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Understanding Basic Soil Properties and Interpretations

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February 9, 2022



United States Department of Agriculture

Objectives:



Understand and explain the definition of soil development

Understand and explain the difference between soil properties and interpretations



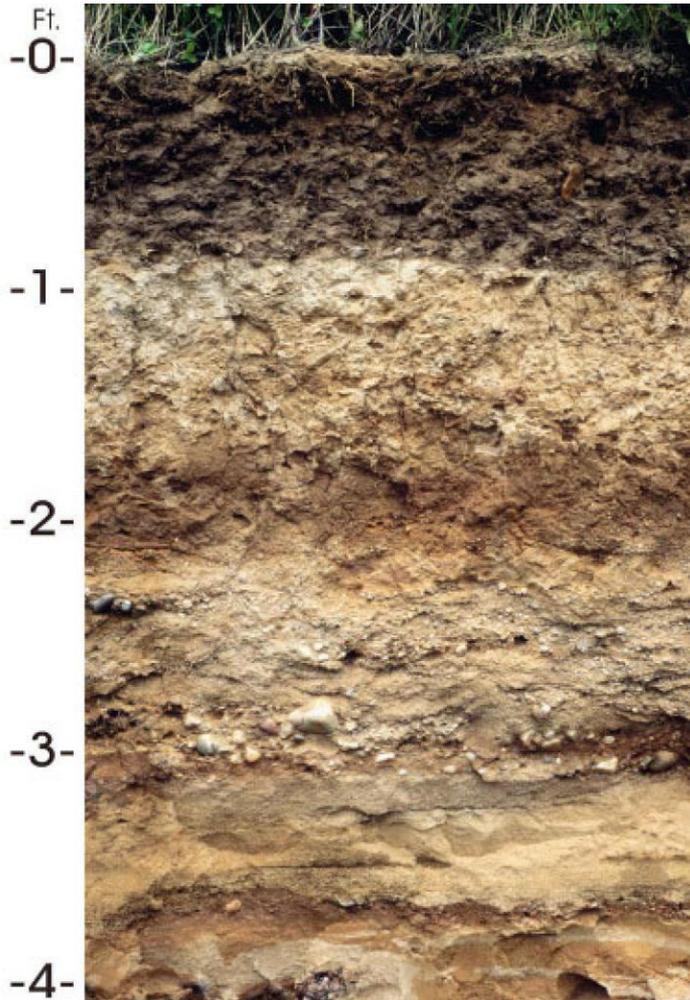
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Why Should We Care About Soil?



Definition of Soil

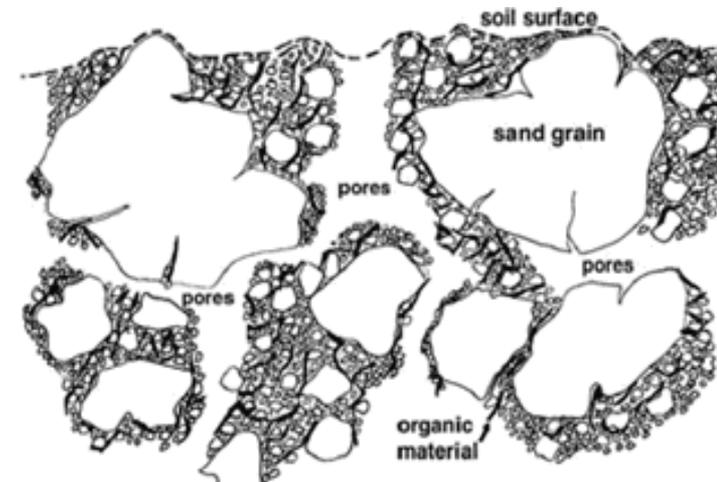
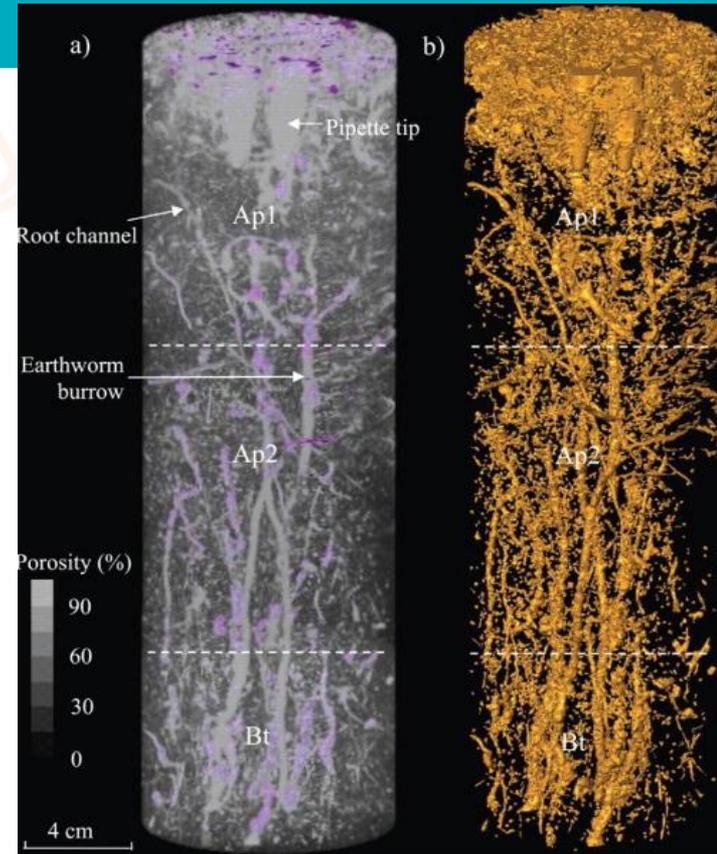
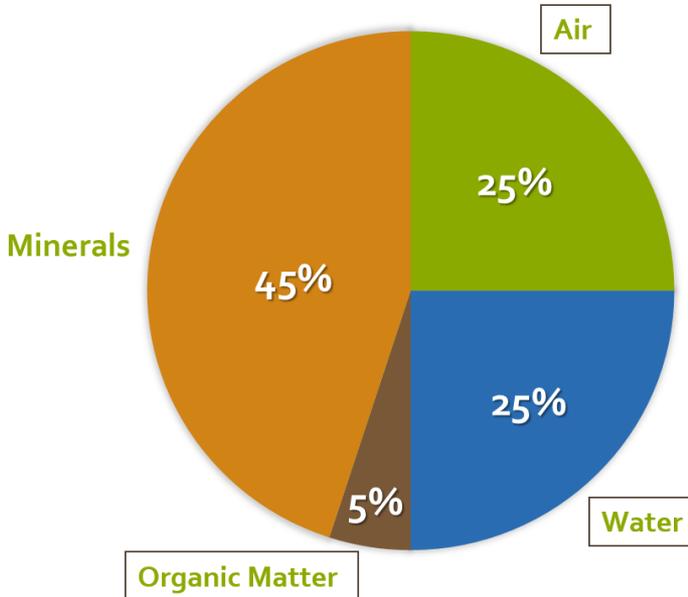
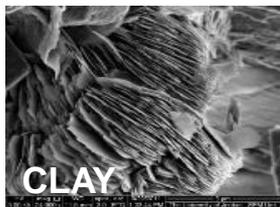
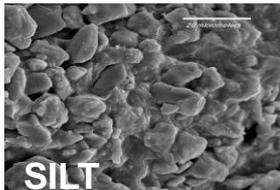


- **USDA-NRCS**: The unconsolidated mineral or organic material on the surface of Earth that supports plant growth and has been subjected to and shows effects of genetic and environmental factors of climate, organisms, relief, and parent material over time (pedogenesis).
- **Hans Jenny**: “Soil is the hidden, secret friend, which is the root domain of lively darkness and silence.”
- **Charles E. Kellogg**: “Essentially, all life depends on soil.... There can be no life without soil and no soil without life they have evolved together.”

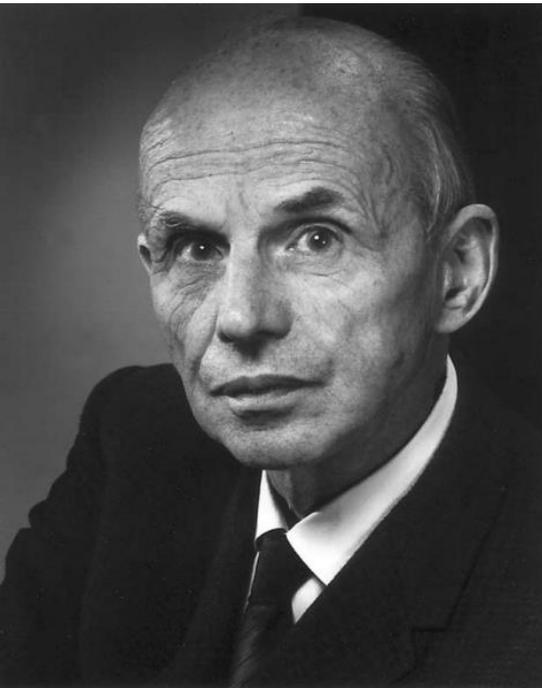


Antigo silt loam
WI State Soil

What is Soil?

