GAMMA-RAY SPECTROMETRY

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Outline

- Gamma radiometrics?
- Examples of applications in soil and earth science
- Proximal sensors (field-scale examples)
- Airborne sensors (regional-scale examples)

Gamma Radiation

- Emitted by naturally-occurring elements in rocks and soils
- Gamma rays have variable energies
  - Energy is characteristic of the radioactive isotope
- Measures from the upper 30 cm of soil or rock
  - Travel for up to 300 m through air
  - Little attenuation by vegetation

Gamma Radiation

- Potassium, Uranium, Thorium (and Cesium)
  - Relatively long half-lives
  - Relatively abundant in the environment
  - Produce gamma radiation of measurable intensity

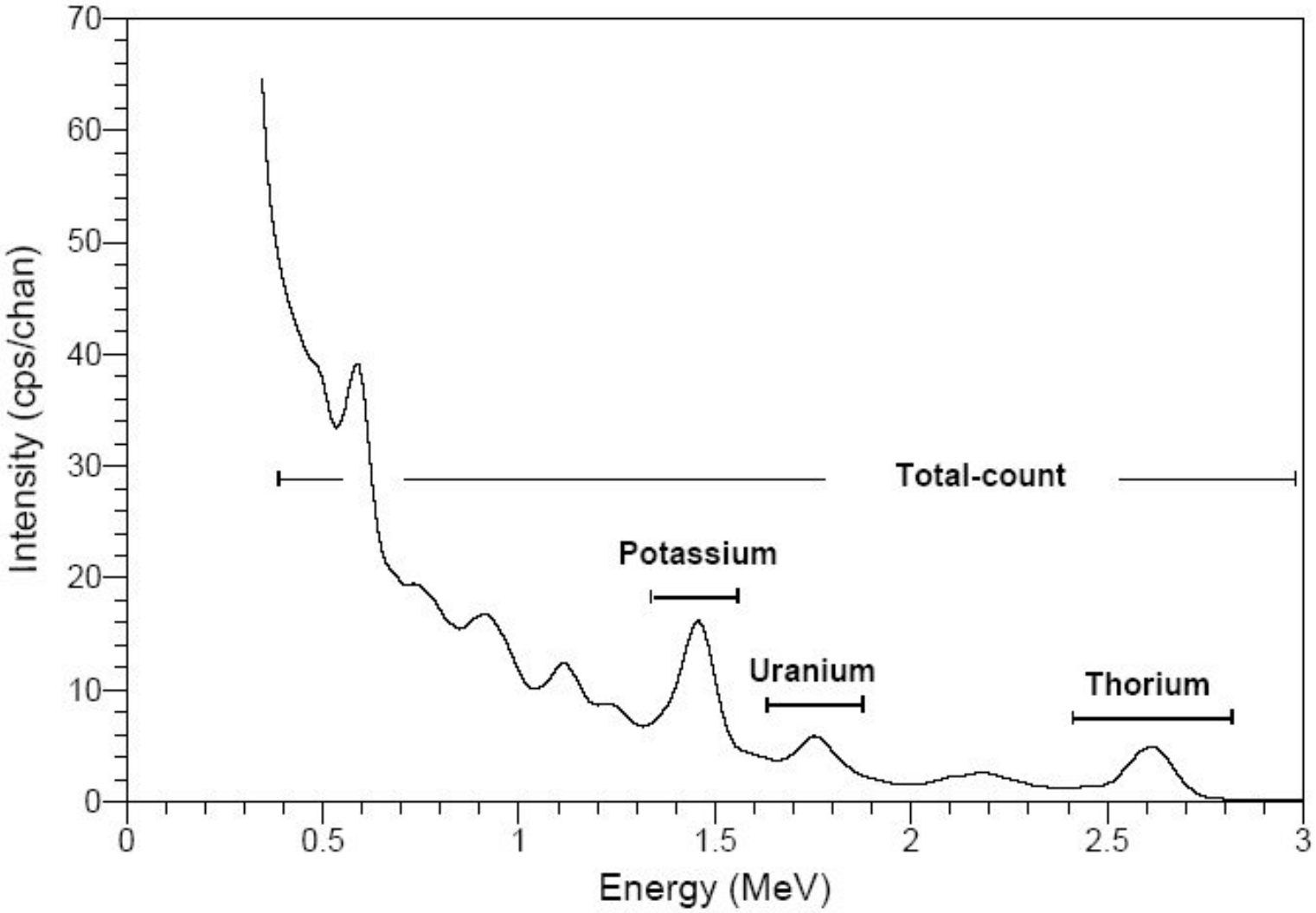
^{40}K

^{238}U, ^{235}U

^{232}Th

^{137}Cs

Gamma Radiation



Applications

- Related to mineralogy and geochemistry
  - Soil parent material
  - Weathering and pedogenesis
  - Geomorphic activity (source, age)
  - Erosion and deposition

What Properties Can Be Mapped?

