



United States Department of Agriculture

# Sensitivity Analysis for Standard Profile Descriptions

Implications for Soil Taxonomy,  
Interpretations, and Mapping



Natural  
Resources  
Conservation  
Service

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Natural  
Resources  
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# Sensitivity and Uncertainty Analysis

**Sensitivity analysis:** Understand sources of uncertainty

- Applying constraints to inform inferences about a system

**Uncertainty analysis:** Propagation and *quantification* of uncertainty

- "Overview of Soil Survey Database History with Uncertainty implications"
  - [https://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/nrcs142p2\\_050742.pdf](https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_050742.pdf)
- NSSH 618.2.C Collecting, Testing, and Populating Soil Property Data
  - Original proposal to use percentiles for Range in Characteristics  
<https://github.com/ncss-tech/soil-range-in-characteristics>



# Soil Profile Geometry

- Soil descriptions as "emulators of natural variation"

## Geometric Elements

- Location description / coordinates
- Layer top and bottom depths
- Boundaries
- Structure
- Fragments / Artifacts

Soil type	Ninigret tal	Date	8-27-78	Stop No.						
Classification		Area	TOWN of Burrillville							
Location	Harrisville, 7.5 mi N of Roundup Rd	2000 ft	Elev.							
N. veg. (or crop)			Climate							
Parent material										
Physiography	outwash terrace									
Relief		Drainage		Salt or alkali						
Elevation		Gr. water		Stoniness						
Slope	1%	Moisture								
Aspect	WEST	Root distrib.		% Clay *						
Erosion				% Coarse fragments *						
Permeability				% Coarser than V.F.S. *						
Additional notes	Described by Sprankle, Laskay, Ditzler, & Stuart									
SOIL DESCRIPTION	* Control section average				USDA-SCS					
SCS-SOILS-232A REV. 12-70										
Horizon	Depth (in (mm))	Color		Texture	Structure	Consistence			Reaction	Boundary
		Dry	Moist			Capsule Dry Wet	Moist	Wet		
Ap (0-25)		10YR 3/3	fs	lfgr	<2%	fr	few fine fragm	5.4	as	
B21 (25-45)		10YR 6/6	fs	lfgr	<2%	fr	-	5.4	cs	
B22 (45-65)	C2d - 10YR 6/6 C2d - 10YR 5/8	10YR 5/4	fs	lfgr	<2%	fr	-	5.8	cw	
B23 (65-85)	M3d - 10YR 6/6 C2p - 10YR 5/8	10YR 6/3	fs	lfgr	<2%	fr	-	6.0	as	
II C1 (85-100)		10YR 5/4	ls	sg	15%	loose	-	6.0	cs	
II C2 (100-120)	2.5Y 4/4	ls	sg	30%	loose	-	6.0			

Source:

[http://nesoil.com/ri/oldpedons/Ninigret\\_historic.pdf](http://nesoil.com/ri/oldpedons/Ninigret_historic.pdf)

# Discretization of the soil body



# Discretization of the soil body

## Pedons (source: FY2020 SQLite snapshots)

- NASIS Pedon: 2,897,664 horizons in 573,919 NASIS pedons; ~5 layers each
- KSSL/LDM: 410,011 horizons in 65,952 laboratory pedons; ~6.2 layers each