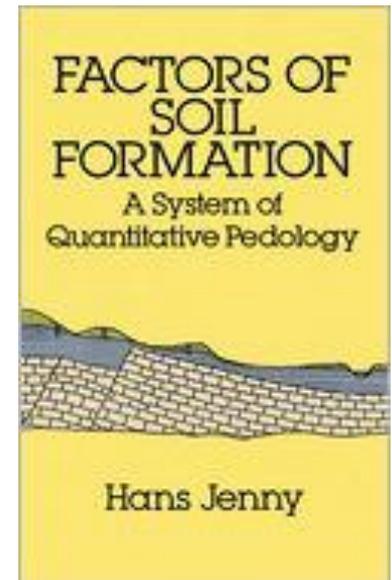


Soil Forming Factors



1941: Soil is open system; properties are functionally related; system changes when property(ies) change(s)

$$s = f(c, l, o, r, p, t, \dots)$$



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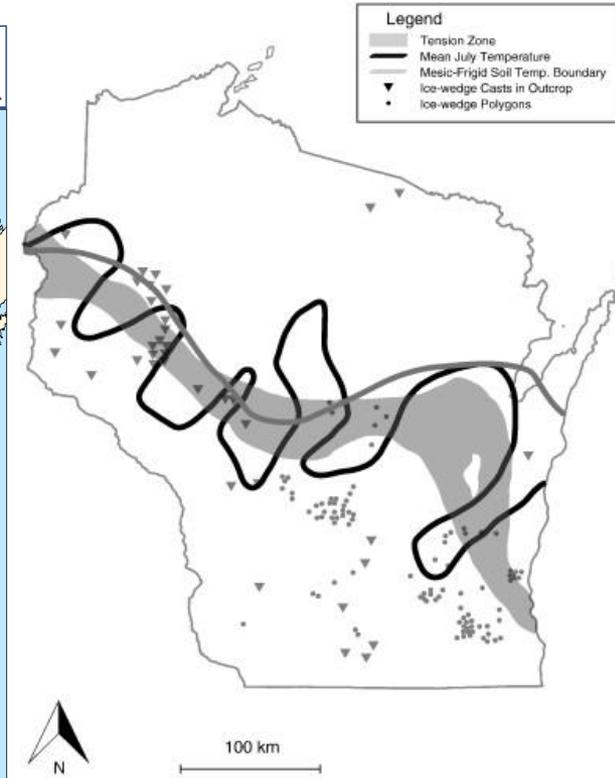
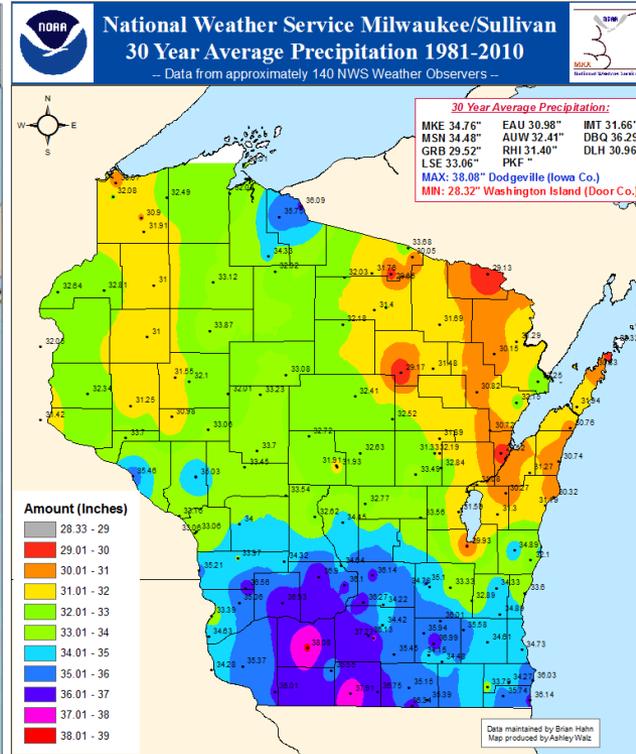
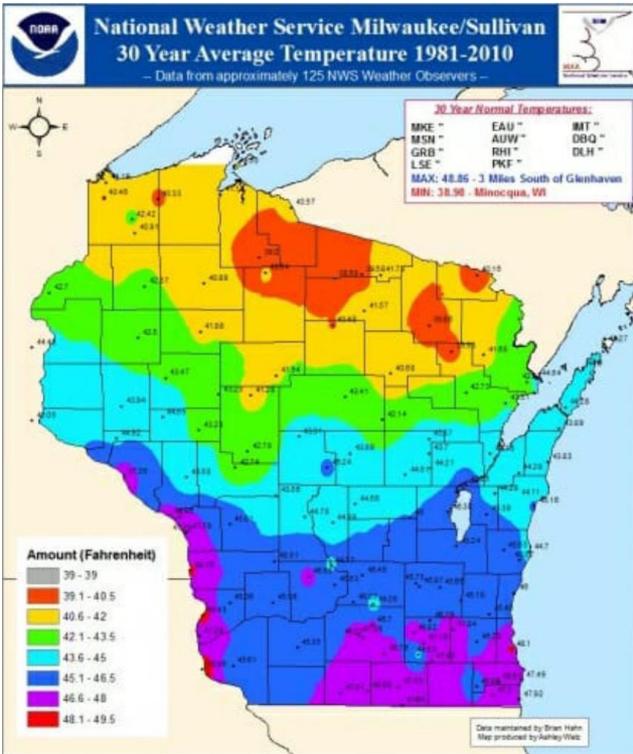
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Climate



WI Tension Zone



NOAA 30 Year Average Temperature & Precipitation (1981-2010)



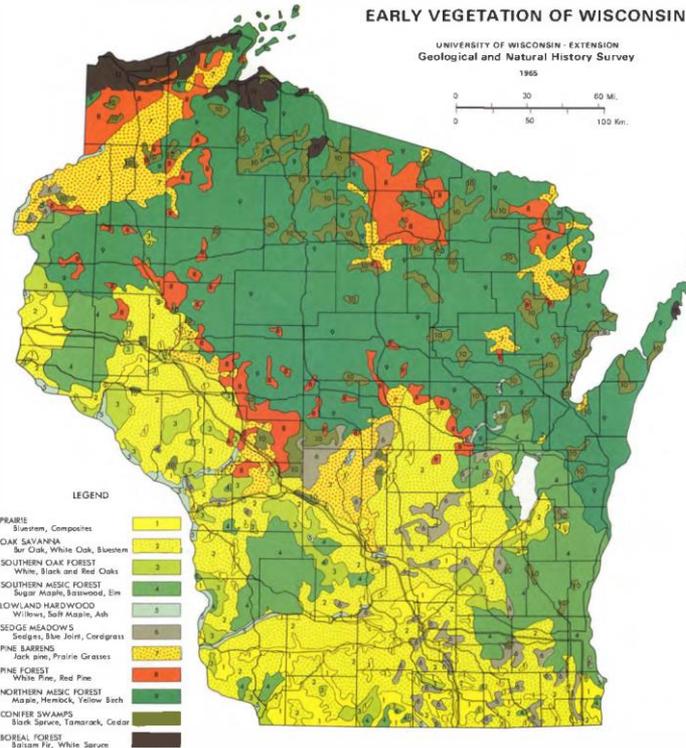
Organisms



Spodosol



Spodosols form in coniferous forest in cool, moist climates



1830s: 63% Forested
27% Savanna
10% Prairie/sedge meadow

Mollisol

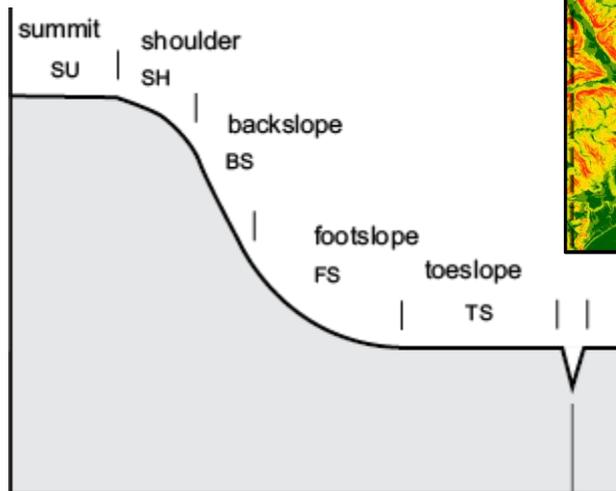
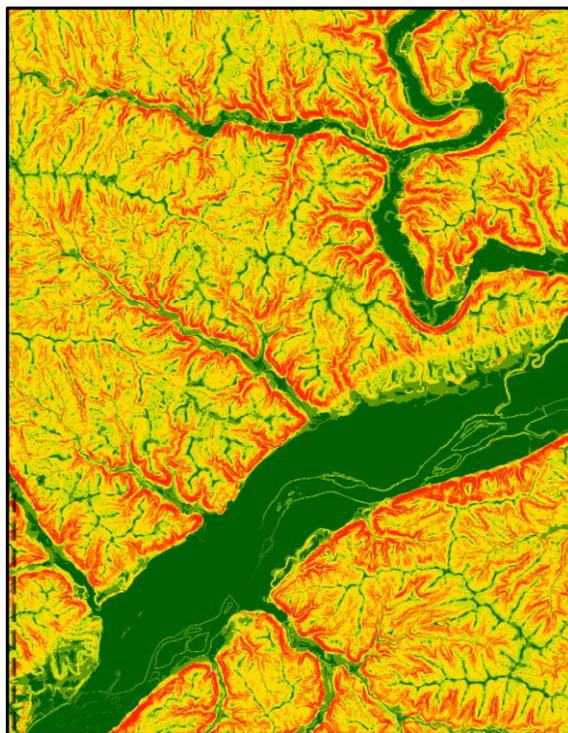
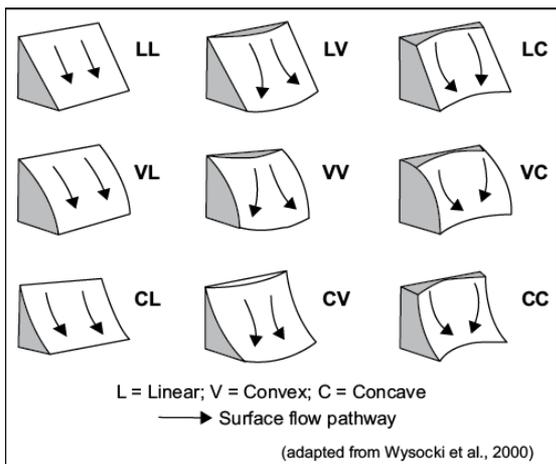