- Parent materials
- Soil texture (sand content, clay content)
- Nutrients and other elements (Fe, K)
- Soil organic matter, O horizon thickness
- pH

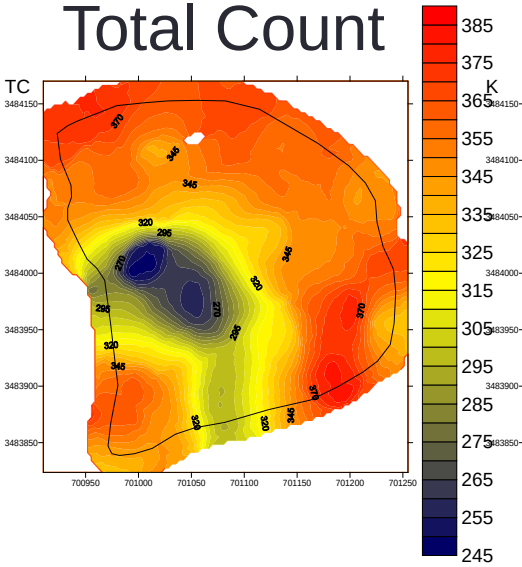
- Bulk density
- Water retention
- Saturated hydraulic conductivity

Proximal Mobile Sensors

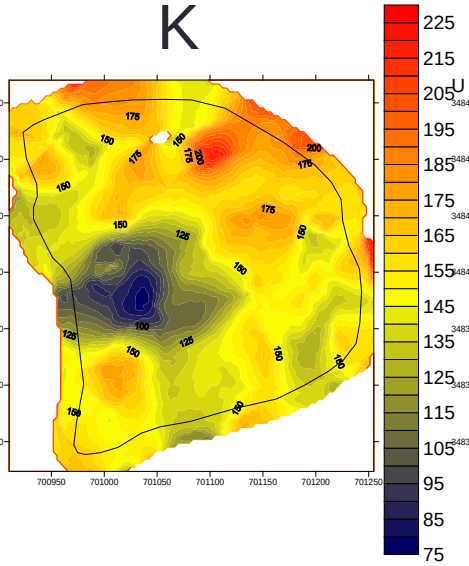
The Mole
The Soil Company