## Components (source: Soil Data Access)

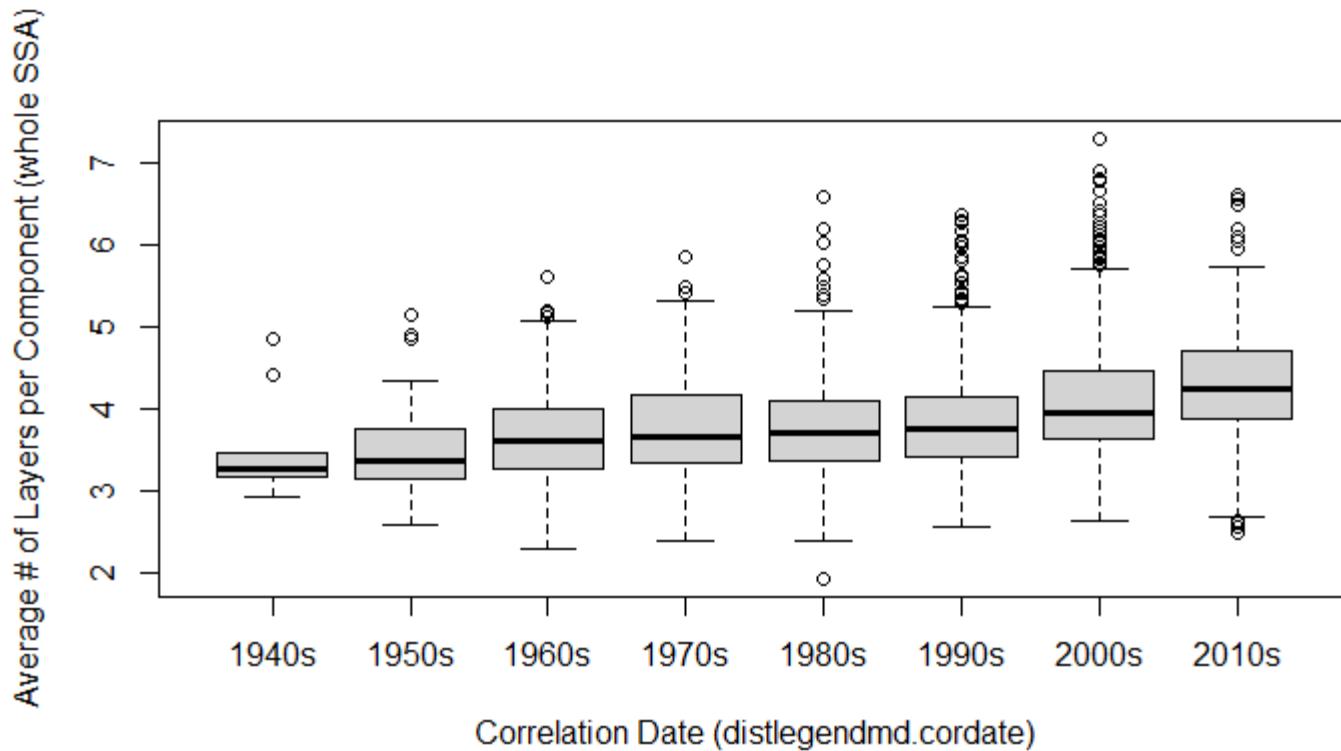
- SSURGO: 3,474,612 horizons in 868,508 components; ~4 layers each
- STATSGO: 333,388 horizons in 102,729 components; ~3.25 layers each

## GlobalSoilMap

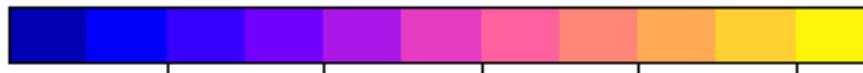
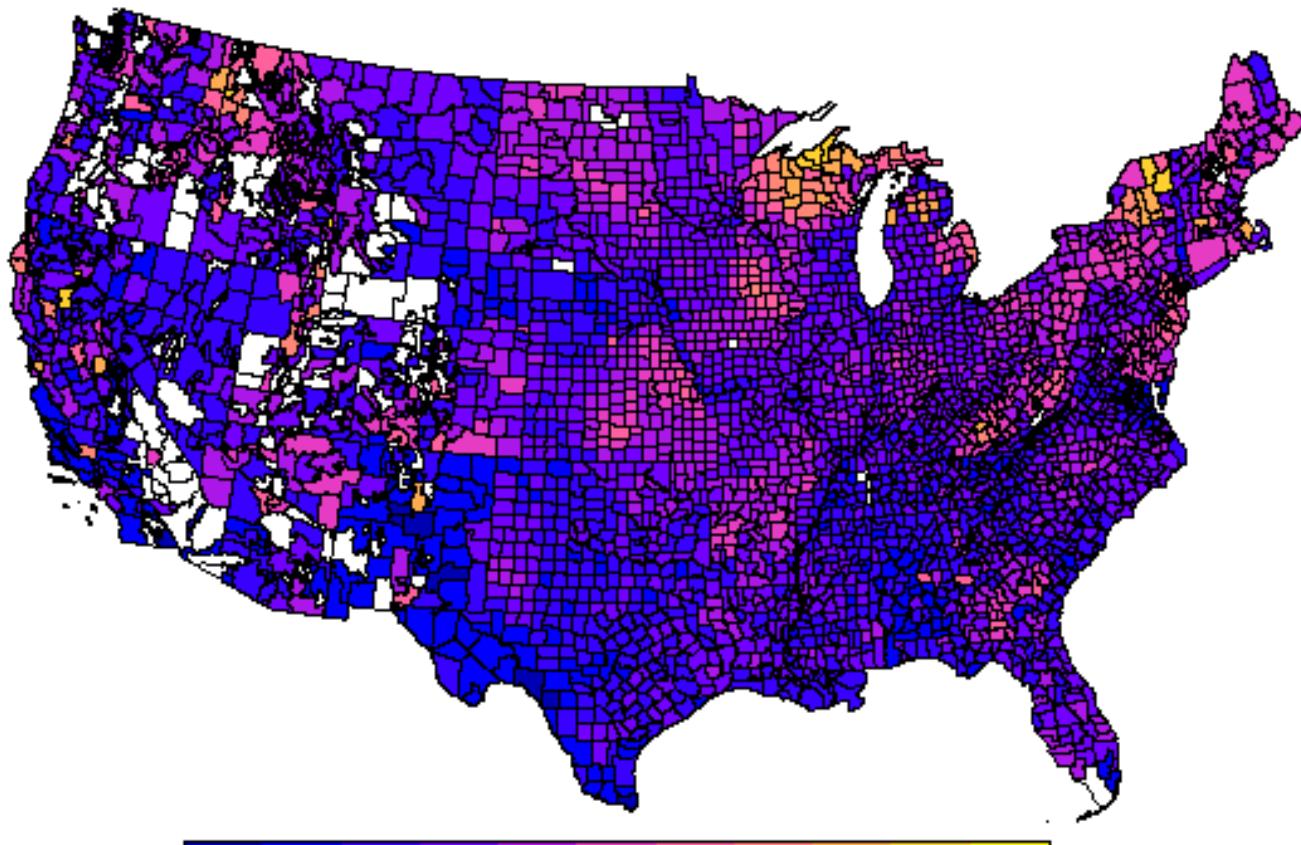
- 6 standard depth intervals:  
0-5 cm, 5-15 cm, 15-30 cm, 30-60 cm, 60-100 cm and 100-200 cm
- [https://www.isric.org/sites/default/files/GlobalSoilMap\\_specifications\\_december\\_2015\\_2.pdf](https://www.isric.org/sites/default/files/GlobalSoilMap_specifications_december_2015_2.pdf)



