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Urban Soil Interpretations

N.A. Jelinski, K. LaBine

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Image: N. Jelinski, Karamu Garden – Minneapolis, MN

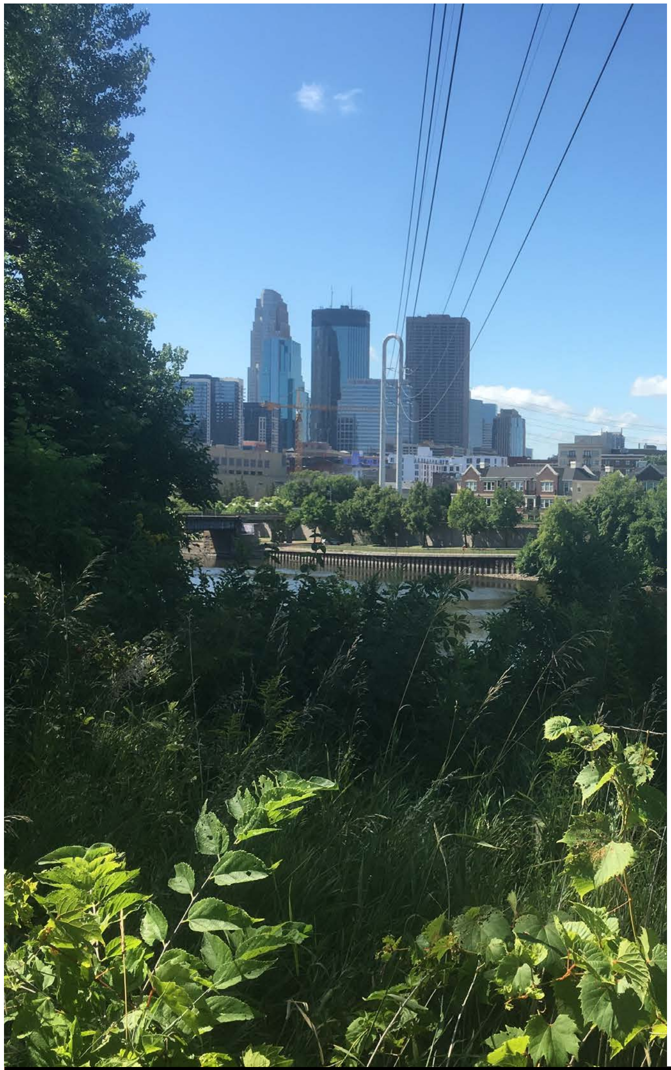
Interpretations

"**The purpose of soil survey interpretation is to provide people with the best possible information about every acre of soil in a form that is directly useful to them**."
– *Aandahl, (1958)*

"**Soil survey interpretations predict soil behavior for specified soil uses and under specified soil management practices**…Soil interpretations provide users of soil survey information with predictions of soil behavior to help in the development of reasonable and effective alternatives for the use and management of soil, water, air, plant, and animal resources. "
- *NSSH (P.617, Subpart A, 617.0.A)*

"**Soil interpretations use soil properties or qualities that directly influence a specified use** or management of the soil. Soil properties and qualities that characterize the soil are criteria for interpretation models."
- *NSSH (P.617, Subpart A, 617.0.B)*

Image: K. LaBine, Frogtown Park and Farm – St. Paul, MN



Interpretive Soil Properties

SITE

CLIMATE
- MAAT
- Frost-free Period
- MAP

LANDSCAPE
- Slope
- Aspect
- Elevation
- Geomorphic Component
- Hillslope Position

Image: K. LaBine, Nicollet Island – Minneapolis, MN

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- Hillslope Position

COMPONENT

WATER
- AWC
- HSGs
- Flood./Pond.

PHYSICAL
- Depth to Restrictive Layers (R, Cr, x, d, f)
- Erodibility Indices
- Corrosivity

Image: N. Jelinski, Frogtown Park and Farm – St. Paul, MN

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PHYSICAL
- Depth to Restrictive Layers (R, Cr, x, d, f, M?)
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- Corrosivity

Image: N. Jelinski, Frogtown Park and Farm – St. Paul, MN

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HORIZON

PHYSICAL
- Texture
- Coarse Fragments
- Bulk Density
- Ksat
- Engineering Metrics

CHEMICAL
- pH
- Carbonates
- OM
- EC

Image: N. Jelinski – St. Paul, MN

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Image: N. Jelinski – St. Paul, MN

How Are Interpretations Developed?

Tables — Septic Tank Absorption Fields — At-Grade (MN) — Summary By Map Unit

Summary by Map Unit — Hennepin County, Minnesota (MN053)

Summary by Map Unit — Hennepin County, Minnesota (MN053)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
D1B	Anoka and Zimmerman soils, terrace, 2 to 6 percent slopes	Not limited	Anoka, terrace (55%)		78.8	4.6%
			Zimmerman, terrace (40%)			
			Kost (5%)			
D6A	Verndale sandy loam, 0 to 2 percent slopes	Not limited	Verndale (80%)		5.0	0.3%
			Nymore (10%)			
D10A	Forada sandy loam, 0 to 2 percent slopes	Extremely limited	Forada (75%)	Soil saturation (1.00)	145.1	8.5%
			Leafriver, frequently ponded (7%)	Ponding (1.00)		
				Soil saturation (1.00)		
				Organic soil (1.00)		
			Marysland (3%)	Soil saturation (1.00)		
D17A	Duelm loamy sand, 0 to 2 percent slopes	Moderately limited	Duelm (80%)	Soil saturation (0.73)	5.3	0.3%

Table: Web Soil Survey, Hennepin County, MN; Inset Table – Soil Survey Staff (2017)

How Are Interpretations Developed?

Historically:

- ➢ Rule set assigns components into category based on most limiting property

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D10A	Forada sandy loam, 0 to 2 percent slopes	Extremely limited				
D17A	Duelm loamy sand, 0 to 2 percent slopes	Moderately limited				

For example…

Table 8-1

Interpretive Soil Properties and Limitation Classes for Septic Tank Absorption Fields

Interpretive soil property	Limitation class			Limiting feature
	Not limited	Somewhat limited	Very limited	
Total subsidence (cm)	---	---	> 60	Subsidence
Flooding	None	Rare	Very frequent, frequent, occasional	Flooding
Bedrock depth (m)	> 1.8	1–1.8	< 1	Too shallow
Cemented pan depth (m)	> 1.8	1–1.8	< 1	Too shallow
Free water occurrence (m)	> 1.8	1–1.8	< 1	Depth to saturation
Saturated hydraulic conductivity (μm/s)—				
Minimum 0.6 to 1.5 m [a/]	10–40	4–10	< 4	Slow water movement
Maximum 0.6 to 1 m [a/]			> 40	Poor filter
Slope (pct)	< 8	8–15	> 15	Too steep
Fragments > 75 mm [b/]	< 25	25–50	> 50	Large stones
Downslope movement			[c/]	Landslides
Permafrost			[d/]	Permafrost

[a/] 0.6 to 1.5 m pertains to the water transmission rate; 0.6 to 1 m pertains to filtration capacity.
[b/] Weighted average to 1 m.
[c/] Rate "severe" if occurs.
[d/] Rate "severe" if occurs above a variable critical depth (see discussion of the

Soil Survey Manual.
Soil Survey Division Staff (2017). Chapter 8 – Revised by Dobos et al.

Table: Web Soil Survey, Hennepin County, MN; Inset Table – Soil Survey Staff (2017)

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D6A	Verndale sandy loam, 0 to 2 percent slopes	Not limited	Verndale (80%)		5.0	0.3%
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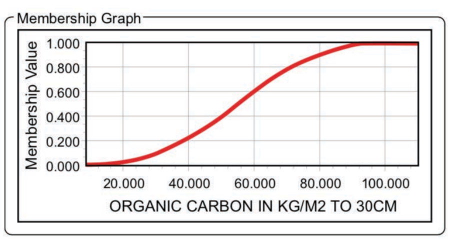
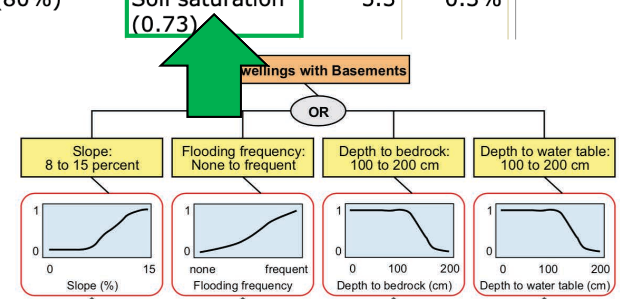
For example…





How Are Interpretations Developed?

Historically:

- ➢ Rule set assigns components into category based on most limiting property

Currently:

- ➢ Fuzzy System Concept and Models

Soil Survey Manual.
Soil Survey Division Staff (2017). Chapter 8 – Revised by Dobos et al.

CHAPTER 8

Interpretations:
The Impact of Soil Properties on Land Use

Soil Survey Division Staff (2017).
Chapter 8 – Revised by Dobos et al.

By Soil Science Division Staff. Revised by Robert Dobos, Cathy Seybold, Joseph Chiaretti, Susan Southard, and Maxine Levin, USDA-NRCS.

Soil Survey of
Bronx River Watershed,
Bronx, New York

Soil Survey of
Cook County,
Illinois

SOIL SURVEY OF
District of Columbia

Supplement to the
Soil Survey of
Los Angeles County,
California,
Southeastern Part

Much previous and ongoing work on interpretations for urban soils…

- Some interps have been used in urban/suburban areas for a long time - Golf, picnic sites, playgrounds, etc. (Soil Survey Division Staff, 2017)

Image: K. LaBine, Hope Community Garden, Minneapolis, MN

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- Need to modernize interps in urban areas with updated user demands (Levine, 2013).

Green Economy and Infrastructure Contributions of USDA Urban and Nonfarm Soil Projects in the U.S.

Maxine J. Levin *Levine (2013). Soil Horizons*

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2 Urban Soil Mapping through the United States National Cooperative Soil Survey

Luis Hernandez, Maxine Levin, Joe Calus, John Galbraith, Edwin Muñiz, Kristine Ryan, Randy Riddle, Richard K. Shaw, Robert Dobos, Steve Peaslee, Susan Southard, Debbie Surabian, and David Lindbo

Hernandez et al. (2017). Chapter 2 in: Lal (Ed.), Urban Soils

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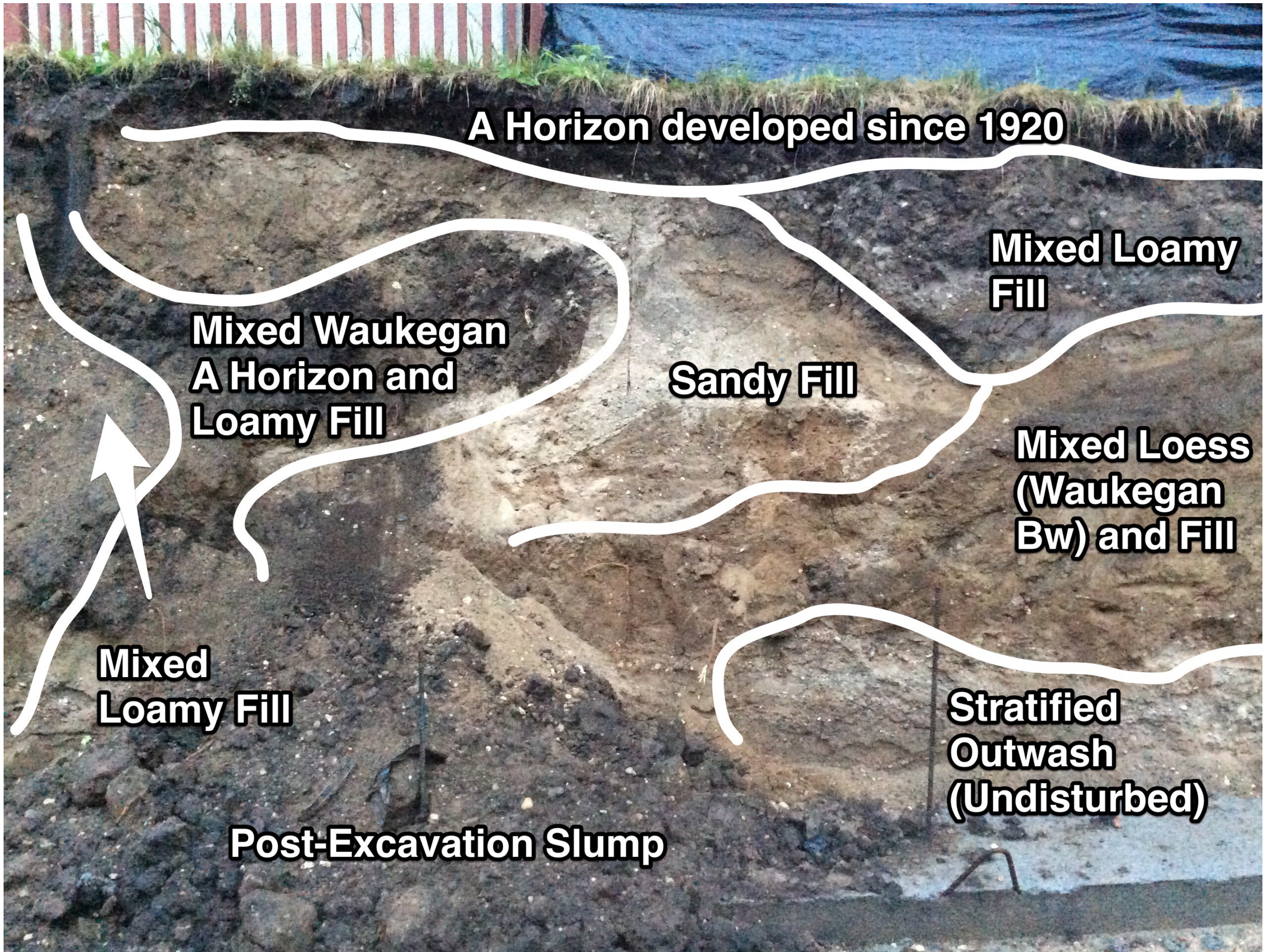
- Need to modernize interps in urban areas with updated user demands (Levine, 2013).
- Criteria developed for Storm Water Management soil rating (Hernandez et al., 2017)

Image: K. LaBine, Hope Community Garden, Minneapolis, MN

Challenges to Developing Interps in Urban Settings…

- Potentially rapid land use change/turnover

Image: K. LaBine, Hope Community Garden, Minneapolis, MN



Challenges to Developing Interps in Urban Settings…

- Potentially rapid land use change/turnover
- Heterogeneity within mapping units

Image: N. Jelinski, Chelsea Heights – St. Paul, MN

Challenges to Developing Interps in Urban Settings…

- Potentially rapid land use change/turnover
- Heterogeneity within mapping units
- Stakeholder demand typically at much smaller scales than mapping scale (Hernandez et al., 2017)

Image: N. Jelinski, Karamu Garden – Minneapolis, MN

Challenges to Developing Interps in Urban Settings…

- Potentially rapid land use change/turnover
- Heterogeneity within mapping units
- Stakeholder demand typically at much smaller scales than mapping scale (Hernandez et al., 2017)
- Interps more closely related to land use than soil types (Gossett et al., 1990, Singleton, 1998)

