



United States Department of Agriculture

# Quantitative uses of soil color for the development and presentation of soil survey data in the United States

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USDA-NRCS



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# Quantitative use of Soil Color

Supporting the Development and Presentation of Soil Survey Data



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USDA-NRCS

# Acknowledgments & Data Sources

- Dr. A.T. O'Geen: supported early efforts
- Dr. Skye Wills, Drew Kinney, Dr. Cynthia Stiles
- R color conversion (grDevices, farver, colorspace)
- aqp package contributors
- Scott Burns: subtractive color mixing strategies
- Paul Centore: Munsell reference spectra
- 100+ years of soil survey efforts
- Curation of 24,000+ Official Series Descriptions
- ~ 95,000 field observations linked to MU components
- gNATSGO, detailed + general soil survey of the U.S.A.



Photo D.E. Beaudette

# Soil Survey Development

- Conversion of Munsell → CIELAB, sRGB, etc.
- Soil color contrast (comparisons)
- Soil color mixtures (simulated)
- Soil color aggregation, central tendency or representative range (RIC)
- Soil color signatures and search system

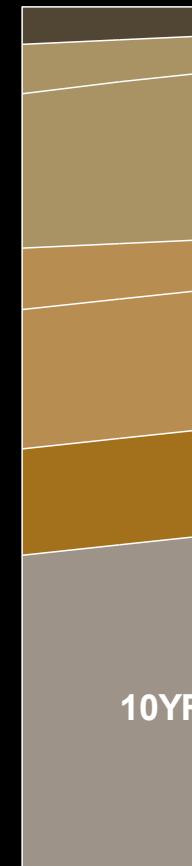
Soil color is a convenient integrator of process/properties



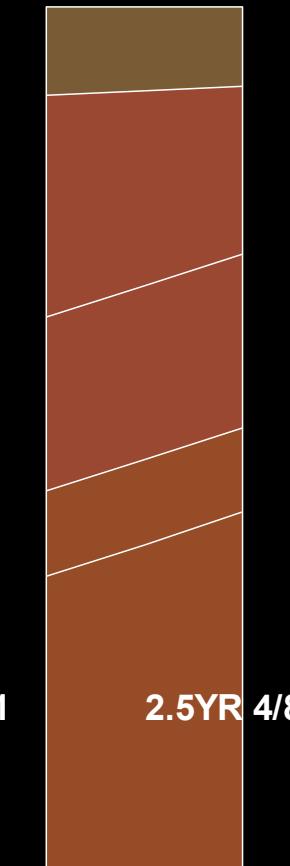
# Color Conversion / Sketches



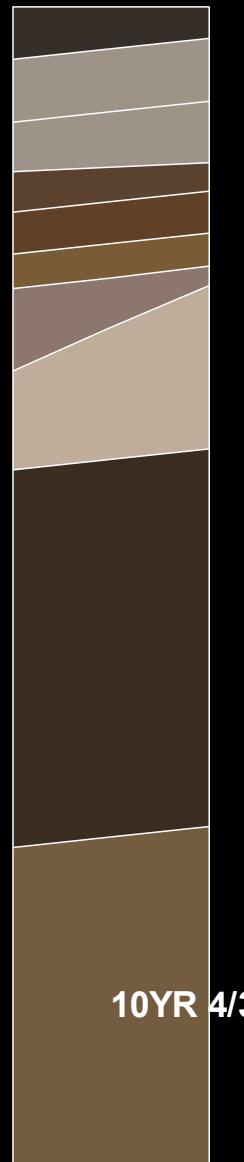
BONNEAU



CECIL



LEON



data → soilDB::fetchOSD()

color → aqp::munsell2rgb()

sketch → aqp::plotSPC()

Photos John A. Kelley

# Color Comparisons (Contrast)

Dry



*Distinct*  
 $\Delta E_{00}$  16.8

*Faint*  
 $\Delta E_{00}$  20.6

*Faint*  
 $\Delta E_{00}$  8.06

*Faint*  
 $\Delta E_{00}$  9.83

*Faint*  
 $\Delta E_{00}$  9.83

*Faint*  
 $\Delta E_{00}$  20.8

Moist



$\Delta E_{00}$  16.8

$\Delta E_{00}$  20.6

$\Delta E_{00}$  8.06

$\Delta E_{00}$  9.83

$\Delta E_{00}$  9.83

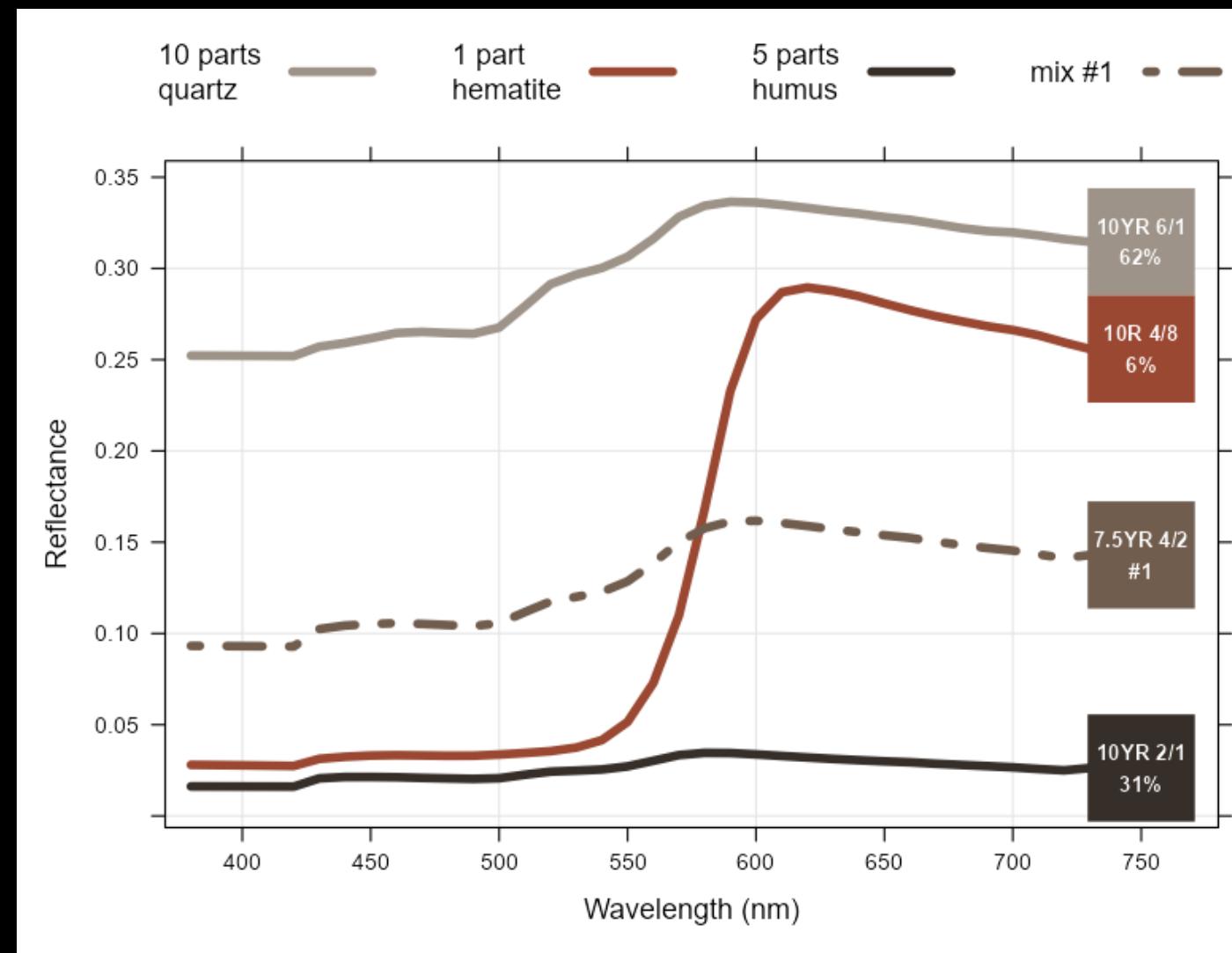
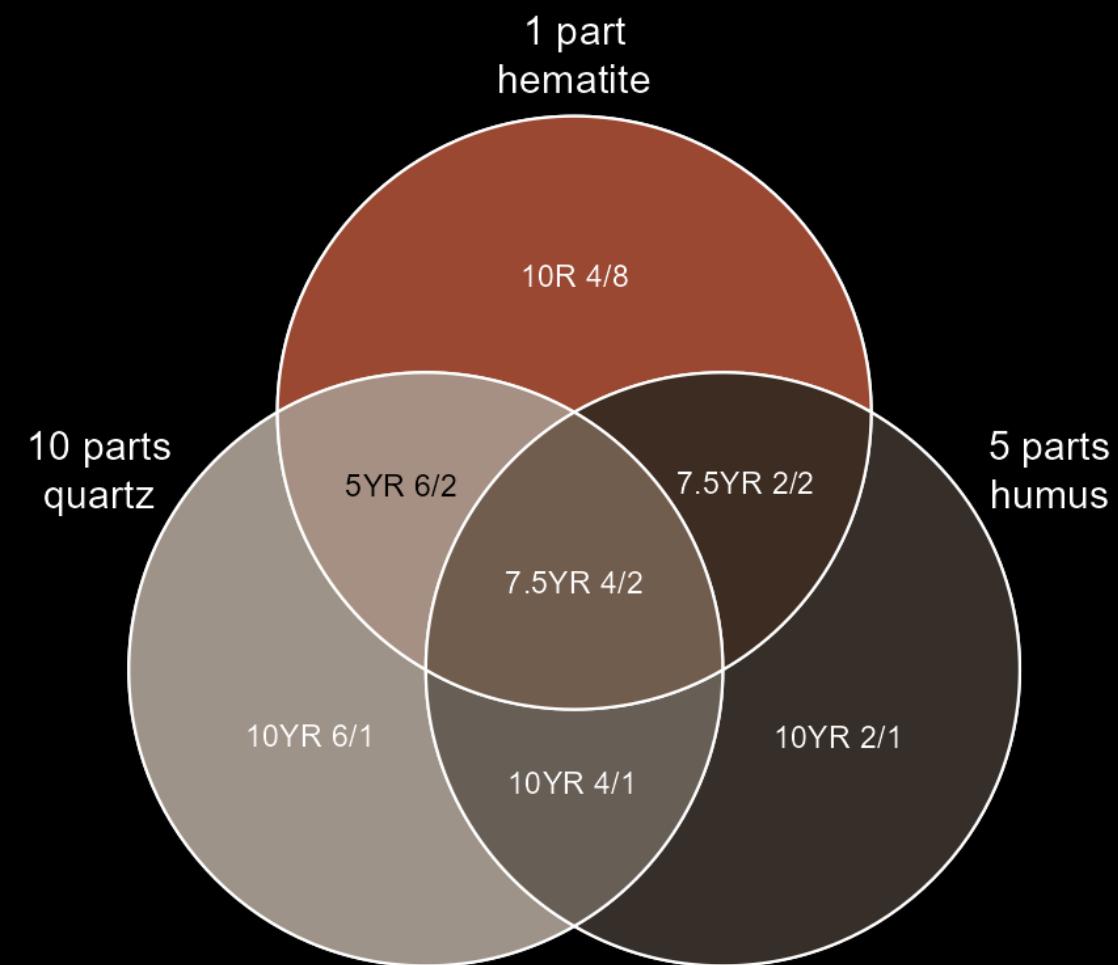
$\Delta E_{00}$  20.8



```
aqp::colorContrast()  
aqp::colorContrastPlot()  
aqp::contrastChart()
```

