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# Sensitivity Analysis for Standard Profile Descriptions


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**Implications for Soil Taxonomy, Interpretations, and Mapping**

**FIELD NOTES WEBINAR - August 2021**

Natural Resources Conservation Service

nrcs.usda.gov/

# 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

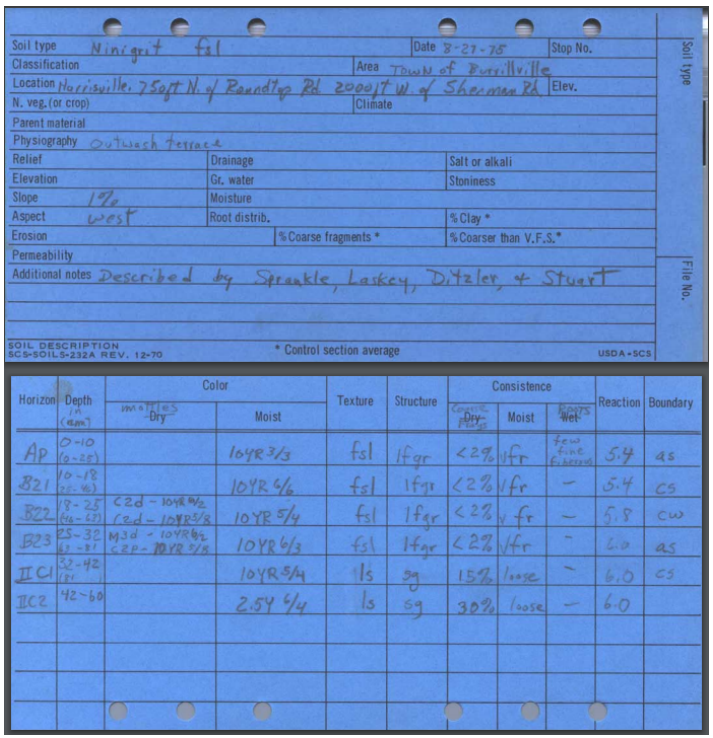
- "Overview of Soil Survey Database History with Uncertainty implications"
  - https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_050742.pdf
- NSSH 618.2.C Collecting, Testing, and Populating Soil Property Data
  - Original proposal to use percentiles for Range in Characteristics https://github.com/ncss-tech/soil-range-in-characteristics

# 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 fsl — Date 8-27-75 — Stop No.
Classification — Area Town of Burrillville
Location Harrisville: 75ft N. of Roundtop Rd 2000ft W. of Sherman Rd — 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 * — % Coarser than V.F.S.*
Permeability
Additional notes Described by Sprankle, Laskey, Ditzler, & Stuart
Soil type / File No.
SOIL DESCRIPTION SCS-SOILS-232A REV. 12-70 — * Control section average — USDA-SCS

| Horizon | Depth (in (cm)) | Color Dry | Color Moist | Texture | Structure | Consistence Dry | Consistence Moist | Consistence Wet | Reaction | Boundary |
|---|---|---|---|---|---|---|---|---|---|---|
| Ap | 0-10 (0-25) | | 10YR 3/3 | fsl | 1fgr | <2% | vfr | few fine F. sticking | 5.4 | as |
| B21 | 10-18 (25-46) | | 10YR 4/6 | fsl | 1fgr | <2% | vfr | – | 5.4 | cs |
| B22 | 18-25 (46-63) | C2d - 10YR 4/2 red - 10YR 5/8 | 10YR 5/4 | fsl | 1fgr | <2% | fr | – | 5.8 | cw |
| B23 | 25-32 (63-81) | M3d - 10YR 6/2 C2p - 10YR 5/8 | 10YR 6/3 | fsl | 1fgr | <2% | vfr | – | 6.0 | as |
| IIC1 | 32-42 (81) | | 10YR 5/4 | ls | sg | 15% | loose | – | 6.0 | cs |
| IIC2 | 42-60 | | 2.5Y 4/4 | ls | sg | 30% | loose | – | 6.0 | |