Image: Web Soil Survey, Hennepin County, MN

Two Major Interpretive Interests for Urban Soils in Minneapolis-St. Paul

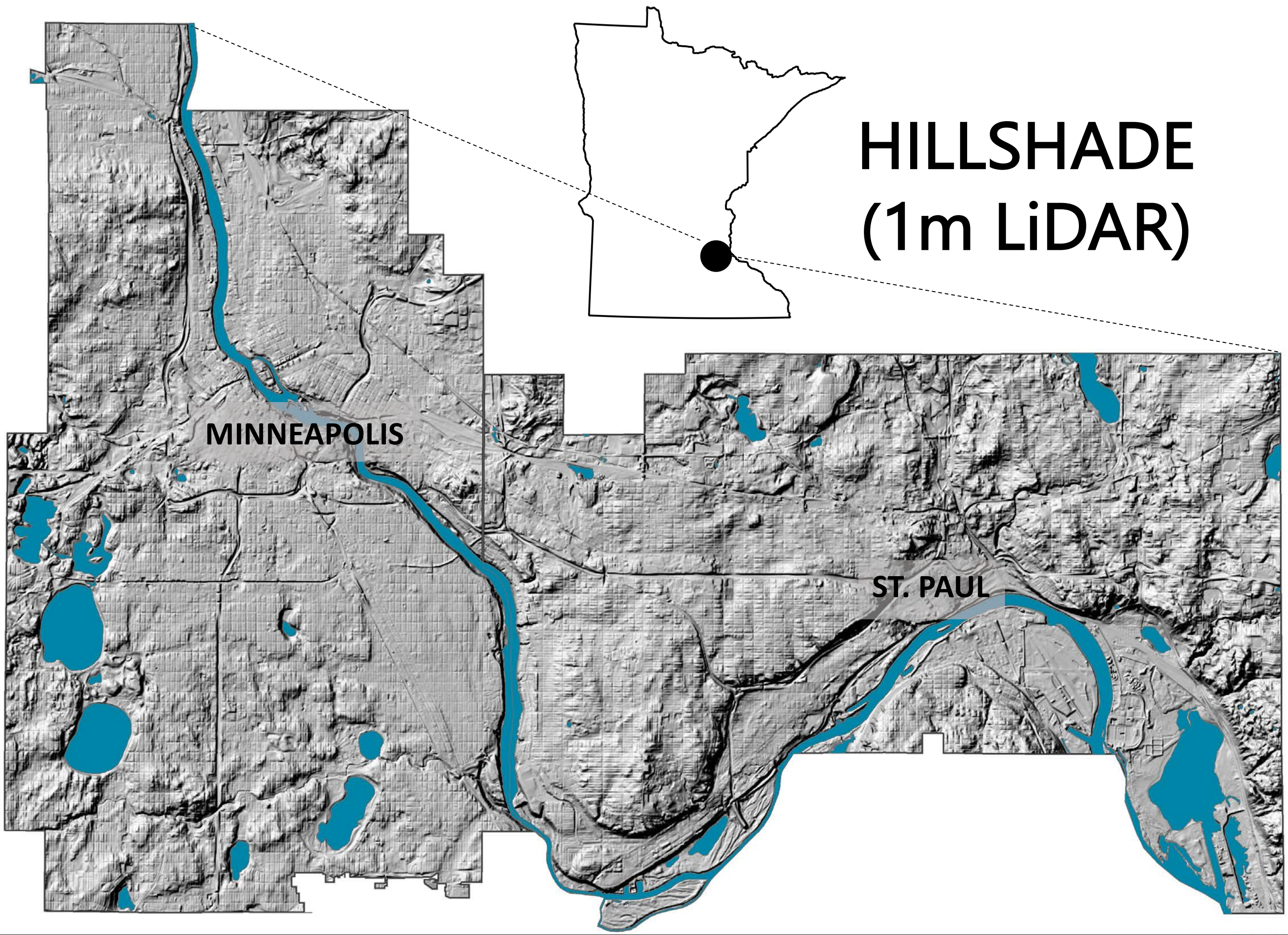
Urban Agriculture

- Large Urban Farms
- Community Gardens
- Households

Stormwater Management

- Watershed Districts
- Neighborhoods
- Municipalities

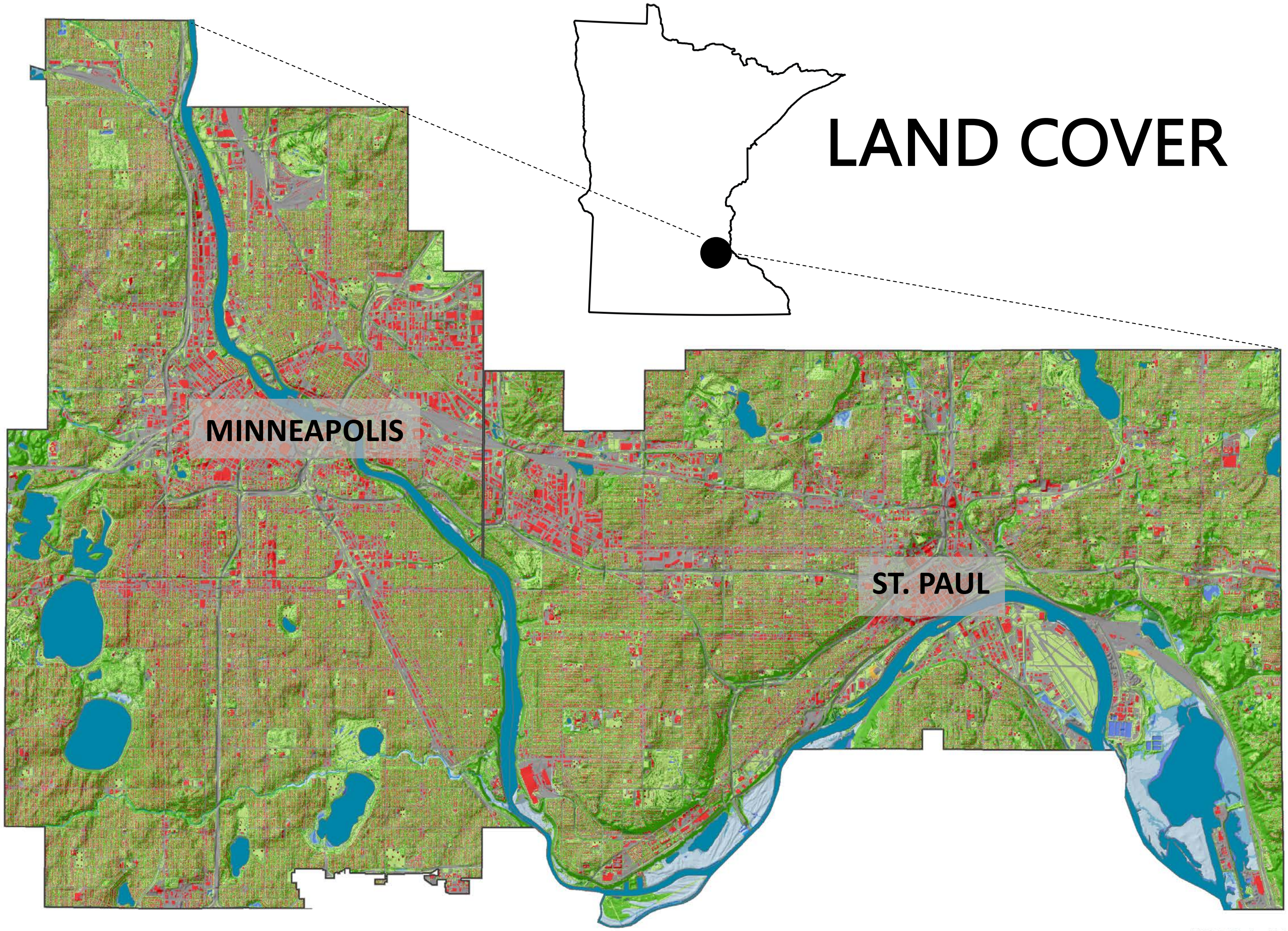
Images: (L) Cannon River Watershed Partnership; (R) K. LaBine, Stone's Throw Urban Farm, Minneapolis, MN



Background: MSP Geography, Land Cover, Parent Material, and Soil Map

- Topographic variability and fluvial morphology drove development of two large cities < 10 mi apart.

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011)

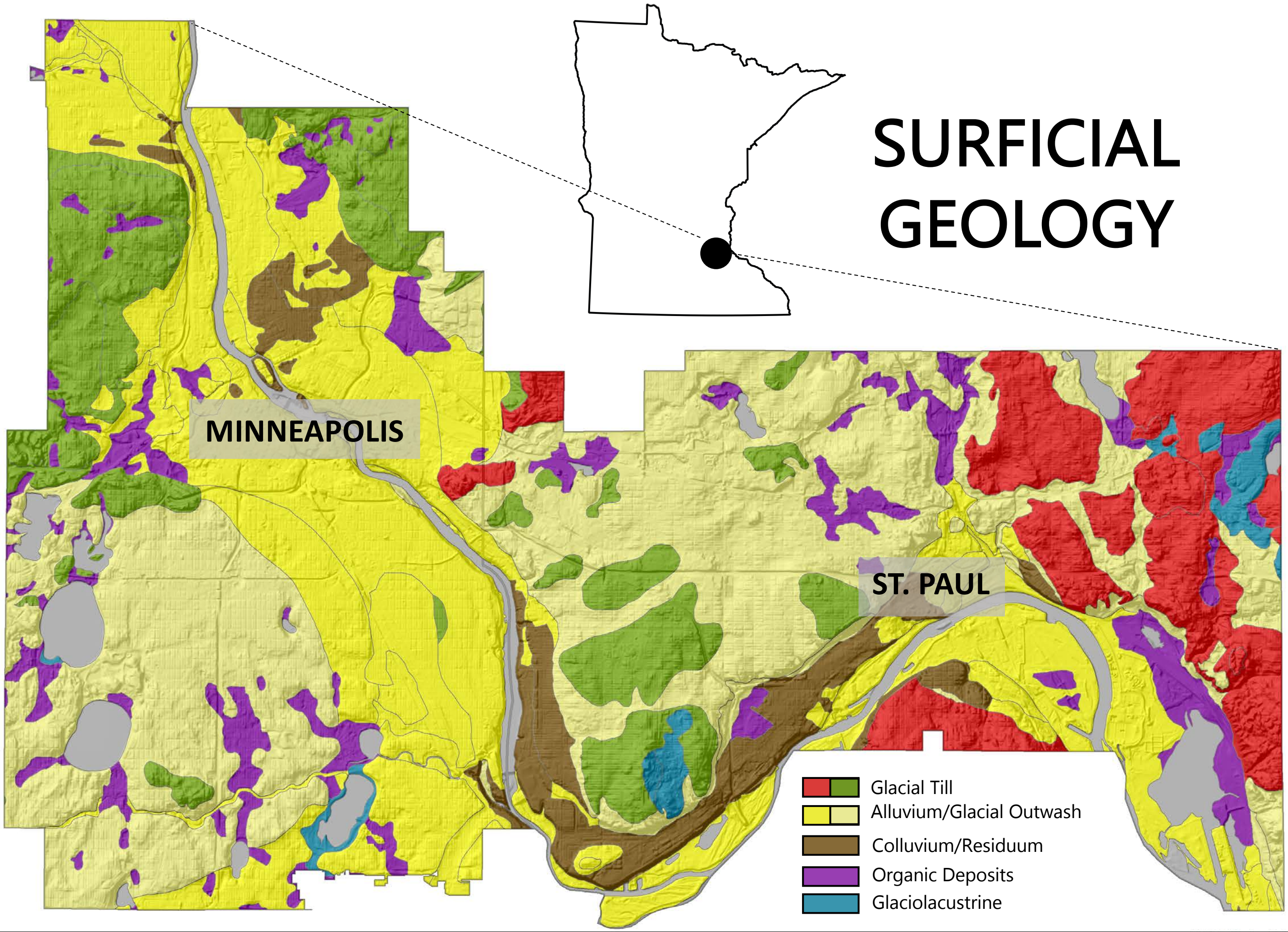


LAND COVER

Background: MSP Geography, Land Cover, Parent Material, and Soil Map

- Minneapolis has the largest extent of concentrated, highly urbanized lands, but St. Paul has large industrial zones outside of the city center.

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011) and Knight (2016)



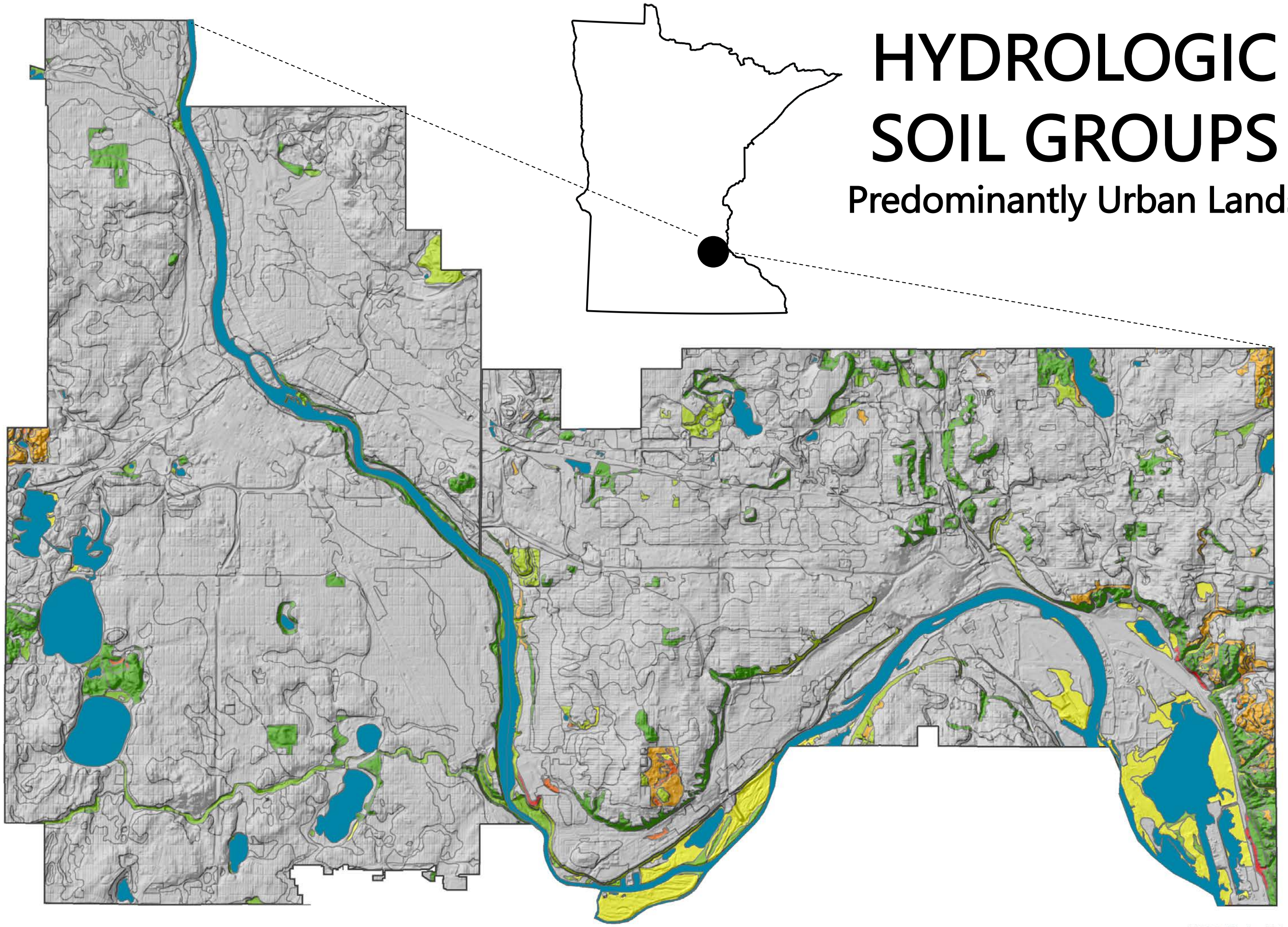
Background: MSP Geography, Land Cover, Parent Material, and Soil Map

- Parent materials are dominated by alluvium, outwash, and glacial till of two different provenances.
- Scattered colluvium, organics, and glaciolacustrine

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011) and Meyer (2007)

HYDROLOGIC SOIL GROUPS

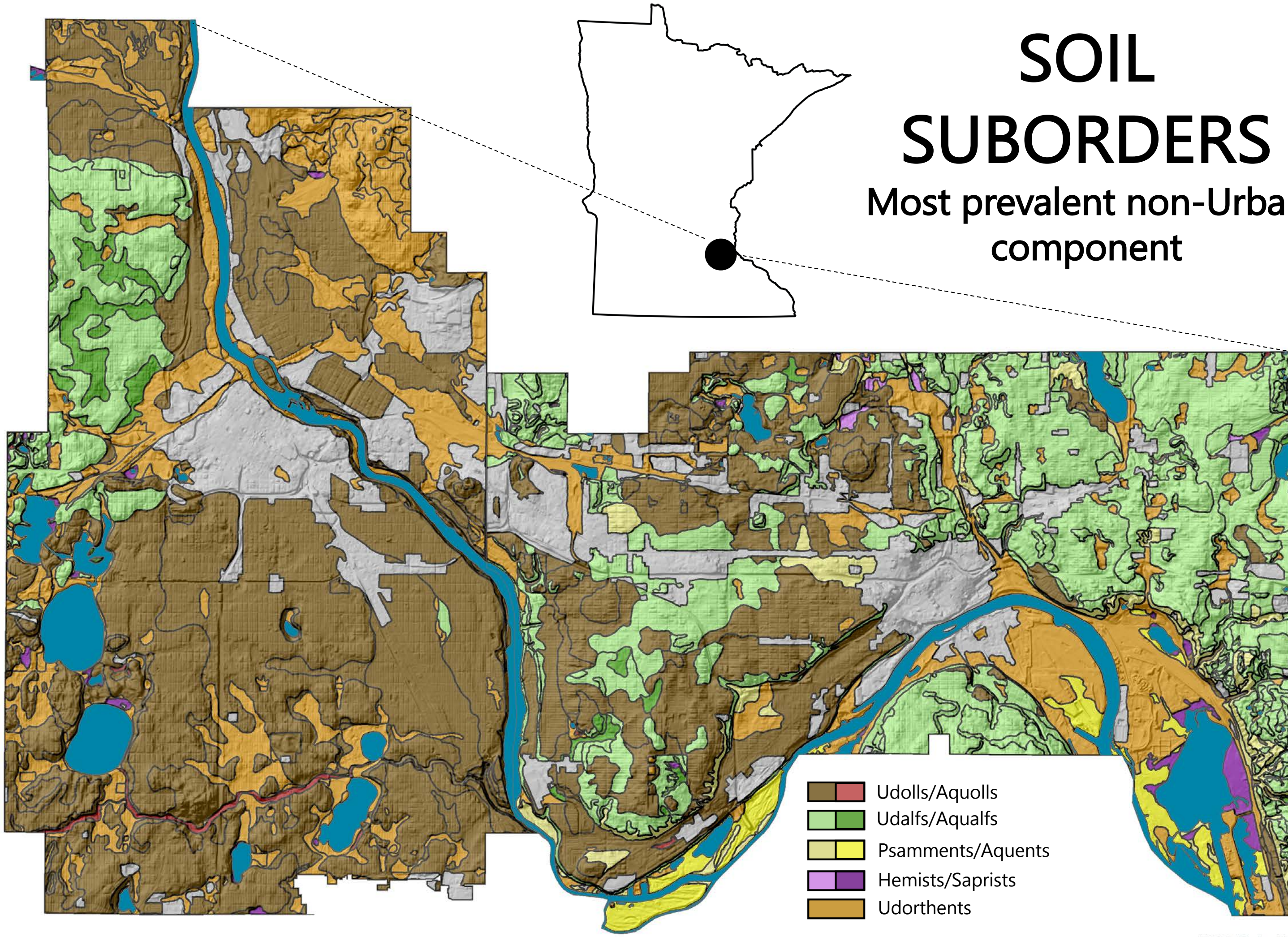
Predominantly Urban Lands



Background: MSP Geography, Land Cover, Parent Material, and Soil Map

- No updated soil map for urban areas
- Database poorly populated

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011) and Web Soil Survey (2019)



SOIL SUBORDERS

Most prevalent non-Urban component

Background: MSP Geography, Land Cover, Parent Material, and Soil Map

- Minor "natural" components fairly well represented, based on geomorphic studies conducted in the 60s-70s.

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011) and Web Soil Survey (2019)

Well-Populated Interpretive Soil Properties in MSP

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COMPONENT

WATER
- AWC
- HSGs
- Flood./Pond.
- Drainage Class

PHYSICAL
- Depth to Restrictive Layers (R, Cr, x, d, f) M?
- Erodibility Indices
- Corrosivity

HORIZON

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- Texture
- Coarse Fragments
- Bulk Density
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- pH
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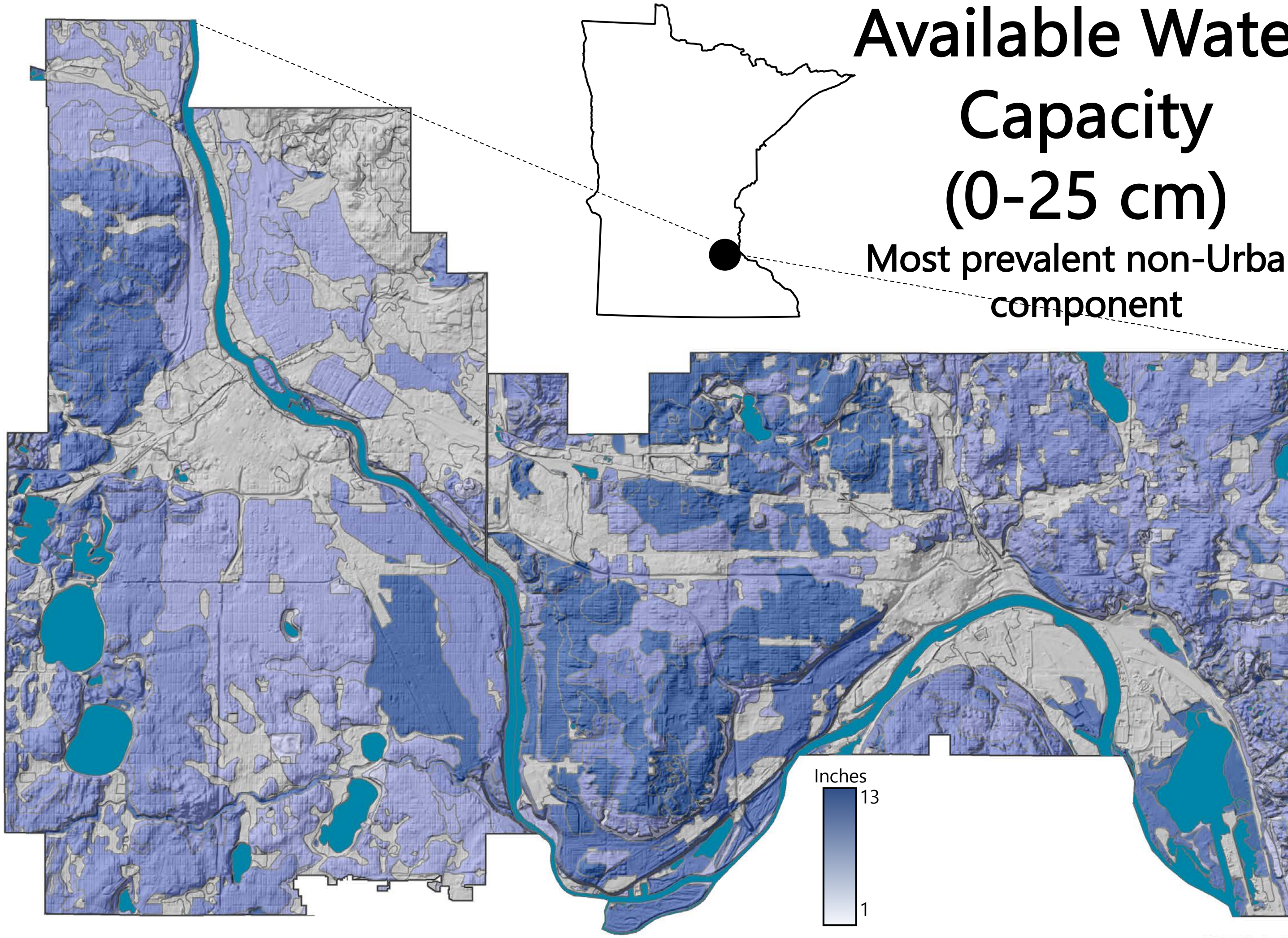
Image: N. Jelinski, Frogtown Park and Farm – St. Paul, MN