Photo Satchel Gaddie

# Simulated Subtractive Mixtures



```
aqp::mixMunsell()  
sharpshootR::colorMixtureVenn()
```

```
aqp::plotColorMixture()
```

# Soil Color Aggregation

aqp::aggregateColor()

0-10cm



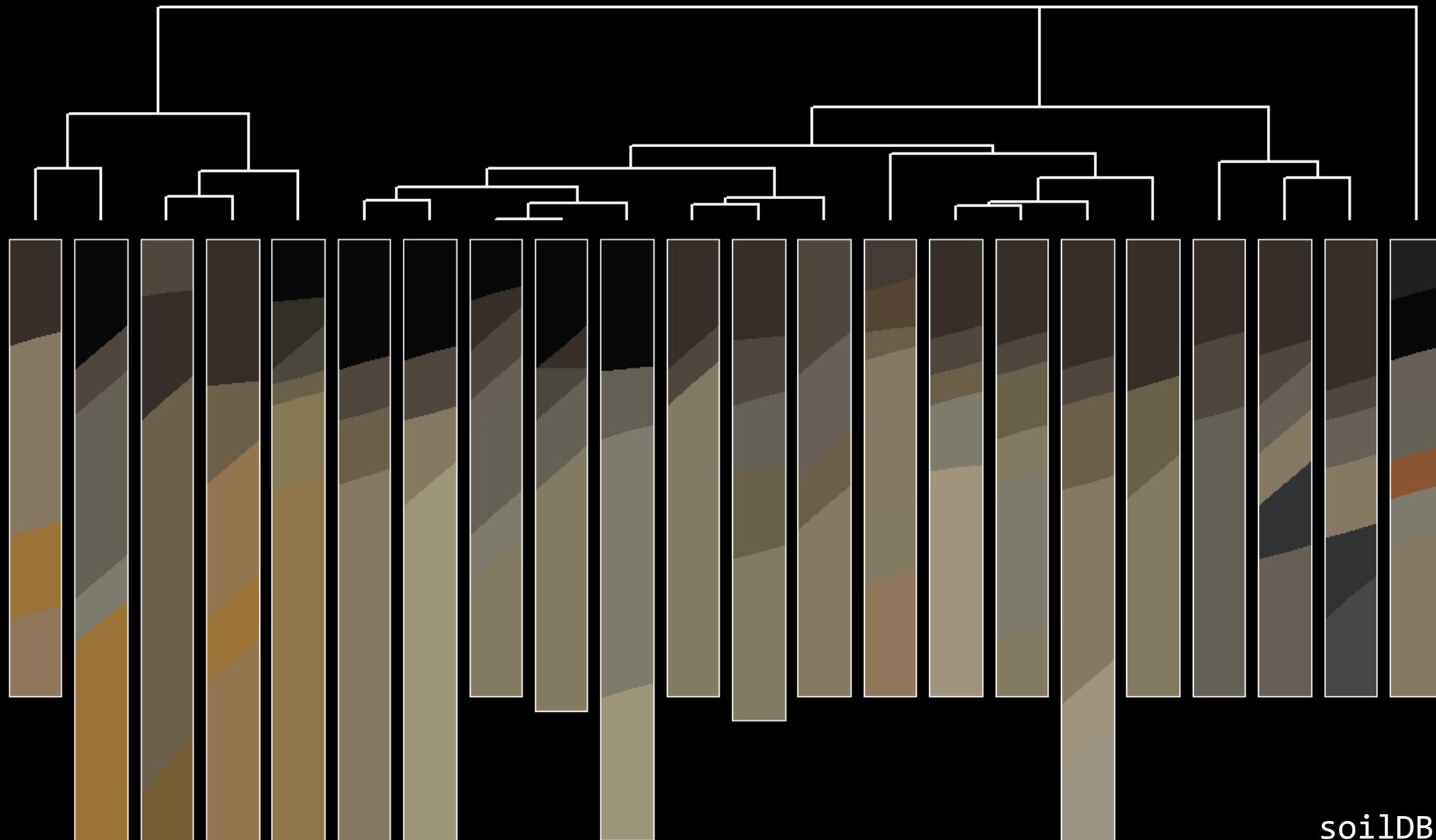
50-75cm



Cumulative Proportion

Cumulative Proportion

# Soil Color Signatures / Search



*fine-silty, mixed, superactive, mesic typic endoaquolls*

`soilDB::fetchOSD()`  
`aqp::soilColorSignature()`  
`sharpshootR::plotProfileDendrogram()`

# Communicating Soil Survey

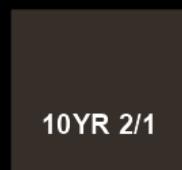
- Soils are complex—we know this, but we don't always deliver a compelling narrative
- It is hard to conserve what you don't understand
- It is hard to understand what you don't perceive
- Make soil properties / processes real

