Alternatives for Managing Wheat Straw: *Assessing Soil Water Storage, Nutrient Status and Removal, and Weed Management*

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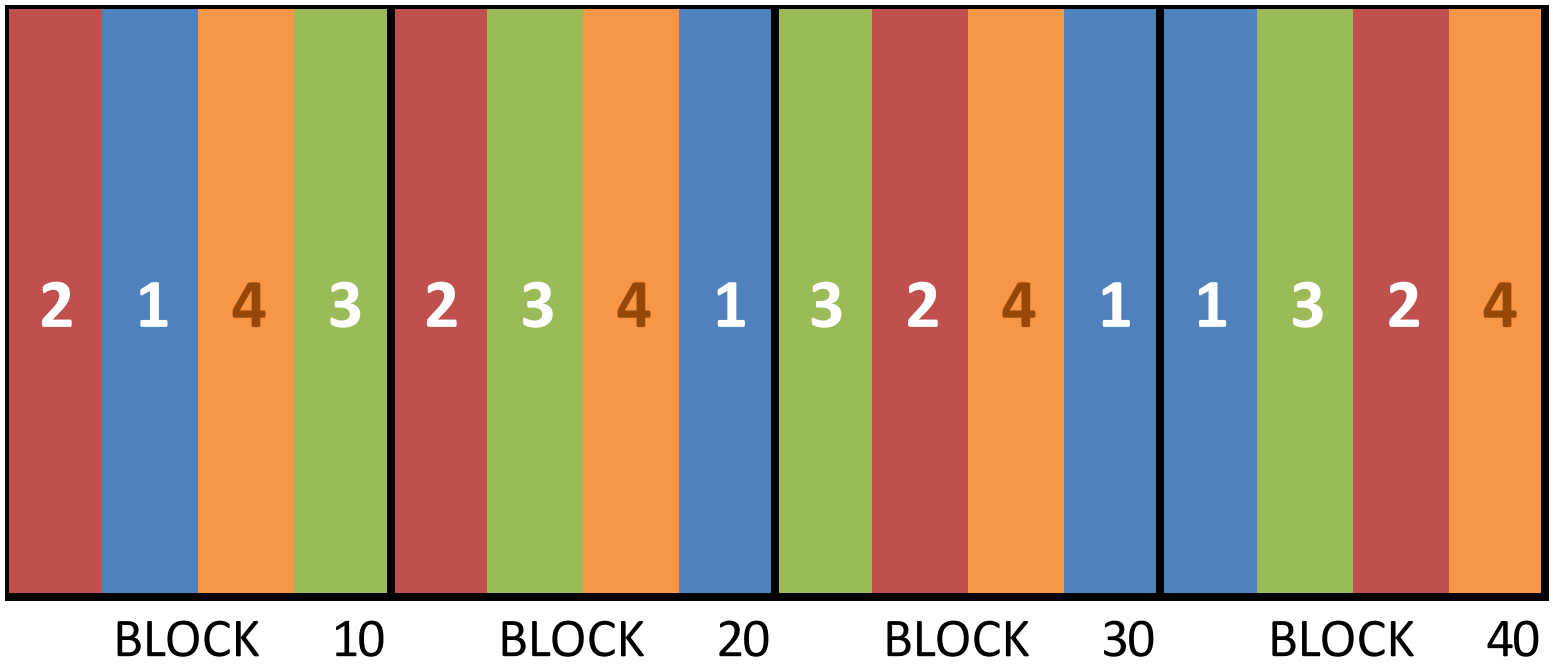
Design

- Uniformity Trial – yields (grain + straw)
  - Measure of inherent spatial variability
  - Provides baseline for evaluating treatment effects
  - Used to improve interpretation accuracy
- Treatment Effects
  - Amount of stubble plus nutrient status

2015 Yields

- Uniformity Trial
  - Measure of inherent spatial variability
- Provides baseline for evaluating treatment effects

Plot layout



RESIDUE MANAGEMENT TREATMENTS

1. Fully Spread Straw, Burn
2. Fully Spread Straw
3. Windrowed Straw Cut Low, Burn
4. Windrowed Straw Cut Low, Simulated Direct Bale System

Treatments

- 1. Cut high, spread, Burn residue
- 2. Cut high, spread, Retained
- 3. Cut low, windrow, Burn
- 4. Cut low, removed, simulated bale
- Measurements
  - Measure yields and nutrient status of biomass, retained stubble and ash
  - Measure water storage efficiency
  - Evaluate trt effect on nutrient status
  - Effects on soil and crop canopy temperatures