Available Water Capacity (0-25 cm)

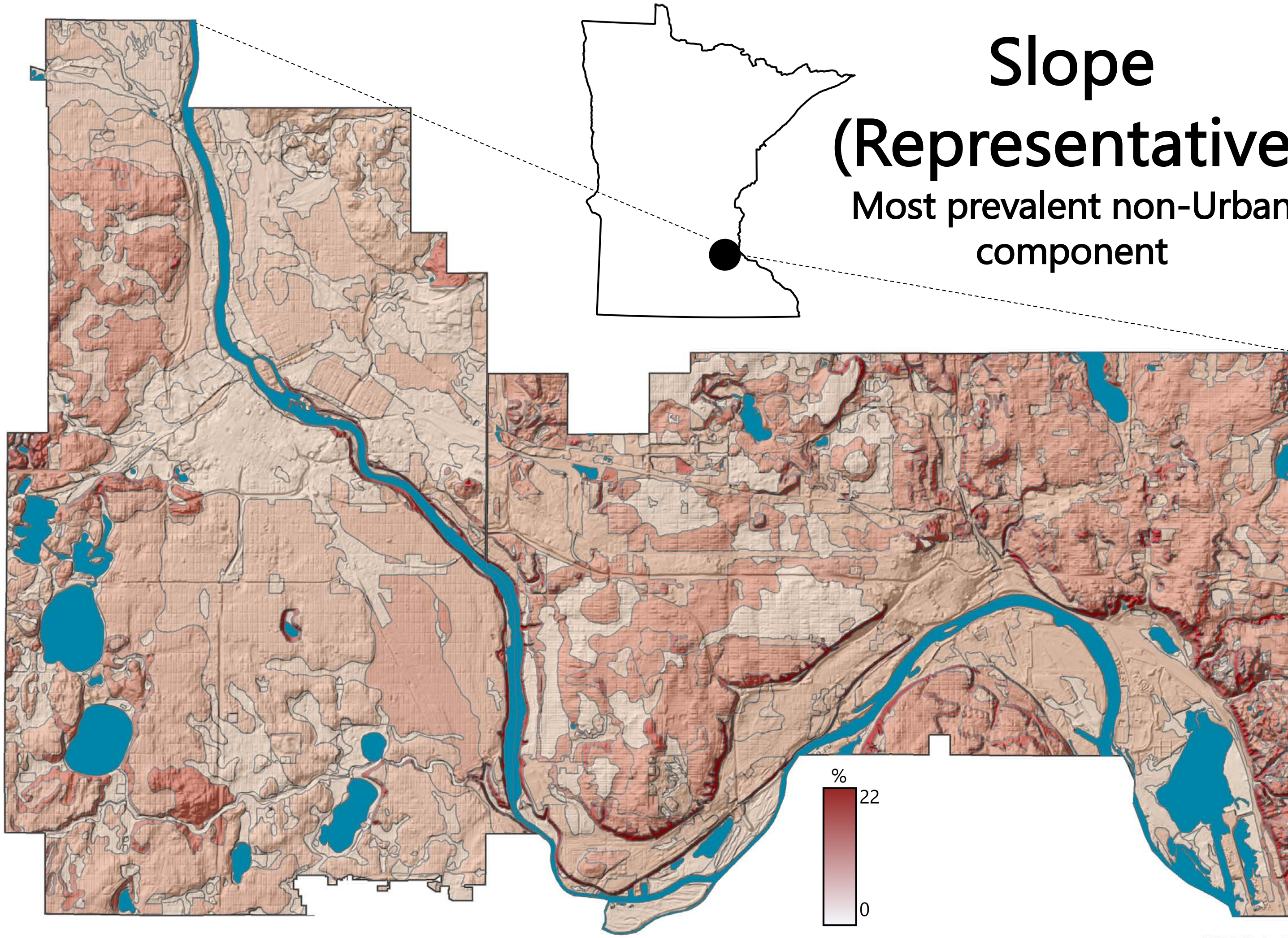
Most prevalent non-Urban component



Well Populated Interpretive Soil Properties in MSP

- Available Water Capacity (AWC): 0-25 cm

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011) and Web Soil Survey (2019)



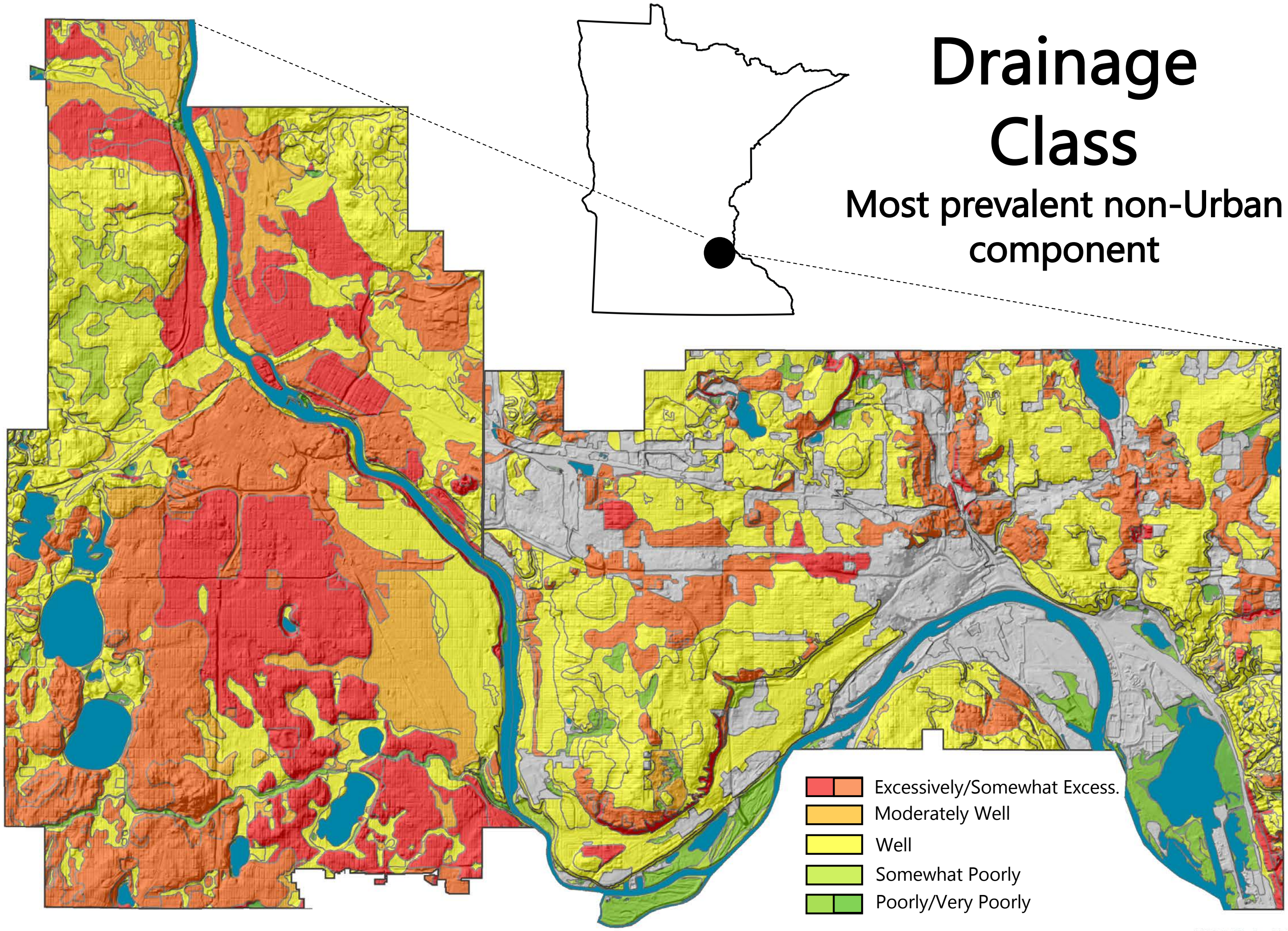
Slope (Representative)

Most prevalent non-Urban component

Well Populated Interpretive Soil Properties in MSP

- Available Water Capacity (AWC): 0-25 cm
- Representative Slope

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011) and Web Soil Survey (2019)



Drainage Class

Most prevalent non-Urban component

Well Populated Interpretive Soil Properties in MSP

- Available Water Capacity (AWC): 0-25 cm
- Representative Slope
- Drainage Class

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011) and Web Soil Survey (2019)

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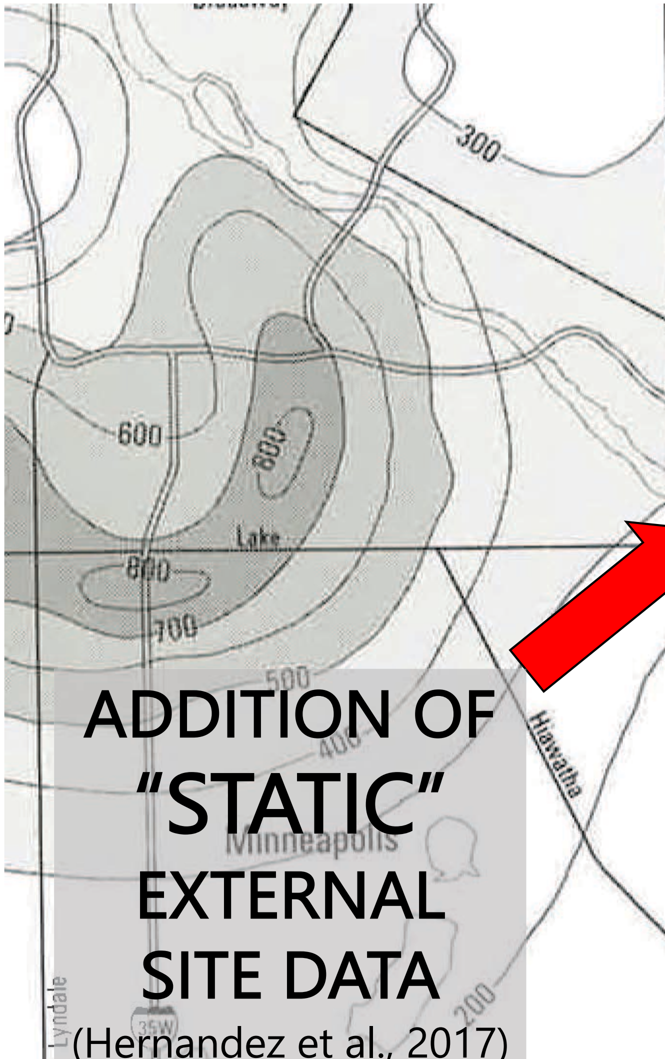

ADDITION OF "STATIC" EXTERNAL SITE DATA

(Hernandez et al., 2017)

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Figure: Mielke and Adams (1989)

URBAN AGRICULTURE

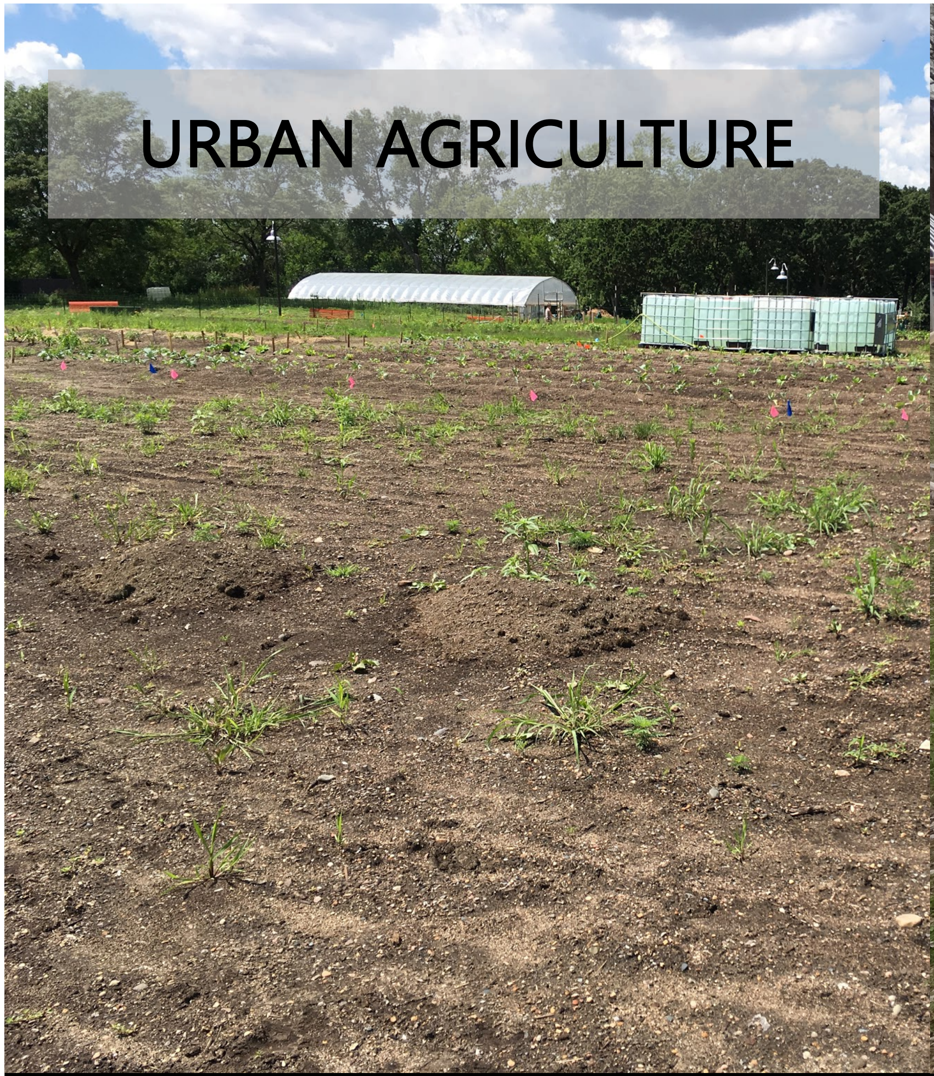


Image: (L) K. LaBine, Frogtown Park and Farm - St. Paul, MN, (R) K. LaBine, Stone’s Throw Urban Farm – Minneapolis, MN

URBAN AGRICULTURE

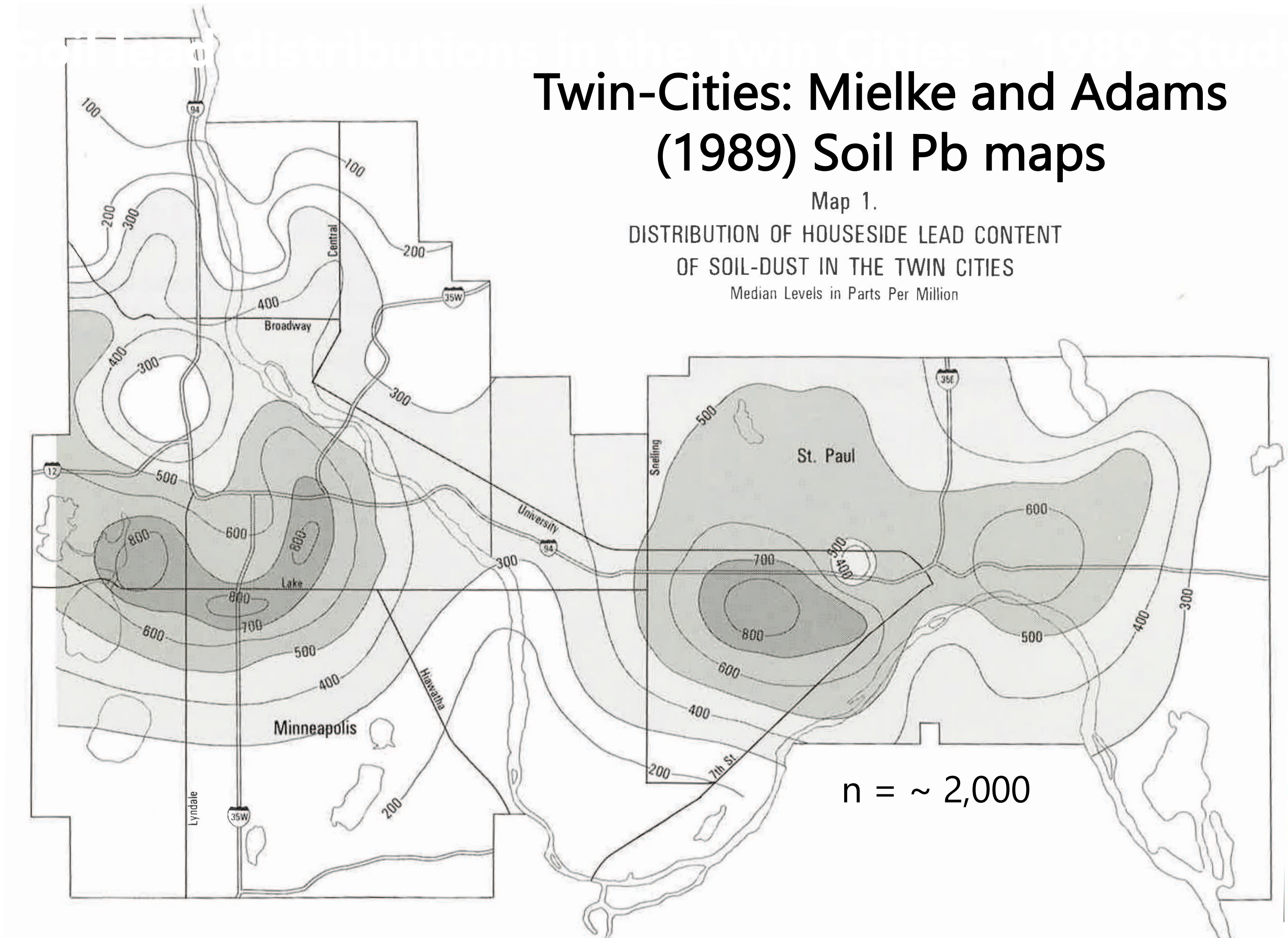
- Few parameters to play with because database poorly populated in MSP.
- AWC less populated than slope and drainage class

"In-Ground" Urban Agriculture

	Limitation		
Criteria	**Not Limited**	**Somewhat Limited**	**Very Limited**
Slope (%)	< 3%	3-8%	> 8%
Drainage Class	Somewhat Excessive, Well, Somewhat Well, Moderately Well	-	Poorly, Very Poorly, Excessively

Image: (L) K. LaBine, Frogtown Park and Farm - St. Paul, MN, (R) K. LaBine, Stone's Throw Urban Farm – Minneapolis, MN