In this context, **soil color** tells a great story

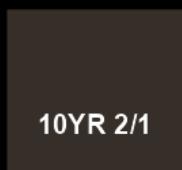


# Pigments in the Soil

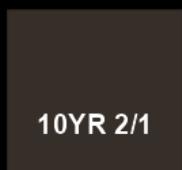
available in aqp package for R



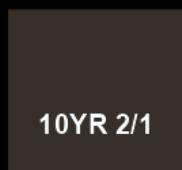
humus



todorokite



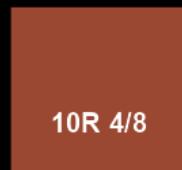
pyrite



iron sulfide



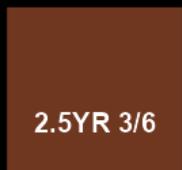
lepidocrocite-fine



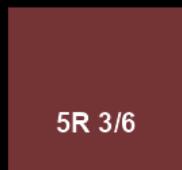
hematite-fine



maghemite



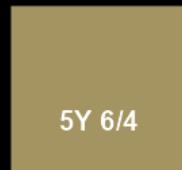
ferrihydrite



hematite-coarse



quartz



jarosite



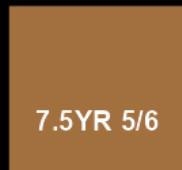
akaganeite



lepidocrocite-coarse



glauconite



goethite-fine



schwertmannite



gypsum



dolomite

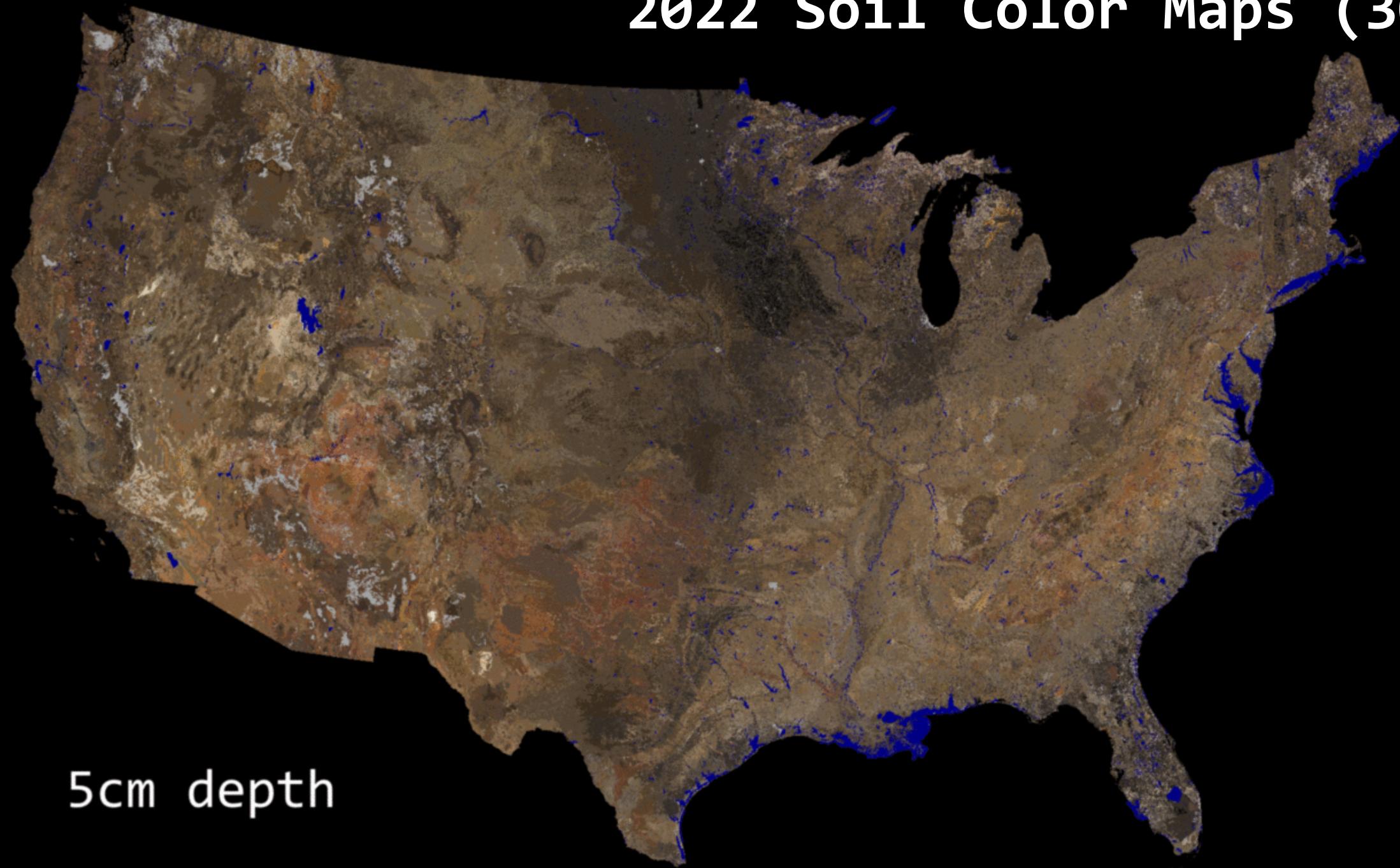


calcite



goethite-coarse

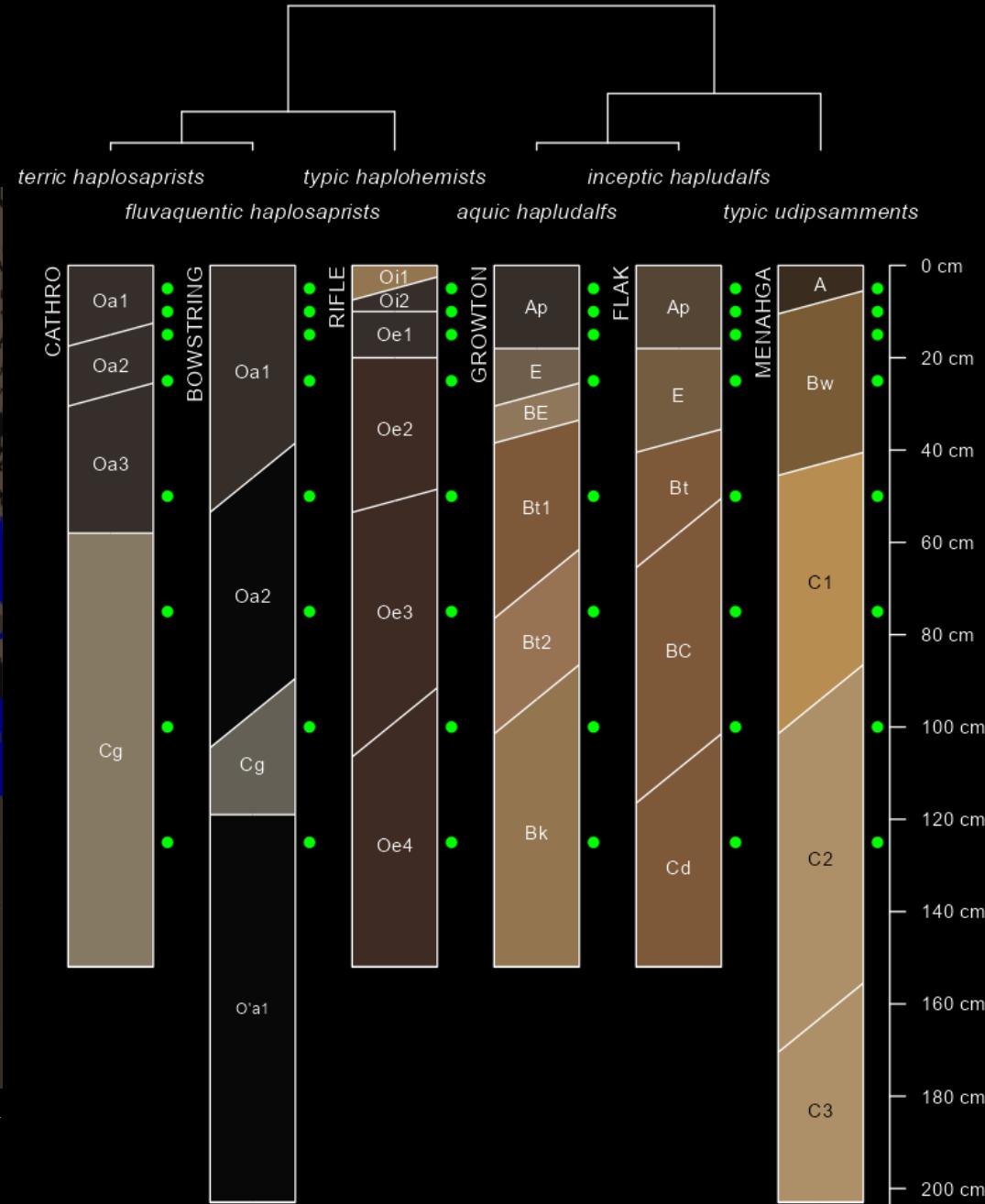
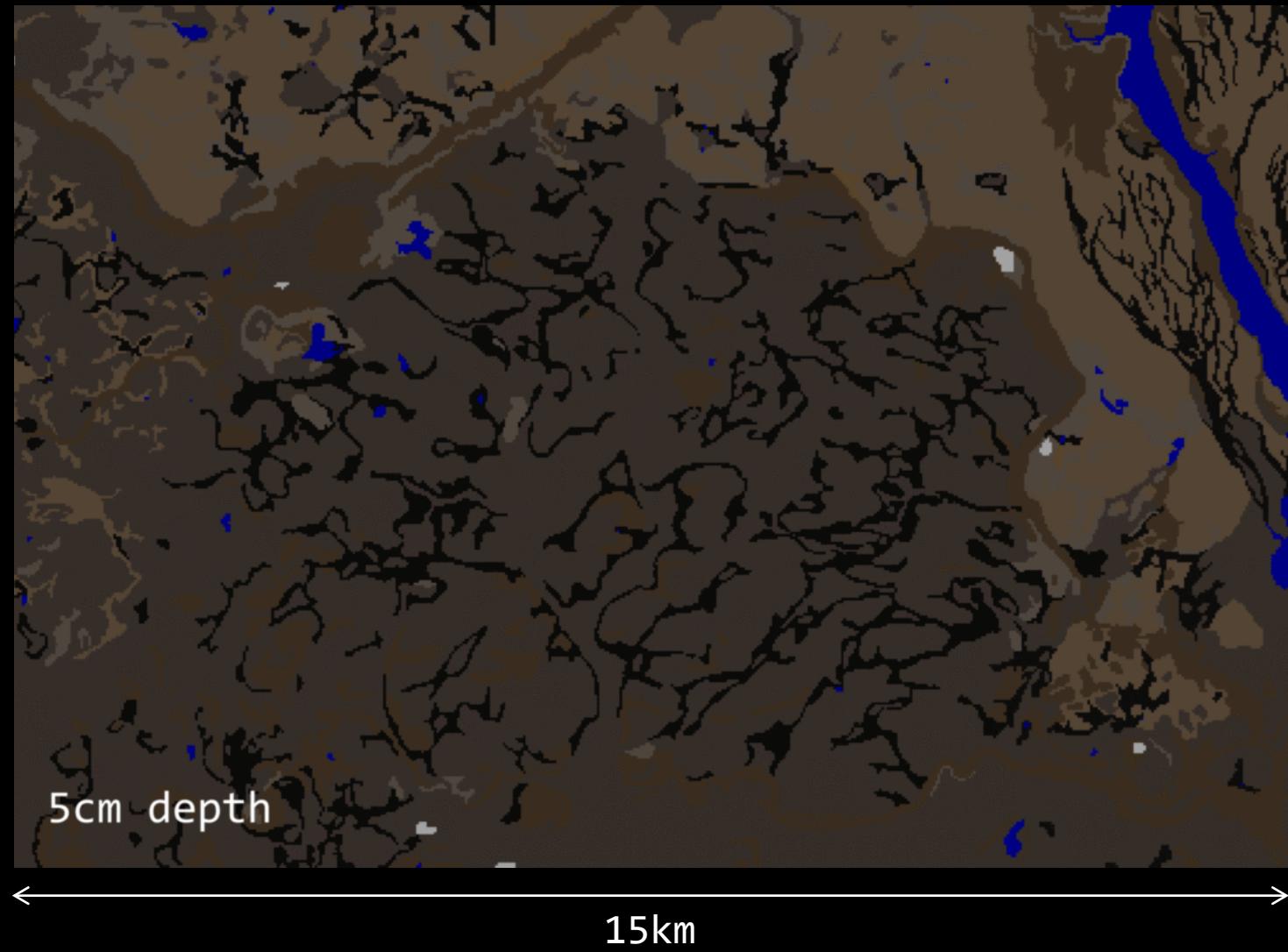
# 2022 Soil Color Maps (30m)