Cruse et al. 2014

Mollisols form on grasslands where vegetation is deep rooted



Relief (Topography)



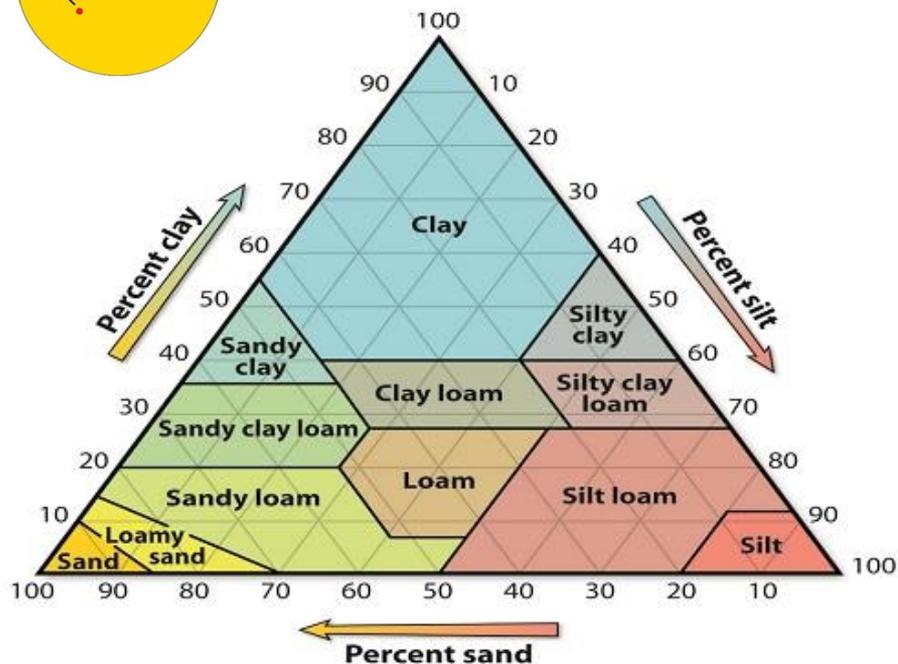
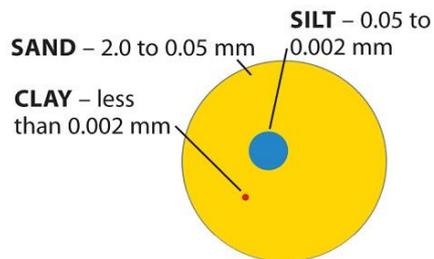
Time



Soil Description



USDA Soil Texture



$$\%sand + \%clay + \%silt = 100\%$$

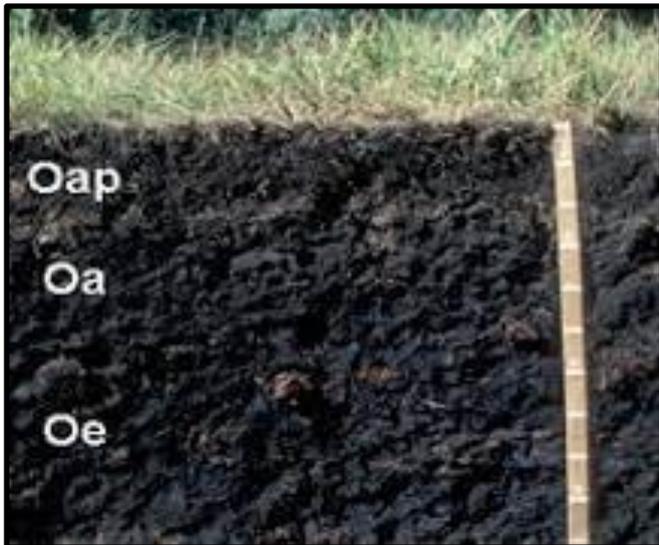


Organic Soils & USDA Soil Textures

Muck (texture = sapric; horizon = Oa)

Mucky peat (texture = hemic; horizon = Oe)

Peat (texture = fibric; horizon = Oi)



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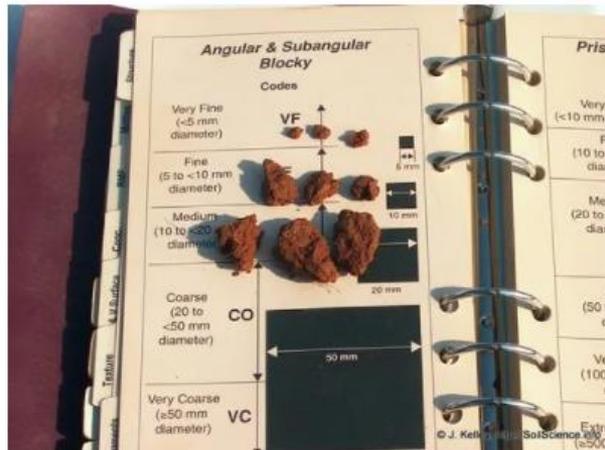
Soil Structure



Granular

Blocky

Prismatic



Single Grained

Massive



Platy

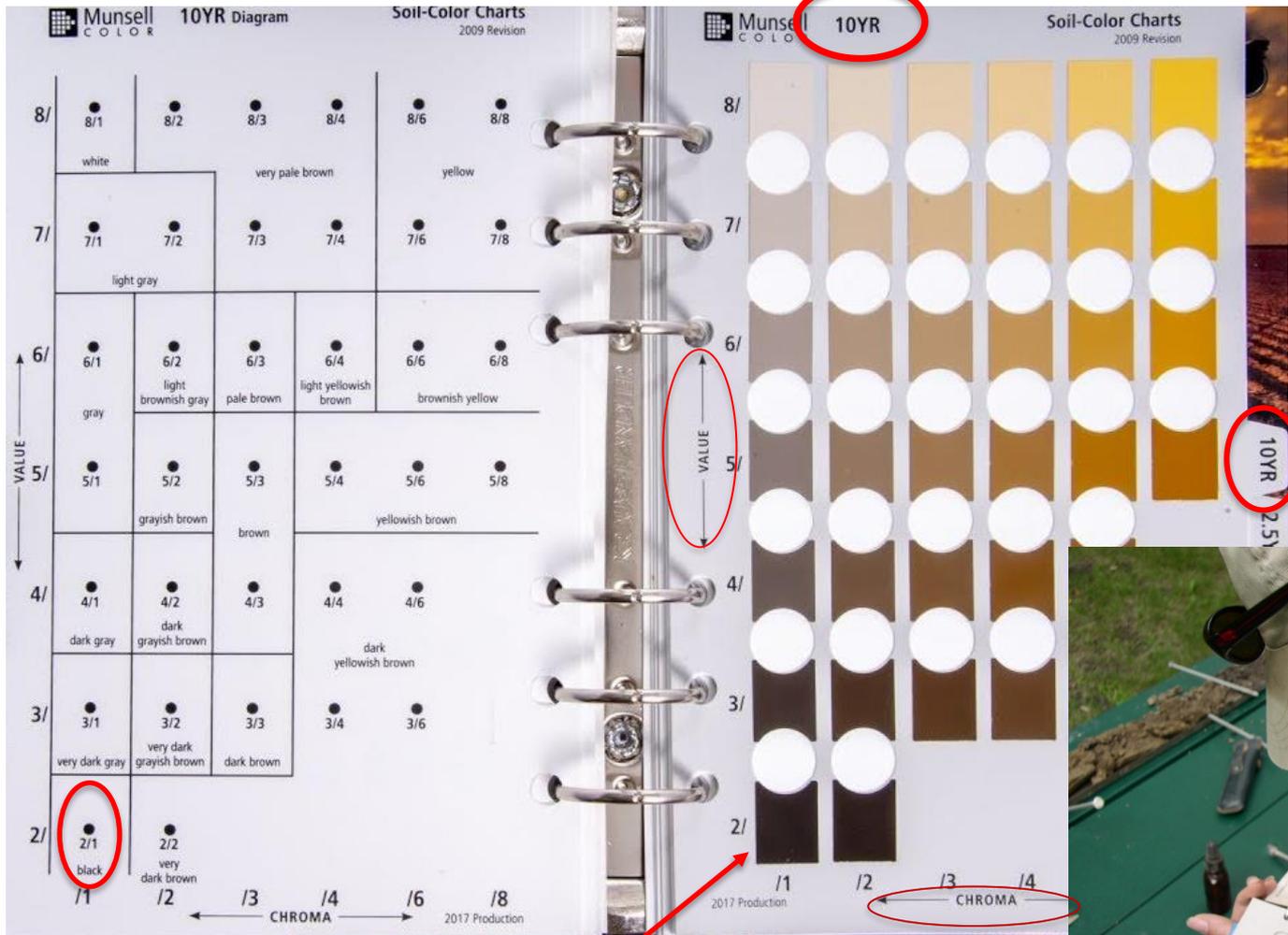
Determining soil structure size. Photo courtesy of the NCSU Soil Science Flickr stream.