Netherlands

RS-700
Radiation Solutions
Canada

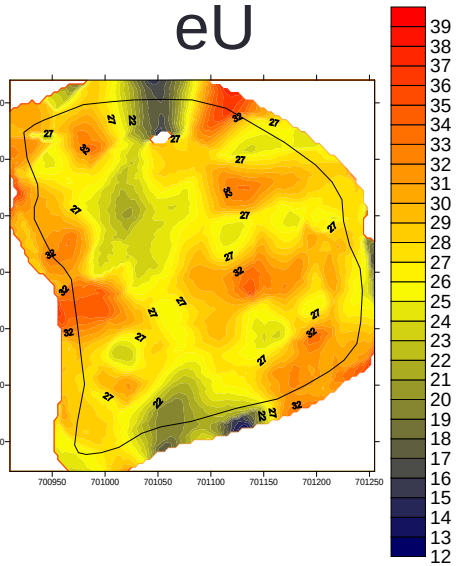
Total Count



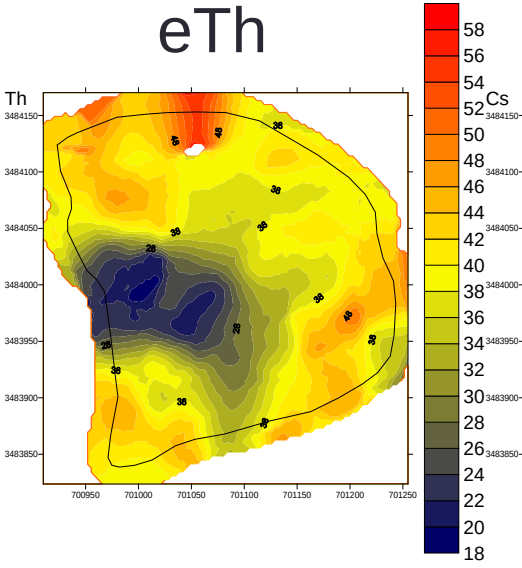
K



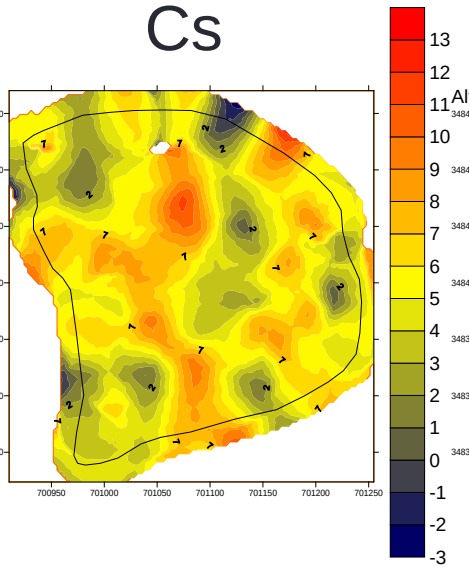
eU



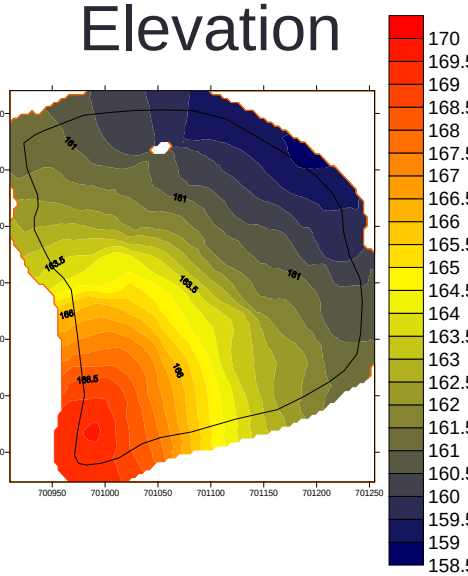
eTh

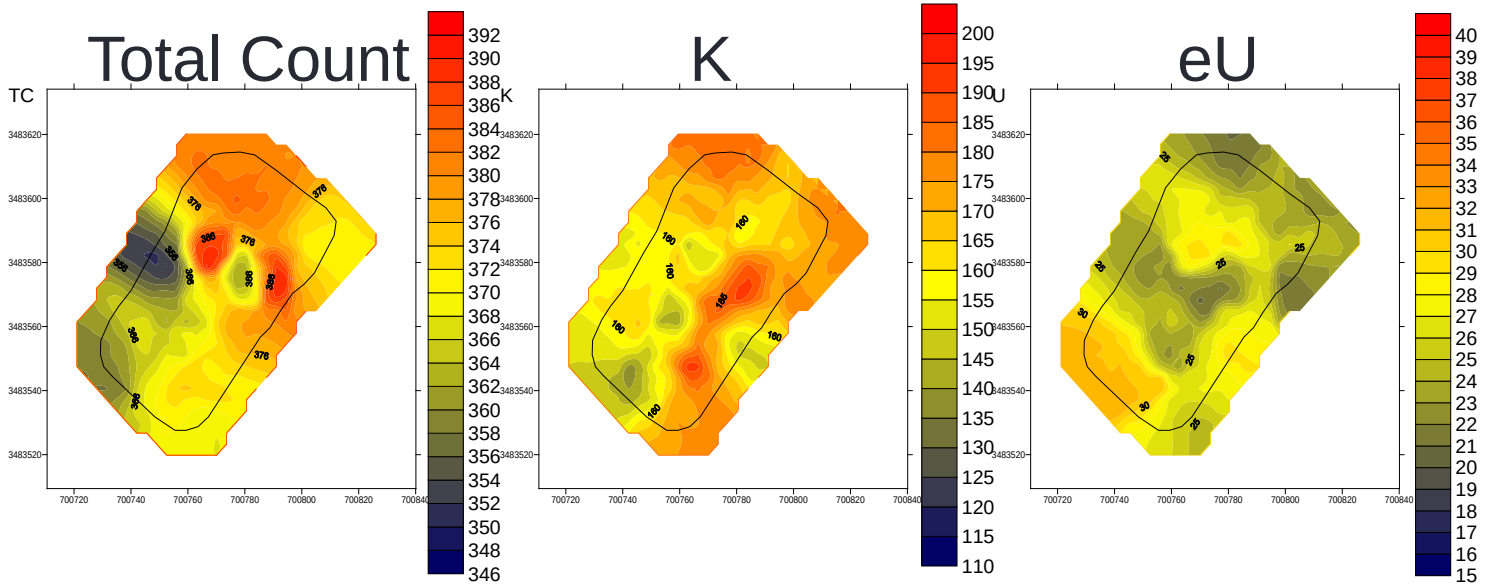


Cs



Elevation



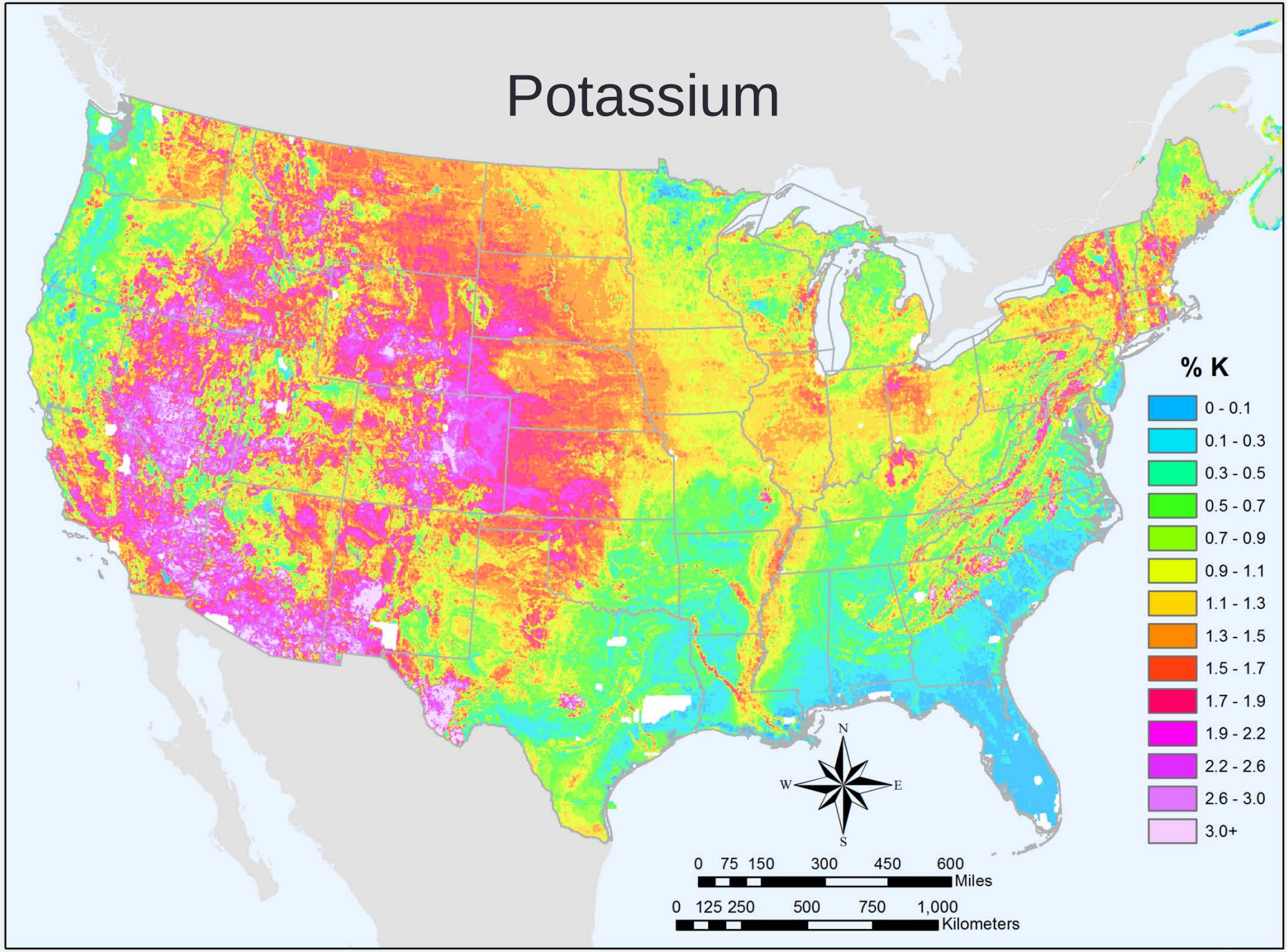