*Source*:
http://nesoil.com/ri/oldpedons/Ninigret_historic.pdf

# Lumpers v.s. Splitters


# Lumpers v.s. Splitters

**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 layers each

**Components** (source: Soil Data Access)

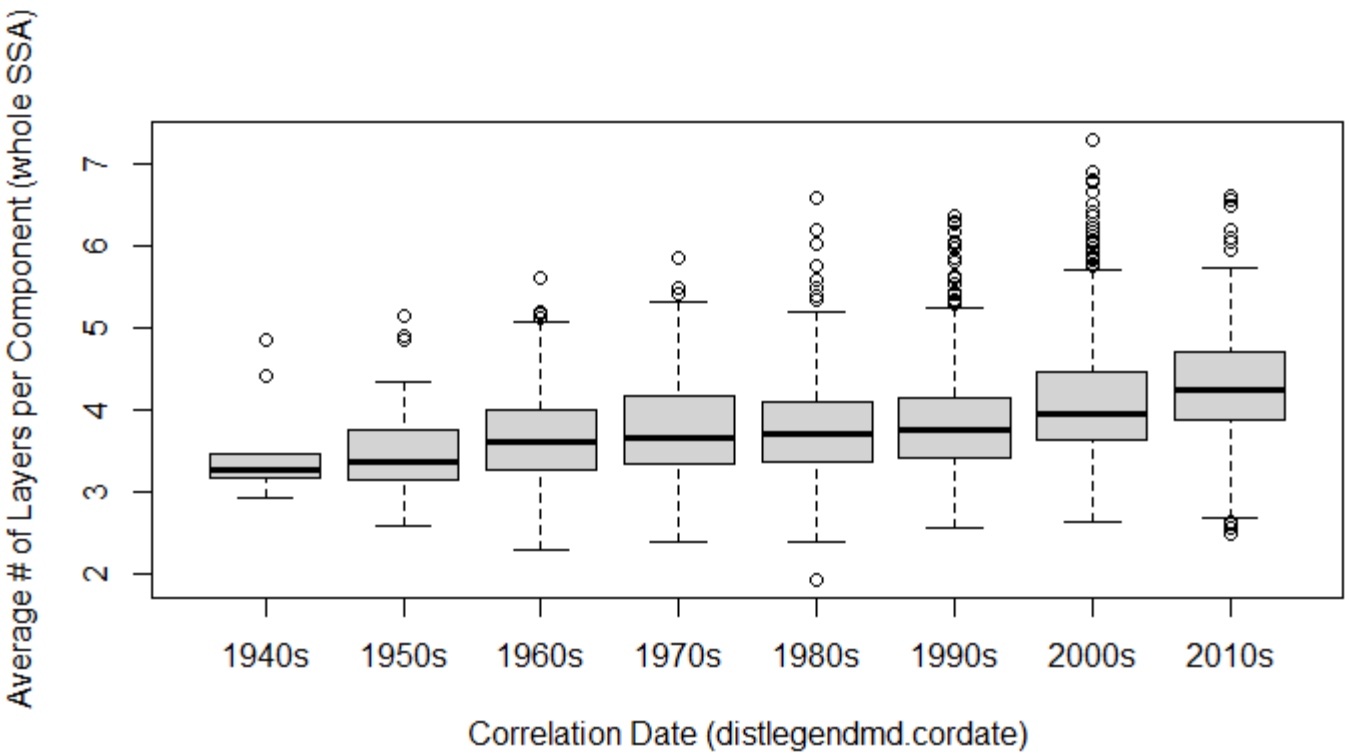
- SSURGO: 3,474,612 horizons in 868,508 components; ~4 layers each
- STATSGO: 333,388 horizons in 102,729 components; ~3 layers each

**GlobalSoilMap**

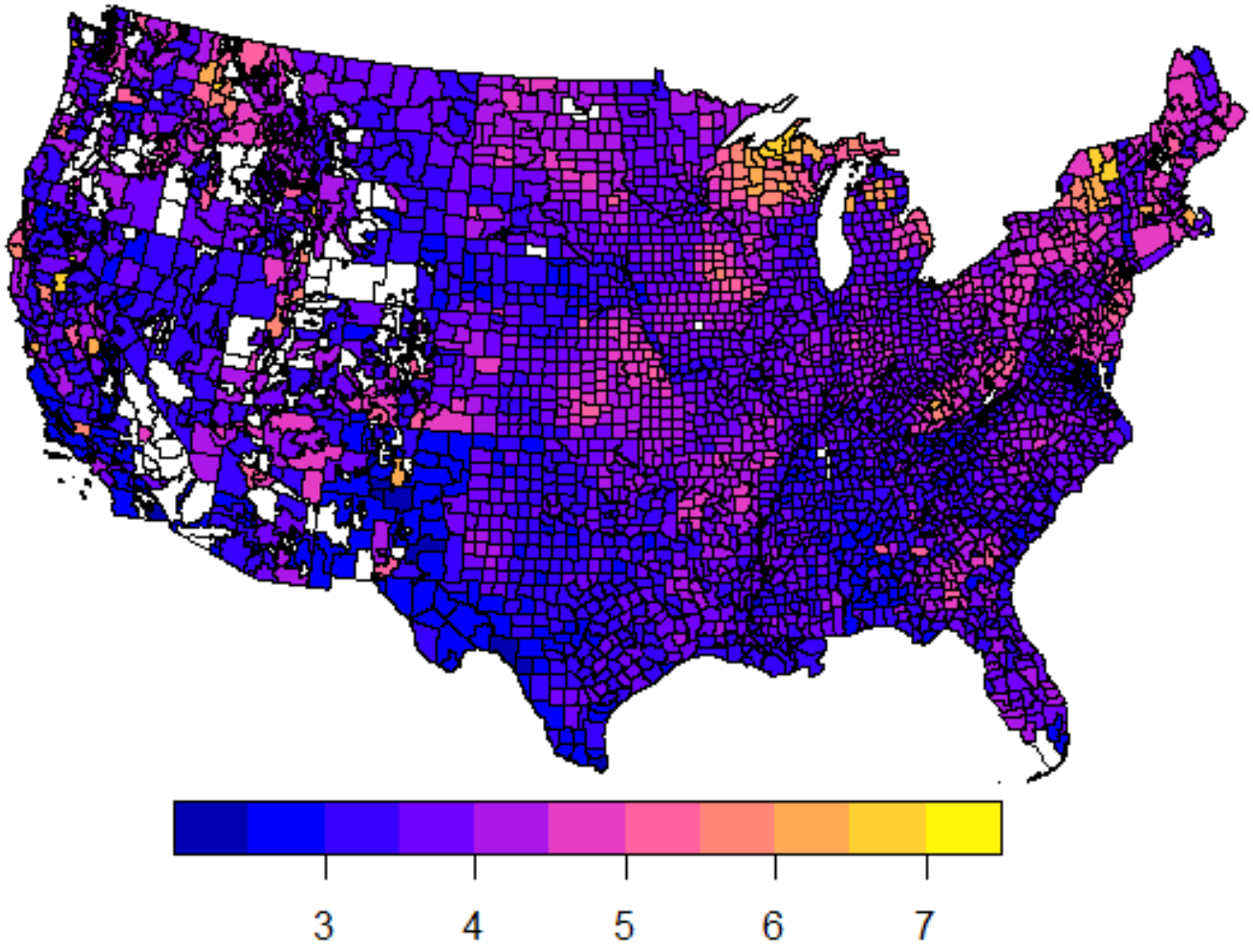
- 6 standard depth intervals:
  0-5 cm, 5-15 cm, 15-30 cm, 30-60 cm, 60-100 cm and 100-200 cm
- https://www.isric.org/sites/default/files/GlobalSoilMap_specifications_december_2015_2.pdf