# Trends in "horizonation" schemes



## Ratio of Component Layers to Components



3

4

5

6

7



# Horizon Boundaries



## Distinctness

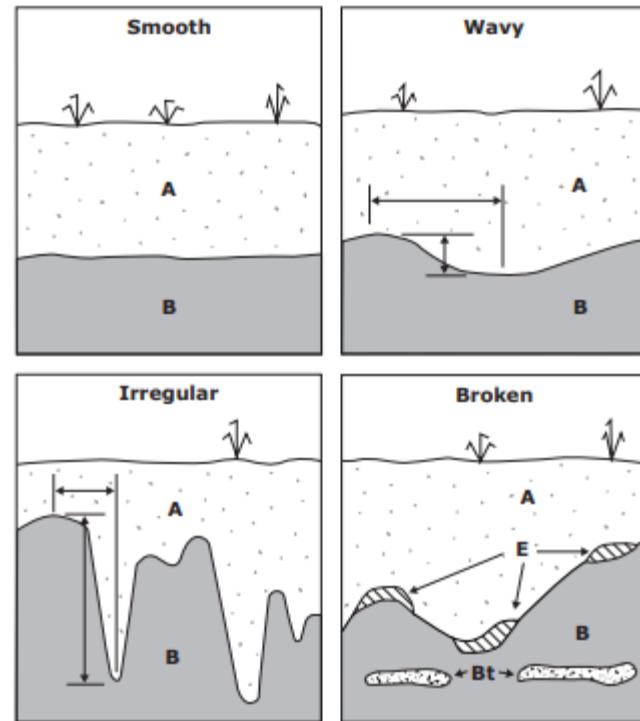
**Distinctness**—The vertical distance (thickness) over which a horizon transitions to the top of the next.

Distinctness Class	Code	Criteria: transitional zone thickness
Very Abrupt	V	< 0.5 cm
Abrupt	A	0.5 to < 2 cm
Clear	C	2 to < 5 cm
Gradual	G	5 to < 15 cm
Diffuse	D	≥ 15 cm

## Topography

**Topography**—Cross-sectional shape of the contact between horizons.

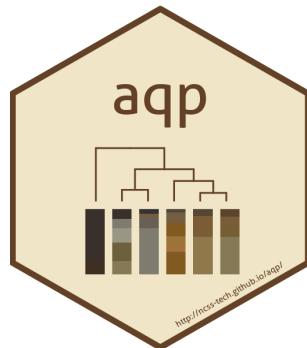
Topography	Code	Criteria
Smooth	S	Planar with few or no irregularities
Wavy	W	Width of undulation is > than depth
Irregular	I	Depth of undulation is > than width
Broken	B	Discontinuous horizons; discrete but intermingled, or irregular pockets



Source: Field Book for Describing and Sampling Soils



# Soil Profile Sketches and Simulation with {aqp} R package



The Algorithms for Quantitative Pedology (AQP) project is a suite of R packages for quantitative analysis of soil profile data.