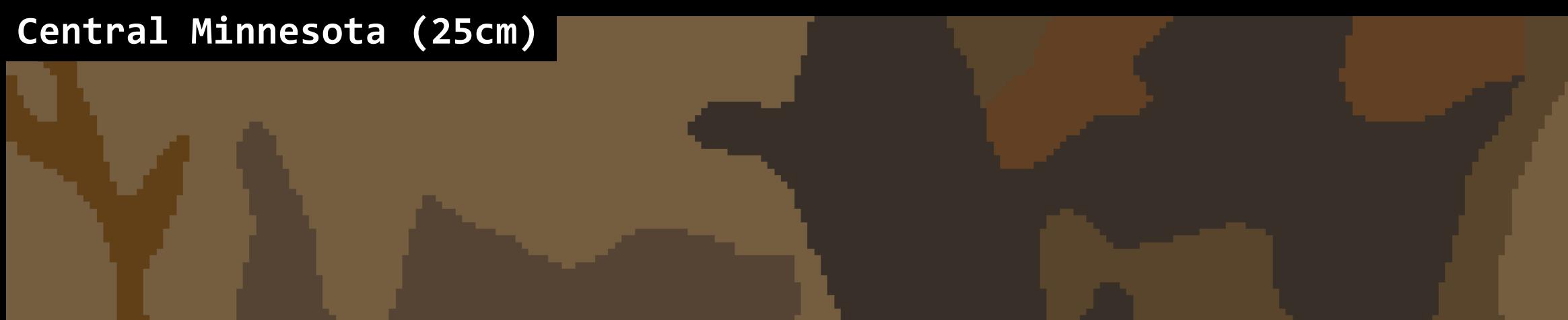
5cm depth

# 2022 Soil Color Maps

## Central Minnesota



# Central Minnesota (25cm)



2014



2018



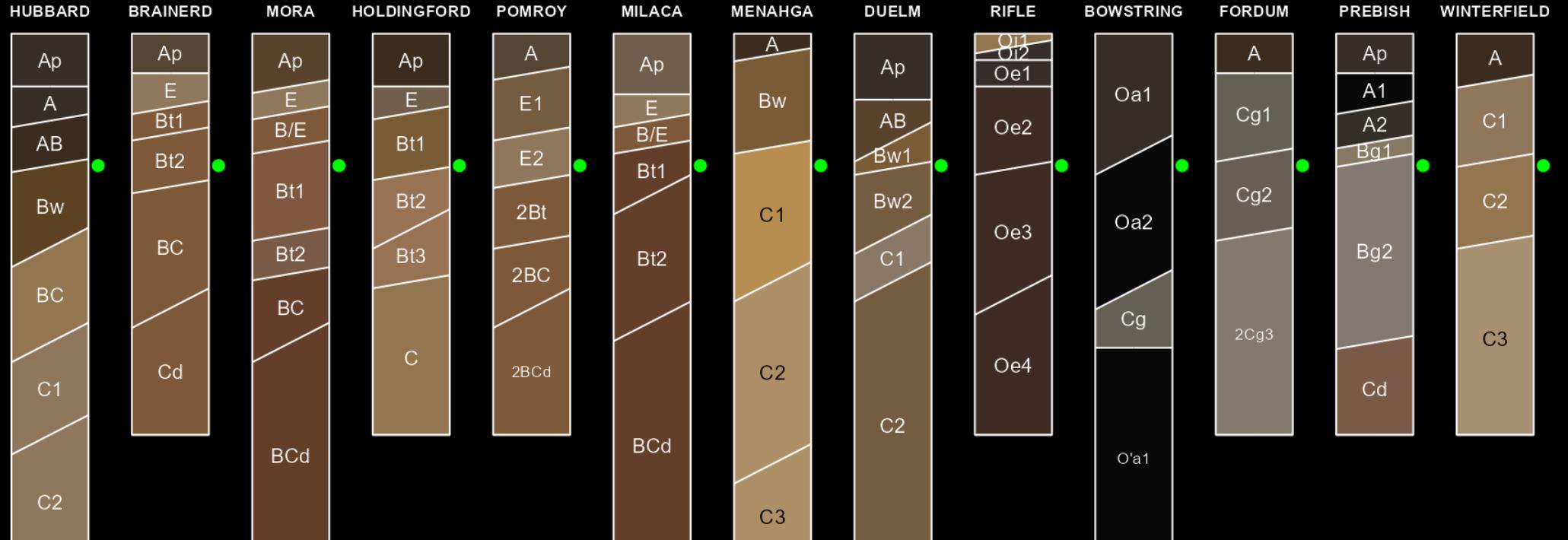
2022

# Central Minnesota (50cm)



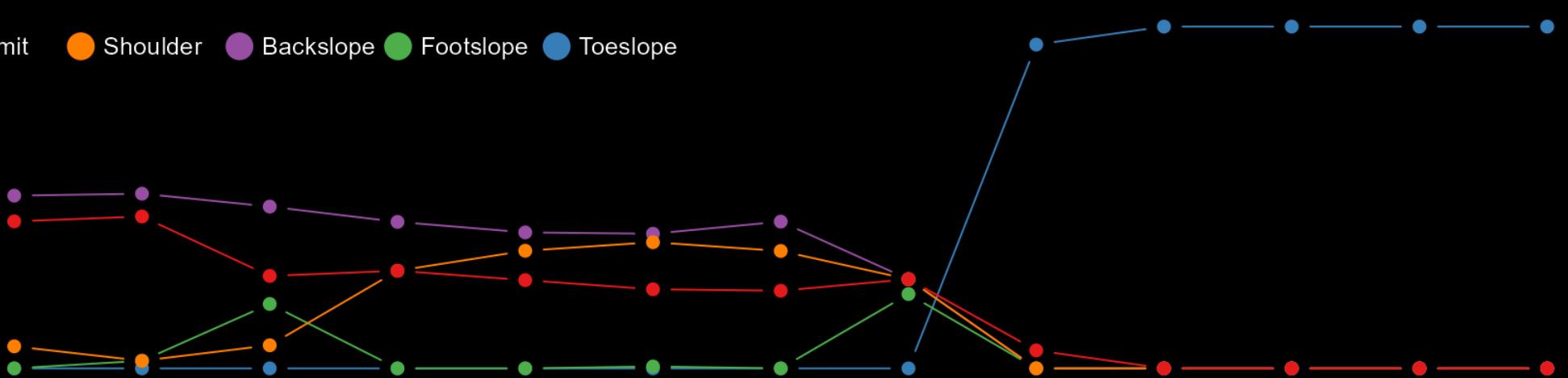
48km

# Central Minnesota (50cm)



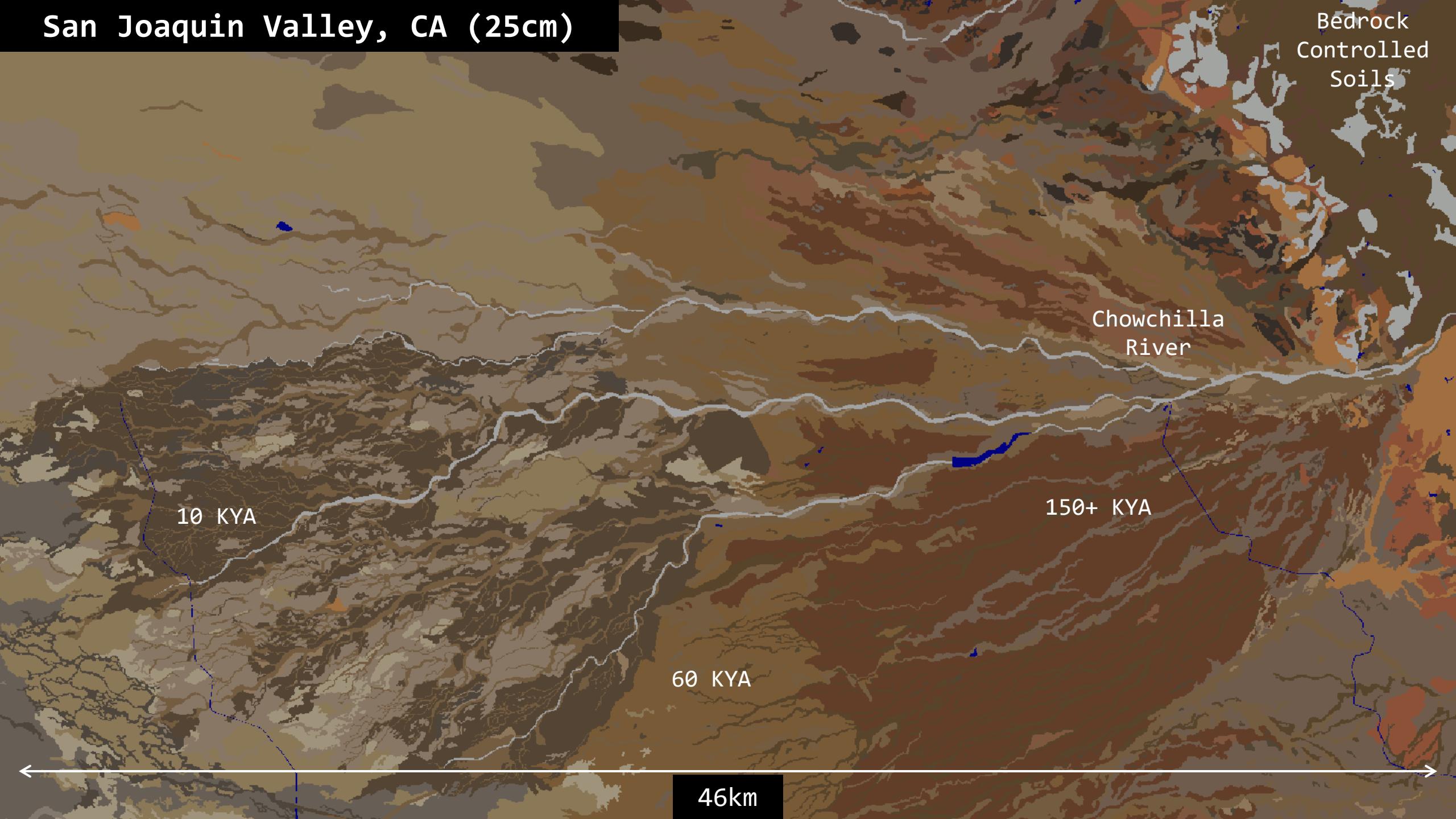
● Summit   ● Shoulder   ● Backslope   ● Footslope   ● Toeslope