# Trends in "horizonation" schemes

Average number of layers per component (per SSA), binned by decade (correlation year)



# Ratio of Component Layers to Components



# Horizon Boundaries

## Distinctness

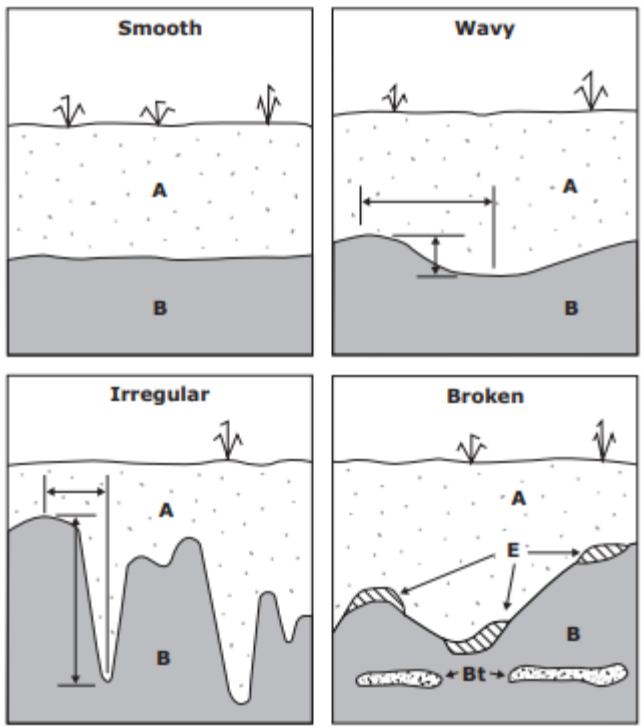
**Distinctness**—The vertical distance (thickness) over which a horizon transitions to the top of the next.

| 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

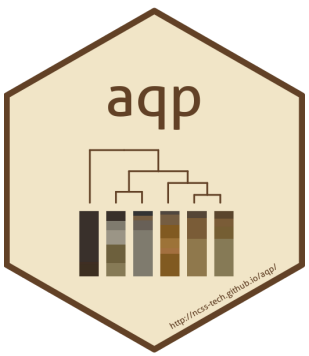
**Topography**—Cross-sectional shape of the contact between horizons.

| 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

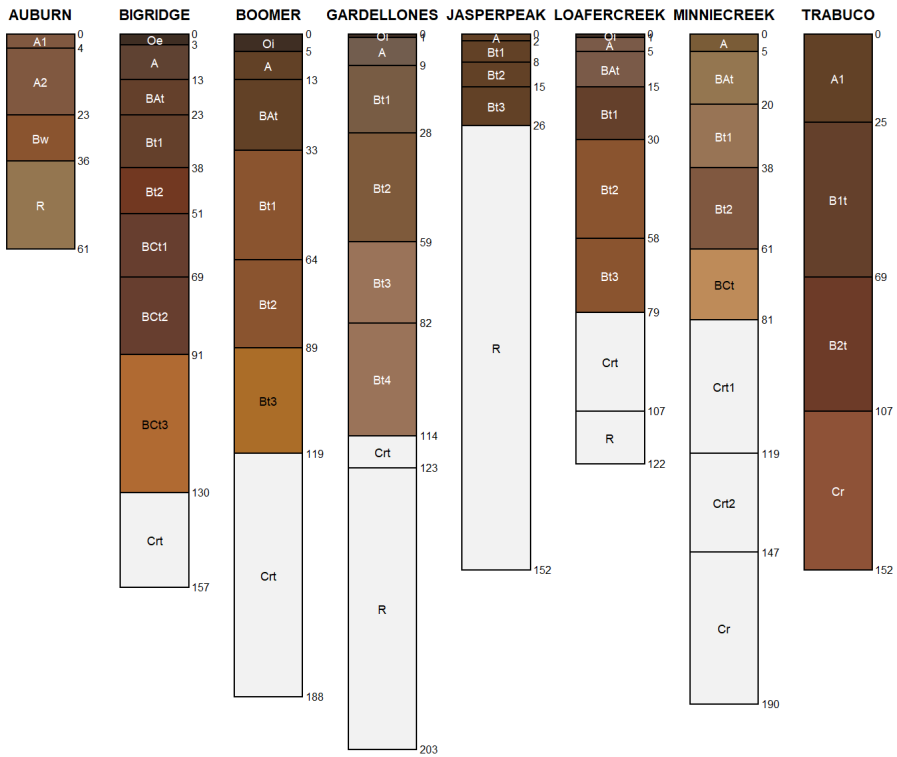
AQP Website: http://ncss-tech.github.io/AQP/