Total Count
TC
K
eU
eTh
Th
Cs
Elevation
Alt

Airborne Sensors

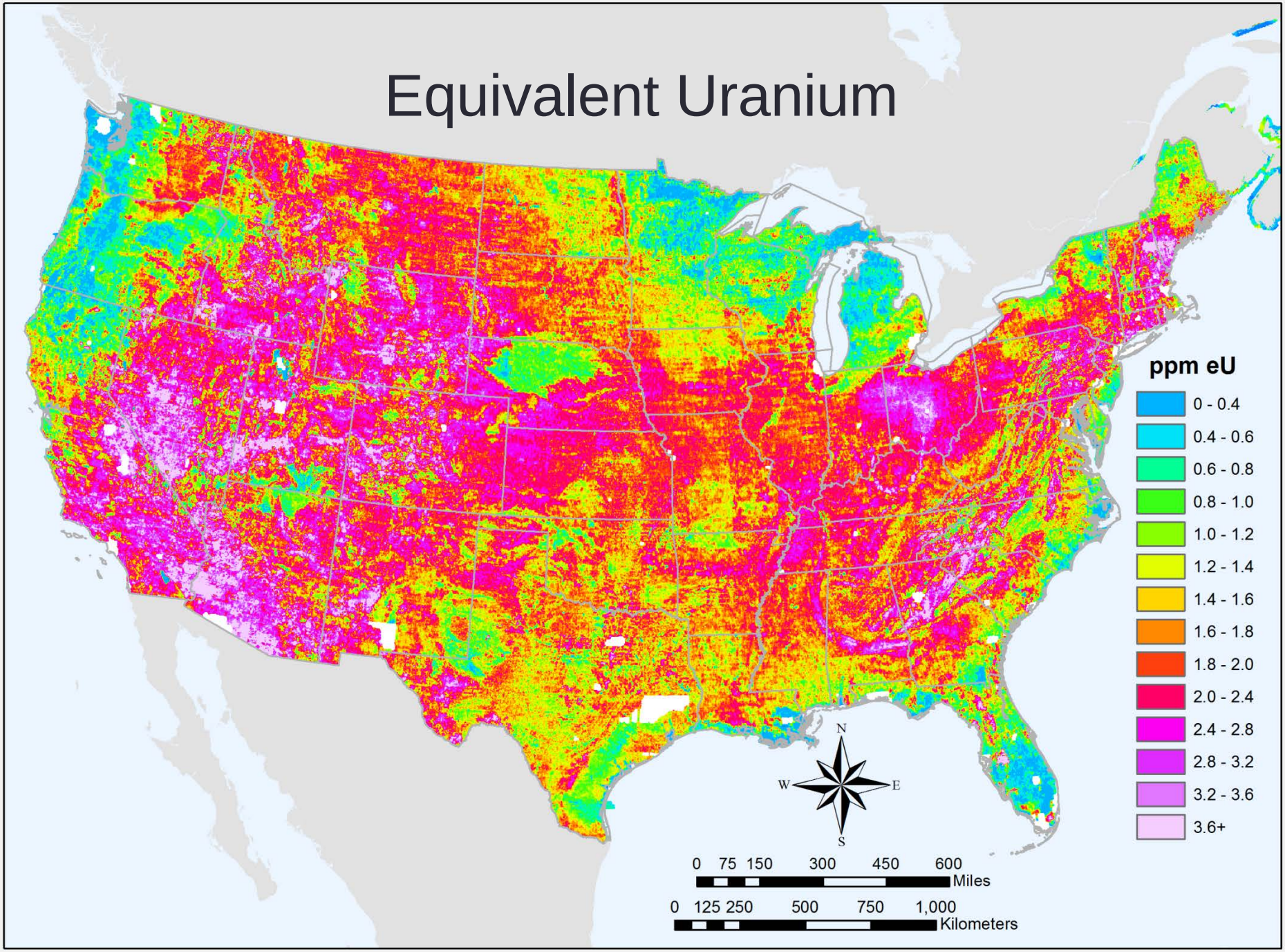
- Available data
  - USGS Aeroradiometric surveys of North America
    - Product of the National Uranium Resource Evaluation (NURE) surveys (1975-1983)
    - 2-km resolution raster data
    - Modeled from widely-spaced (5-10 km) flightlines