Soil Color



Soil Color Notation



10YR 2/1

Hue

Value

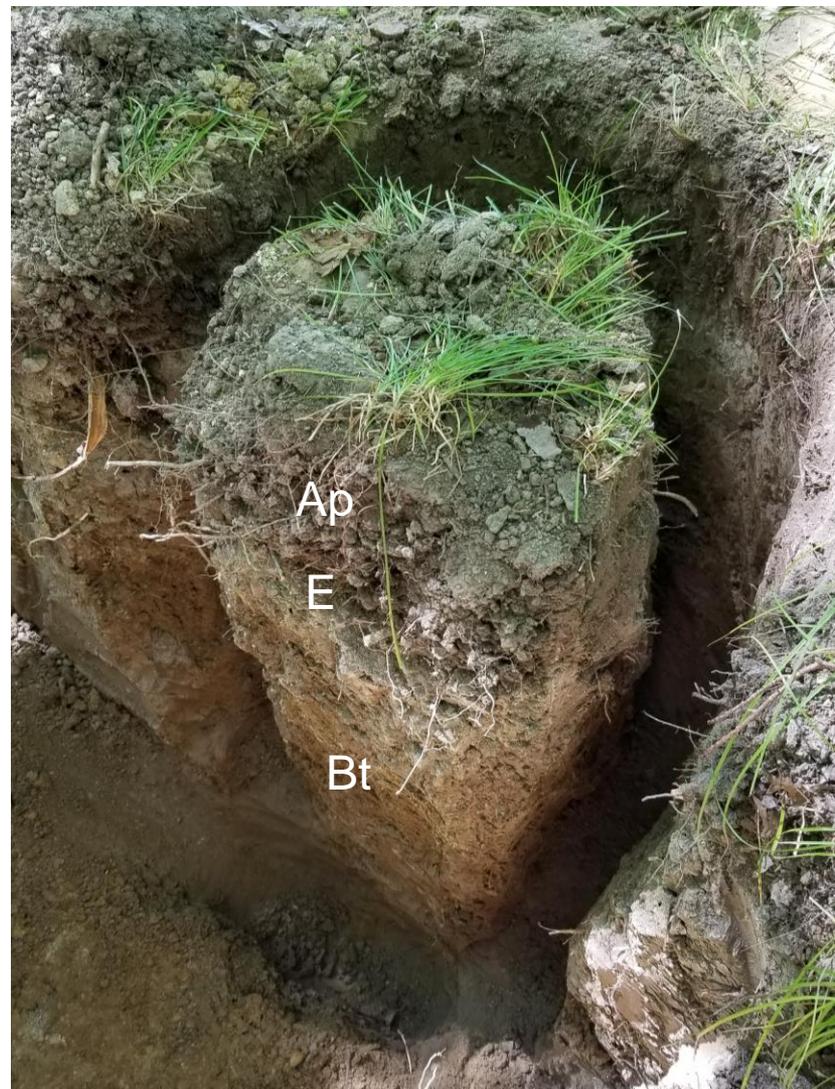
Chroma



Idealized Master Soil Horizons



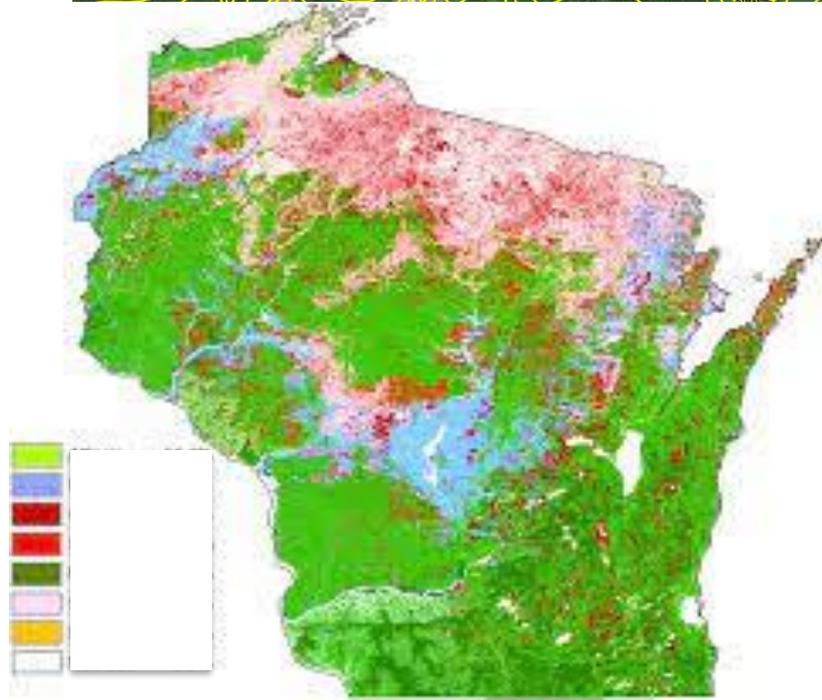
- O Horizon
- A Horizon
- E Horizon
- B Horizon
- C Horizon
- R Horizon



Soil Classification & Mapping



Alfisols, 44%
Entisols, 12%
Histosols, 9%
Inceptisols, 4%
Mollisols, 10%
Spodosols, 16%
Ultisols, <0.5%
Non-Soil, 6%

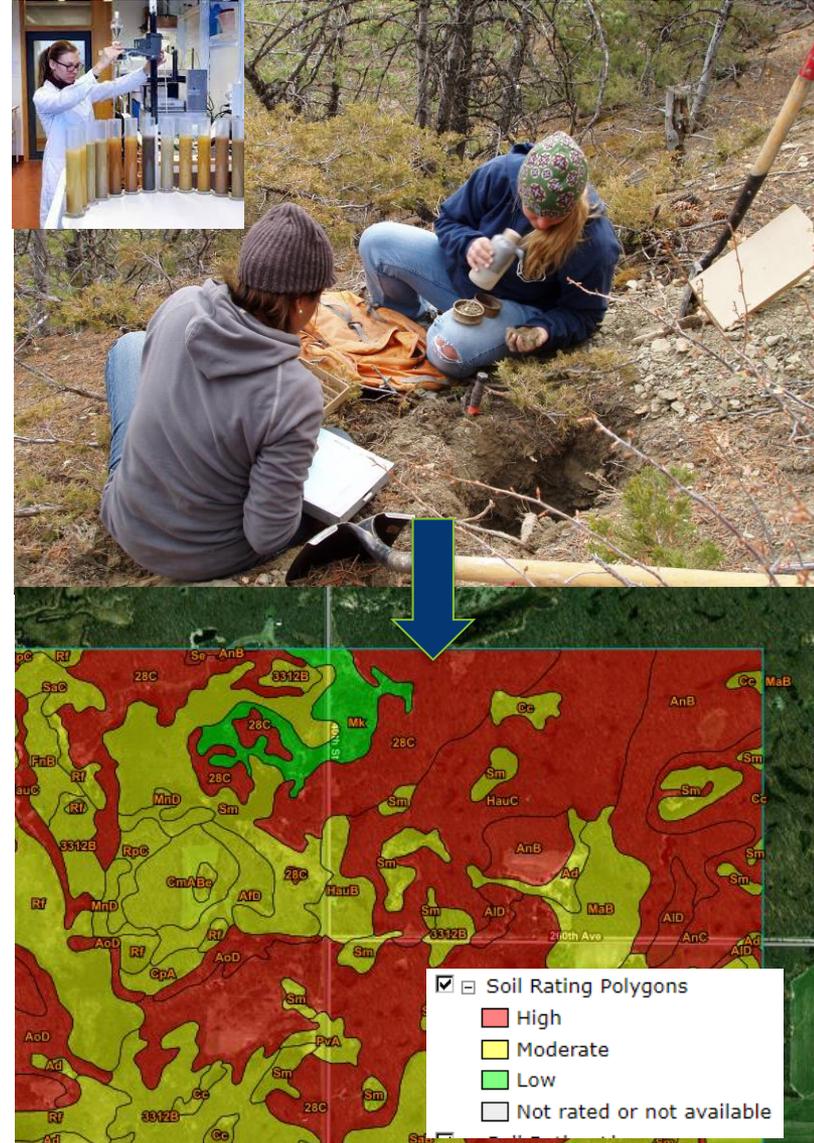


Soil Properties, Qualities and Interpretations

Properties can be measured or inferred from direct observations in the field or lab

Qualities cannot be directly measured; behavior or performance attribute

Interpretations are predictions about how soil will behave (suitability and limitations)



Interpretations

Soil survey interpretations predict soil behavior for specified soil uses and under specified soil management practices.

- Laws, programs, and regulations
- Broad land use planning
 - NSSH 617

The accuracy of the prediction depends on the how well the data is populated and the completeness of the criteria.