Probability

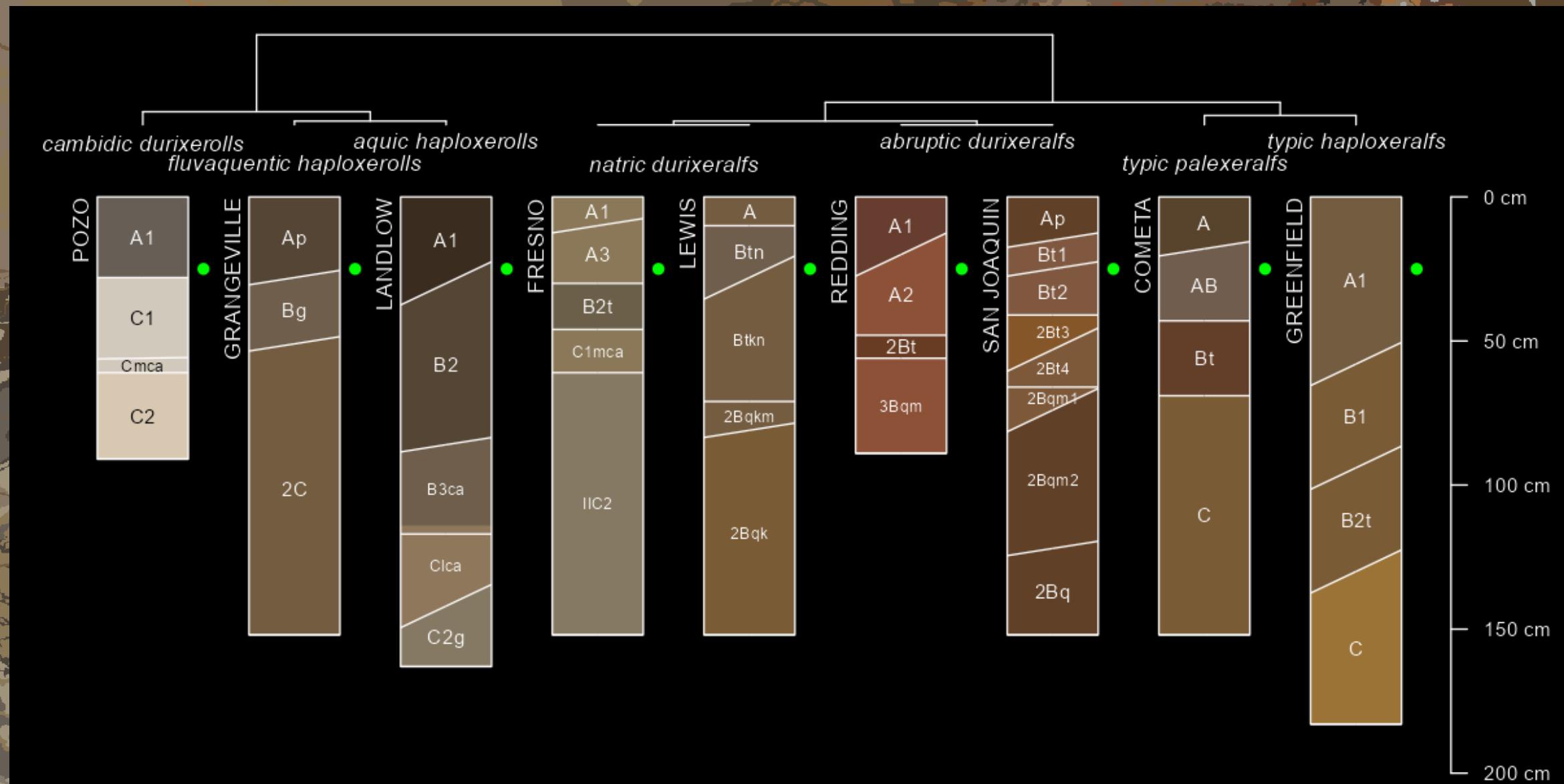


1.0  
0.8  
0.6  
0.4  
0.2  
0.0

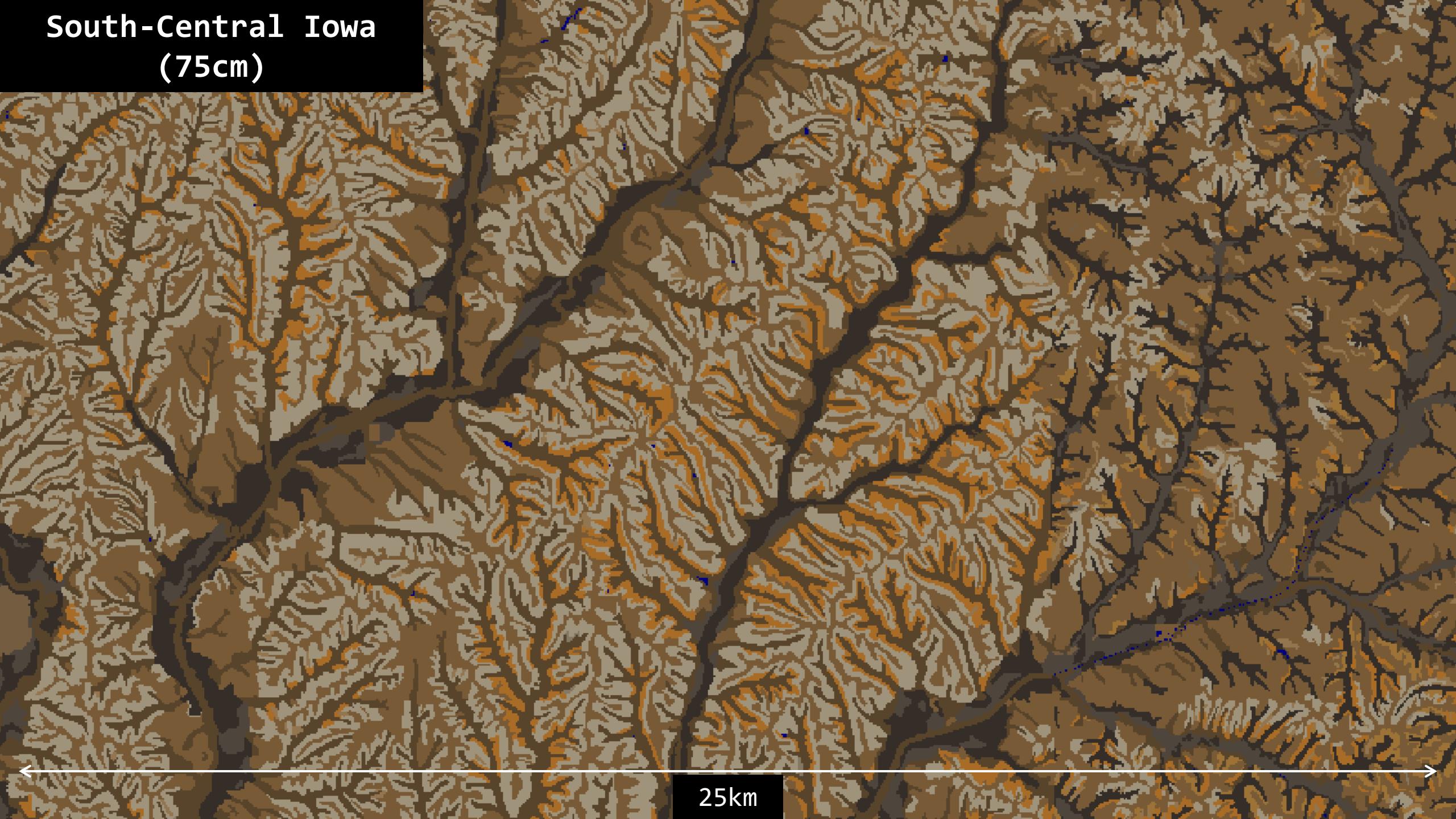