Random Effects by Treatment

- Uniformity Trial

	TRT		W	E	P
Grain Yield (bu/A)	1		126	119	59
	2		126	120	58
	3		133	118	59
	4		128	128	70
Straw Yield (lb/A)	1		17880	17097	10289
	2		17569	16975	10285
	3		18997	16850	9722
	4		18115	18077	11815
Biomass Yield (ton/A)	1		9.00	8.61	5.17
	2		8.85	8.55	5.17
	3		9.57	8.48	4.89
	4		9.12	9.10	5.94
Harvest Index	1		0.42	0.42	0.34
	2		0.43	0.42	0.34
	3		0.42	0.42	0.36
	4		0.42	0.42	0.35

Random Effects by Treatment

- Uniformity Trial

	P-Value
Grain Yield (bu/A)	0.0089
Straw Yield	0.0089
Biomass Yield (ton/A)	0.0189
Harvest Index	0.6028

Nutrient in Straw (ppm)

	Full Burn	Retained	Windrow	Removed
Boron	6.41	5.76	6.32	6.20
Zinc	3.48	3.74	3.32	3.62
Manganese	45.25	45.29	42.80	42.73
Copper	3.16	3.16	3.99	3.11
Iron	40.19	40.68	37.11	39.48
Aluminum	17.62	18.49	17.06	18.06
Arsenic	0.68	0.58	0.67	0.65
Cadmium	0.08	0.10	0.08	0.09
Cobalt	0.05	0.06	0.04	0.06
Chromium	1.49	1.47	2.01	1.71
Molybdenum	0.86	0.93	0.85	0.85
Nickel	0.23	0.27	0.20	0.26
Lead	0.28	0.33	0.36	0.38
Selenium	0.64	0.53	0.66	0.58
Strontium	9.34	9.85	9.09	9.17
Barium	44.49	45.50	46.04	46.45

Nutrient in Grain (ppm)

	Full Burn	Retained	Windrow	Removed
Boron	5.43	5.53	5.39	5.30
Zinc	17.72	17.31	16.84	17.83
Manganese	44.27	43.30	41.32	45.54
Copper	4.34	4.26	4.21	4.30
Iron	37.13	33.36	32.83	35.57
Aluminum	9.66	5.92	4.36	6.27
Arsenic	0.55	0.59	0.63	0.62
Cadmium	0.04	0.06	0.05	0.05
Cobalt	0.04	0.06	0.05	0.06
Chromium	1.49	1.50	1.75	1.52
Molybdenum	0.57	0.60	0.60	0.59
Nickel	0.56	0.50	0.53	0.47
Lead	0.20	0.27	0.34	0.24
Selenium	0.69	0.61	0.45	0.67
Strontium	3.20	3.11	2.95	3.28
Barium	9.92	9.87	9.26	10.16

Nutrient in Stubble (ppm)

	Full Burn	Retained	Windrow	Removed
Boron	.	5.65	5.83	5.60
Zinc	.	7.47	7.96	7.36
Manganese	.	92.5	96.3	92.2
Copper	.	2.89	3.16	2.81
Iron	.	1309	1554	1013
Aluminum	.	1185	1359	871
Arsenic	.	0.83	0.85	0.66
Cadmium	.	0.17	0.15	0.17
Cobalt	.	0.75	0.92	0.62
Chromium	.	1.76	2.77	1.82
Molybdenum	.	0.25	0.25	0.31
Nickel	.	1.33	1.49	1.17
Lead	.	0.77	0.85	0.52
Selenium	.	0.04	-0.02	0.09
Strontium	.	18.28	17.11	17.74
Barium	.	60.33	56.63	50.67

Nutrient in Ash (ppm)

	Full Burn	Retained	Windrow	Removed
Boron	5.94	.	3.94	.
Zinc	29.10	.	38.01	.
Manganese	301.85	.	402.83	.
Copper	12.61	.	15.54	.
Iron	7873	.	8170	.
Aluminum	6630	.	6577	.
Arsenic	1.86	.	1.83	.
Cadmium	0.14	.	0.23	.
Cobalt	4.73	.	4.18	.
Chromium	27.35	.	13.41	.
Molybdenum	0.46	.	0.78	.
Nickel	14.69	.	7.90	.
Lead	3.37	.	3.06	.
Selenium	1.91	.	0.88	.
Strontium	38.02	.	63.51	.
Barium	149.06	.	261.30	.

Nutrient Status on Soil ?