mrdata.usgs.gov/radiometric

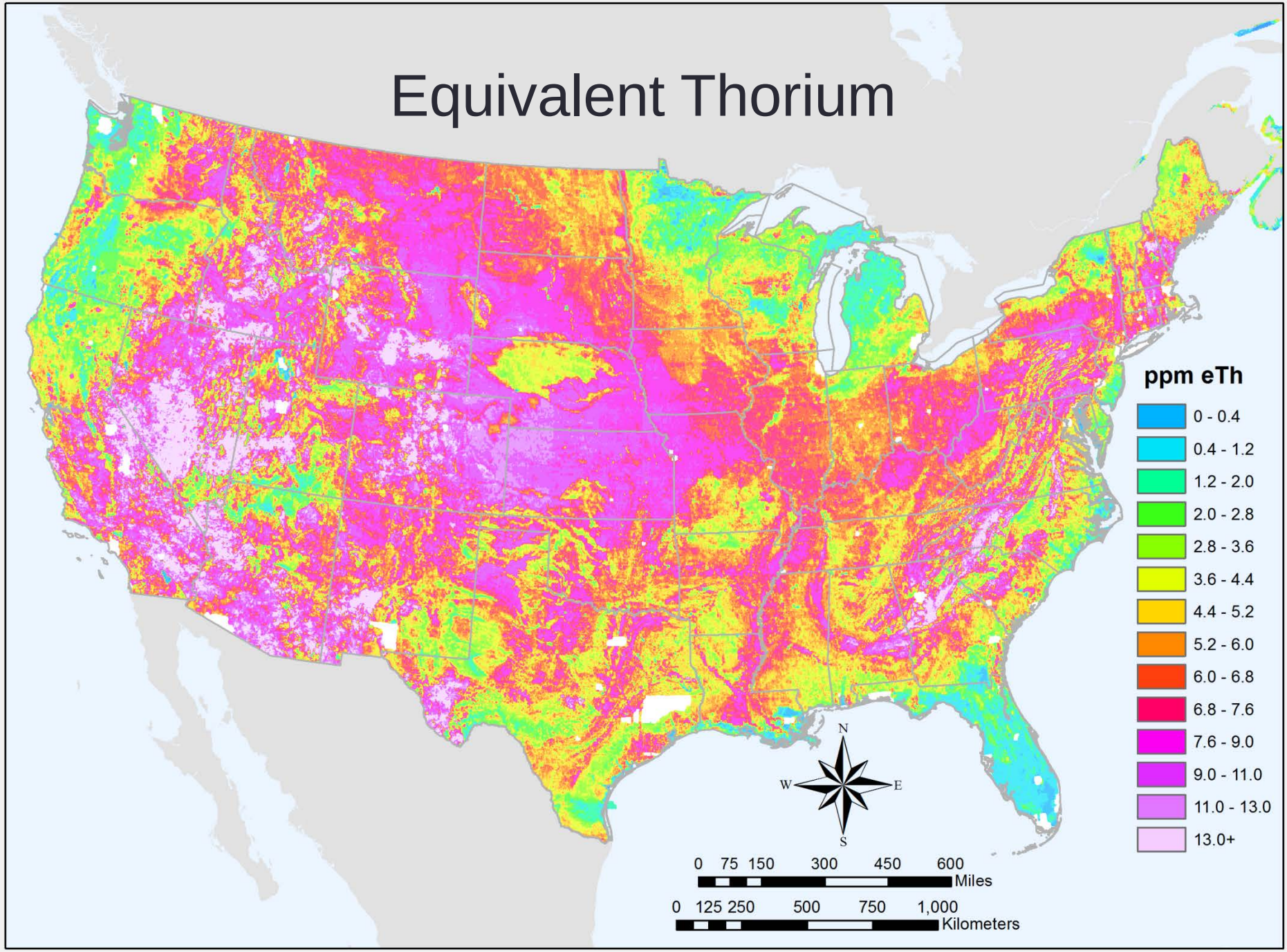
Potassium


% K
0 - 0.1
0.1 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.1
1.1 - 1.3
1.3 - 1.5
1.5 - 1.7
1.7 - 1.9
1.9 - 2.2
2.2 - 2.6
2.6 - 3.0
3.0+
N
W
E
S
0 75 150 300 450 600
Miles
0 125 250 500 750 1,000
Kilometers