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

SSSA 2020 Presentations:
https://github.com/brownag/SSSA2020/

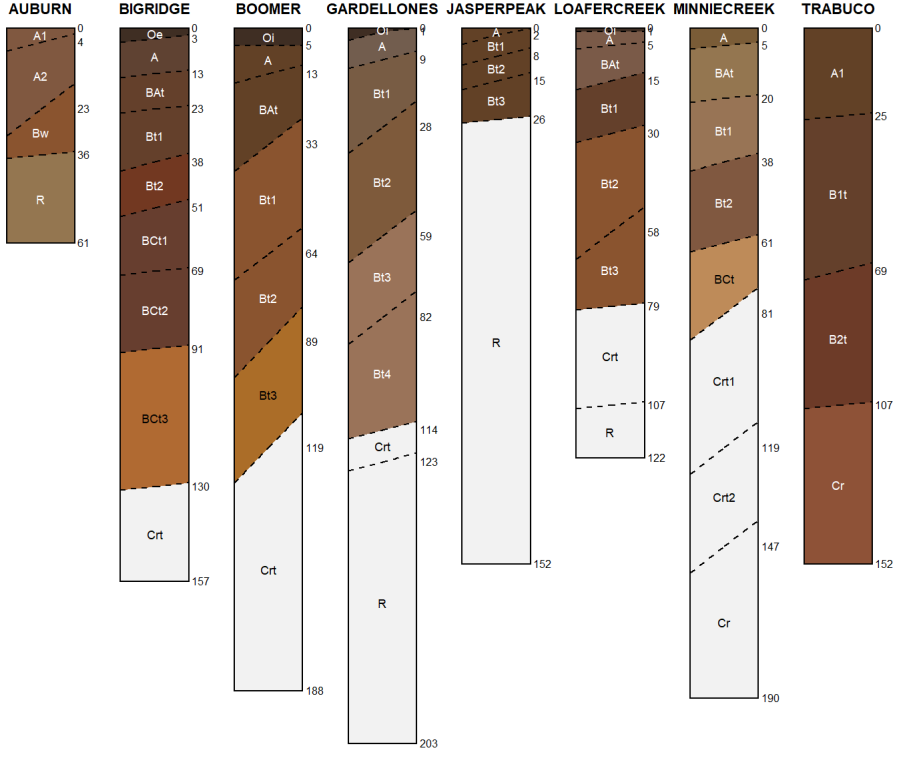
# OSD Profile Sketches

Using representative depths as boundaries



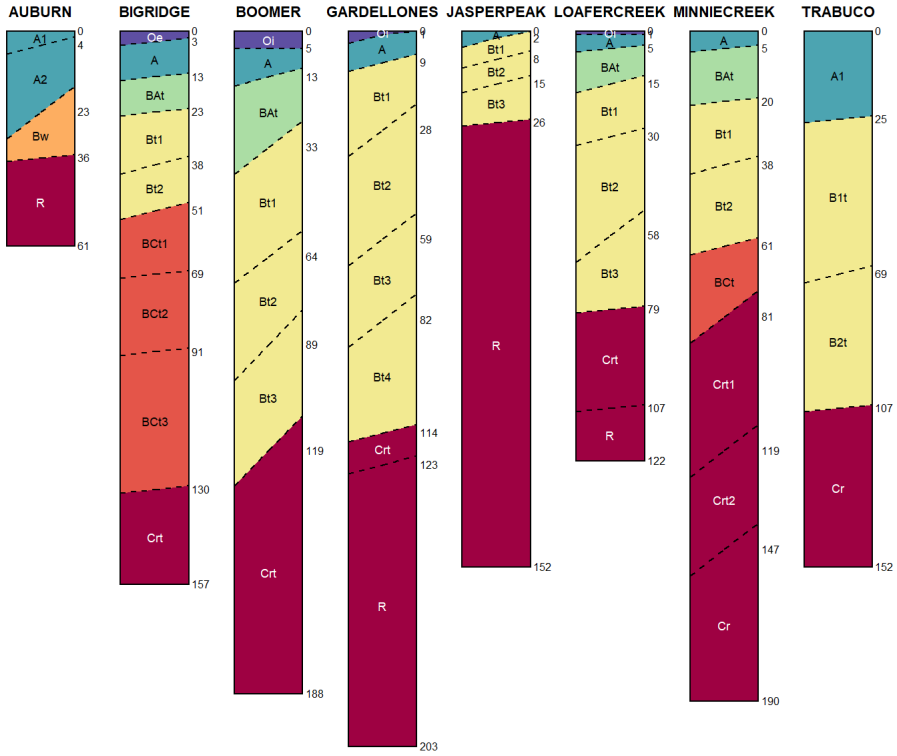