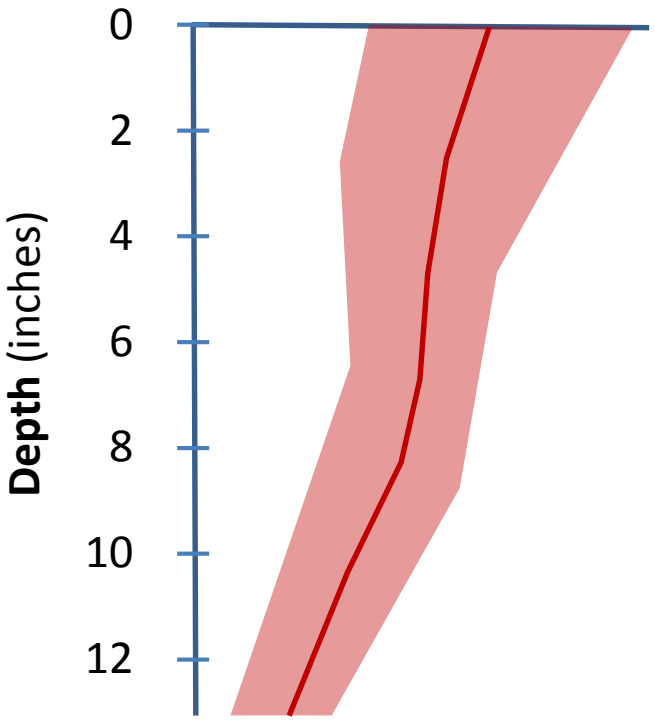
- Trt Effects on nutrient status
  - By site replication and treatment
- Examples

Tillage Effects on Stratification

- One-foot soil profile chart …

X-axis: Nutrient or Condition

Y-axis: Sampling Depth

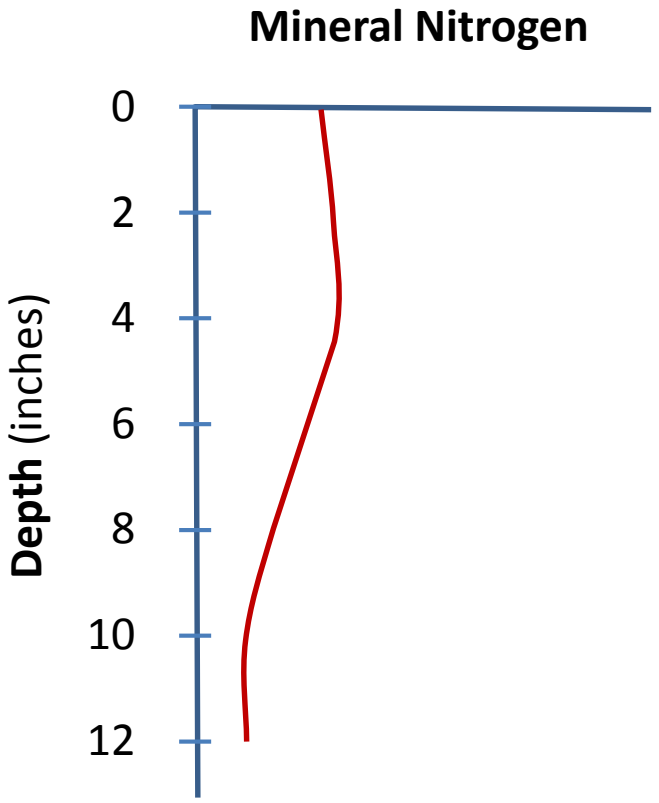


Stratification can affect:

1. Nutrient availability
2. Microbial activity
3. Biomass decomposition rates
4. Nutrient cycling
5. Root development

Tillage Effects on Stratification

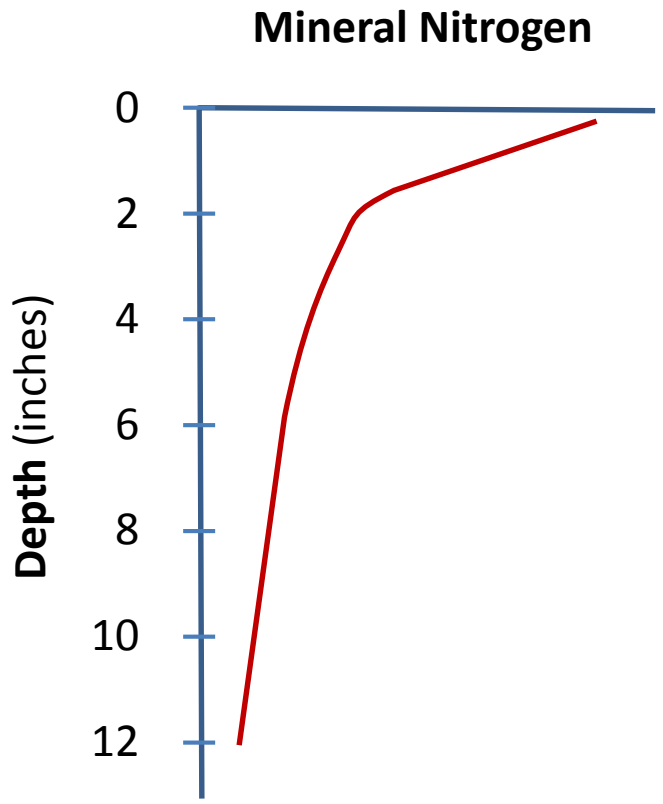
- Soil profile chart format … *Conventional*