- "aqp" package provides a vocabulary (functions and data structures)
- "soilDB" package provides interfaces to databases and web services

AQP Website: <http://ncss-tech.github.io/AQP/>

aqp R package on GitHub: <https://github.com/ncss-tech/aqp>

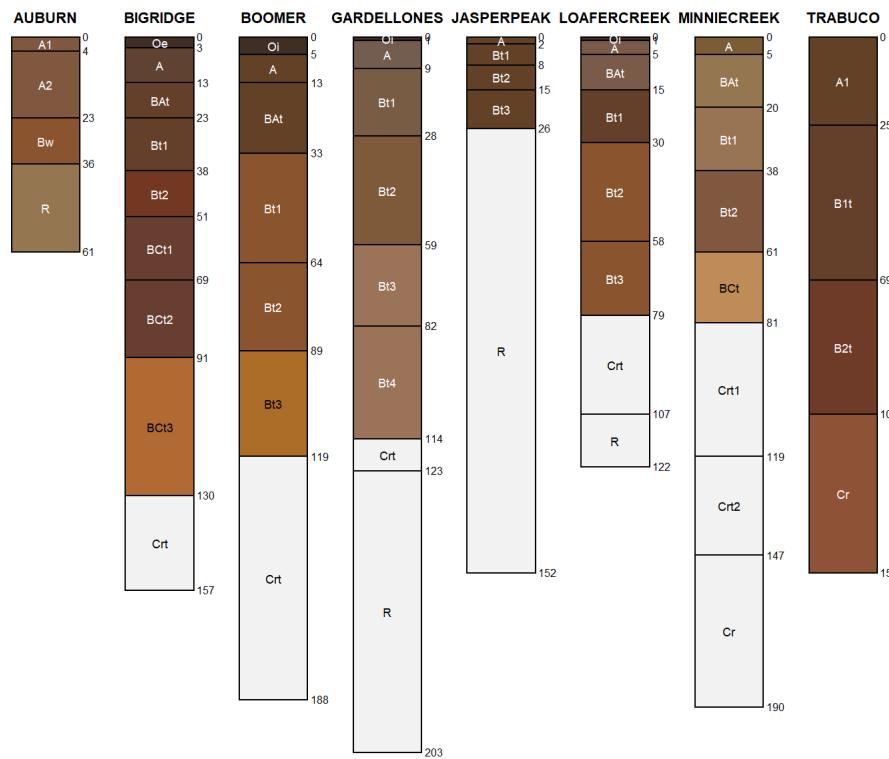
SSSA 2020 Presentations:

<https://github.com/brownag/SSSA2020/>



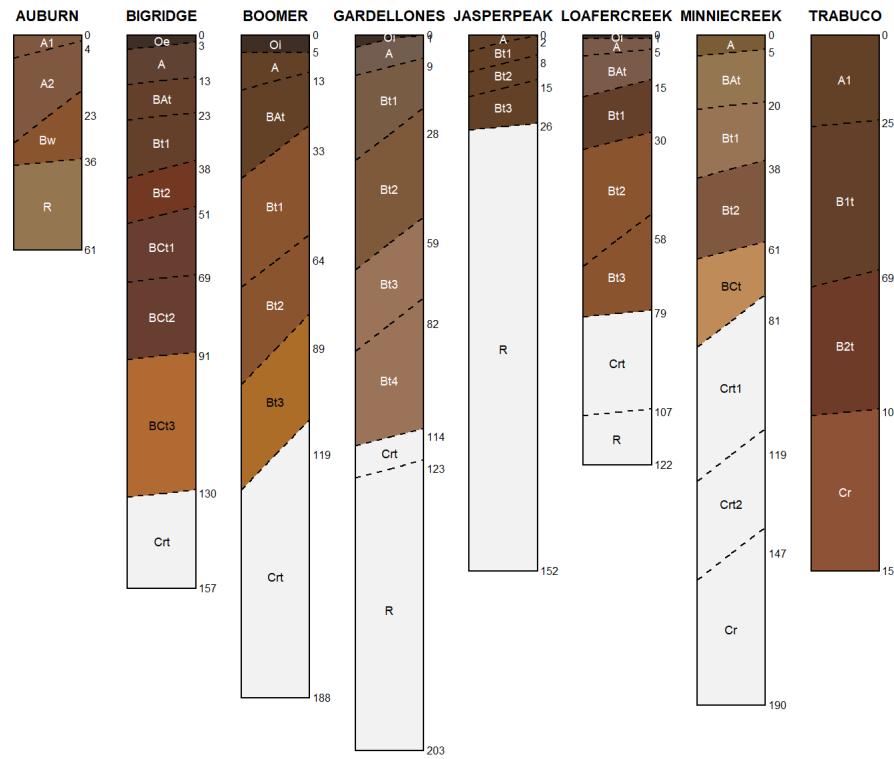
# OSD Profile Sketches

Using representative depths as boundaries



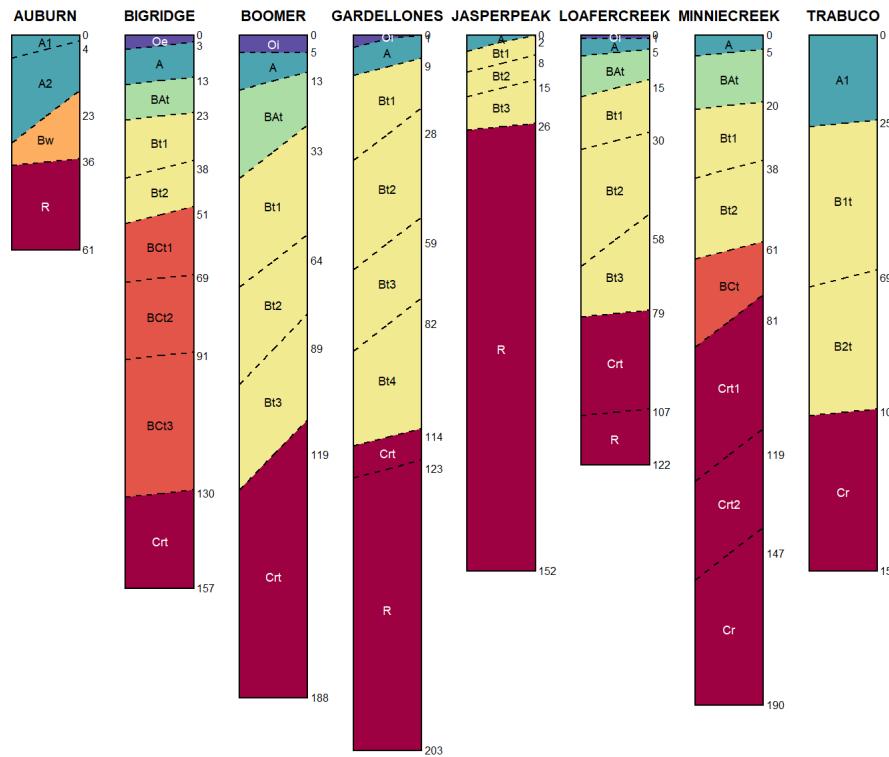
# OSD Profile Sketches + distinctness

Using `aqp :: hzDistinctnessCodeOffset()`



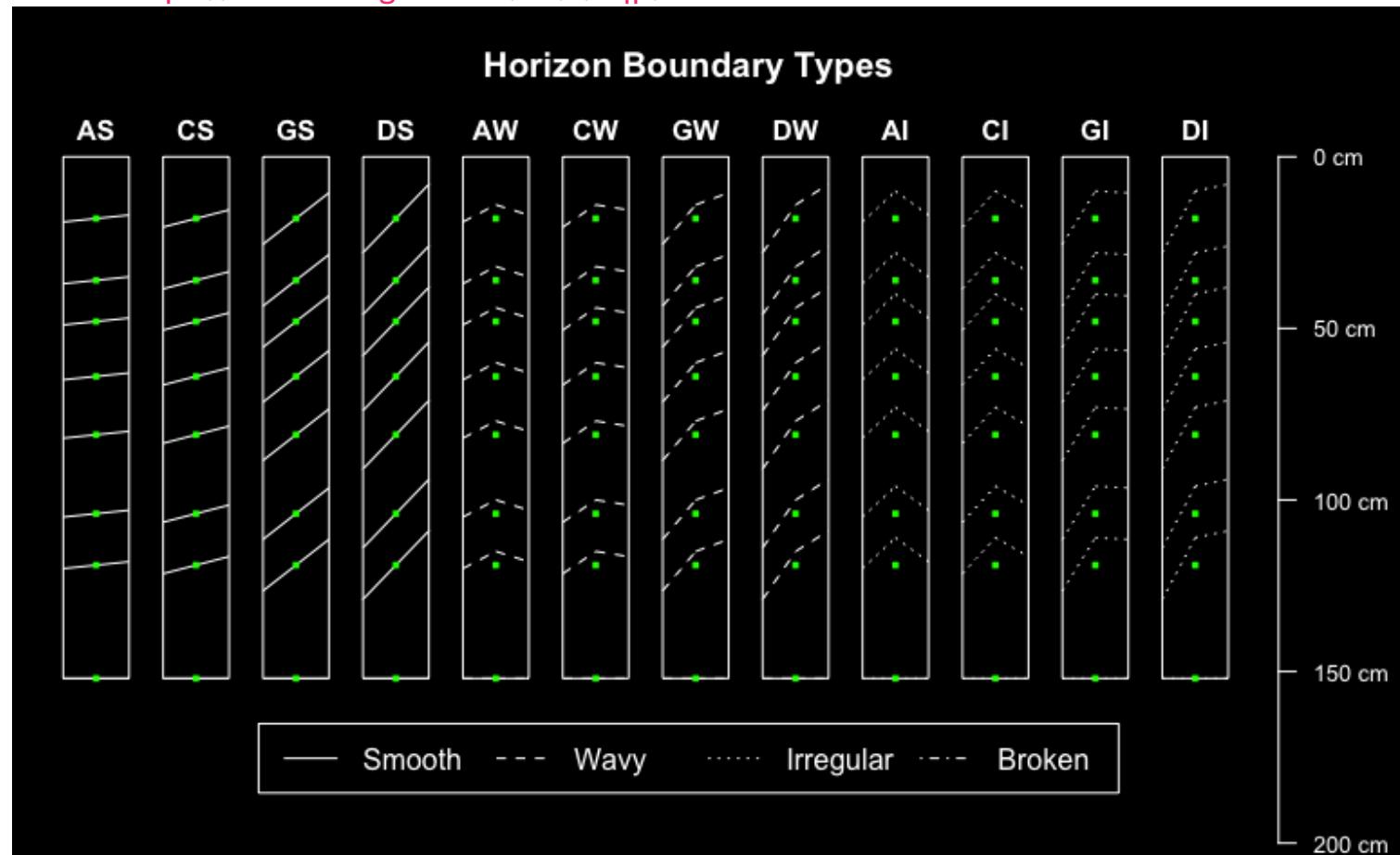
# Generalization of Horizons

Using regular expressions to group similar horizons with `aqp :: generalize.hz()`



# Horizon Boundary Sketches

Source: <https://ncss-tech.github.io/AQP/aqp/hz-boundaries.html>