- Need to be written with the participant who works with the intended use

Intro to Soils		Suitabilities and Limitations for Use		Soil Properties Qualities	
Search					
Suitabilities and Limitations Ratings					
				Open All	Close All ?
Building Site Development ?					
Corrosion of Concrete					
Corrosion of Steel					
Dwellings With Basements					
Dwellings Without Basements					
Lawns, Landscaping, and Golf Fairways					
Local Roads and Streets					
Shallow Excavations					
Small Commercial Buildings					
Unpaved Local Roads and Streets					
Construction Materials				?	▼
Disaster Recovery Planning				?	▼
Land Classifications				?	▼
Land Management				?	▼
Military Operations				?	▼



Interpretations

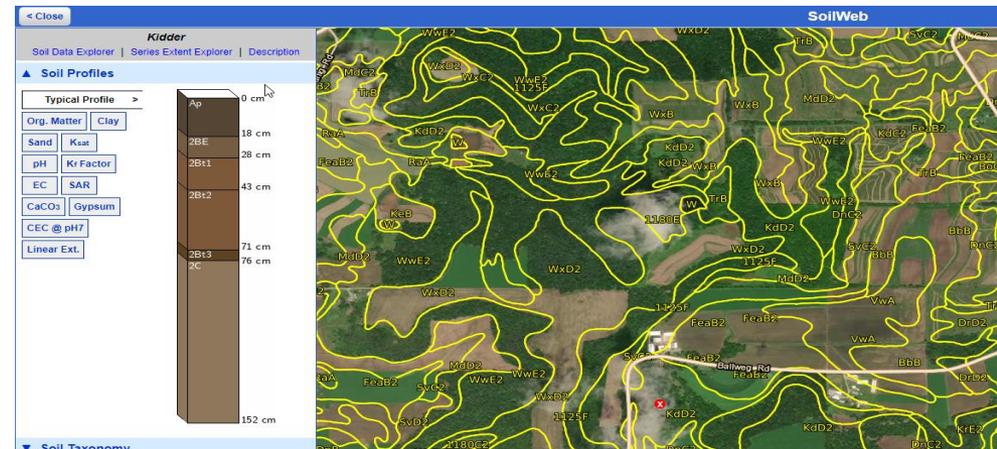
Site features, such as slope gradient and mean annual air temperature

Whole soil properties, such as depth to a restrictive layer or depth to seasonal high water

Individual horizon features, such as clay content, pH, or content of rock fragments

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 ($\mu\text{m/s}$)				
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





Interpretation Style

Types of Interpretations:

Suitability 0 – 1

0 = not suited
1 = highly suited (suitability for roads)

Limitation 0 – 1

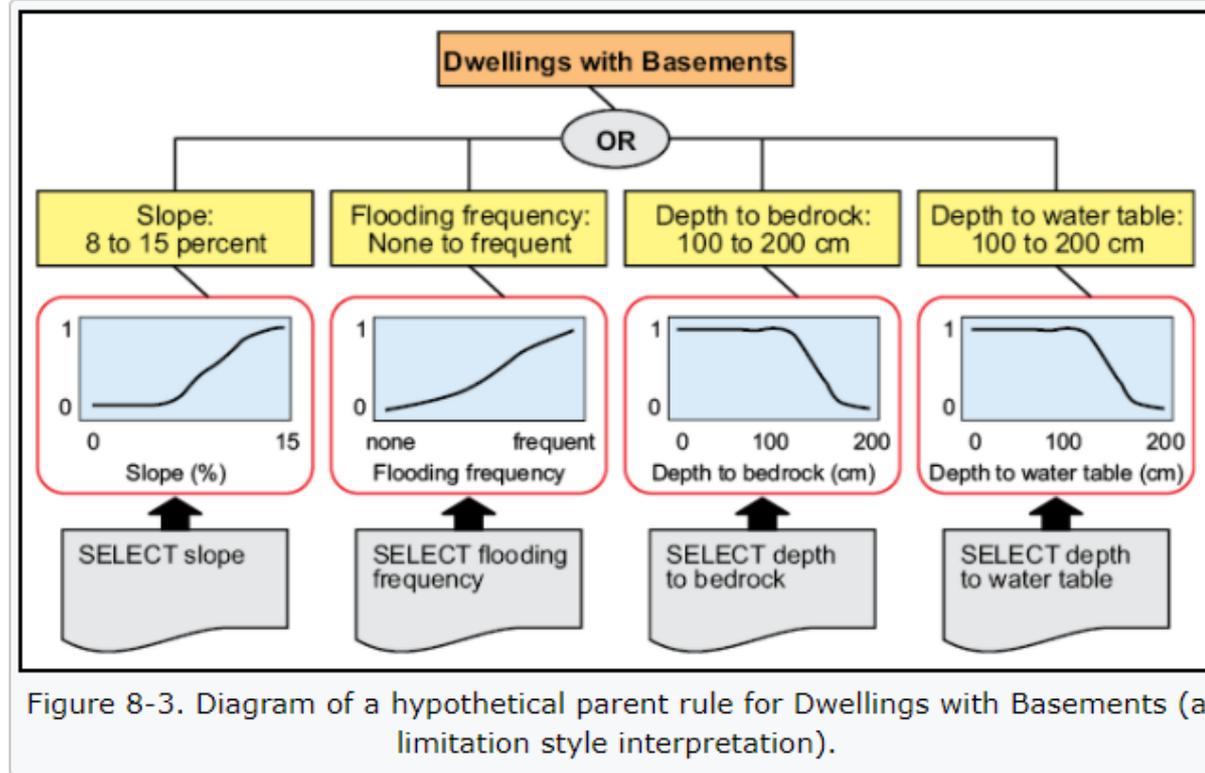
0 = not limited
1 = highly limited (dwellings with basements)

Numeric

- Crop Productivity
- Soil Erodibility Factors

Classes

- Hydrologic Soil Groups
- Drainage Class
- Farmland Classification

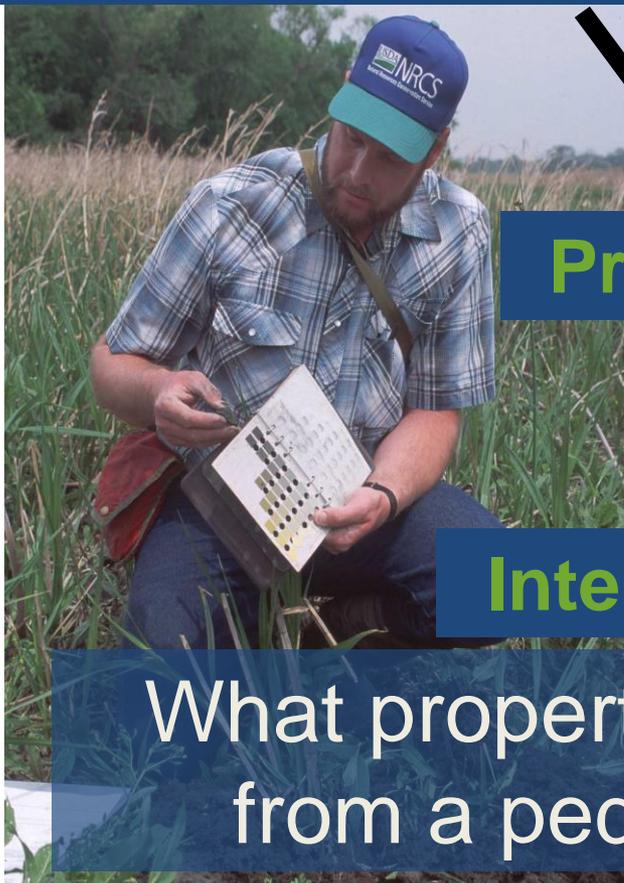


Soil Properties



Pedon Description

Lab Data



Properties

Interpretations

What properties do you extract from a pedon description?



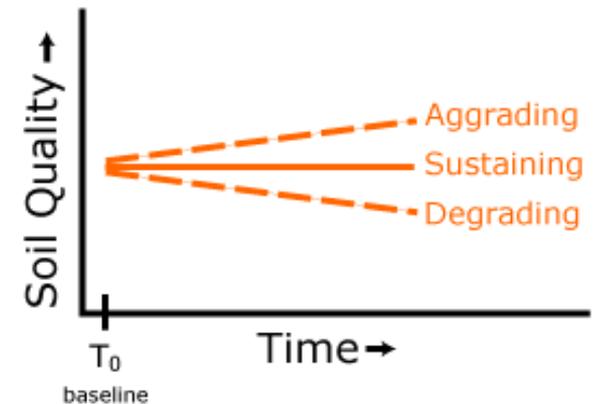
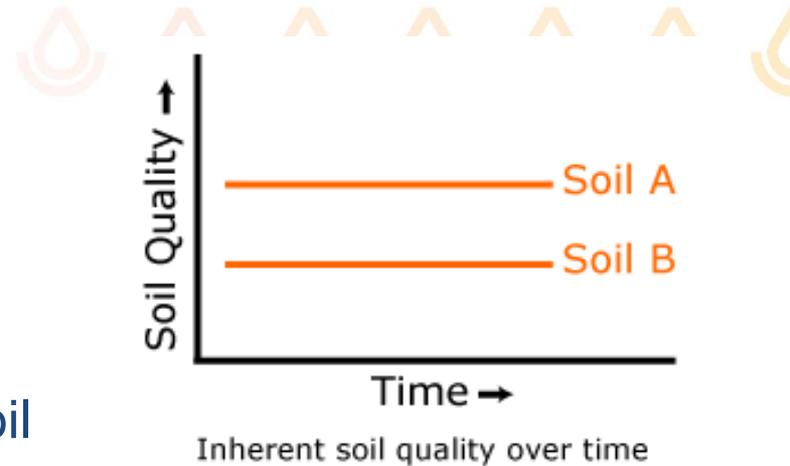
Soil Properties

Inherent Properties:

- Change little, if at all, with land use or management practices.
- Reflects natural characteristics, based on soil forming factors.

Dynamic Properties:

- Properties that change with land use, management, and disturbance over the human time scale (decades to centuries).