Thorough mixing action

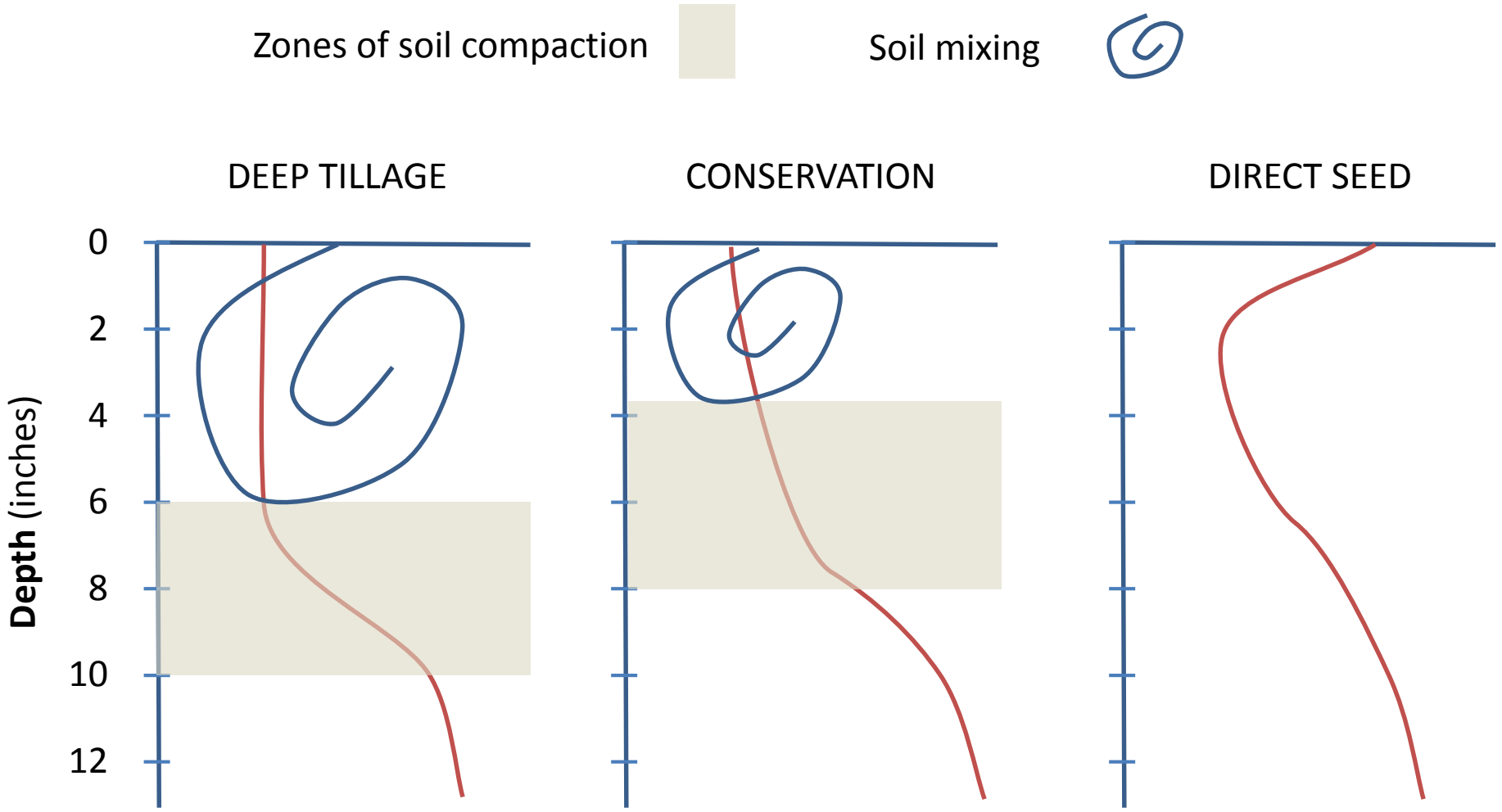
Tillage Effects on Stratification

- Soil profile chart format … *No-Till*



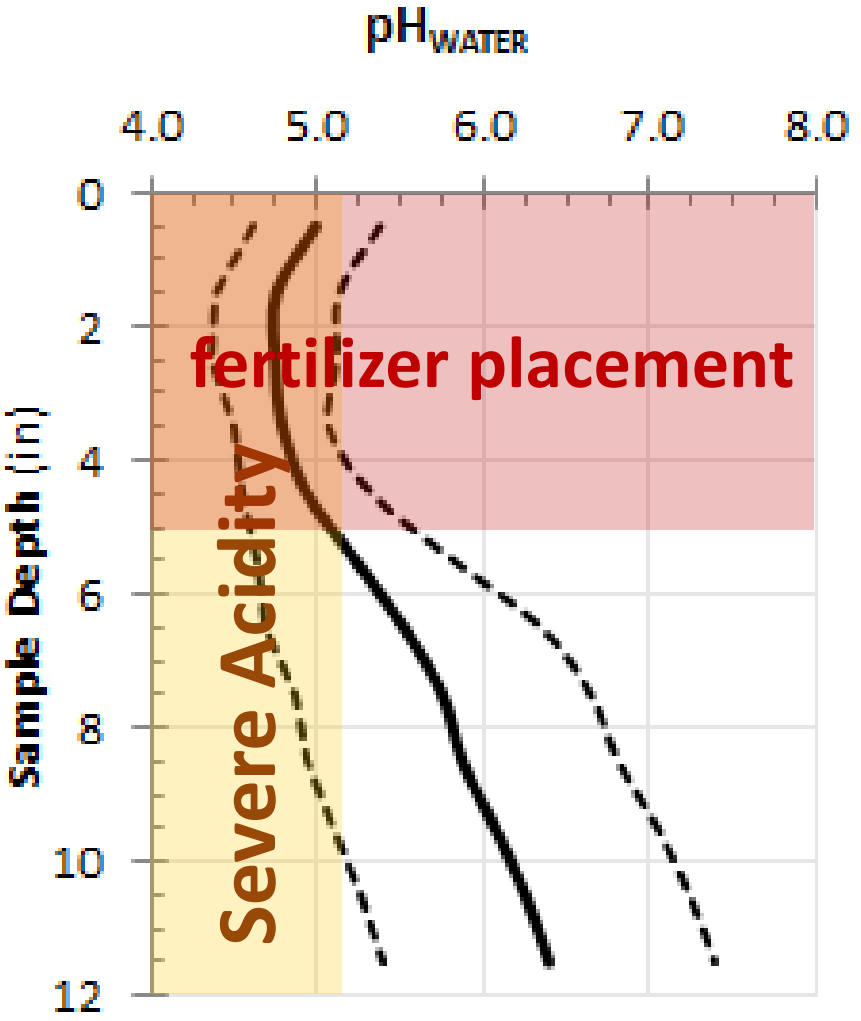
Minimal mixing action