# OSD Profile Sketches + distinctness

Using `aqp::hzDistinctnessCodeOffset()`



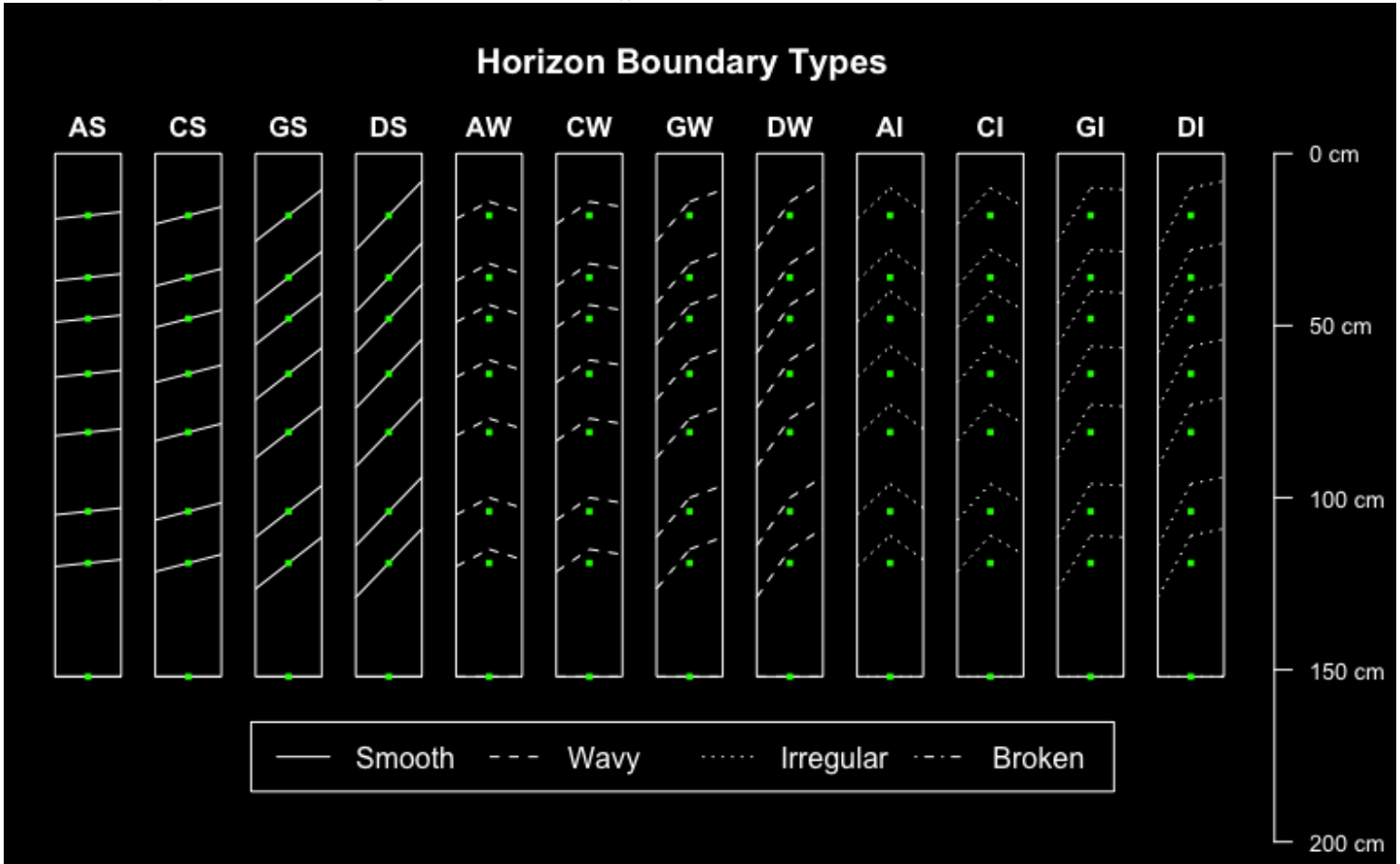
# Generalization of Horizons

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.

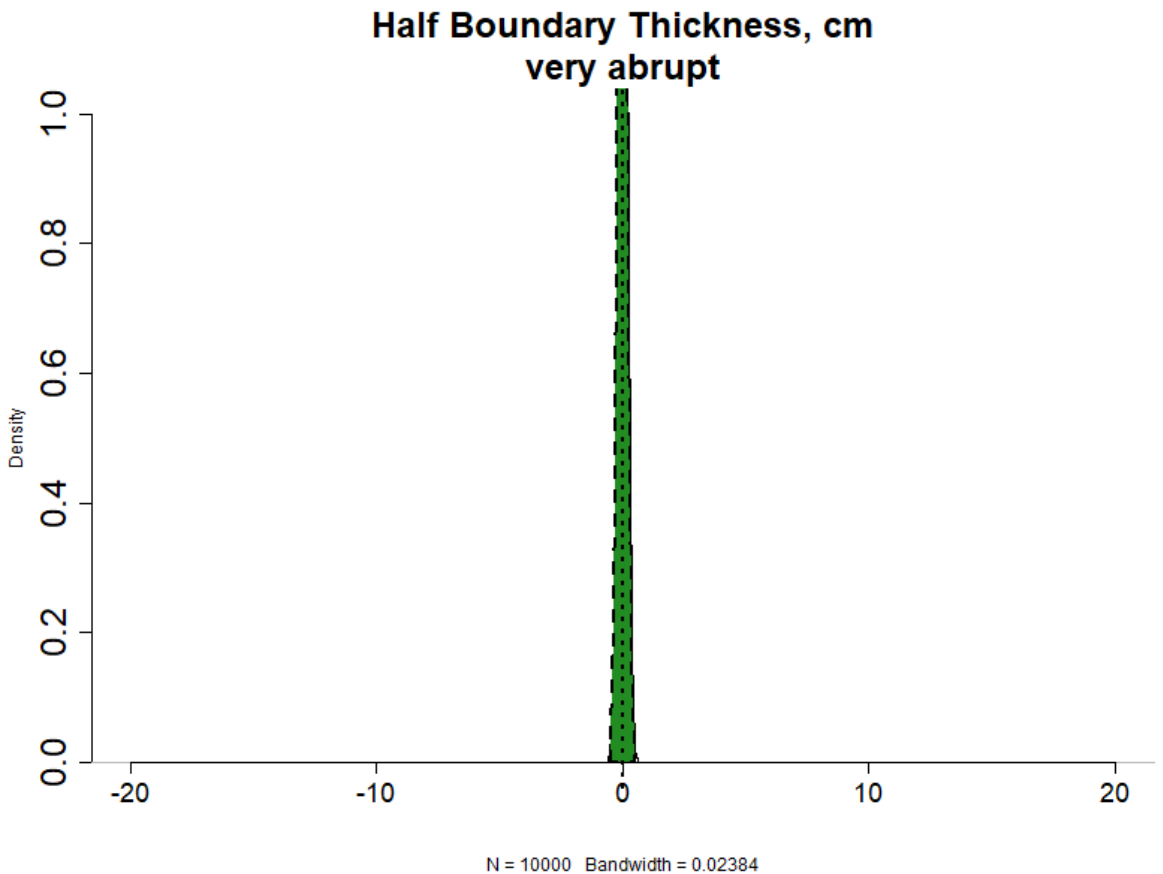
By the empirical rule:

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

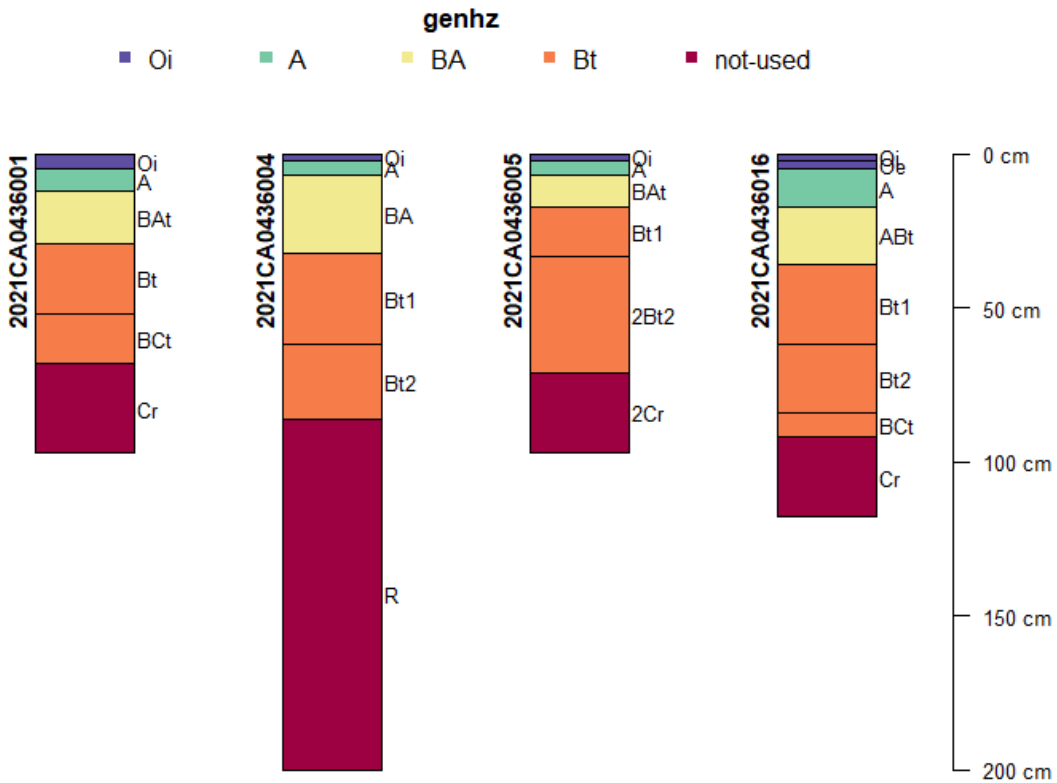
Distributional assumption applies only to the *geometry*. Not horizon or aggregate "site level" properties.