# San Joaquin Valley, CA (25cm)



# San Joaquin Valley, CA (25cm)

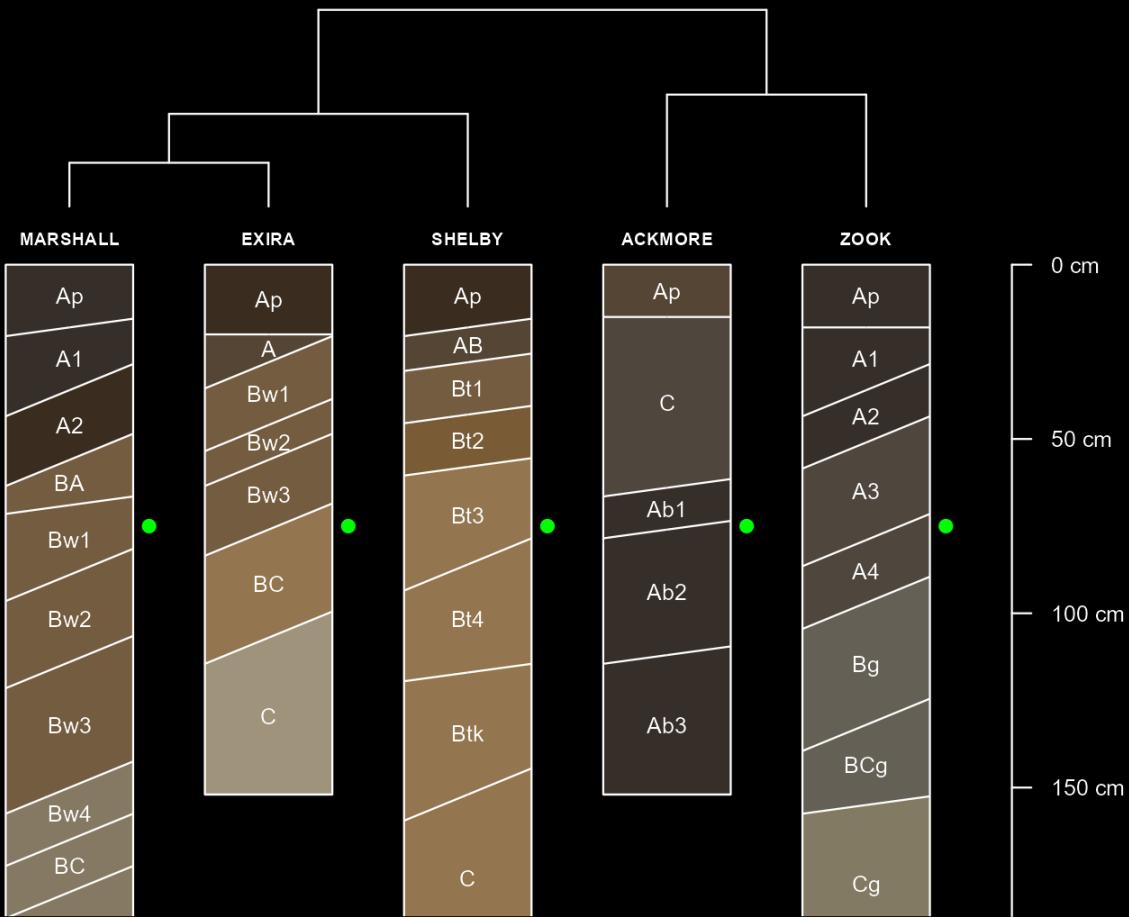
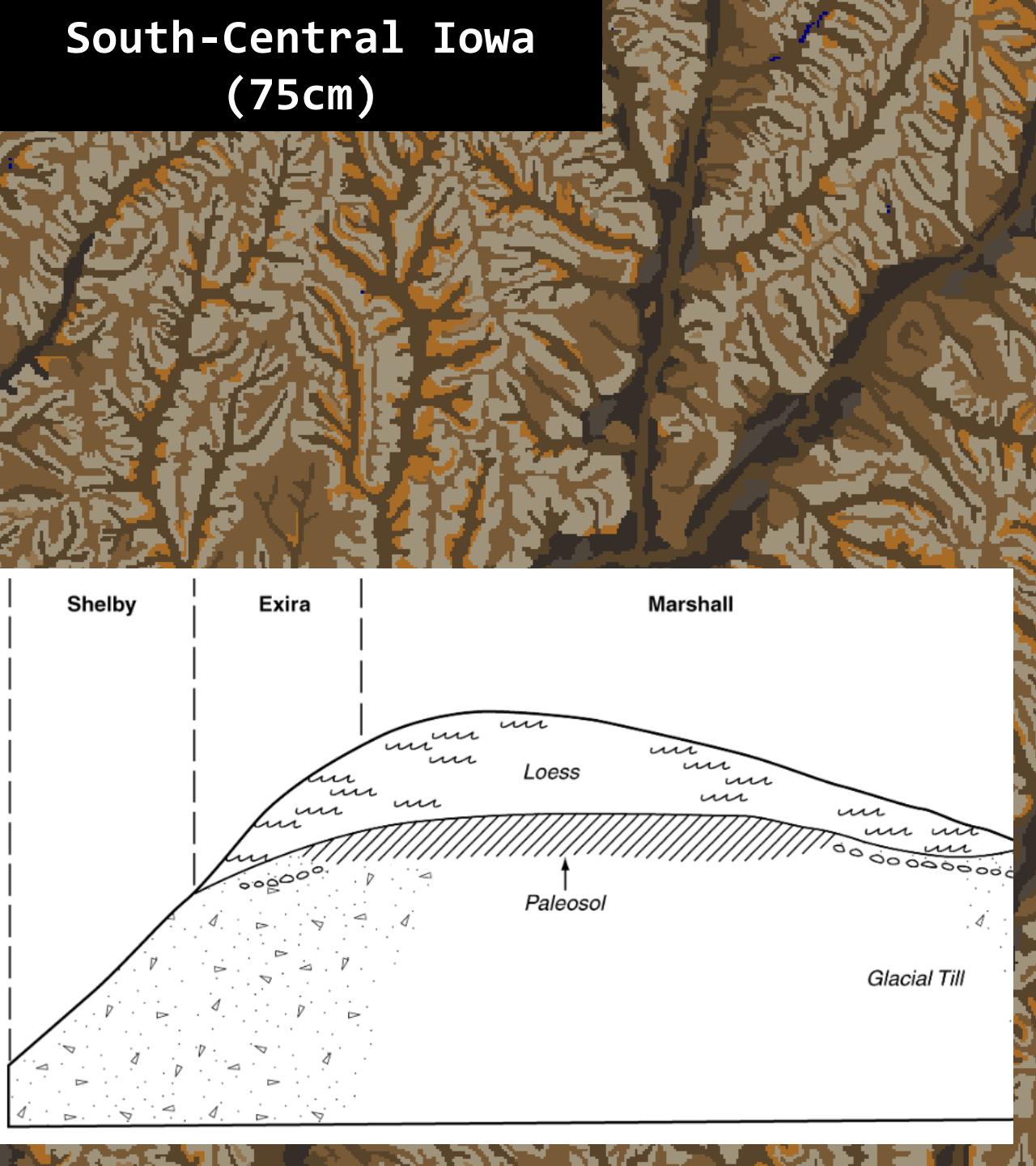