Patterns of Stratification. *Tillage*



Soil pH (H_2O)

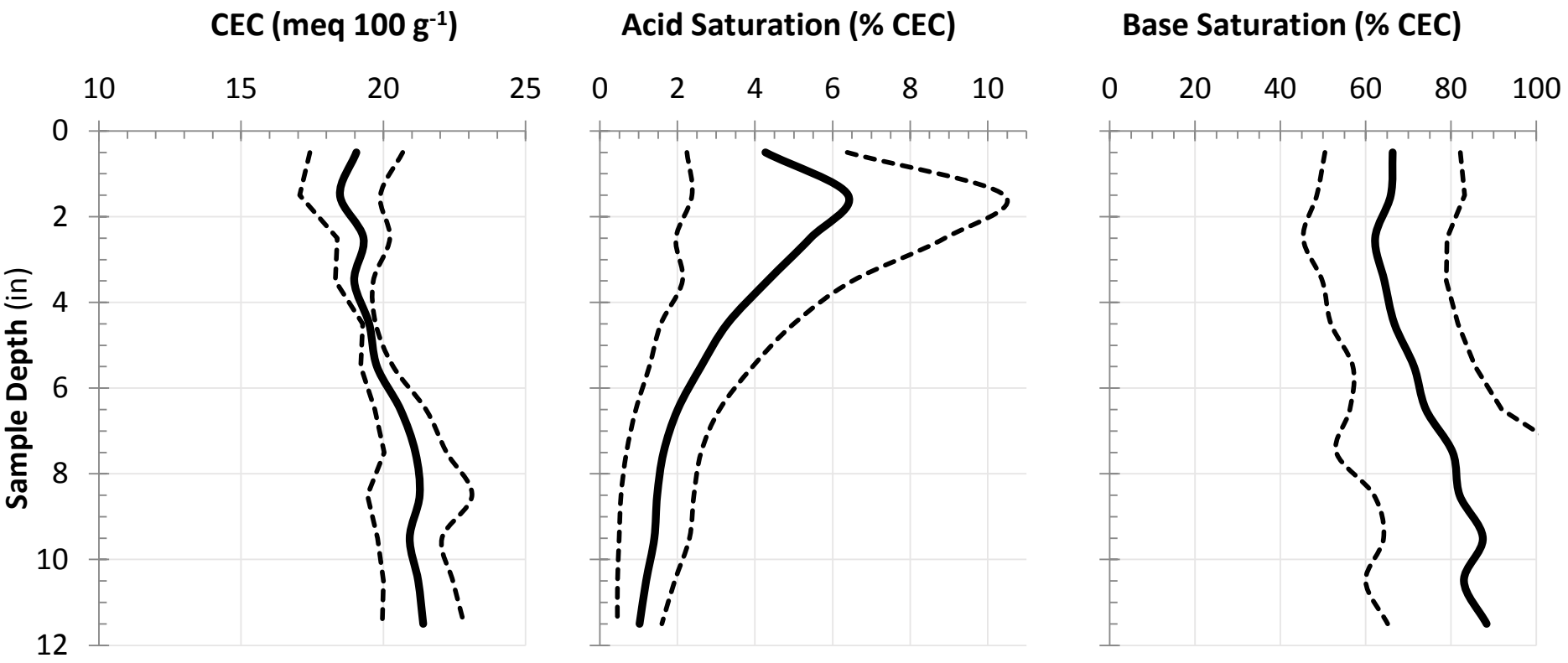
- Soil pH below 5.2 is considered severe, a sign of soil degradation
- Nitrogen- and sulfur-based fertilizers acidify soil