Twin-Cities: Mielke and Adams (1989) Soil Pb maps



Addition of "Static" External Site Data

- Minneapolis-St. Paul Houseside Soil Pb Content (Mielke and Adams, 1989)

- Traffic Density
- Housing Age
- Building Density
- Siding Type
- Historical Industry

Figure: Mielke and Adams, 1989

Twin-Cities: Mielke and Adams (1989) Soil Pb maps

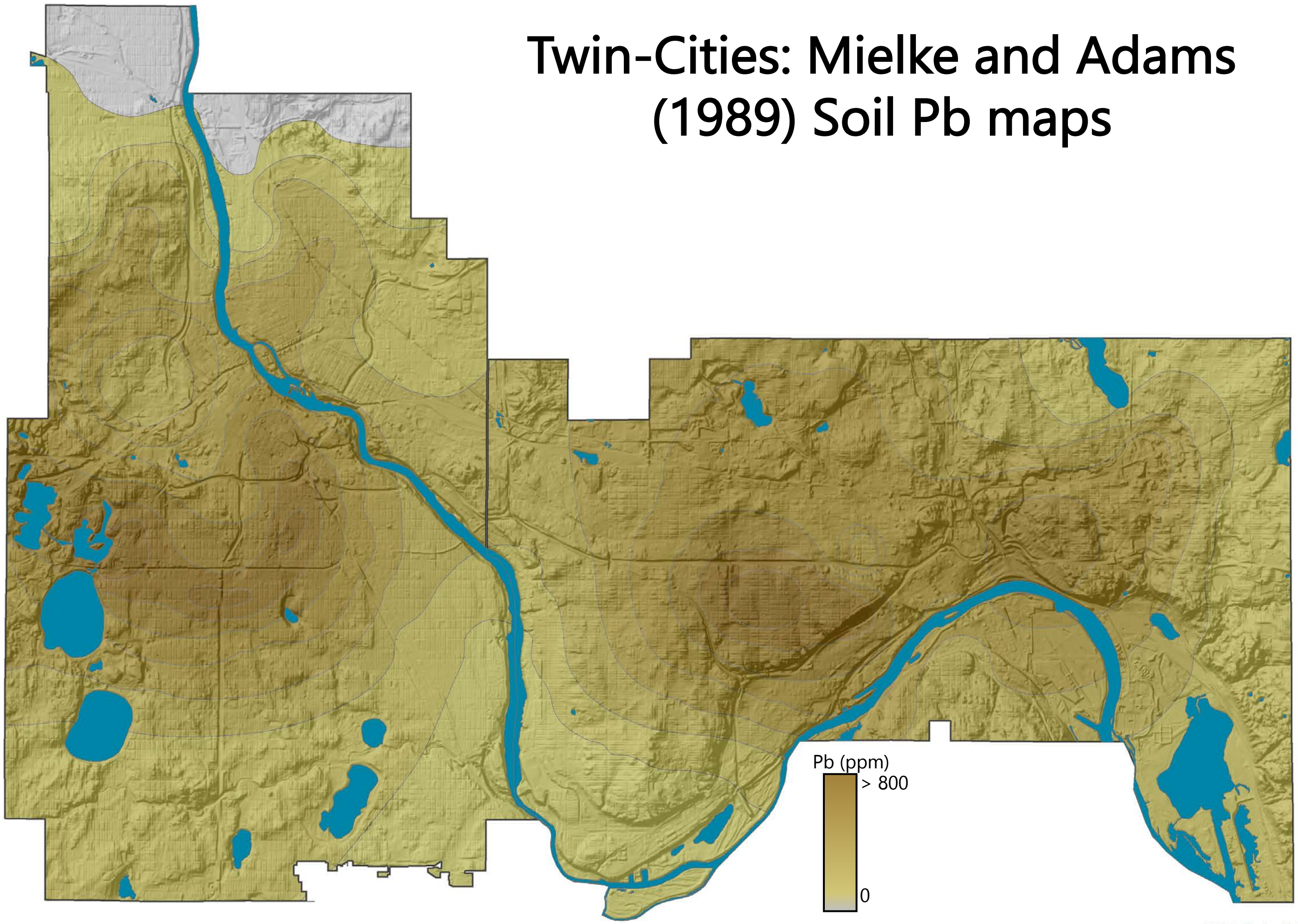


Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011) and Mielke and Adams (1989)

Addition of "Static" External Site Data

- Digitize and rasterize Mielke and Adams (1989) Pb map.

Twin-Cities: Mielke and Adams (1989) Soil Pb maps

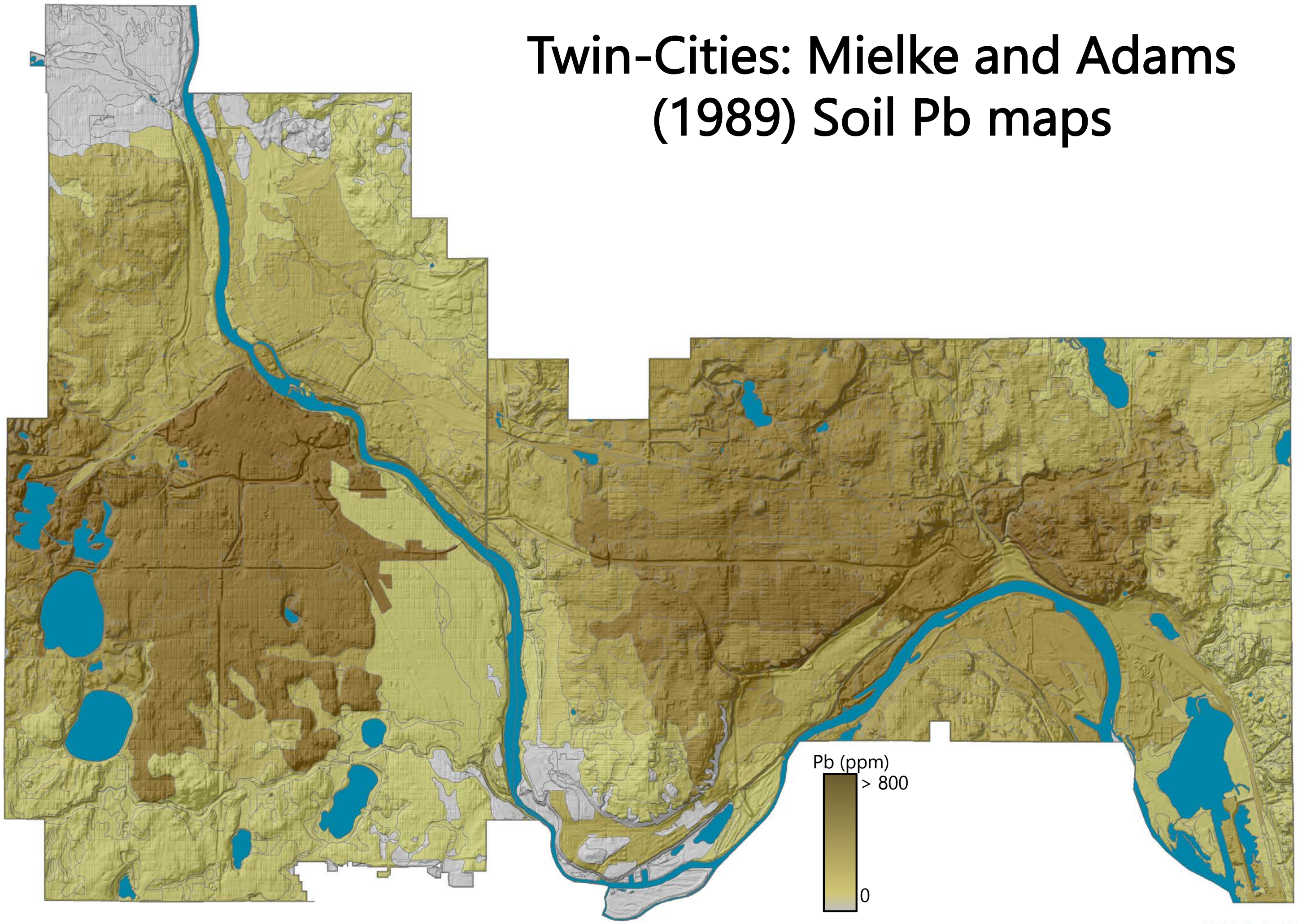


Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011) and Mielke and Adams (1989)

Addition of "Static" External Site Data

- Digitize and rasterize Mielke and Adams (1989) Pb map
- Generate average Pb values for each map unit

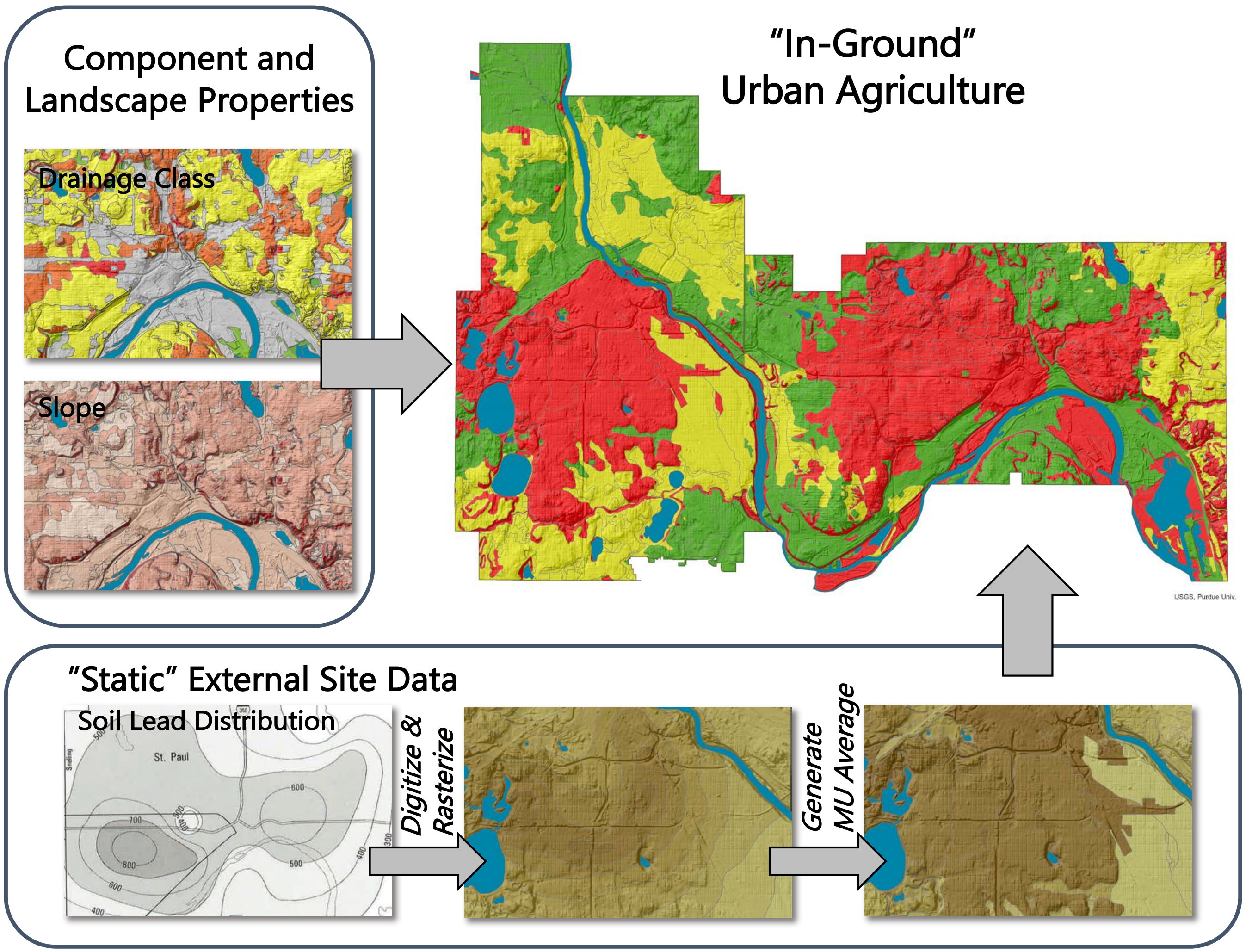
URBAN AGRICULTURE

- Few parameters to play with because database poorly populated in MSP.
- AWC less populated than slope and drainage class
- Add Pb as static site property

"In-Ground" Urban Agriculture

	Limitation		
Criteria	Not Limited	Somewhat Limited	Very Limited
Slope (%)	< 3%	3-8%	> 8%
Drainage Class	Somewhat Excessive, Well, Somewhat Well, Moderately Well	-	Poorly, Very Poorly, Excessively
Lead (ppm)	< 100	100-300	> 300

Image: K. LaBine, Frogtown Park and Farm, St. Paul, MN

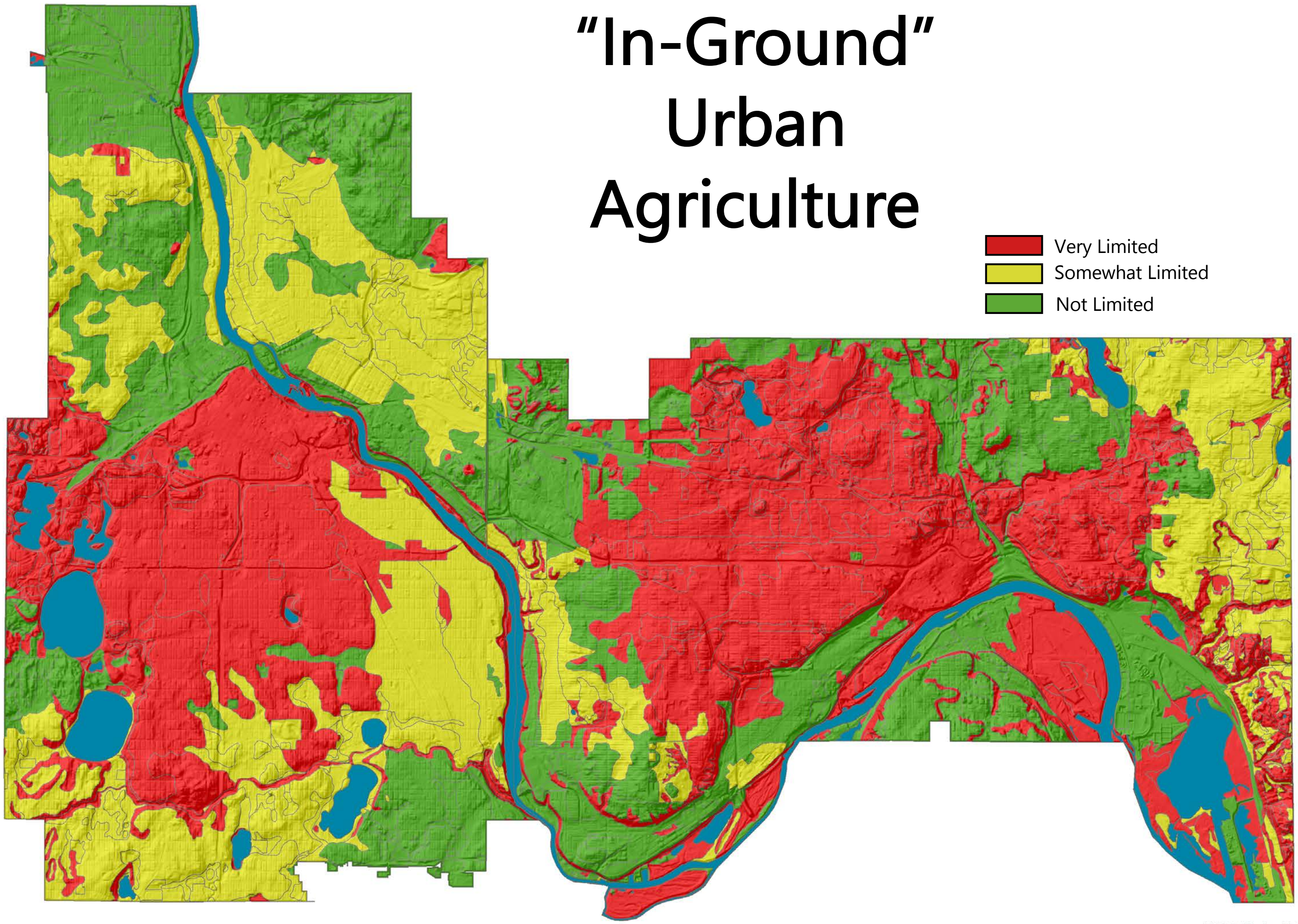


Addition of “Static” External Site Data

- Digitize and rasterize Mielke and Adams (1989) Pb map
- Generate average Pb values for each map unit
- Incorporate into interp rules

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011), Mielke and Adams (1989), Web Soil Survey (2019)

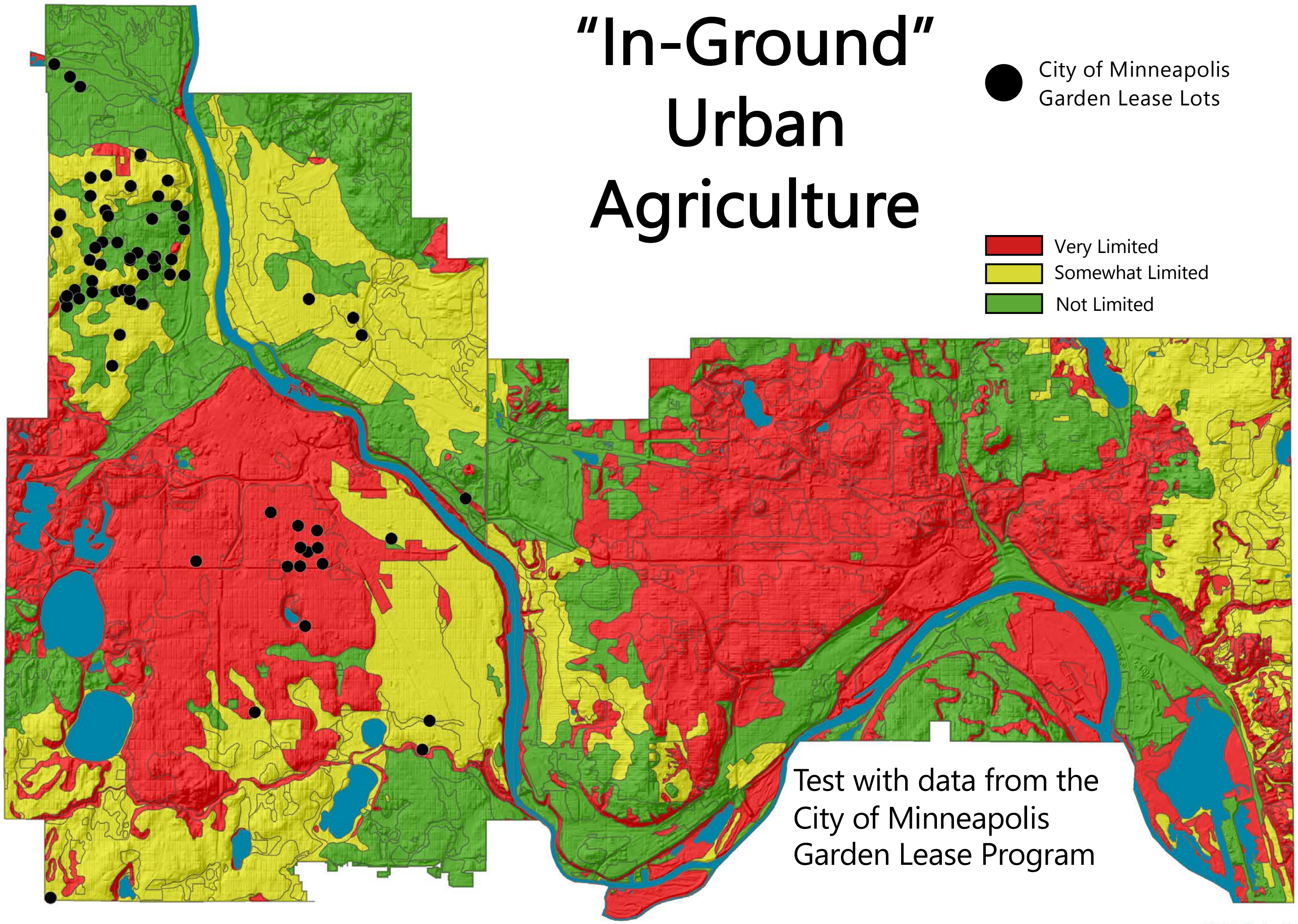
"In-Ground" Urban Agriculture



Simple "In-Ground" Urban Agriculture Interp

- How'd we do??