South-Central Iowa  
(75cm)

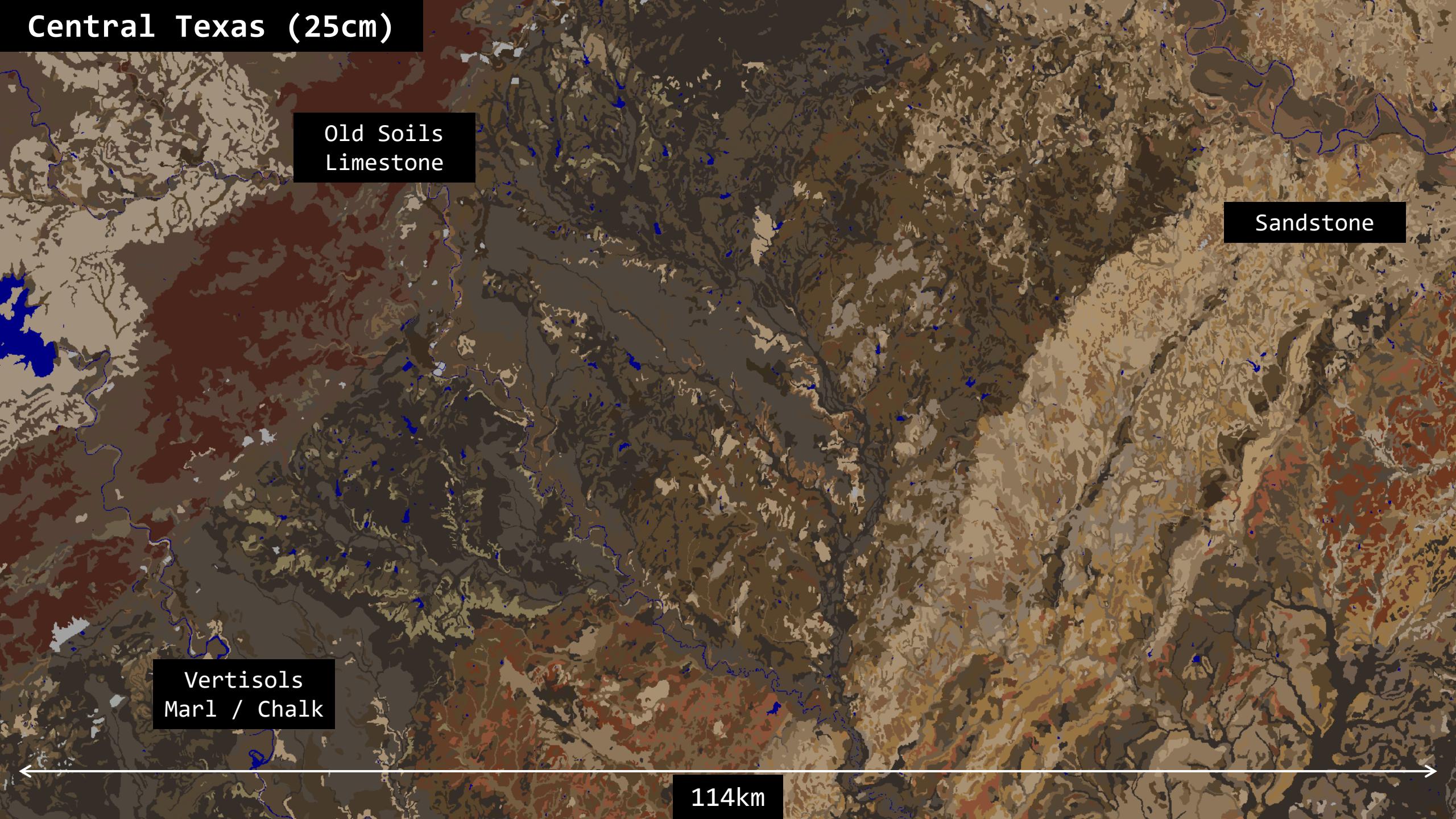


25km

# South-Central Iowa (75cm)

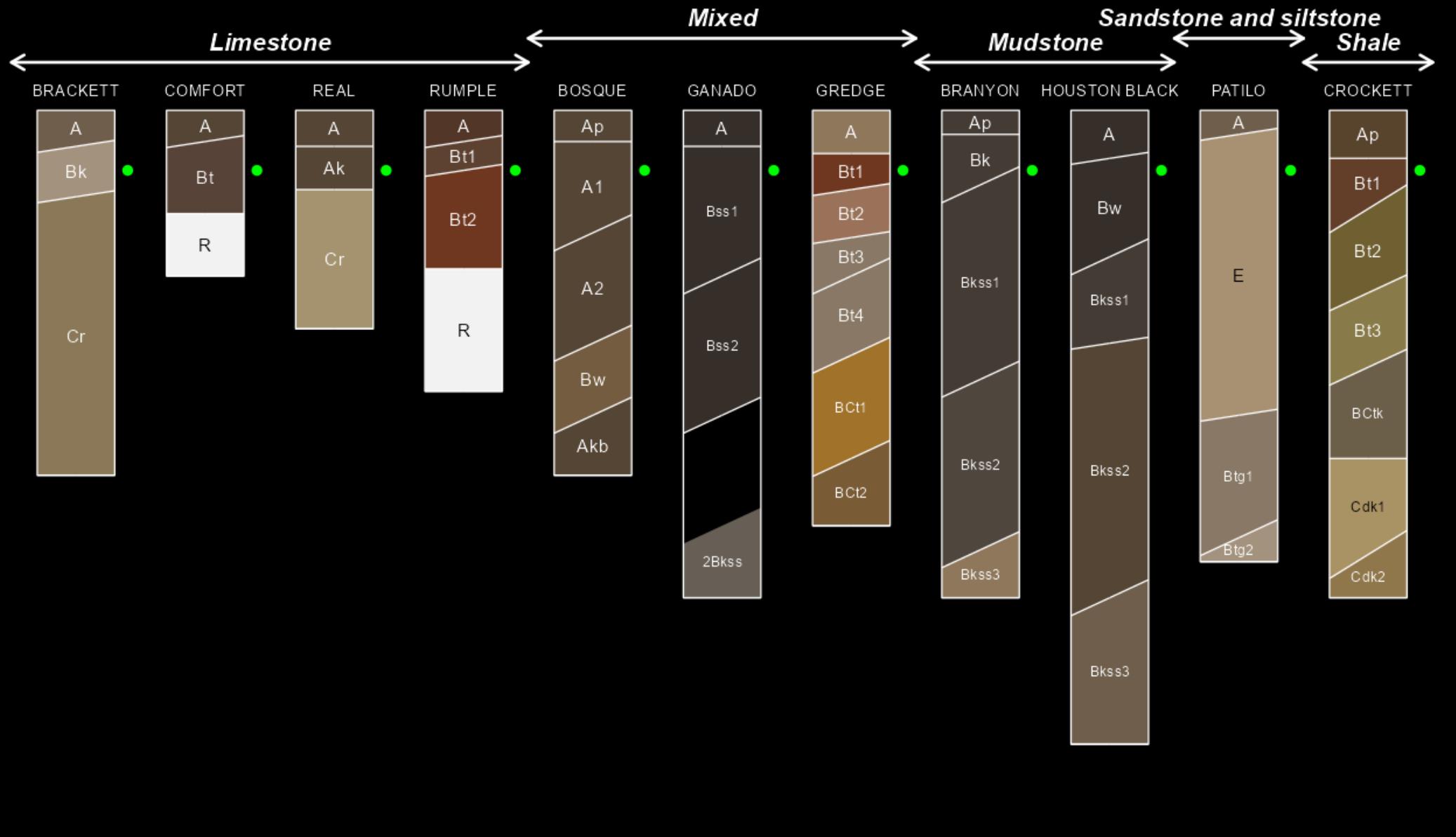


# Central Texas (25cm)

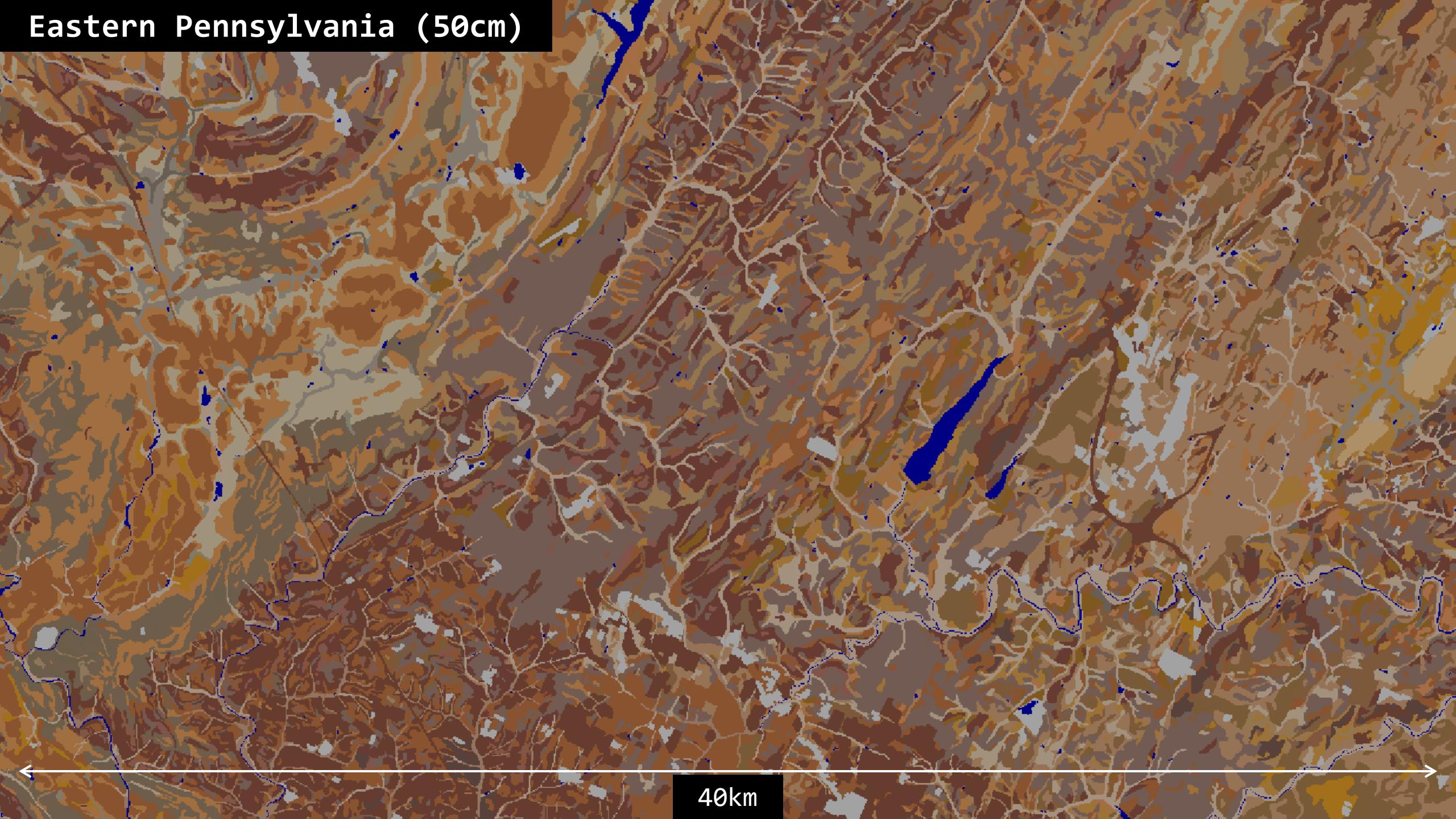


114km

# Central Texas (25cm)

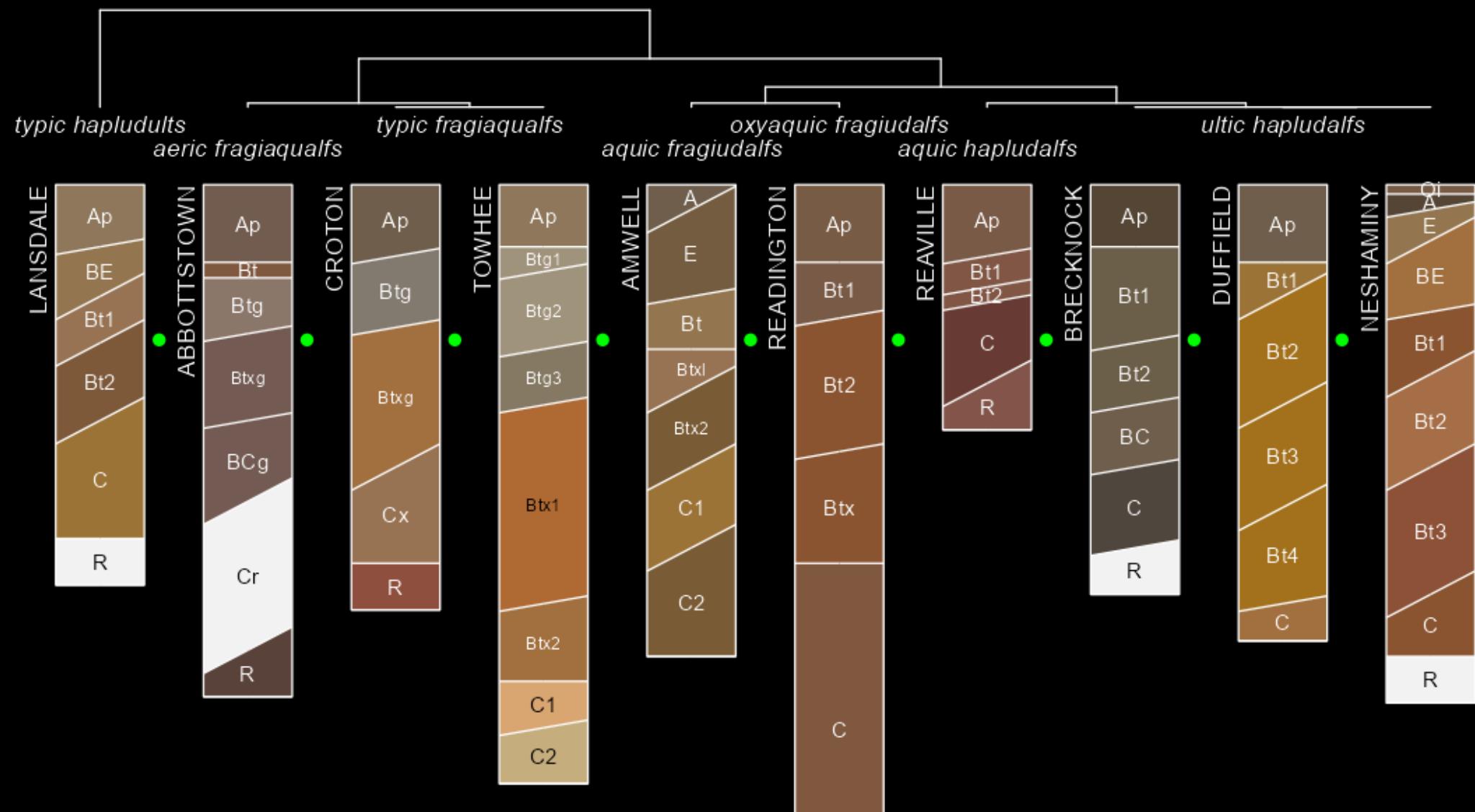


Eastern Pennsylvania (50cm)



40km

# Eastern Pennsylvania (50cm)



# Thank You

## R Packages

- **aqp**: ncss-tech.github.io/aqp
- **soilDB**: ncss-tech.github.io/soilDB
- **sharpshootR**: ncss-tech.github.io/sharpshootR
- **SoilTaxonomy**: ncss-tech.github.io/SoilTaxonomy

## Tutorials / Publications

- ncss-tech.github.io/AQP
- doi.org/10.1016/j.cageo.2012.10.020
- Geopedology 2<sup>nd</sup> Ed. (in-press)

## Soil Colors of the Continental United States

- [www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcseprd1423827](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcseprd1423827)

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