Cation Exchange

([Al] + [Mn] + [Fe]) ÷ CEC

([Ca] + [Mg] + [Na] + [K]) ÷ CEC

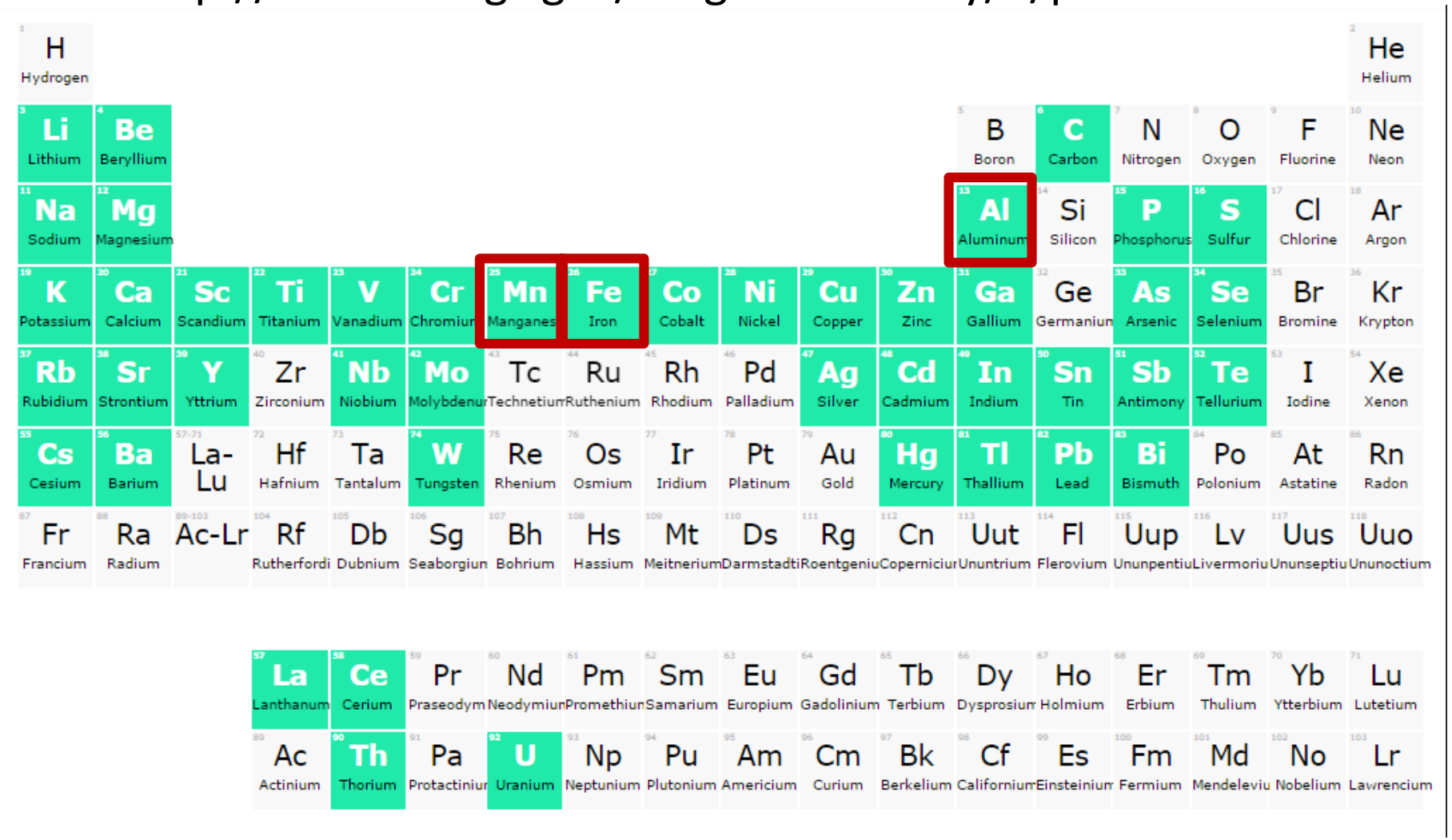


Nutrients

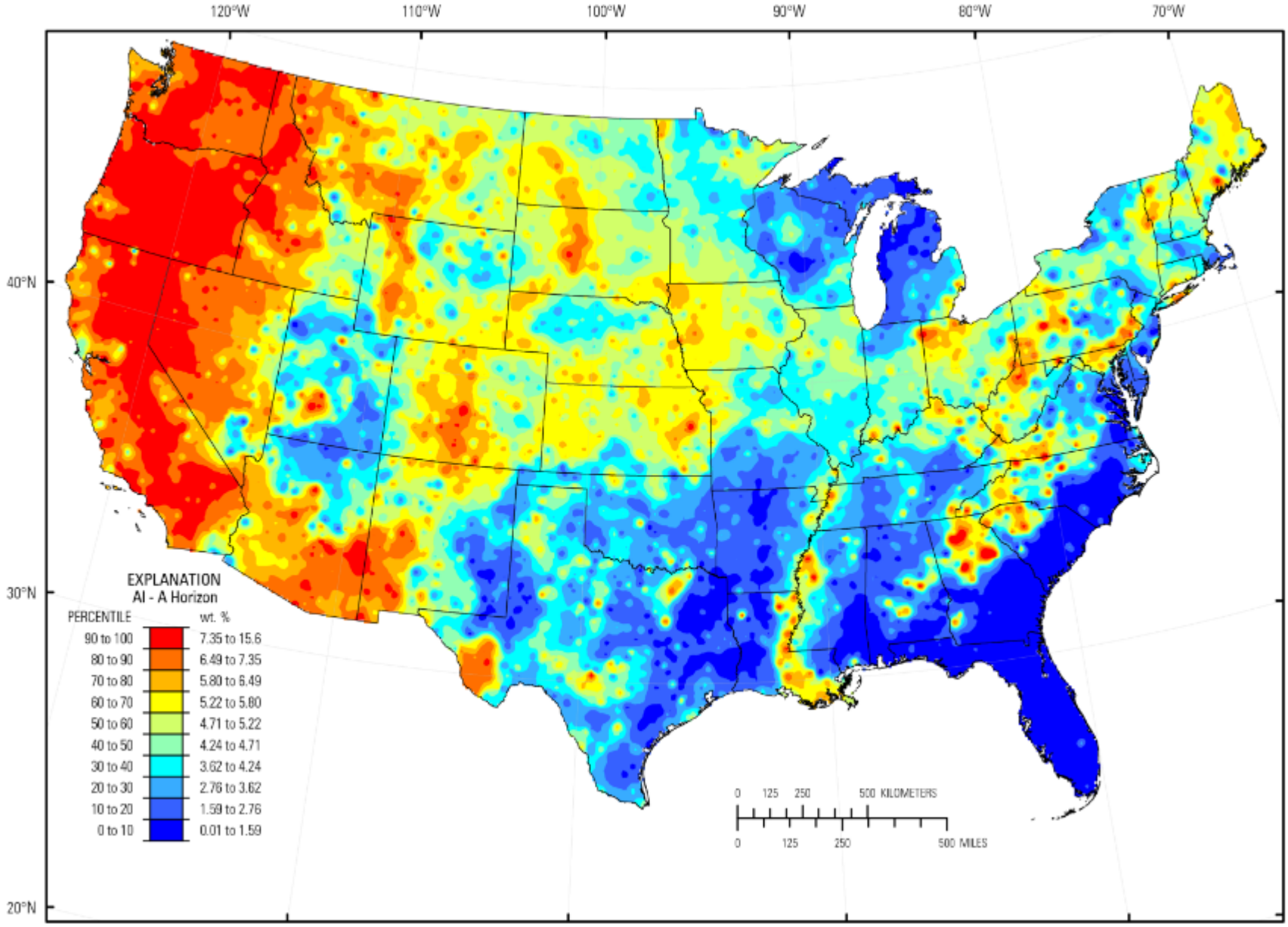
- Residual nutrients are strongly held inside of soil particles – high concentrations
- Exchangeable nutrients occupy exchange sites at or near surfaces of soil particles – lower concentrations
- How is the CEC affected by changes in soil pH?
  - Consider exchangeable acidity
  - Consider base saturation