# Perturbation-based Methods

- `aqp :: perturb()` "Perturbs" the *boundary thickness between horizons* or the *thickness of horizons* using a standard deviation specified as a horizon-level attribute.

By the empirical rule:

- 68% of the boundary/horizon thicknesses within 1 standard deviation of source
- 95% within 2 standard deviations
- 99.7% within 3 standard deviations

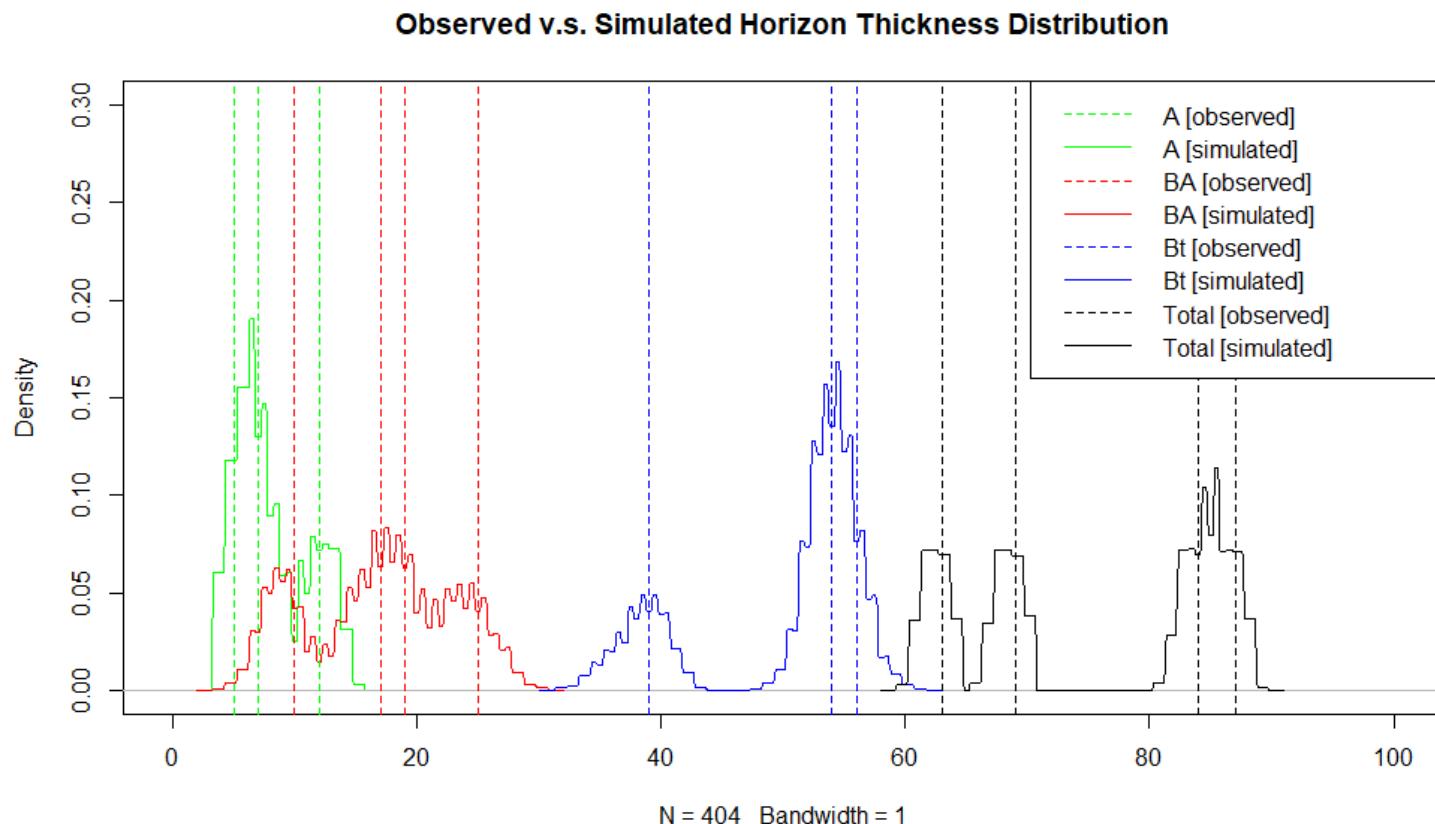
Distributional assumption applies only to the *geometry*. Not horizon or aggregate "site level" properties.