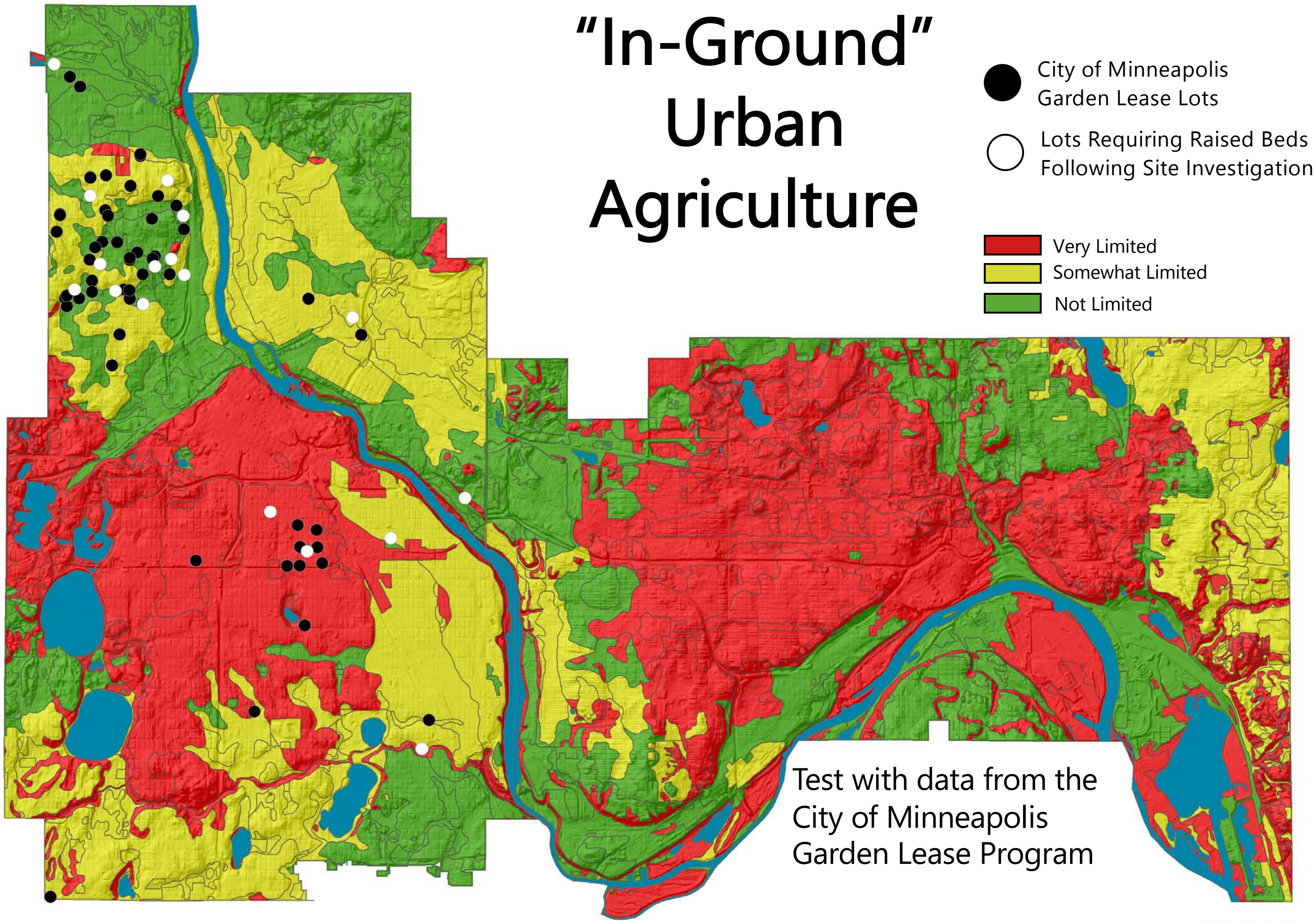
Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011), Mielke and Adams (1989), Web Soil Survey (2019)



Simple "In-Ground" Urban Agriculture Interp

- How'd we do??

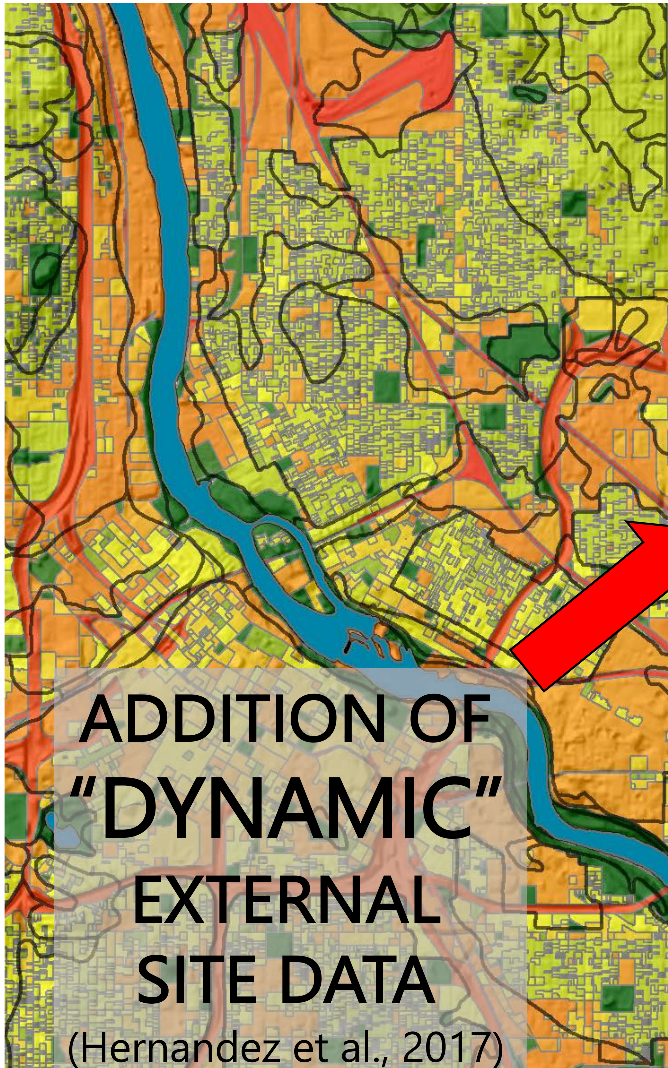
Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011), Mielke and Adams (1989), Web Soil Survey (2019)



Simple "In-Ground" Urban Agriculture Interp

- How'd we do??
- <u>**Not good!!!**</u>
- Only 42% of properties requiring raised beds were severely or moderately limited
- 58% of lots requiring raised beds were only slightly limited.

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011), Mielke and Adams (1989), Web Soil Survey (2019)



Interpretive Soil Properties

SITE

CLIMATE
- MAAT
- Frost-free Period
- MAP

LANDSCAPE
- Slope
- Aspect
- Elevation
- Geomorphic Component
- Hillslope Position

COMPONENT

WATER
- AWC
- HSGs
- Flood./Pond.
- Drainage Class

PHYSICAL
- Depth to Restrictive Layers (R, Cr, x, d, f) M?
- Erodibility Indices
- Corrosivity

HORIZON

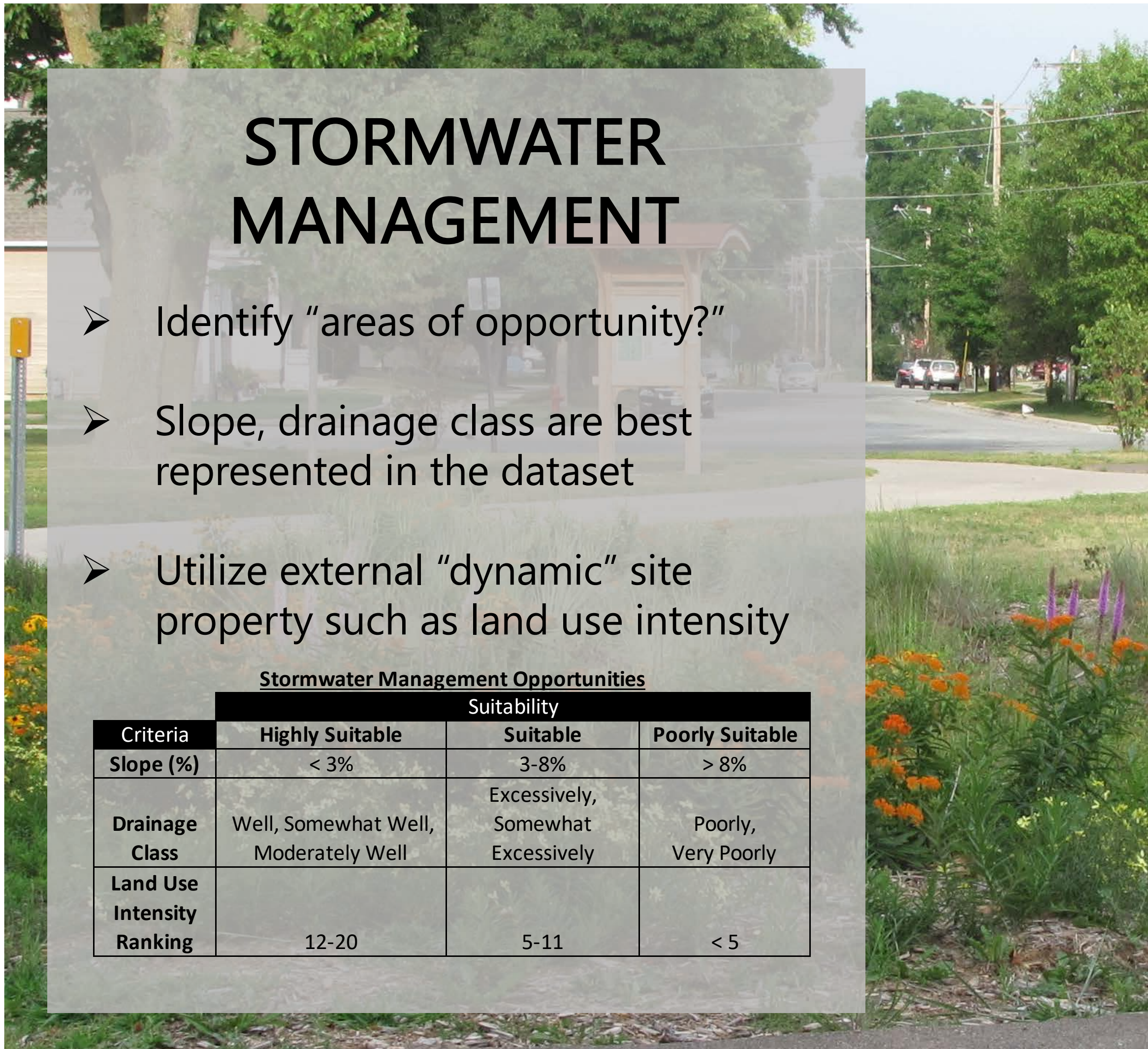
PHYSICAL
- Texture
- Coarse Fragments
- Bulk Density
- Ksat
- Engineering Metrics

CHEMICAL
- pH
- Carbonates
- OM
- EC

Figure: N. Jelinski, adapted from Metropolitan Council (2016)

STORMWATER MANAGEMENT

Images: (L) Cannon River Watershed Partnership; (R) K. LaBine – Minneapolis, MN



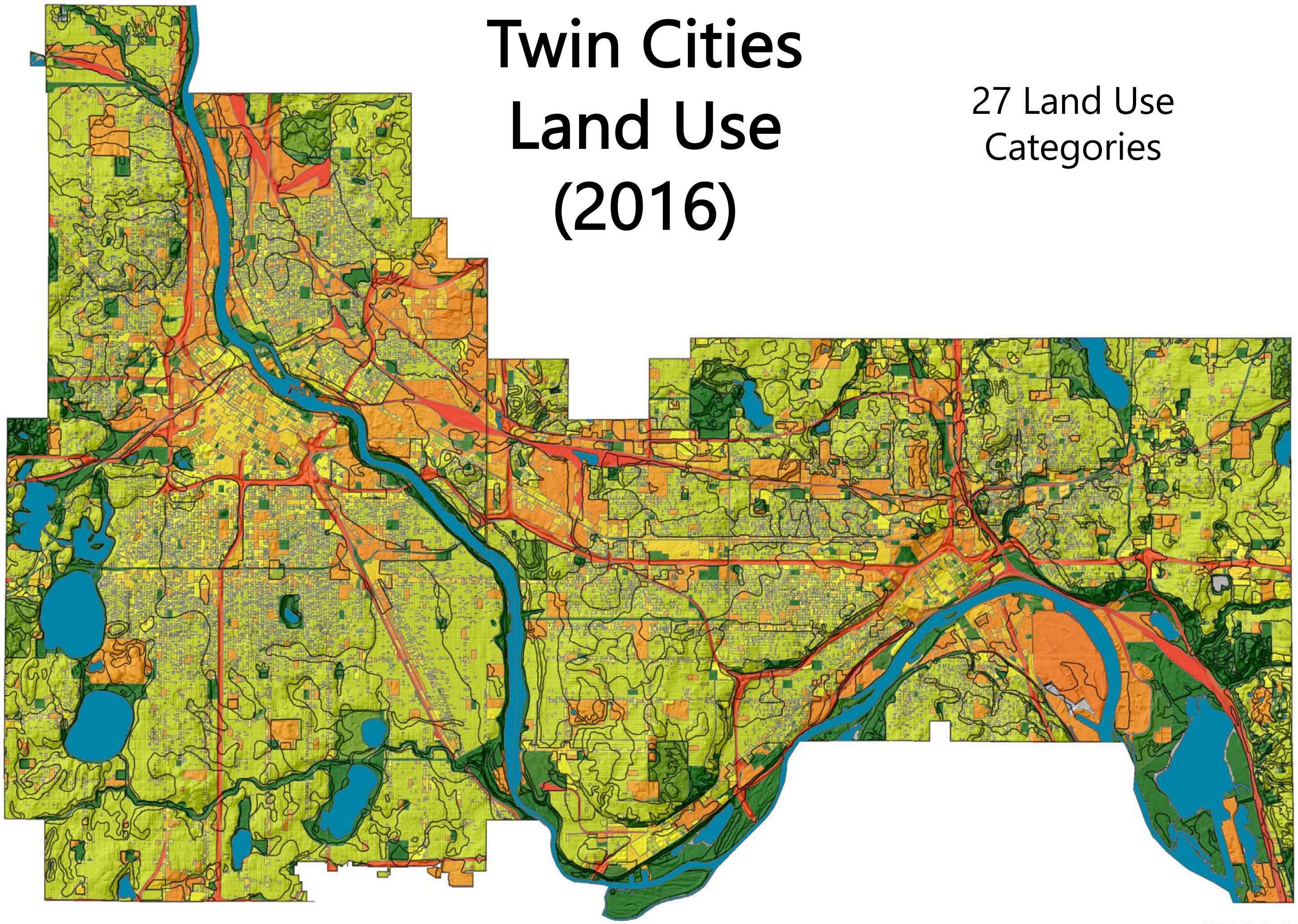
STORMWATER MANAGEMENT

- Identify "areas of opportunity?"
- Slope, drainage class are best represented in the dataset
- Utilize external "dynamic" site property such as land use intensity

Stormwater Management Opportunities

	Suitability		
Criteria	**Highly Suitable**	**Suitable**	**Poorly Suitable**
Slope (%)	< 3%	3-8%	> 8%
Drainage Class	Well, Somewhat Well, Moderately Well	Excessively, Somewhat Excessively	Poorly, Very Poorly
Land Use Intensity Ranking	12-20	5-11	< 5

Images: (L) Cannon River Watershed Partnership; (R) K. LaBine – Minneapolis, MN

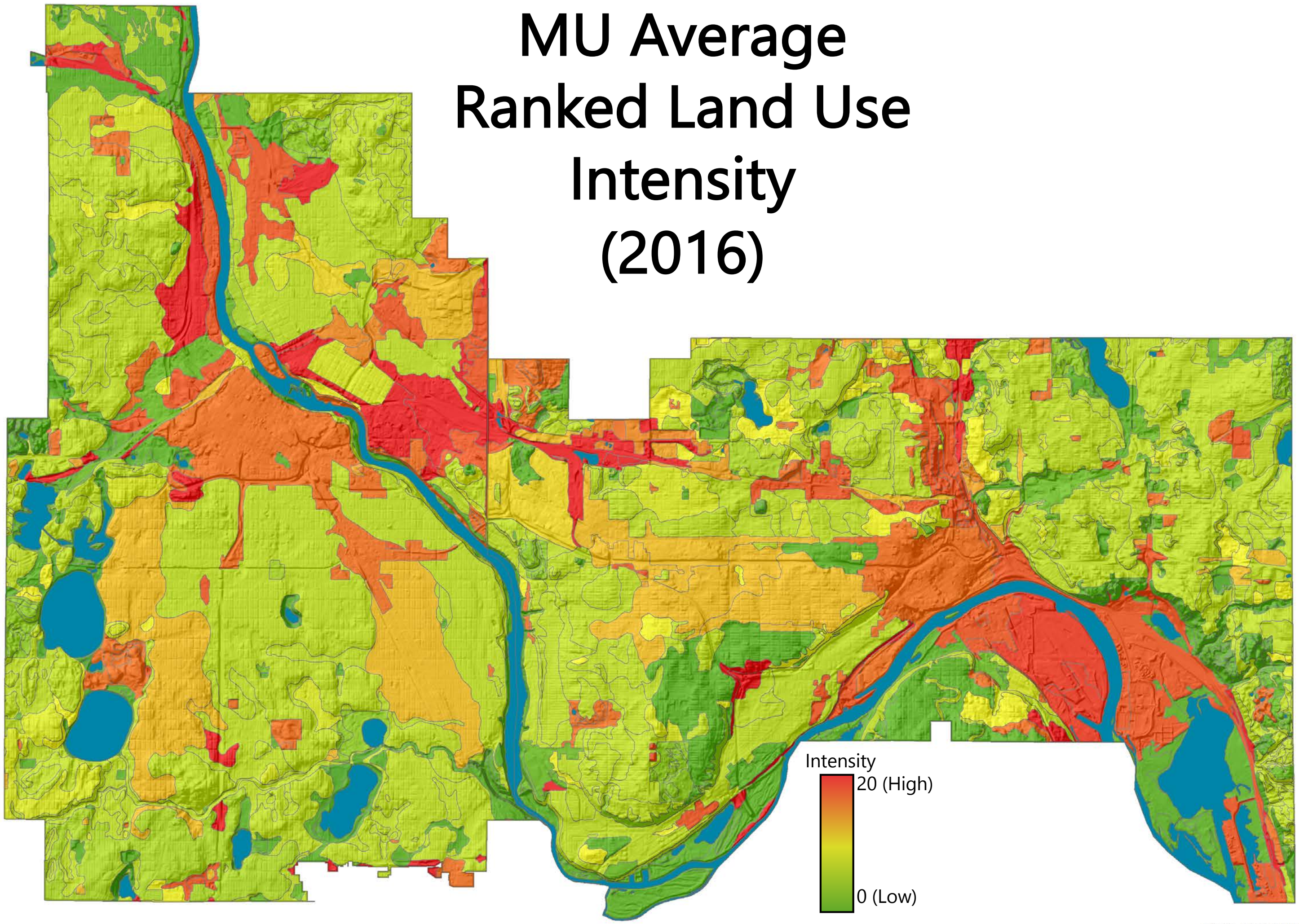


Addition of "DYNAMIC" External Site Data

- Twin Cities land use map (updated periodically)