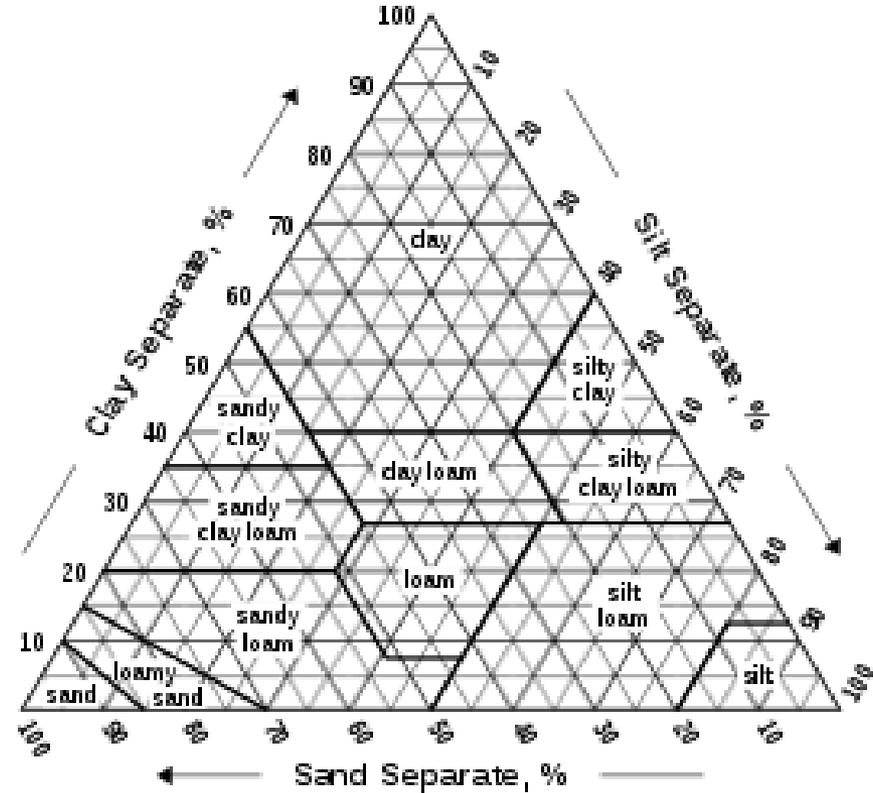
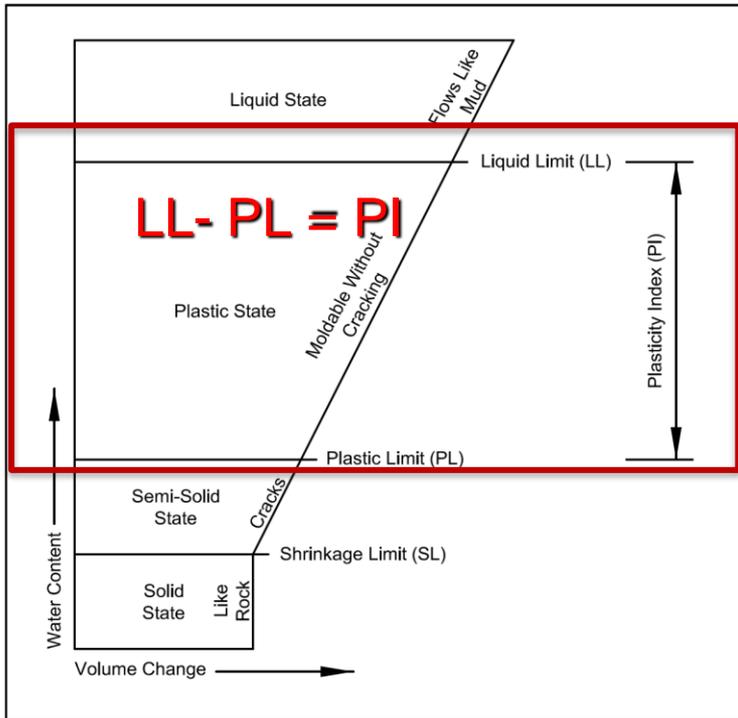
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Soil Properties

Soil Texture: USDA vs USCS



COMPARISON OF PARTICLE SIZE SCALES

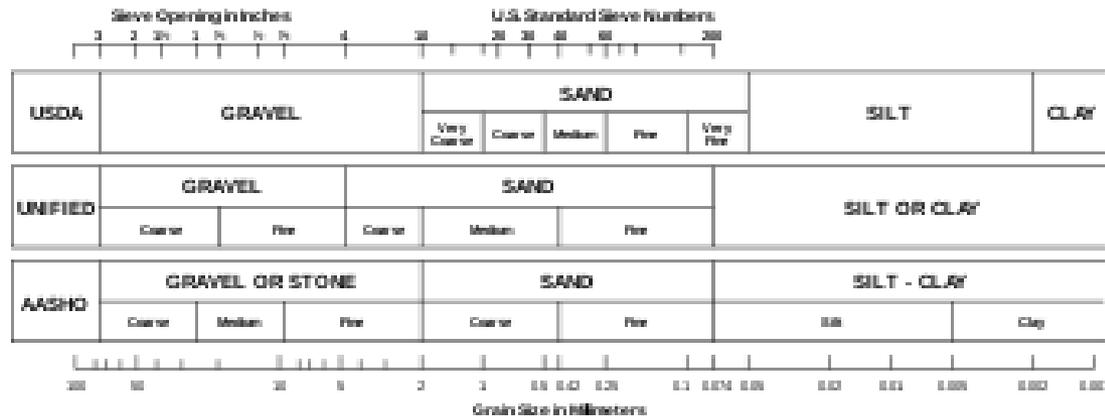


Table 4.1
GENERALIZED INFLUENCE OF SOIL SEPARATES ON SOME PROPERTIES AND BEHAVIOR OF SOILS^a

Rating associated with soil separates

<i>Property/behavior</i>	<i>Sand</i>	<i>Silt</i>	<i>Clay</i>
Water-holding capacity	Low	Medium to high	High
Aeration	Good	Medium	Poor
Drainage rate	High	Slow to medium	Very slow
Soil organic matter level	Low	Medium to high	High to medium
Decomposition of organic matter	Rapid	Moderate	Slow
Warm-up in spring	Rapid	Moderate	Slow
Compactability	Low	Medium	High
Susceptibility to wind erosion	Moderate (high if fine sand)	High	Low
Susceptibility to water erosion	Low (unless fine sand)	High	Low if aggregated, high if not
Shrink–swell potential	Very low	Low	Moderate to very high
Sealing of ponds, dams, and landfills	Poor	Poor	Good
Suitability for tillage after rain	Good	Medium	Poor
Pollutant leaching potential	High	Medium	Low (unless cracked)
Ability to store plant nutrients	Poor	Medium to high	High
Resistance to pH change	Low	Medium	High

^aExceptions to these generalizations do occur, especially as a result of soil structure and clay mineralogy.



Soil Properties

Restrictive Features:

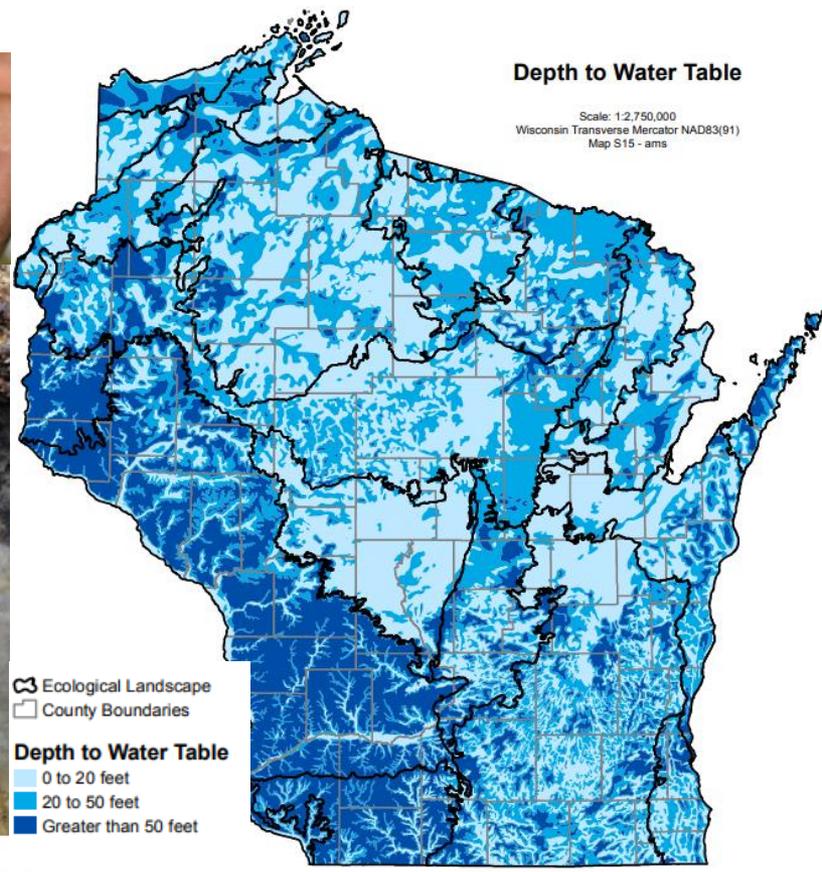
Physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment.