- Documentation: <http://ncss-tech.github.io/aqp/docs/reference/perturb.html>
- Demo: <https://ncss-tech.github.io/AQP/aqp/perturb.html>



# Thickness of Generalized Horizons

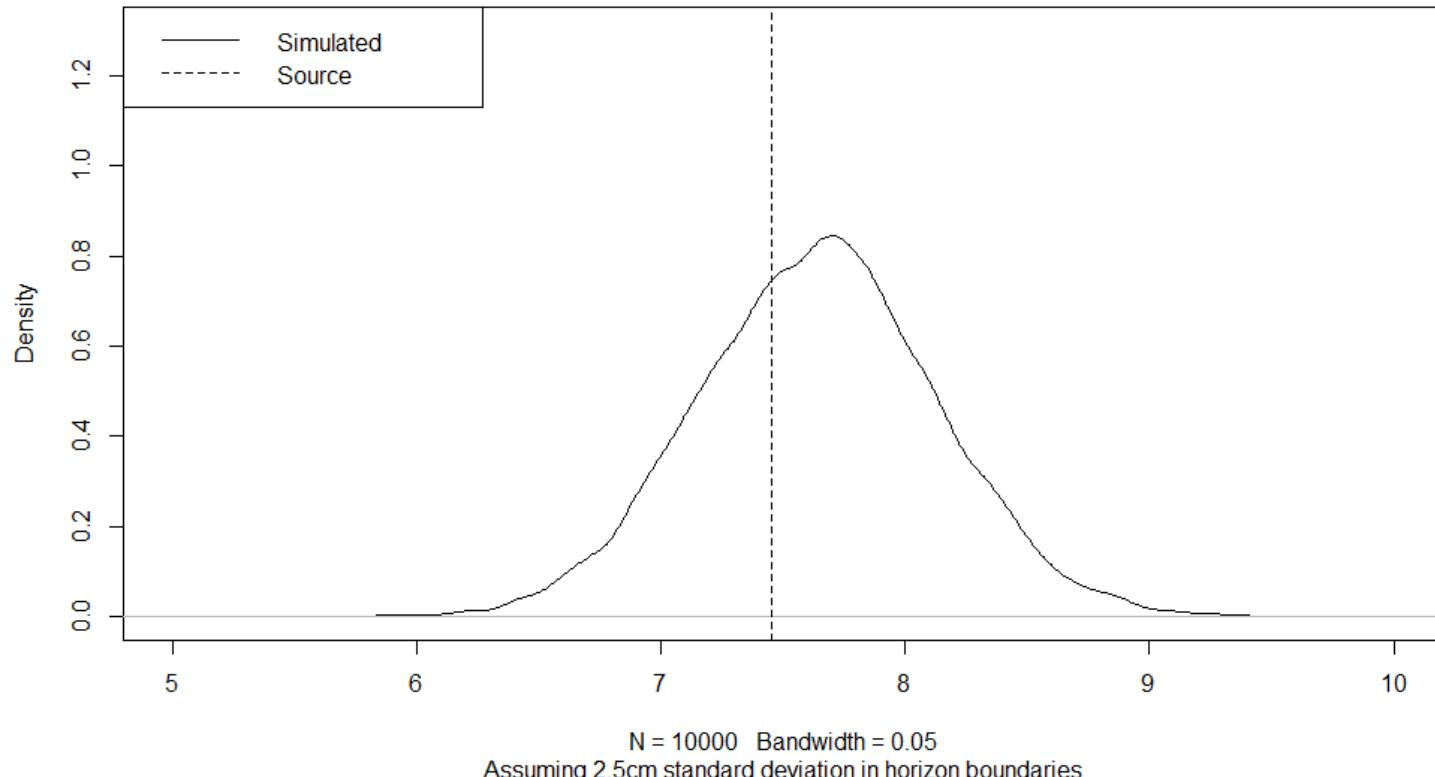
n=1000 realizations for each of 4 profiles ("Minniecreek" full pedons in CA649)