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011) and Metropolitan Council (2016)

MU Average Ranked Land Use Intensity (2016)



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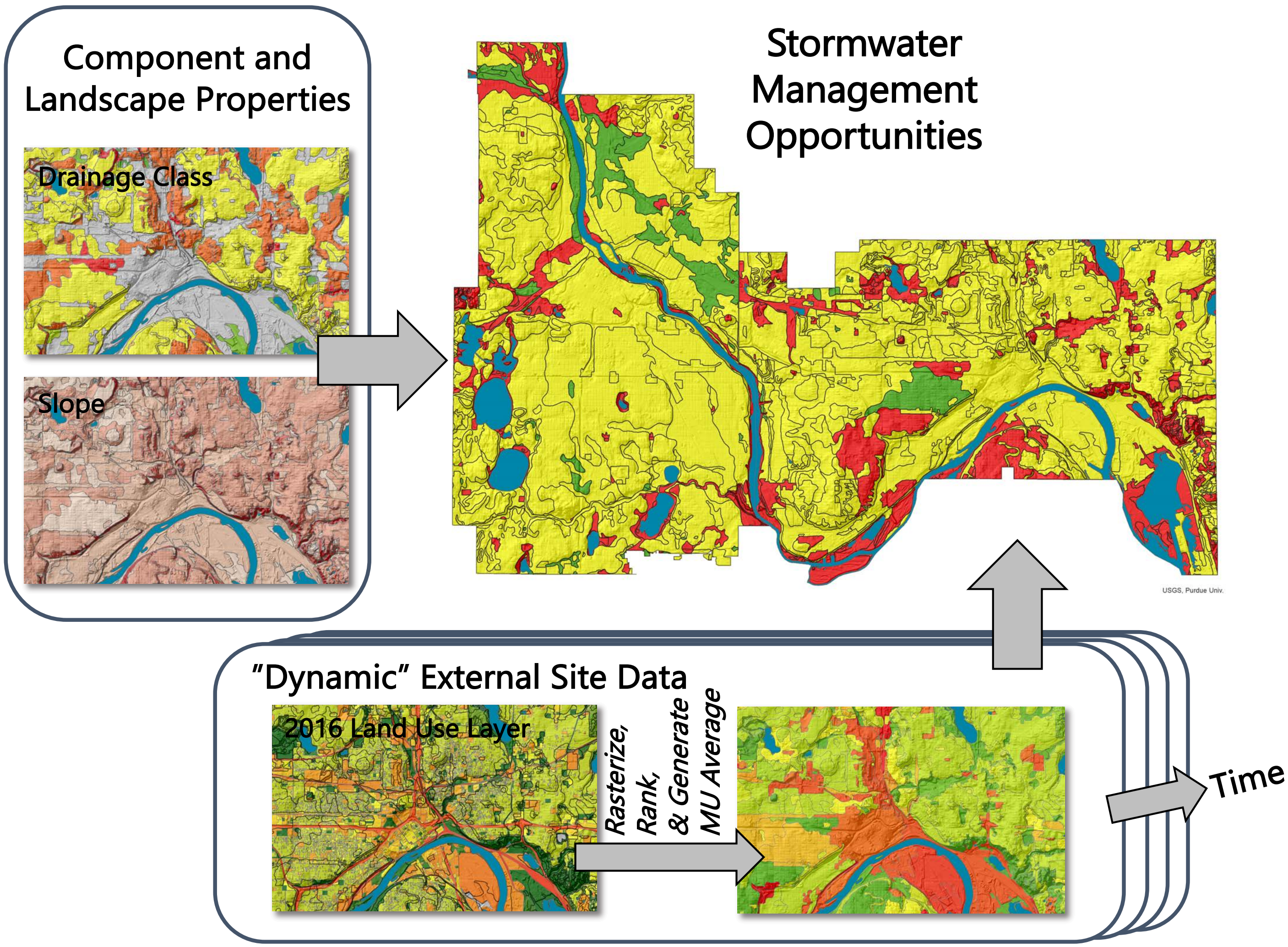

Addition of "DYNAMIC" External Site Data

- Twin Cities land use map (updated periodically)
- Rasterize, rank by intensity, and generate average by MU
- Incorporate into interp rules
- Pull "live" annually as land use layer is updated.

Figures: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011), Web Soil Survey (2019), and Metropolitan Council (2016)

Stormwater Management Opportunities

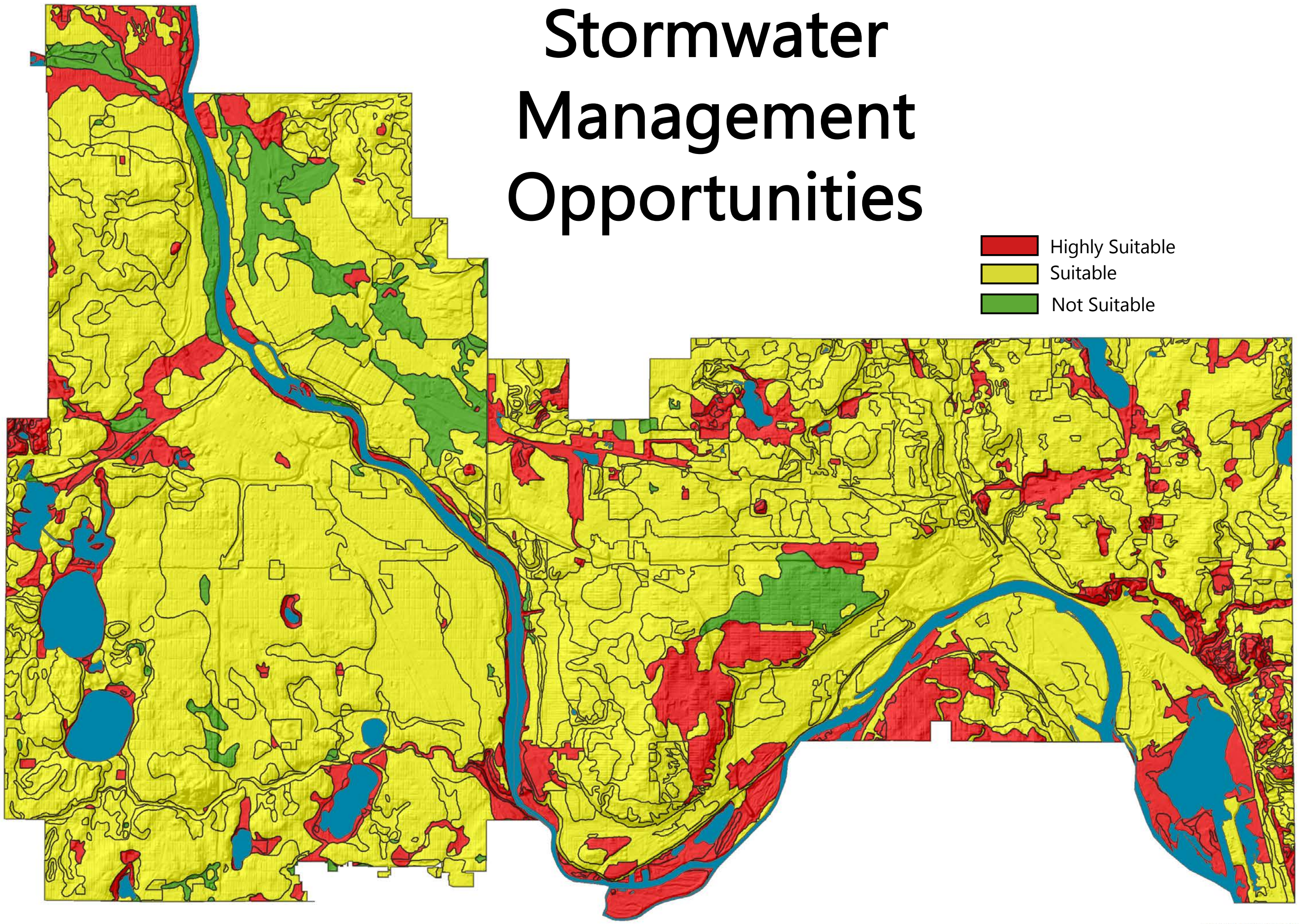

Figure: N. Jelinski, adapted from 1m LiDAR data – MN DNR (2011), Web Soil Survey (2019), and Metropolitan Council (2016)

Simple Stormwater Management "Opportunities" Interp

- Useful??

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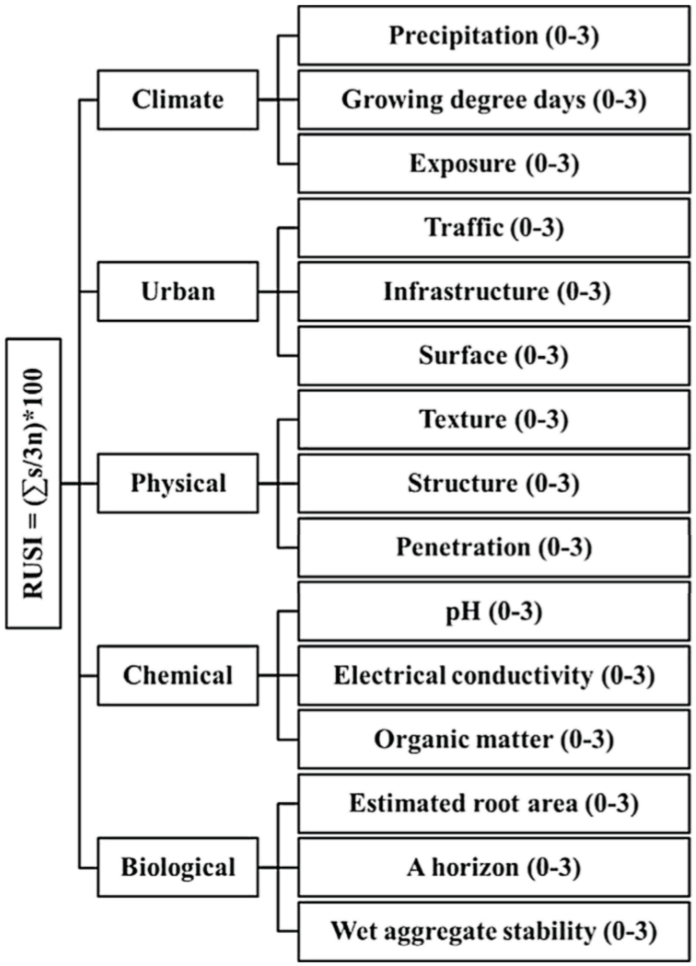
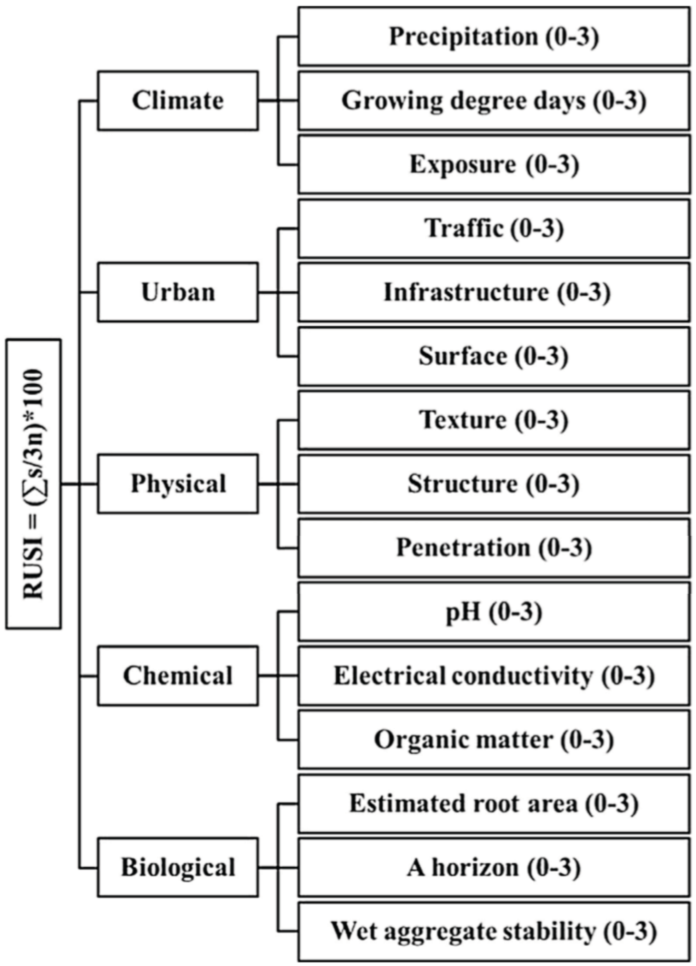


Rapid Urban Site Index (RUSI): Scharenbroch et al. (2017)

Addition of User-Defined, Adaptive Metrics

- RUSI (Scharenbroch et al., 2017) is a combination of a wide range of site-specific variables.

Figure: Scharenbroch et al. (2017)



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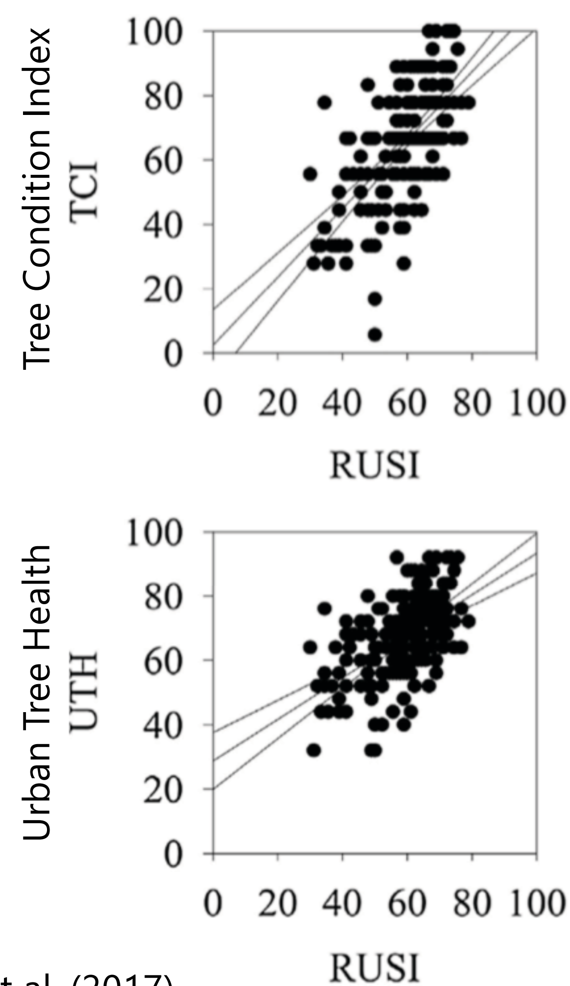
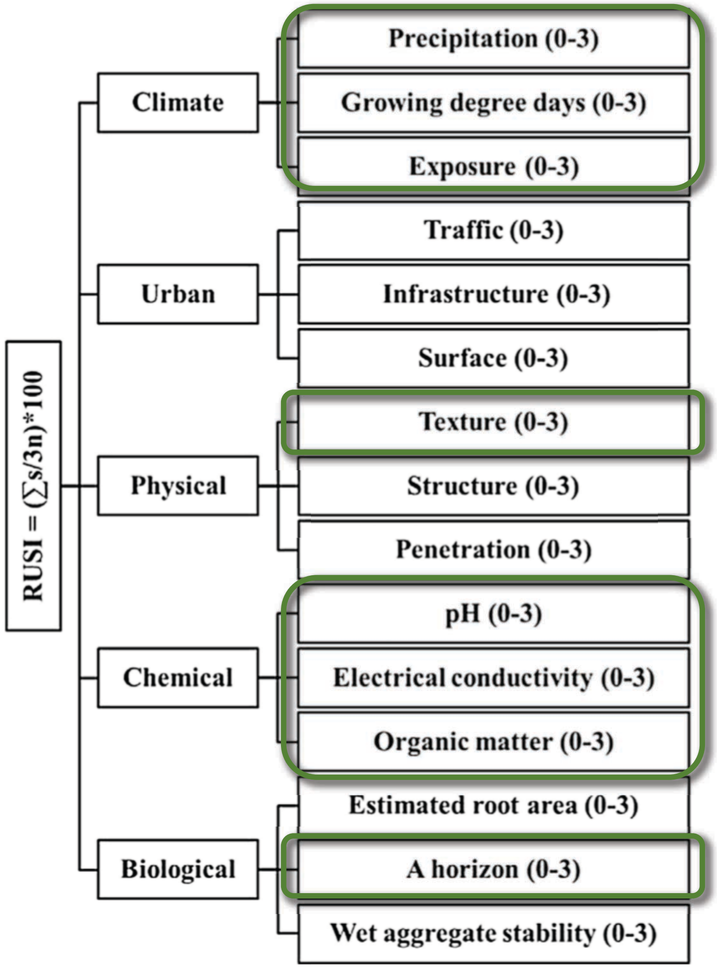


Addition of User-Defined, Adaptive Metrics

- RUSI (Scharenbroch et al., 2017) is a combination of a wide range of site-specific variables.
- Correlated with urban tree condition and health indices

Figures: Scharenbroch et al. (2017)



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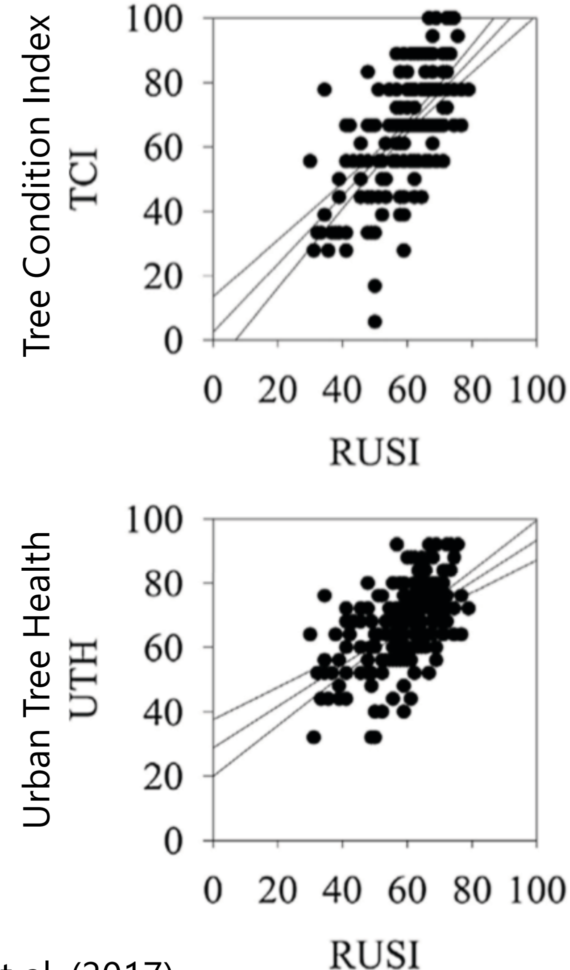
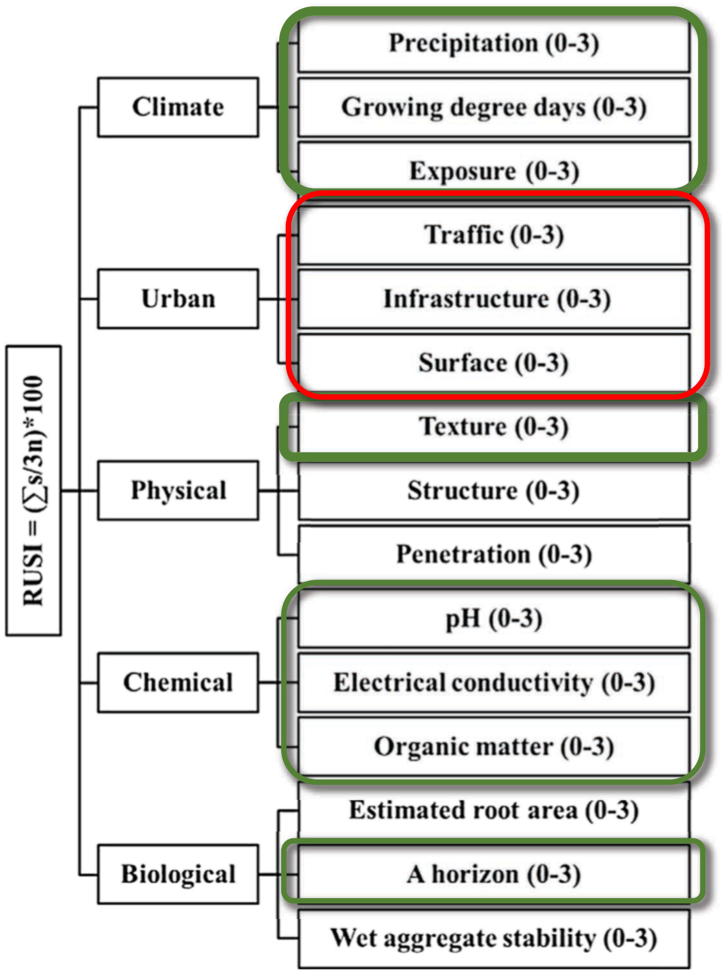


Addition of User-Defined, Adaptive Metrics

- If a high-quality, updated urban soil map was available, many of the RUSI factors could be combined into a "base" RUSI score for each MU.

