ 1.25 cm/hr

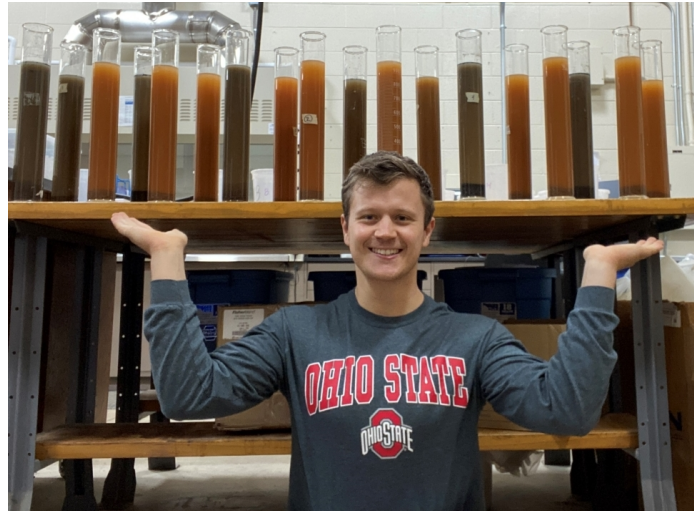


Conclusions & Wider Context

- Organic matter and fines accumulate in bioretention soil media over time
- However, the surface intake rate remains high
- Traditional laboratory and analysis methods should be reconsidered
- Applicable to other contexts around the world
- Human factors (design standard, forebay, land use, loading ratio, mulching) and natural factors (accumulation, animals, plants) influence bioretention pedogenesis

Future Work

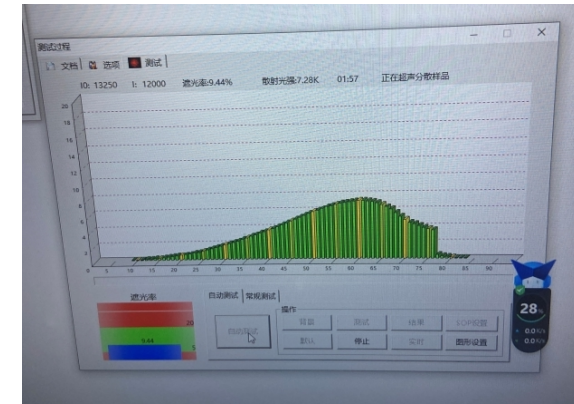
- Soil texture methods



Hydrometer



Sieve



Laser diffraction

Future Work

- Soil texture methods
- Compare “as-built” data to data sampled years/decades later

PARTICLE SIZE (ASTM F1632)

| Lab ID# | Sample Name | Gravel % | | | | Soil Separate* % | | | Sieve Size / Sand Fraction Sand Particle Diameter % Retained | | | | |
|---------|--------------------|-------------|-----------------|----------------|----------------|------------------|------|------|--|-----------------------------|-----------------------------|----------------------------|-------------------------------|
| | | 1" 25 mm | 1/2" 12.5 mm | 1/4" 6.3 mm | No. 10 2 mm | Sand | Silt | Clay | No. 18 V. Coarse 1.0 mm | No. 35 Coarse 0.50 mm | No. 60 Medium 0.25 mm | No. 140 Fine 0.10 mm | No. 270 V. Fine 0.05 mm |
| 40866-1 | Bioretention 4-1-2 | 0.0 | 1.0 | 2.7 | 14.7 | 79.6 | 13.5 | 7.0 | 24.4 | 24.1 | 18.7 | 9.6 | 2.9 |
| | | | | | | | | | | | | | |

INFILTRATION RATE (Ksat) / pH / ORGANIC MATTER / TEXTURAL CLASS

| Lab ID# | Sample Name | | | | Ksat In/hr | Density g/cc | EC dS/m | pH ¹ 1:1 | Organic Matter ² % | Textural Class |
|---------|--------------------|--|--|--|---------------|-----------------|------------|------------------------|-------------------------------------|---------------------|
| 40866-1 | Bioretention 4-1-2 | | | | 22.1 | 1.43 | | 7.2 | 3.29 | Gravelly Loamy Sand |
| | | | | | | | | | | |

^{*}ASTM F1632 Method B

¹ ASTM D4972, method A, CaCl₂, 25 g sample used

² ASTM F1647 Method A

Future Work

- Soil texture methods
- Compare “as-built” data to data sampled years/decades later
- Column studies

Column Cross Section

24" diameter

3" ponding free space

36" sandy loam filter

3" concrete sand

4" fine gravel aggregate (#8)

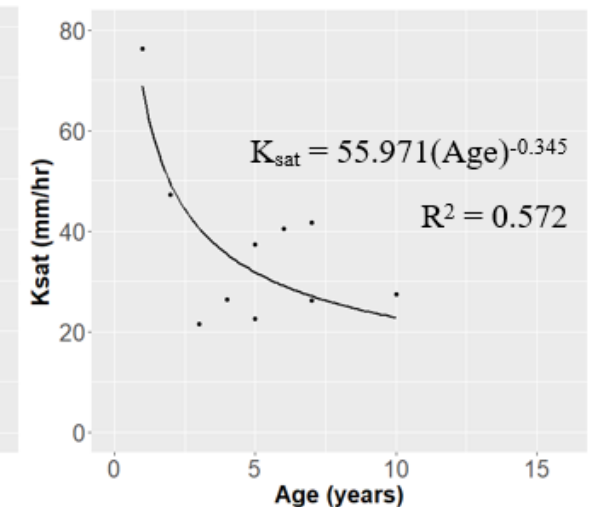
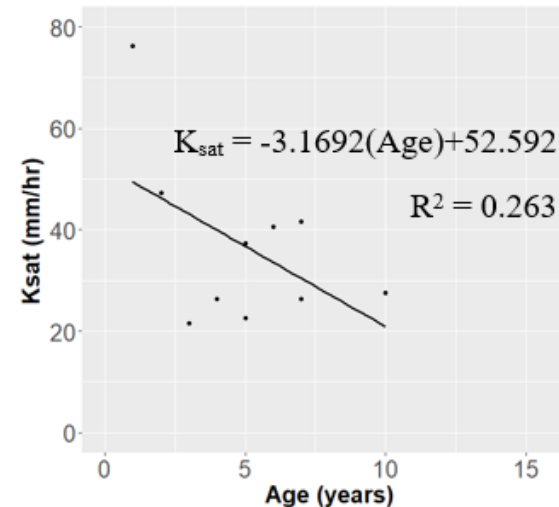
Simulated underdrain

46" height



Future Work

- Soil texture methods
- Compare “as-built” data to data sampled years/decades later
- Column studies
- Long-term monitoring, multiple visits
- Models, pedotransfer functions
- Database



Select References

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Thank you! Questions?

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