# Organic Carbon Stocks

n=10,000 aggregate carbon stocks; constant 2.5cm standard deviation

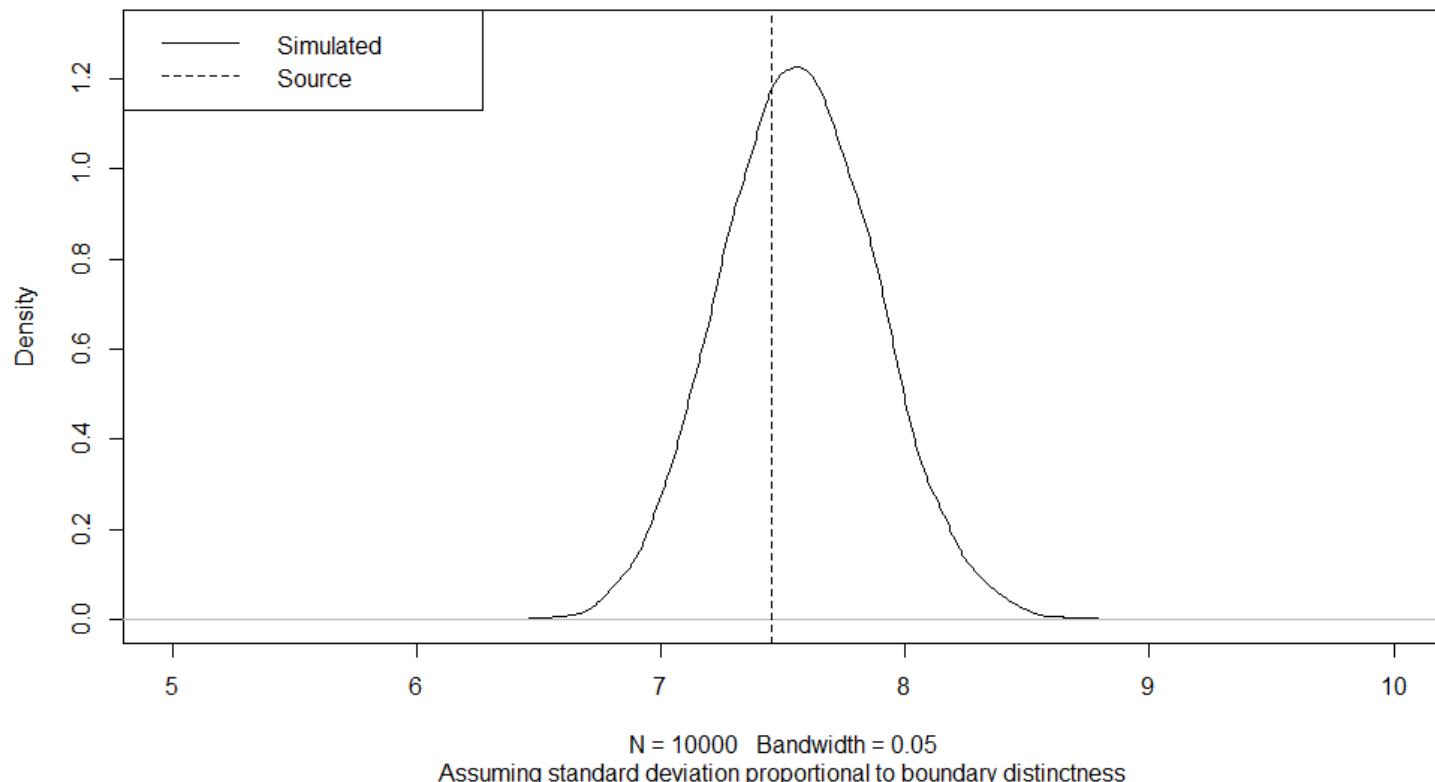
Simulated 0-100cm Organic Carbon Stocks, kg/m<sup>2</sup>  
(S09CA109002)



# Organic Carbon Stocks

n=10,000 aggregate carbon stocks using field horizon boundary distinctness

Simulated 0-100cm Organic Carbon Stocks, kg/m<sup>2</sup>  
(S09CA109002)



# "Problems"



**"Narrow" or disturbed observation methods  
(probe, bucket auger)**

**Irregular and Broken Topography**

**Total Soil Depth**

**Integrating results from multiple pedons ->  
component and series decisions**



# Thank you!



Feel free to contact me with comments/questions/criticism.

We also welcome you to take part in discussions related to {aqp} algorithms and {soilDB} data access methods on the GitHub issues pages:

- <https://github.com/ncss-tech/aqp/issues>
- <https://github.com/ncss-tech/soilDB/issues>

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