Figures: Scharenbroch et al. (2017)



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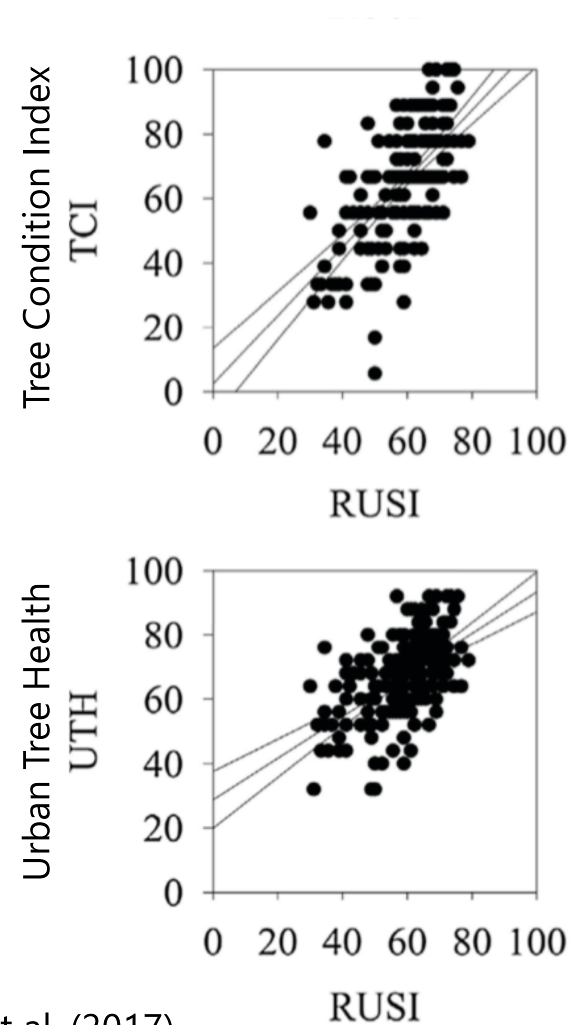

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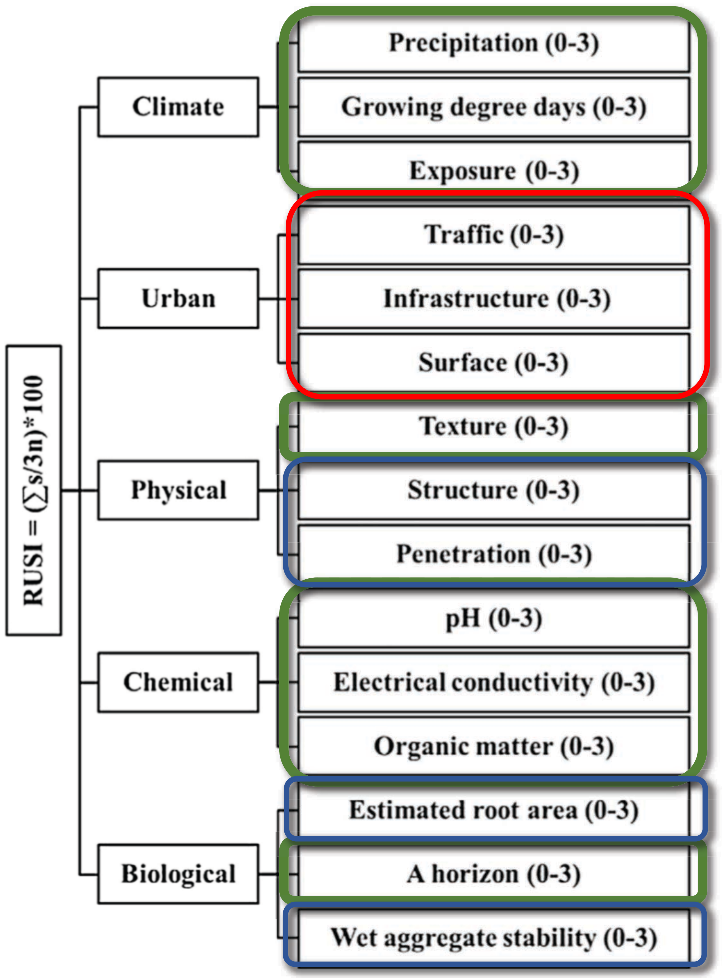

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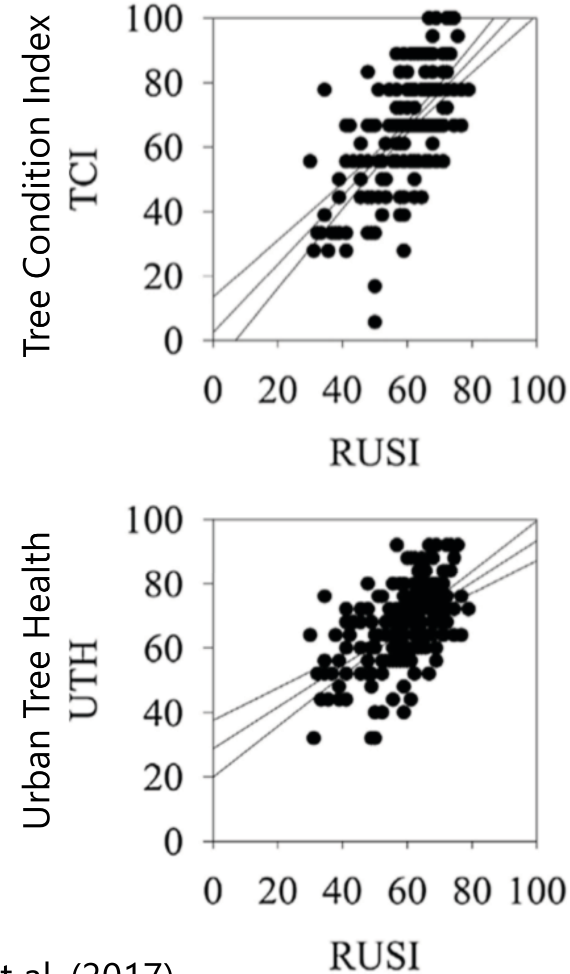

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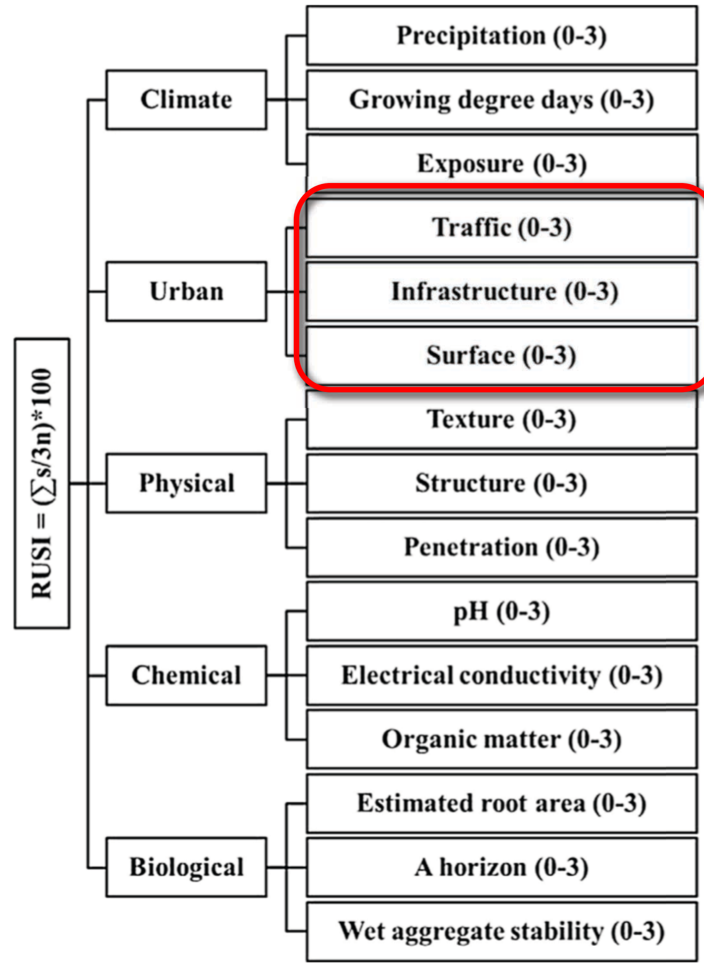
- A few others could be observed rapidly or remotely or with some additional measurement capacity by a user.

Figures: Scharenbroch et al. (2017)

Images: K. LaBine; Figure: Scharenbroch et al. (2017)



Rapid Urban Site Index (RUSI): Scharenbroch et al. (2017)

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Partial RUSI

Traffic
(Road Size)
0: 4 + Lanes
1: 2-4 Lanes, No Parking
2: 2-4 Lanes, Parking
3: < 2 Lanes

Infrastructure
(Distance to Nearest Building or Paved Surface)
0: < 1m
1: 1-5m
2: 5-10m
3: > 10m

Surface
(Ground Cover)
0: Bare/Impermeable
1: Patchy
2: Thick
3: Organic Mulch

Total Possible = 9

Addition of User-Defined, Adaptive Metrics

Figures and Data: N. Jelinski, K. LaBine

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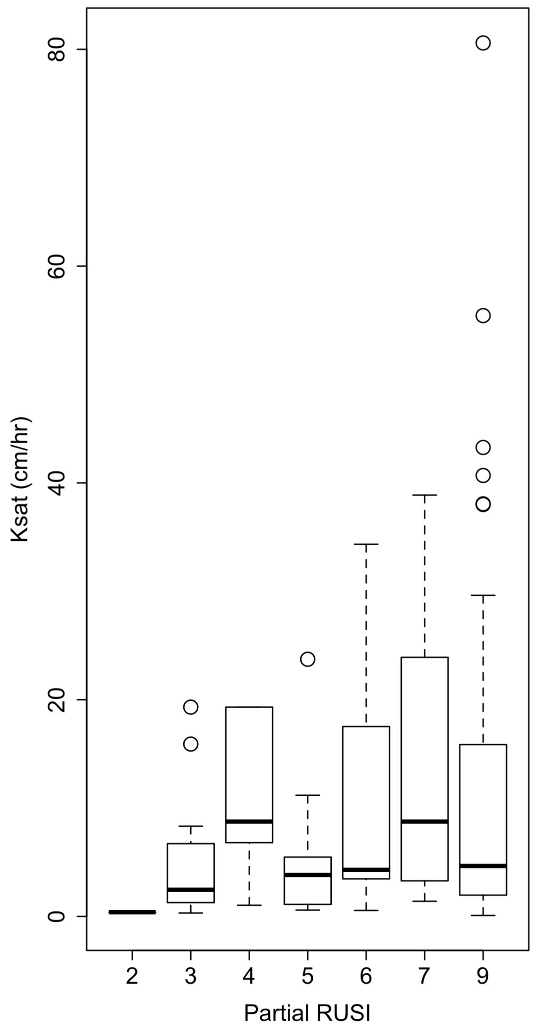

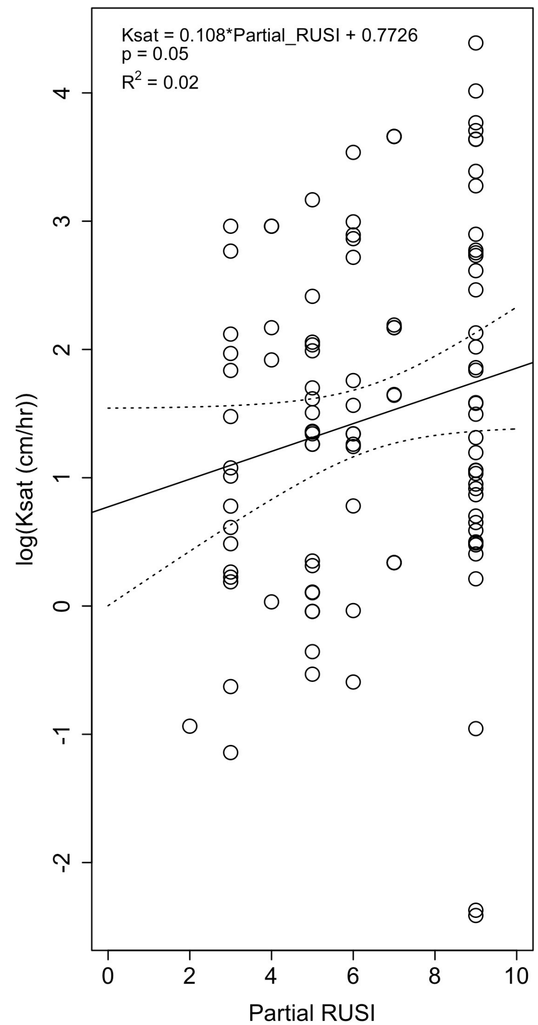

Addition of User-Defined, Adaptive Metrics

- Across 33 sites (n = 111) Ksat was weakly correlated with a partial RUSI score (Urban only).
- Correlation improvement with more RUSI metrics?

Figures and Data: N. Jelinski, K. LaBine

Conclusions

- Developing novel **urban soil interpretations** can be **difficult**….but perhaps **rewarding** with large groups of potential stakeholders/users.