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

# "Normal" Boundaries

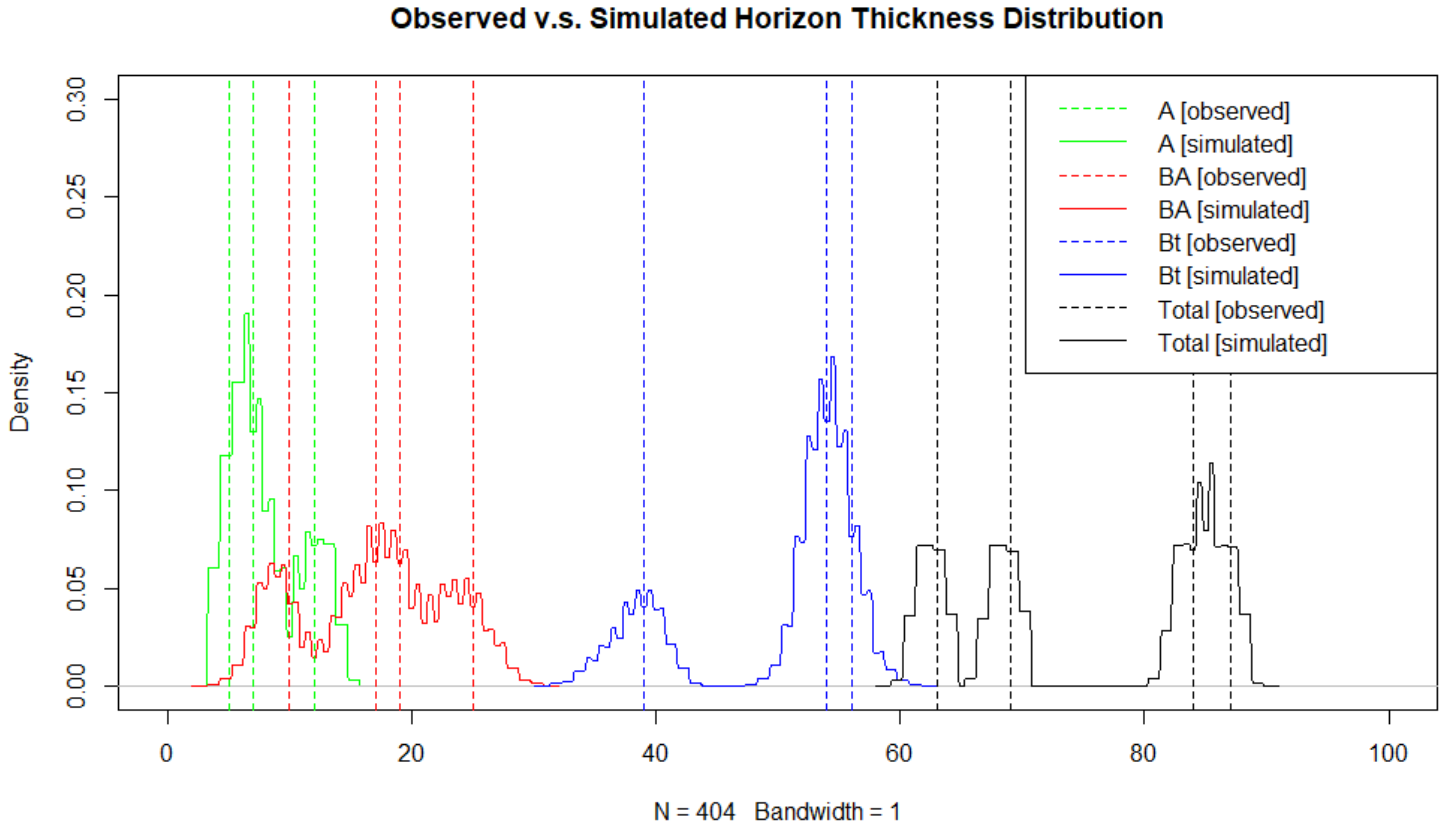


# Minniecreek Generalized Horizons



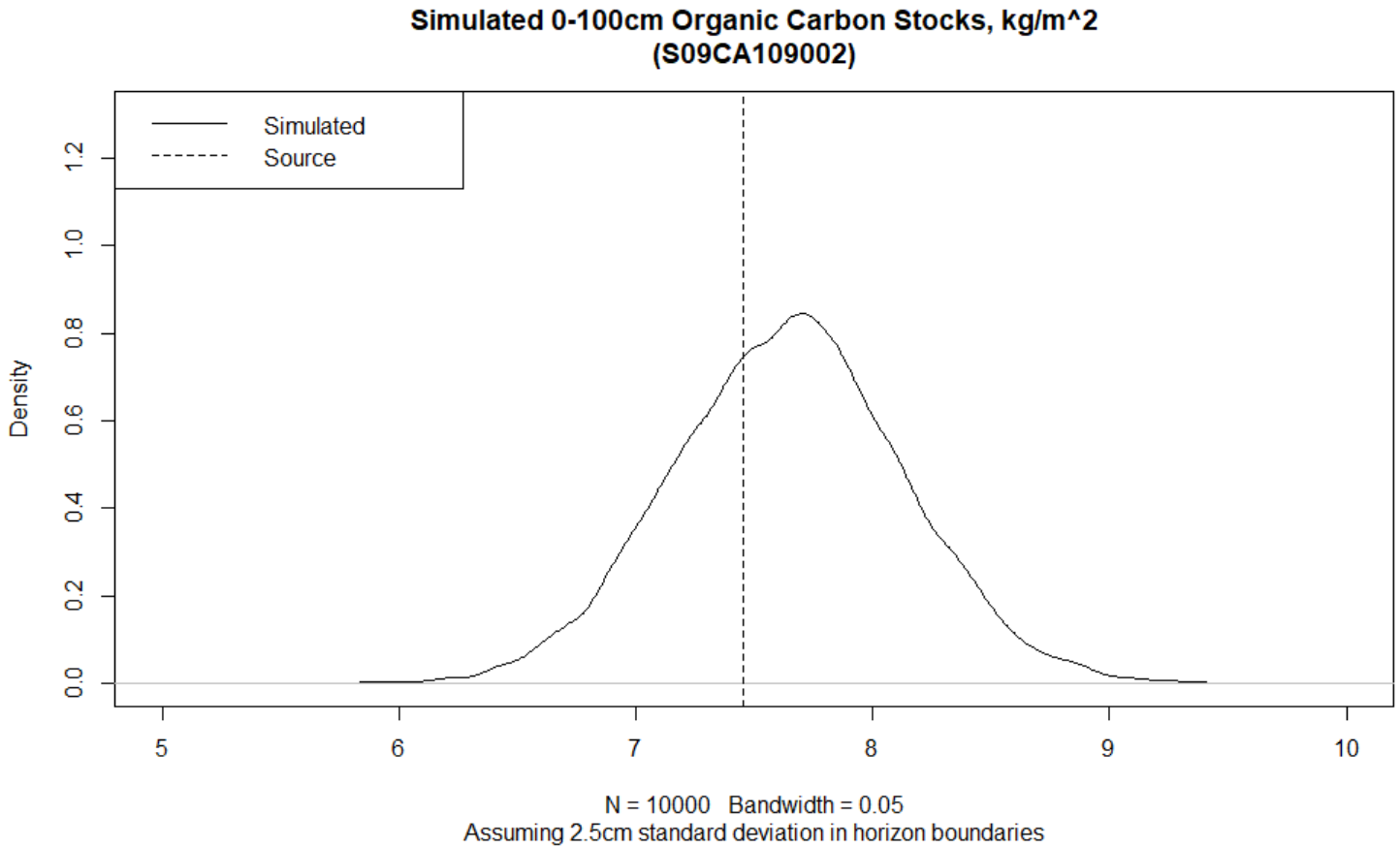
## Thickness of Generalized Horizons

n=100 realizations for each of 4 profiles



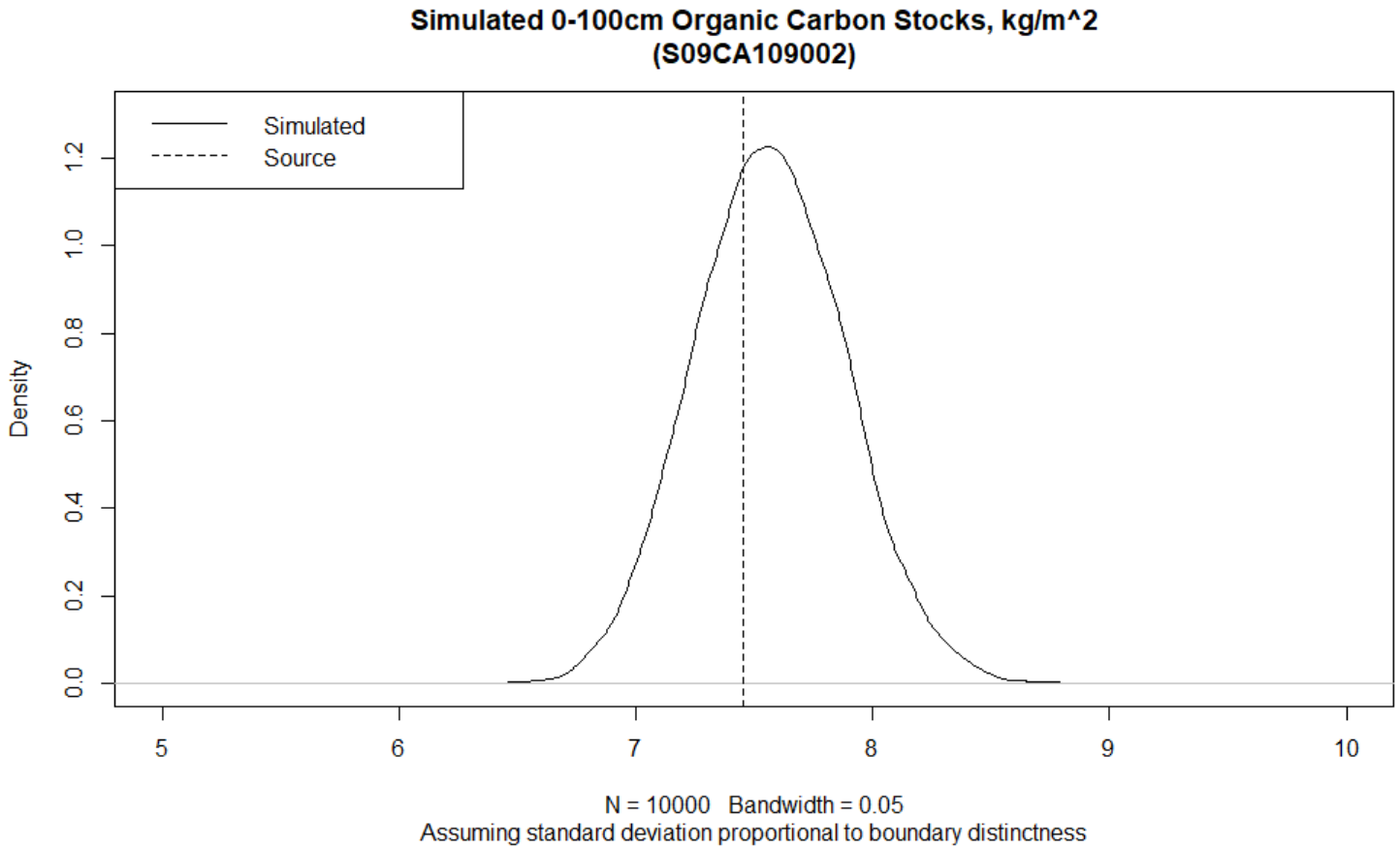
## Example: Organic Carbon Stocks

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



## Example: Organic Carbon Stocks

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



# "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.

Presentation and related materials on GitHub:
https://github.com/brownag/FieldNotes202108

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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