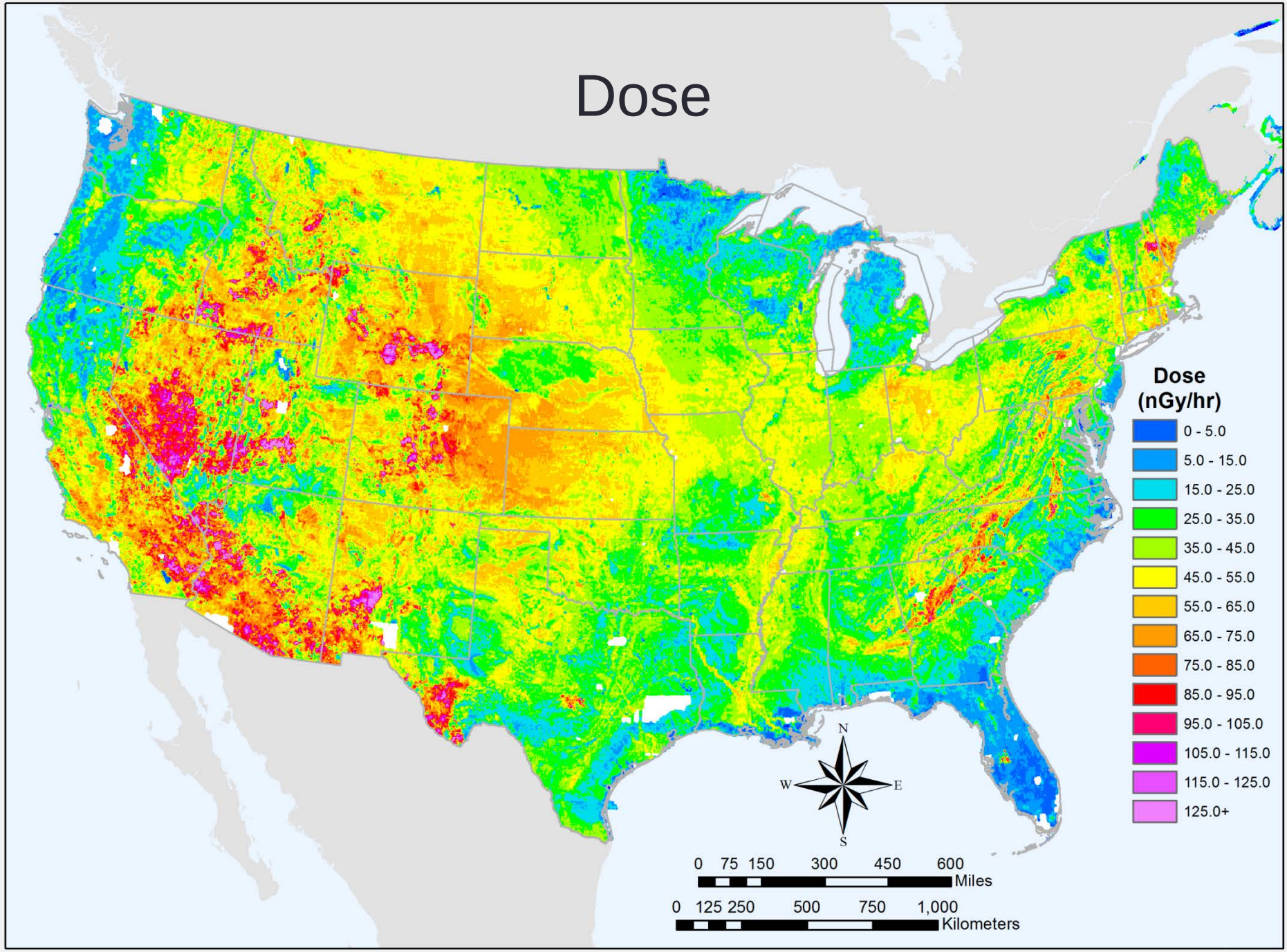
Equivalent Uranium



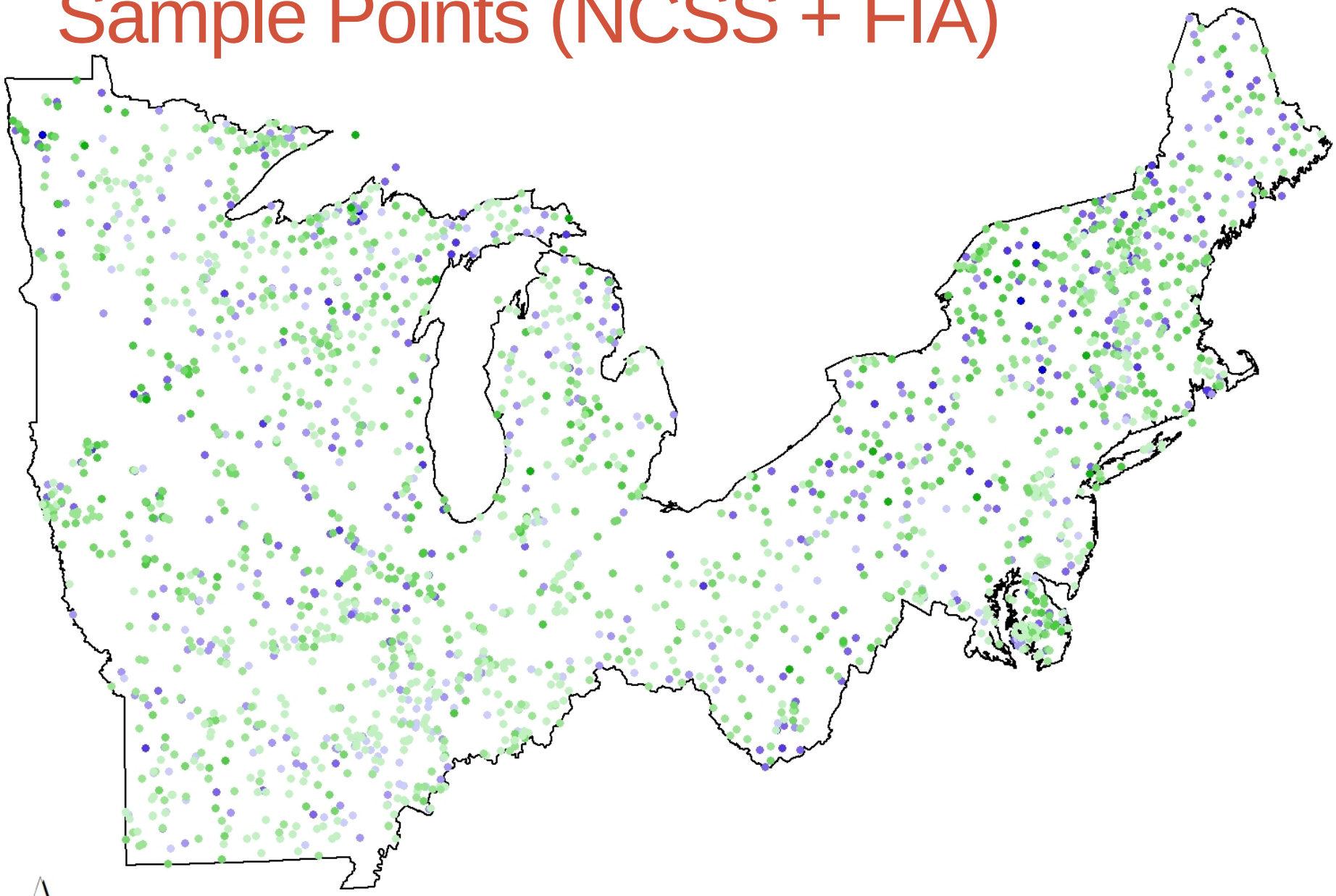
Equivalent Thorium



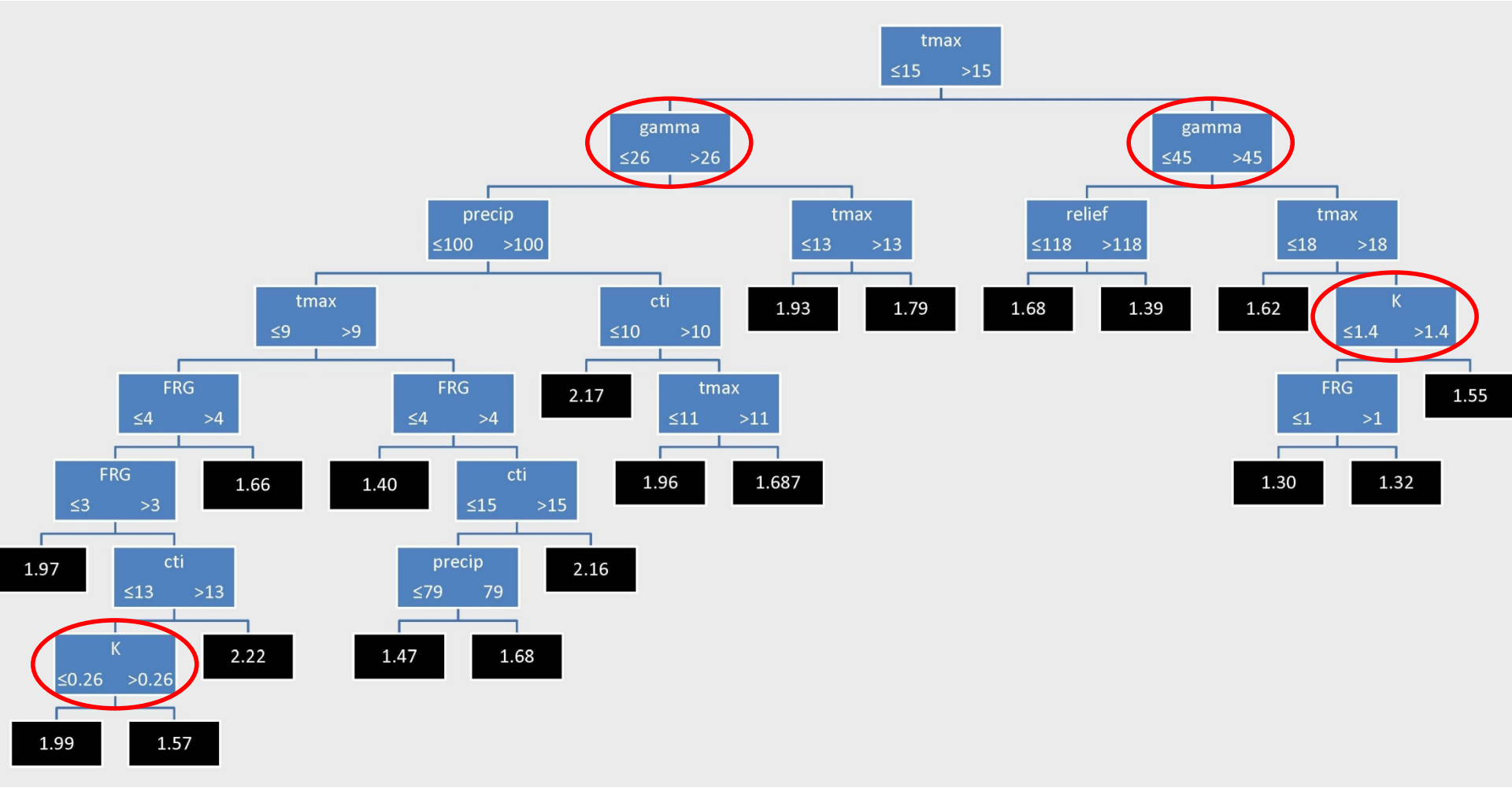
Dose


Dose
(nGy/hr)
0 - 5.0
5.0 - 15.0
15.0 - 25.0
25.0 - 35.0
35.0 - 45.0
45.0 - 55.0
55.0 - 65.0
65.0 - 75.0
75.0 - 85.0
85.0 - 95.0
95.0 - 105.0
105.0 - 115.0
115.0 - 125.0
125.0+
N
W
E
S
0 75 150 300 450 600
Miles
0 125 250 500 750 1,000