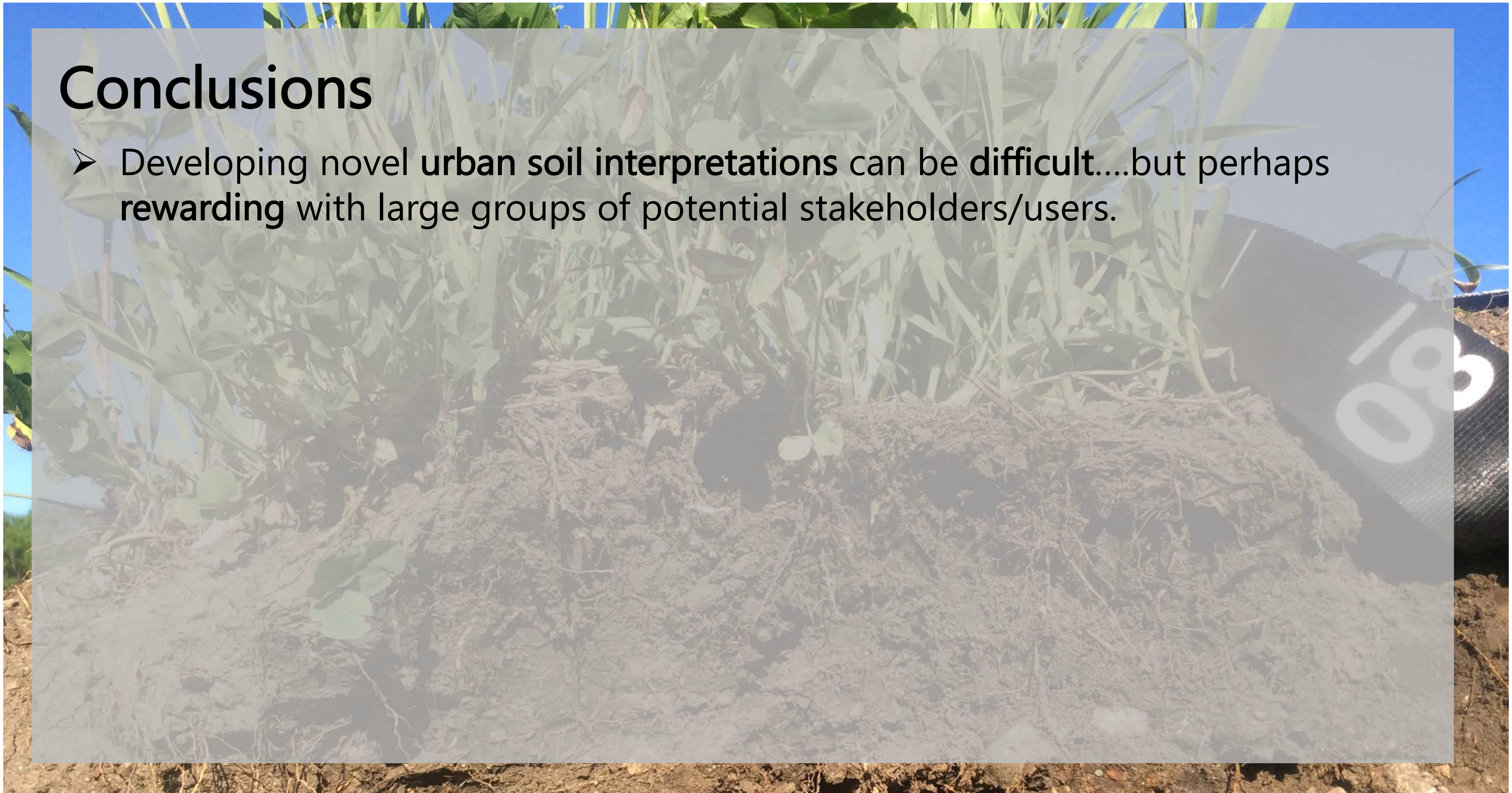

Image: N. Jelinski, Frogtown Park and Farm, St. Paul, MN

Conclusions

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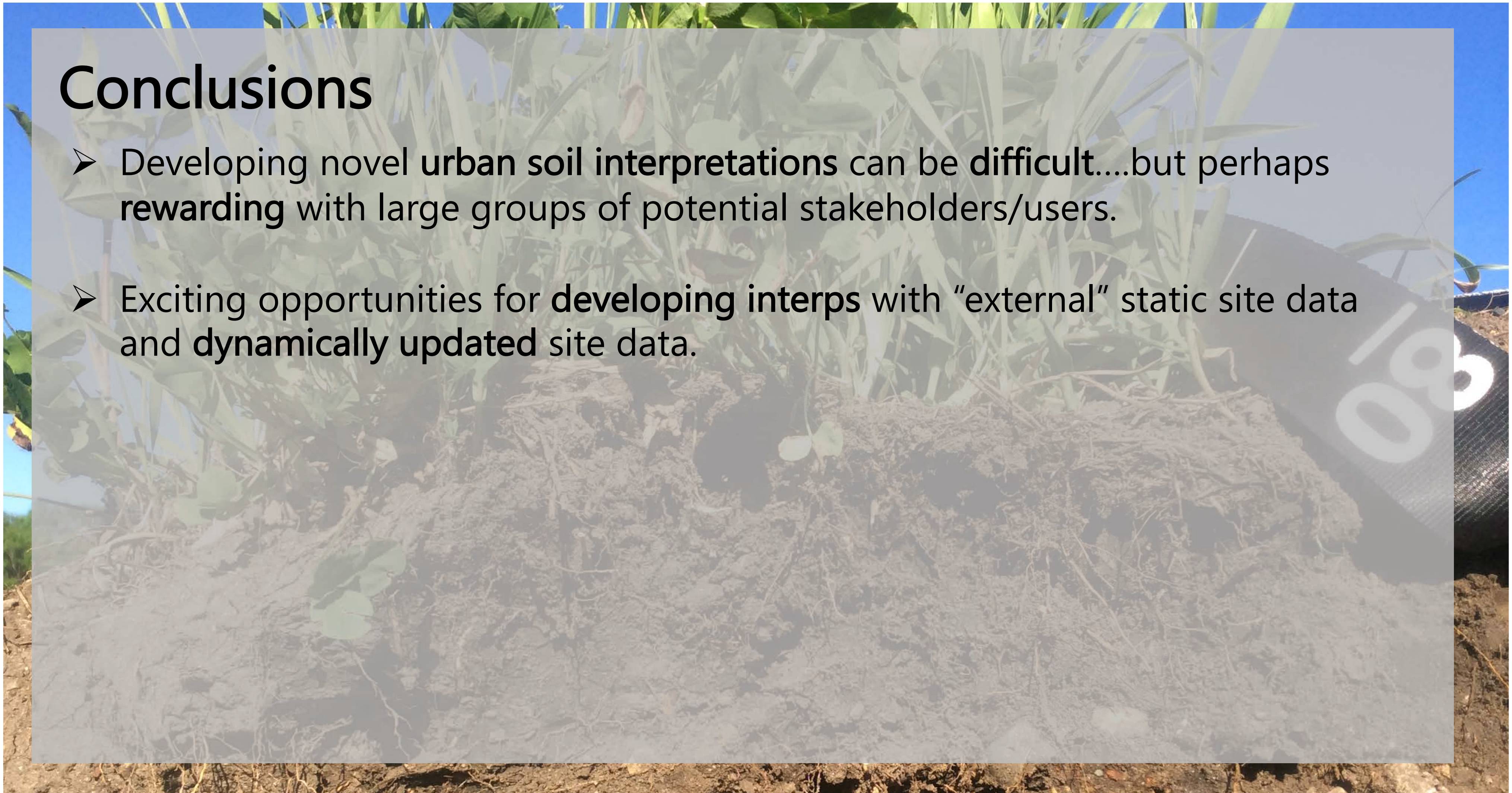

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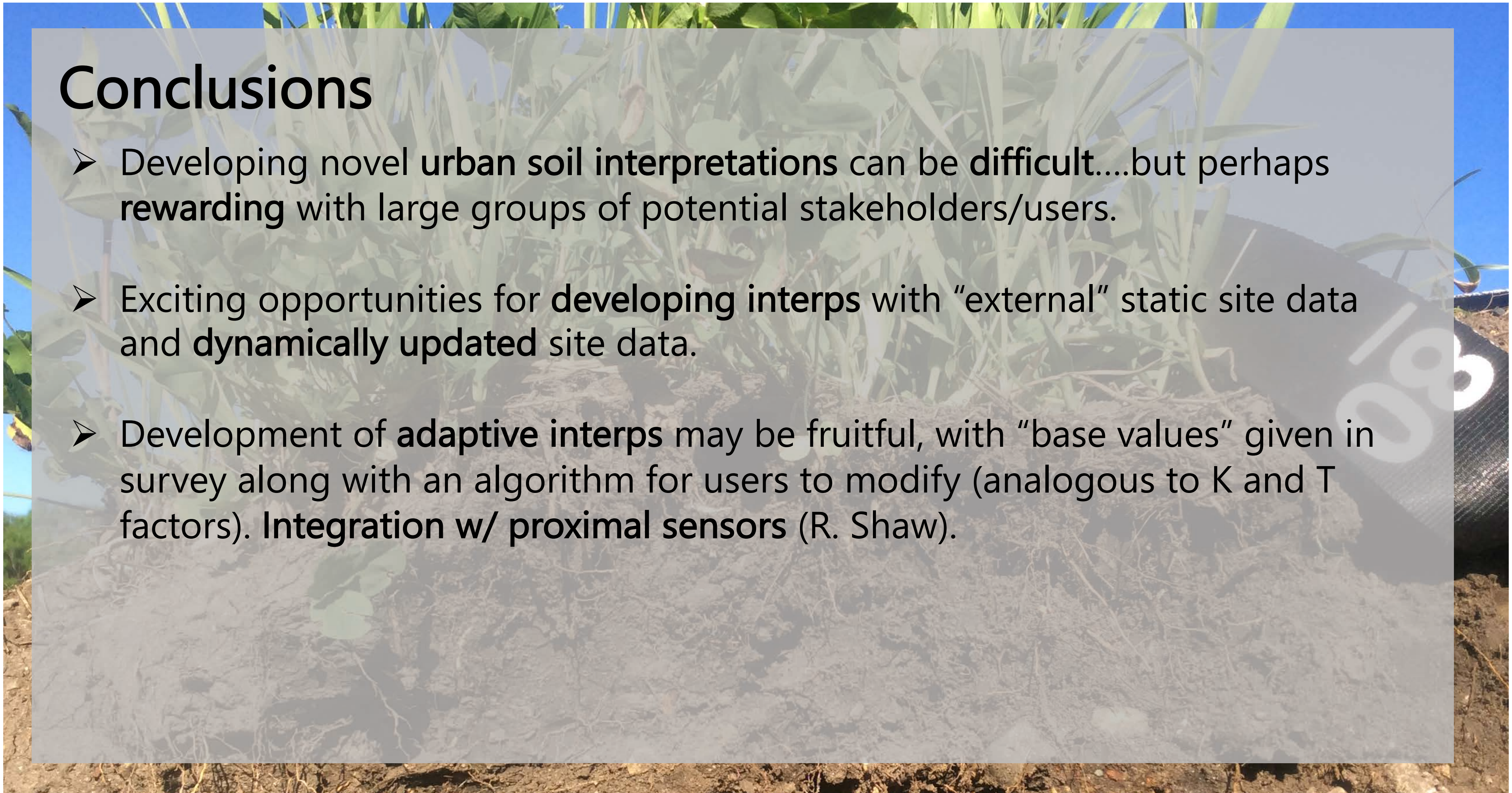

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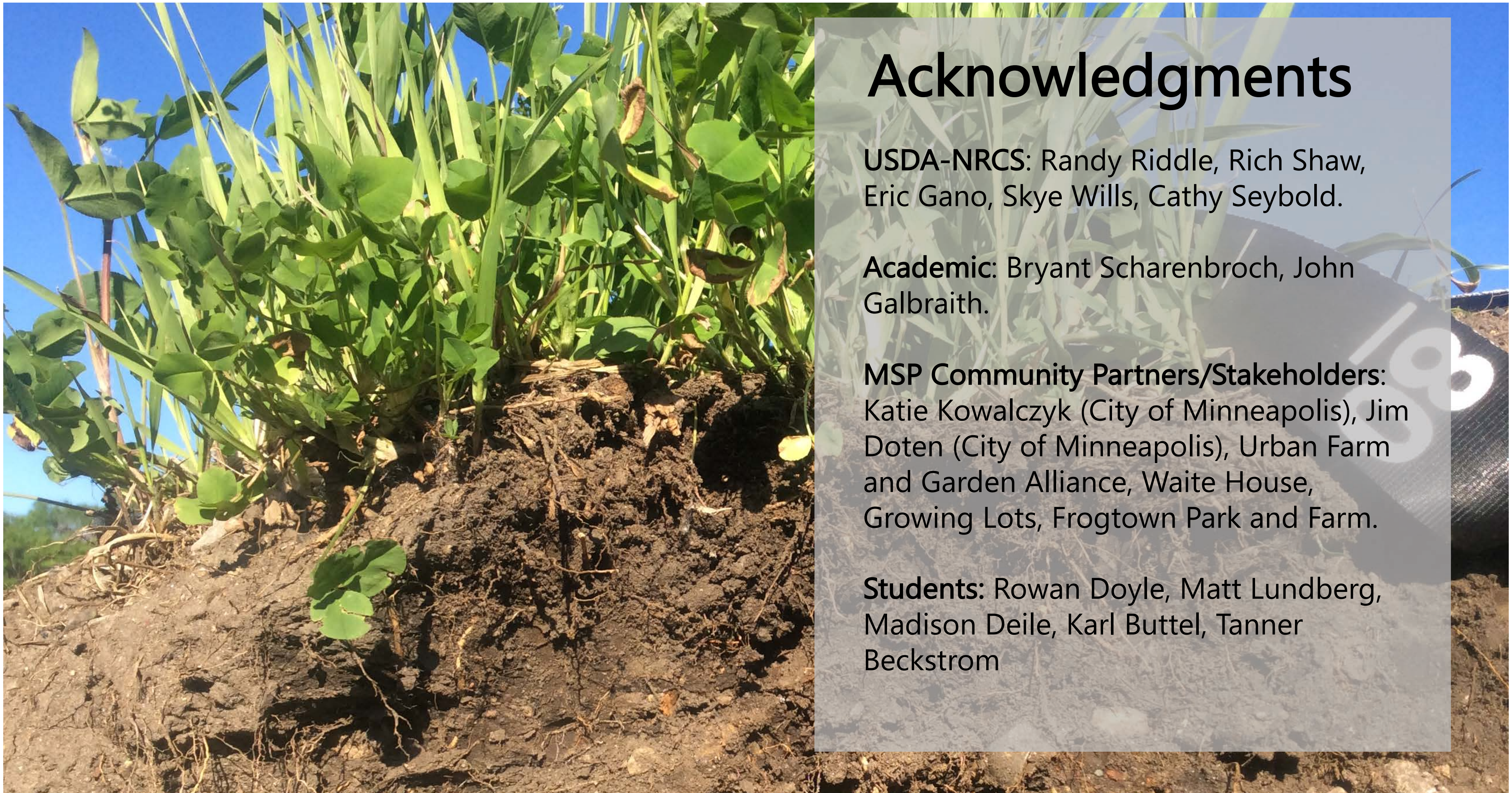
- There are **other interps of interest** either developed or conceptualized not addressed here: Liquefaction, Native Vegetation, Storm Water Management Practices, California Groundwater Banking Index, + more?…….

Image: N. Jelinski, Frogtown Park and Farm, St. Paul, MN



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Students: Rowan Doyle, Matt Lundberg, Madison Deile, Karl Buttel, Tanner Beckstrom

Image: N. Jelinski, Frogtown Park and Farm, St. Paul, MN

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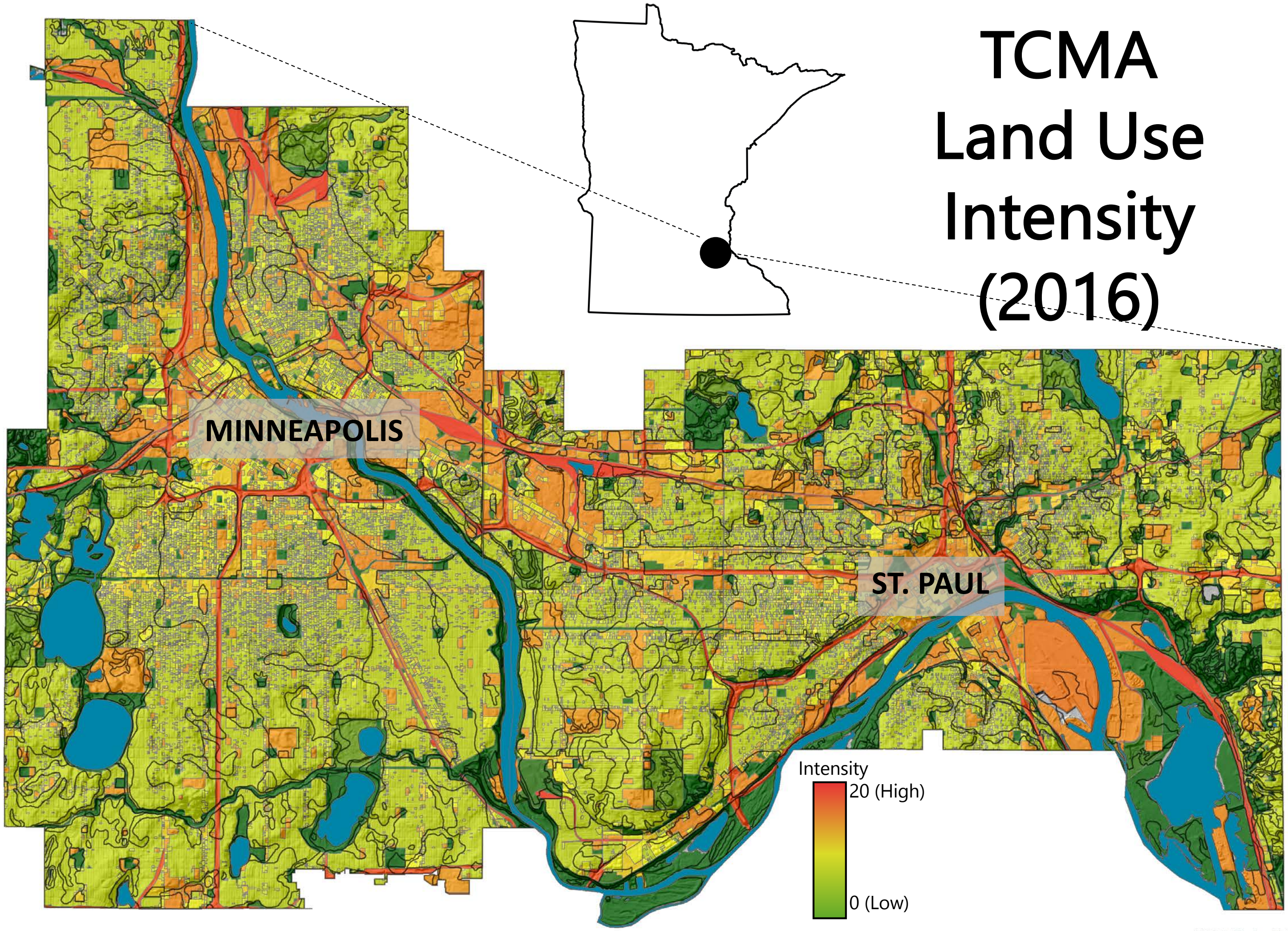

TCMA Land Use Intensity (2016)

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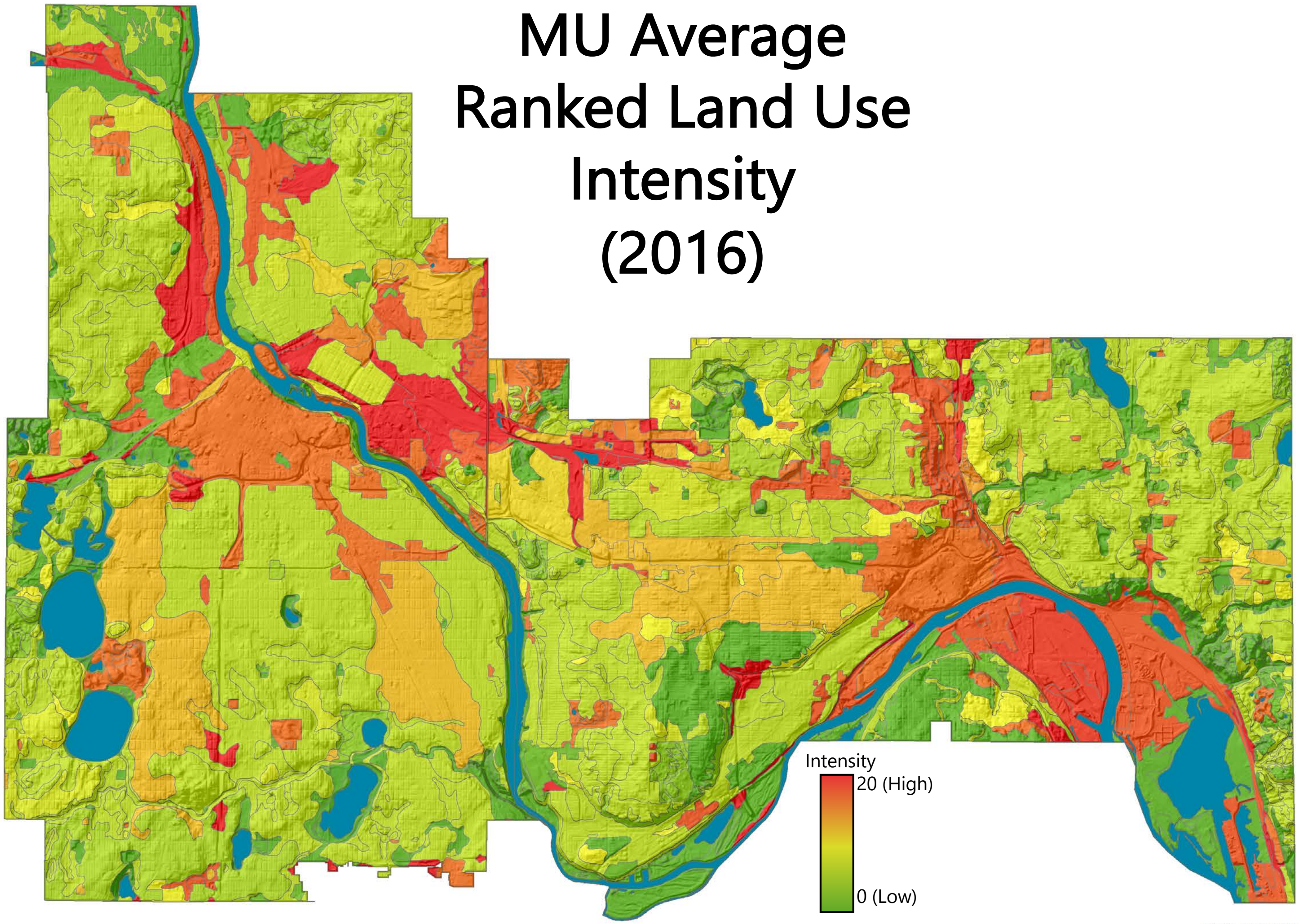

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