Depth to Bedrock



Water Table and Drainage



Soil Properties

Soil Organic Matter (SOM):

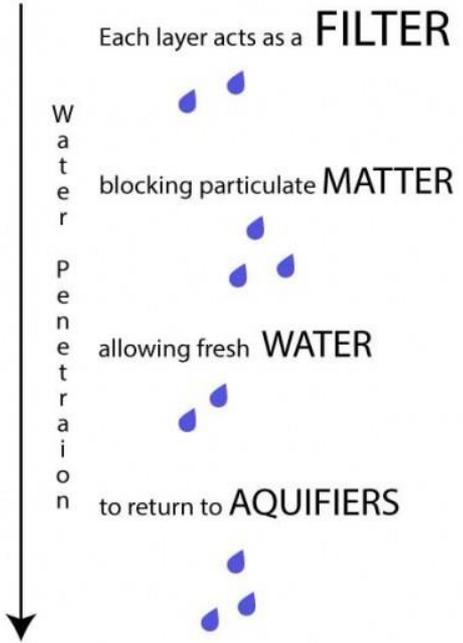
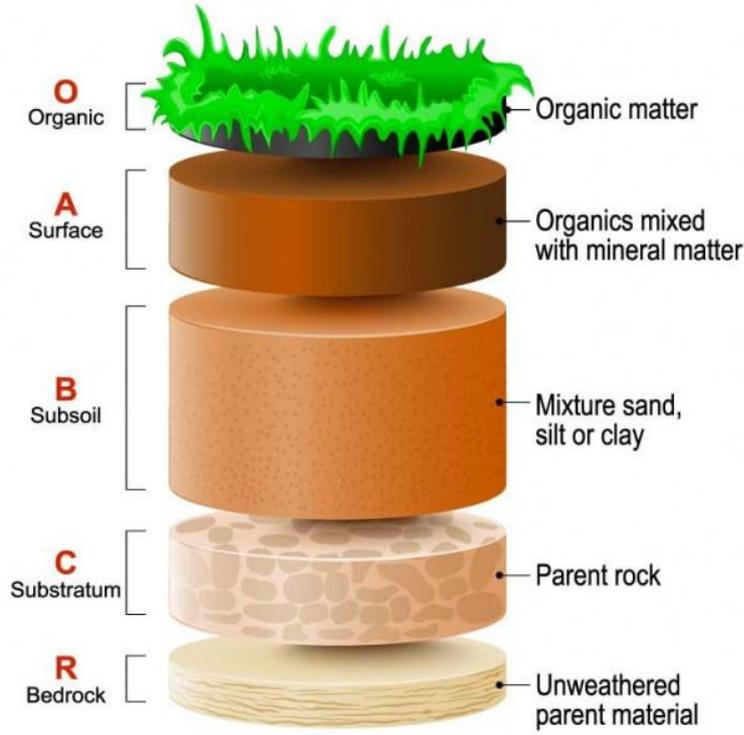
Decomposed plant, animal, and microbial residues



(SavoryInstitute: (L) rotational grazing; (R) Conventional Grains)

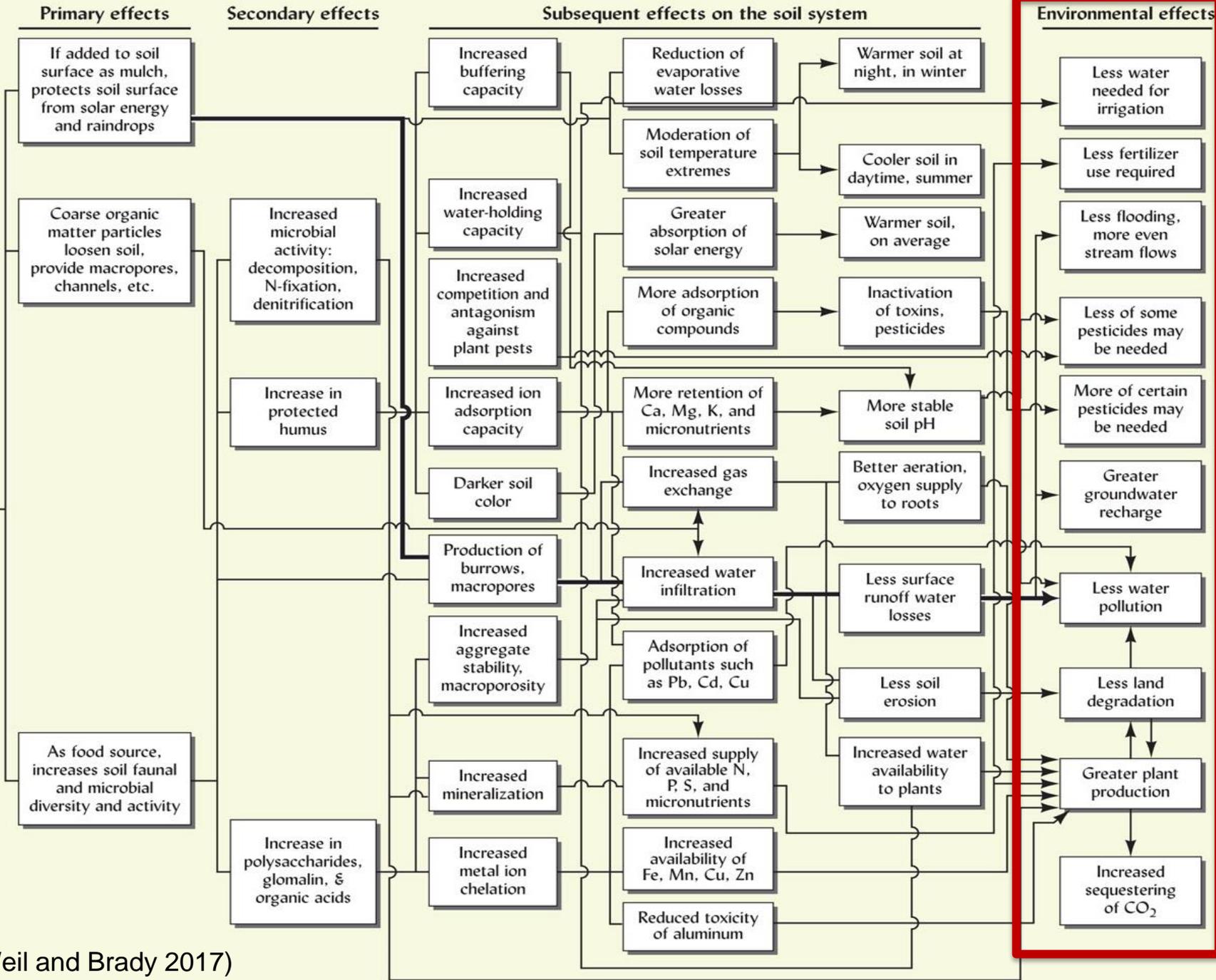


SOIL LAYERS



Organic Matter

Plant and animal residues and wastes added to soil





Soil Properties

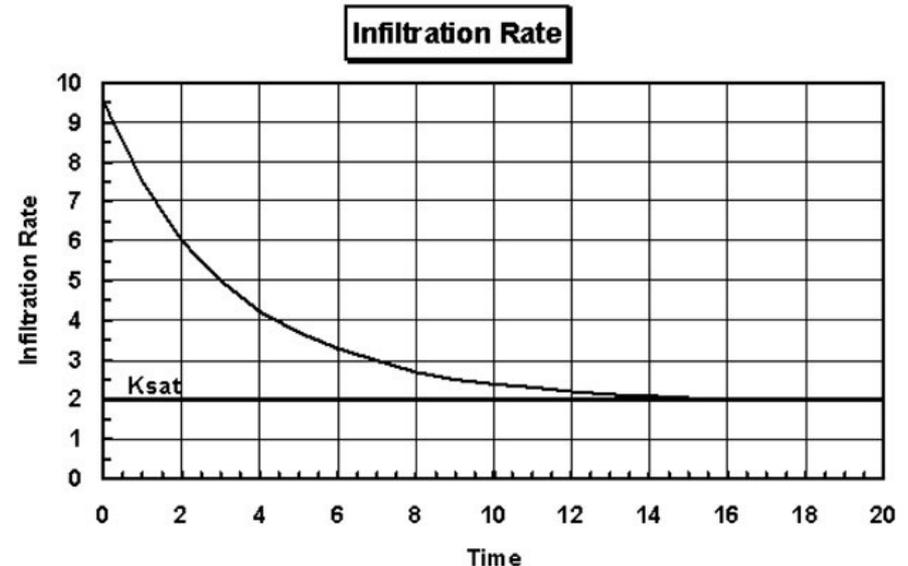
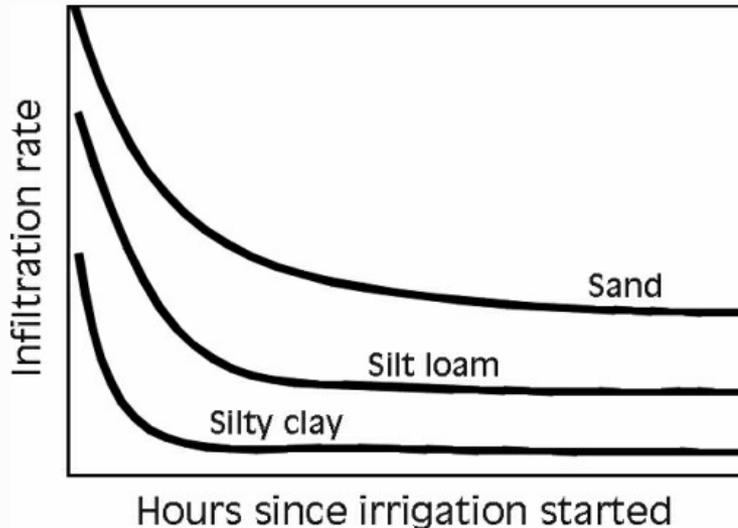
Soil Water Dynamics