Kilometers

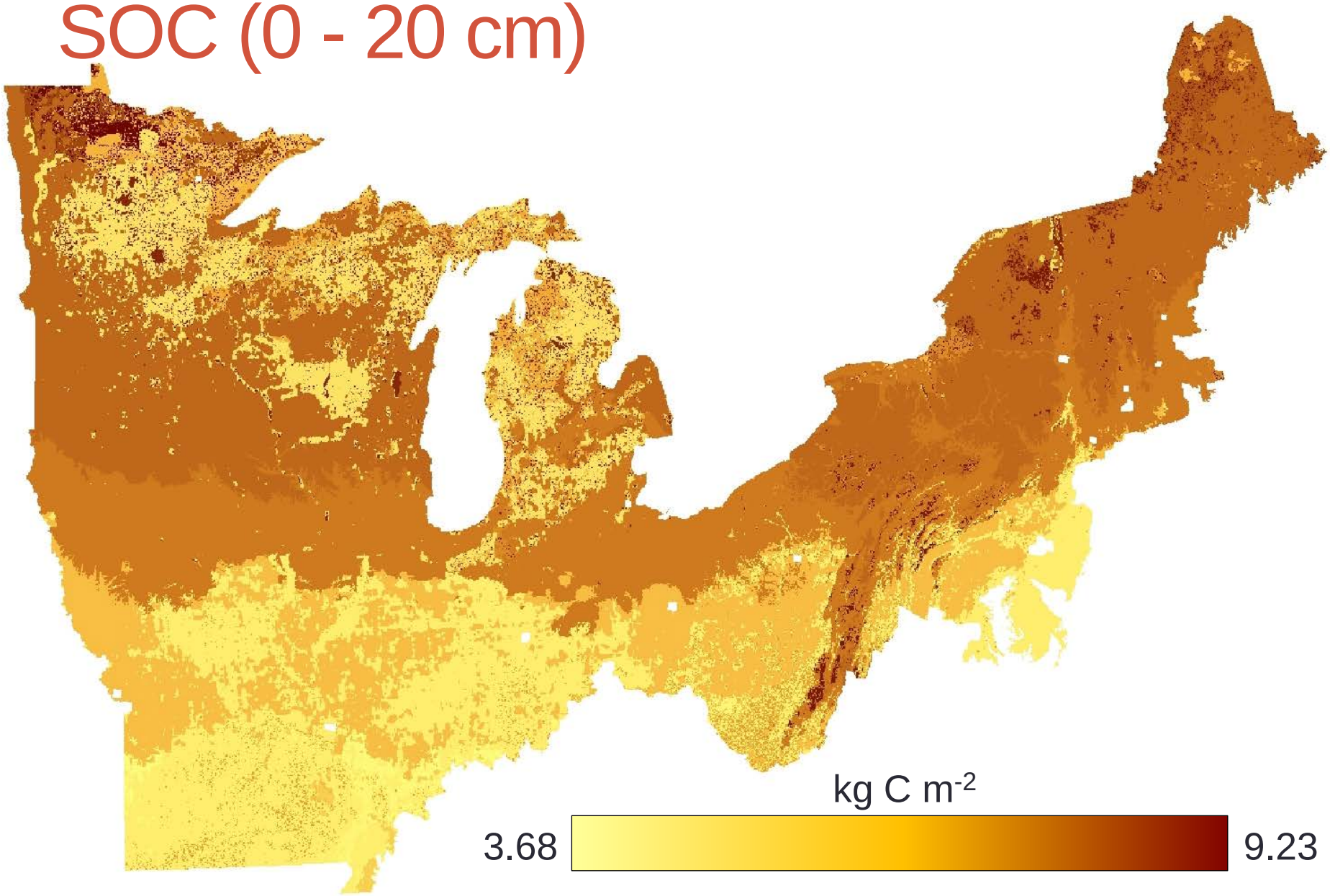
Sample Points (NCSS + FIA)



Preliminary Model



SOC (0 - 20 cm)



Summary

- Positive
  - Fast
  - Quasi-continuous
  - Useful for large areas
  - Nearly non-destructive
- Negative
  - Only indirect measurements
  - Need precise spatial and non-spatial transfer functions
  - Interpretation of geophysical results can be non-unique in terms of soil properties

Summary

- Combined with other environmental data, gamma has great potential as a tool for soils survey
  - Harmonization
  - Disaggregation
- Need a national strategy
  - How is gamma responding to soil variability in different parent materials?
  - What scale of gamma data is needed to provide effective information?
  - Best practices for harmonization and updating?