Permeability: defined qualitatively as the ease with which gases, liquids, or plant roots penetrate or pass through a soil mass or layer

Infiltration Rate: Speed at which water enters into a soil during rainfall event

Saturated Hydraulic Conductivity (Ksat): Ease at which pores of a saturated soil permit water movement (m/s or in/hr); Used in soil interpretations and based on structure, porosity, texture, consistence

Available Water Capacity: Amount of available soil water that a soil of a given texture will hold (water held between field capacity and the wilting point)



Hydrologic Soil Groups (HSGs)

Groups of soils that have similar runoff potential under similar storm and cover conditions

- A: Low runoff potential
- B: Moderately low runoff potential
- C: Moderately high runoff potential
- D: High runoff potential

A/D, B/D, C/D: high runoff potential unless drained

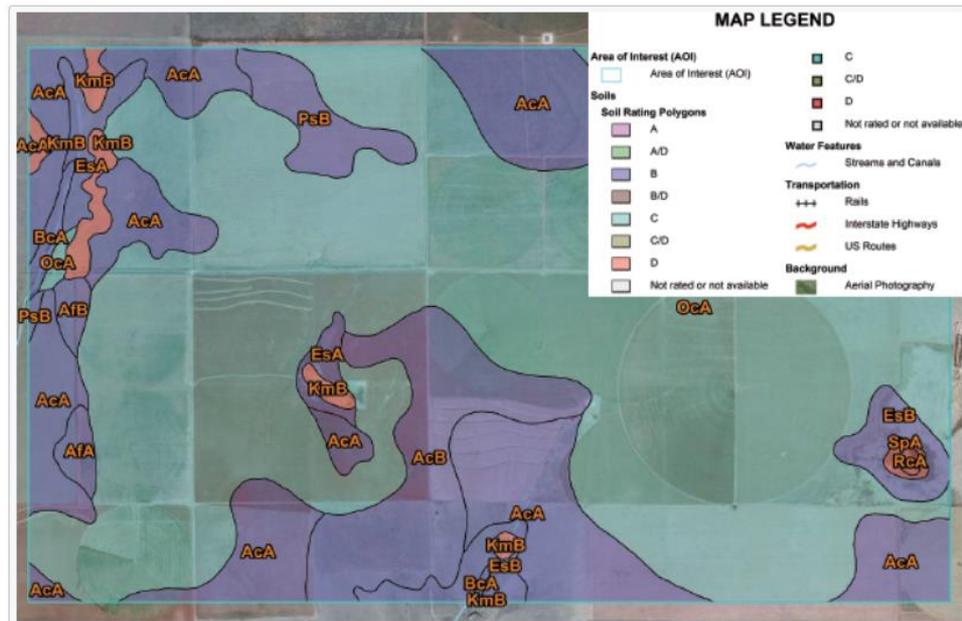


Figure A-5. Map showing hydrologic soil groups. Soils in group A are most permeable and soils in group D least permeable. Dual classes (e.g., C/D) indicate hydrological soil groups for both the drained and undrained conditions.

LA	AB	AC		Curve Numbers for Hydrologic Soil Type			
				A	B	C	D
1	Cover Type	Treatment					
2	RESET TABLE						
3	CULTIVATED AGRICULTURAL LANDS		hydrologic condition				
4	Fallow	Bare soil	----	77	86	91	94
5		Crop residue (CR)	poor	76	85	90	93
6		Crop residue (CR)	good	74	83	88	90
7	Row Crops	Straight row (SR)	poor	72	81	88	91
8		Straight row (SR)	good	67	78	85	89
9		SR + Crop residue	poor	71	80	87	90
10		SR + Crop residue	good	64	75	82	85
11		Contoured (C)	poor	70	79	84	88
12		Contoured (C)	good	65	75	82	86
13		C + Crop residue	poor	69	78	83	87



SOILS INFO

HSGs: Criteria



Saturated Hydraulic Conductivity



Depth to Water Table



Depth to Restrictive Layer



Assumptions:

- Conditions of maximum yearly wetness
- Soil is not frozen
- Bare soil surface
- Maximum swelling of expansive clays.
- Slope is not considered

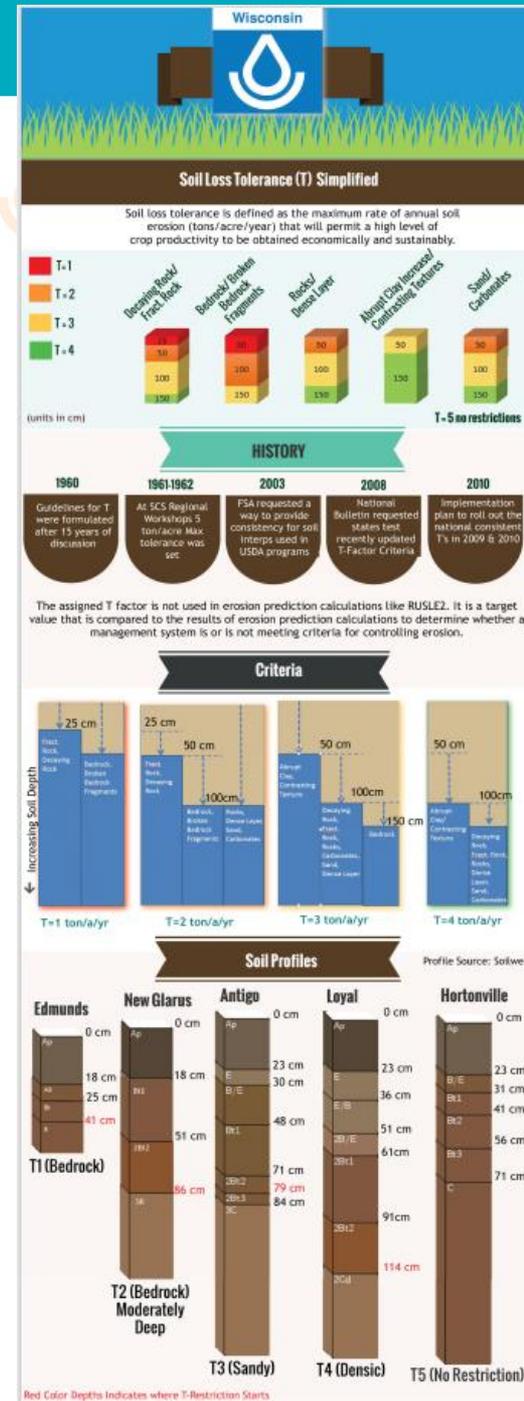


Soil Erosion Factors

K Factor: Susceptibility of soil to sheet and rill erosion by water (0.02 to 0.69)

T Factor: Estimate of the maximum average annual rate of soil erosion that can occur without affecting crop productivity (tons per acre per year)

Wind Erodiability Group (WEG)/Index (WEI): Susceptibility to wind erosion in cultivated areas. (Group 1-8)



Planning Reports

Report — Conservation Planning

Soil properties and interpretations for conservation planning. The surface mineral horizon properties are displayed. Organic surface horizons are not displayed.

Buffalo County, Wisconsin

Map symbol and soil name	Pct. of map unit	Slope RV	USLE Slope Length ft.	Runoff	T Factor	WEI	WEG	Erosion	Drainage	NIRR LCC	Hydrologic Group	Surface					
												Depths in.	Kf Factor	Frag-ments RV	Sand RV	Silt RV	Clay RV
115C2—Seaton silt loam, driftless ridge, 6 to 12 percent slopes, moderately eroded																	
Seaton, driftless ridge	97	9.0	203	—	5	56	5	Class 2	Well drained	3e	B	0 - 9	.49	0	6	77	17
115D2—Seaton silt																	

Report — Engineering Properties

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(<http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba>). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Polk County, Wisconsin

Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			<i>In</i>											
28B—Haugen-Rosholt complex, 2 to 6 percent slopes, very stony														
Haugen, very stony	50	C	0-4	Loam, fine sandy loam, sandy loam	ML, SM	A-2-4, A-4	0- 0- 5	0- 0- 8	77-89-98	76-89-98	58-74-92	29-40-52	20-28-40	1-3 -7

Soil Survey: A tool for exploring soil properties, qualities, and interpretations

The screenshot shows the USDA Soil Data Explorer web application. At the top, there is a navigation bar with links for Contact Us, Subscribe, Archived Soil Surveys, Soil Survey Status, Glossary, Preferences, Link, Logout, and Help. Below this is a secondary navigation bar with buttons for Area of Interest (AOI), Soil Map, Soil Data Explorer (which is highlighted), Download Soils Data, and Shopping Cart (Free). The main content area is titled 'View Soil Information By Use:' and has a dropdown menu set to 'All Uses'. Below this are several tabs: Intro to Soils, Suitabilities and Limitations for Use (which is active), Soil Properties and Qualities, Ecological Sites, and Soil Reports. On the left side, there is a 'Search' panel with a 'Basic Search' section containing an 'Enter keywords' input field and 'Clear' and 'Search' buttons. Below this is an 'Advanced Search' section. Further down is a 'Suitabilities and Limitations Ratings' section with an 'Open All' button and a list of categories such as Building Site Development, Construction Materials, and Land Classifications. The main map area is titled 'Soil Map' and shows a satellite-style map with various soil types labeled with codes like AID, HauC, Ad, MaB, etc. A red arrow points to the 'Enter keywords' input field in the search panel.

So many interps!

Use the search bar!

Ask your local soil scientist for technical assistance





QUESTIONS?