Residual Nutrients. *Soil Profile Survey*

http://mrdata.usgs.gov/soilgeochemistry/#/periodictable

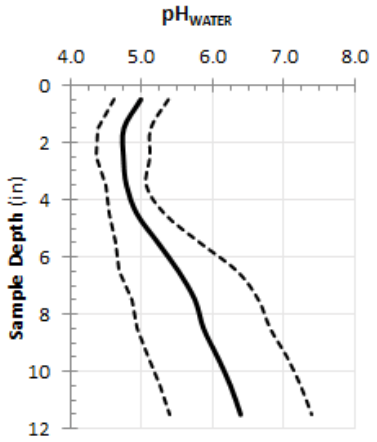


“A” horizon residual. *Aluminum [Al]*



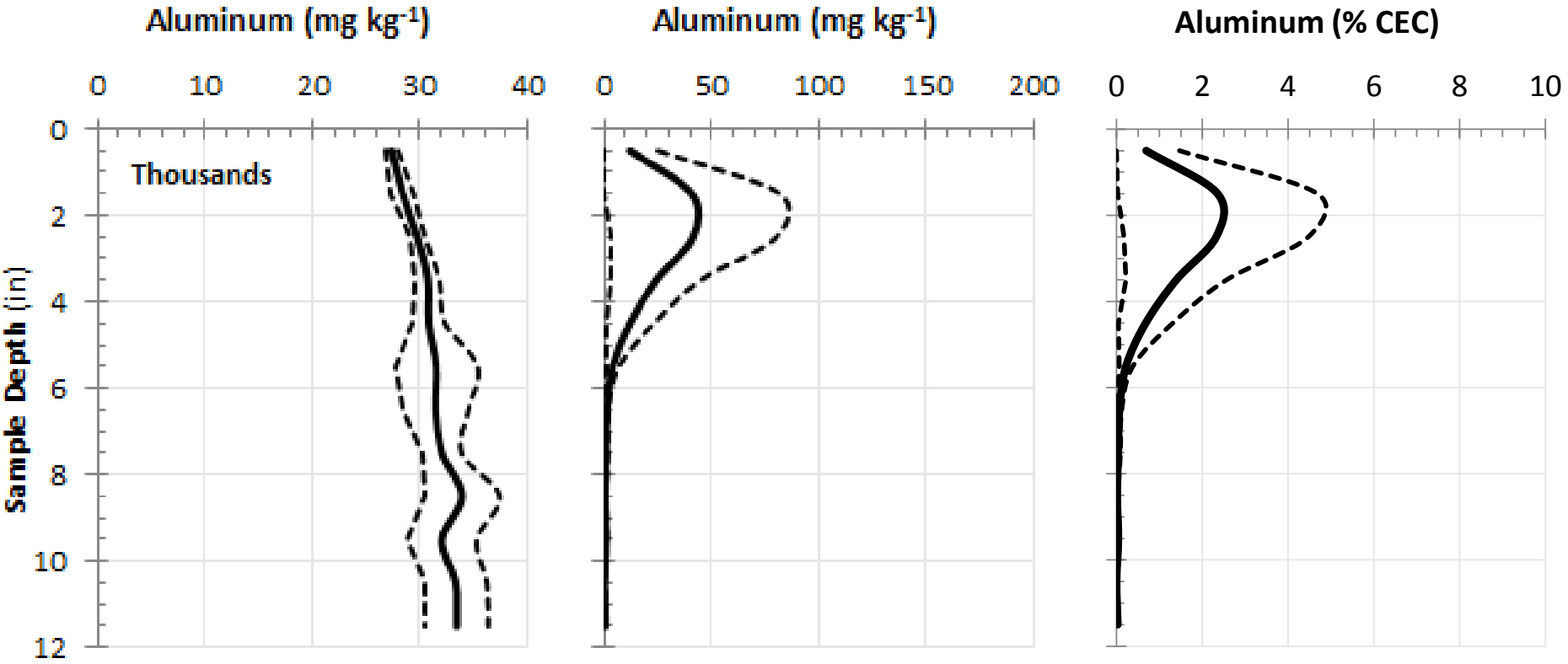
Aluminum [Al]

Al = Acid-forming cation. Causes root stunting under acid conditions, can obstruct nutrient and water uptake, decreases microbial activity, binds phosphorus under acid conditions

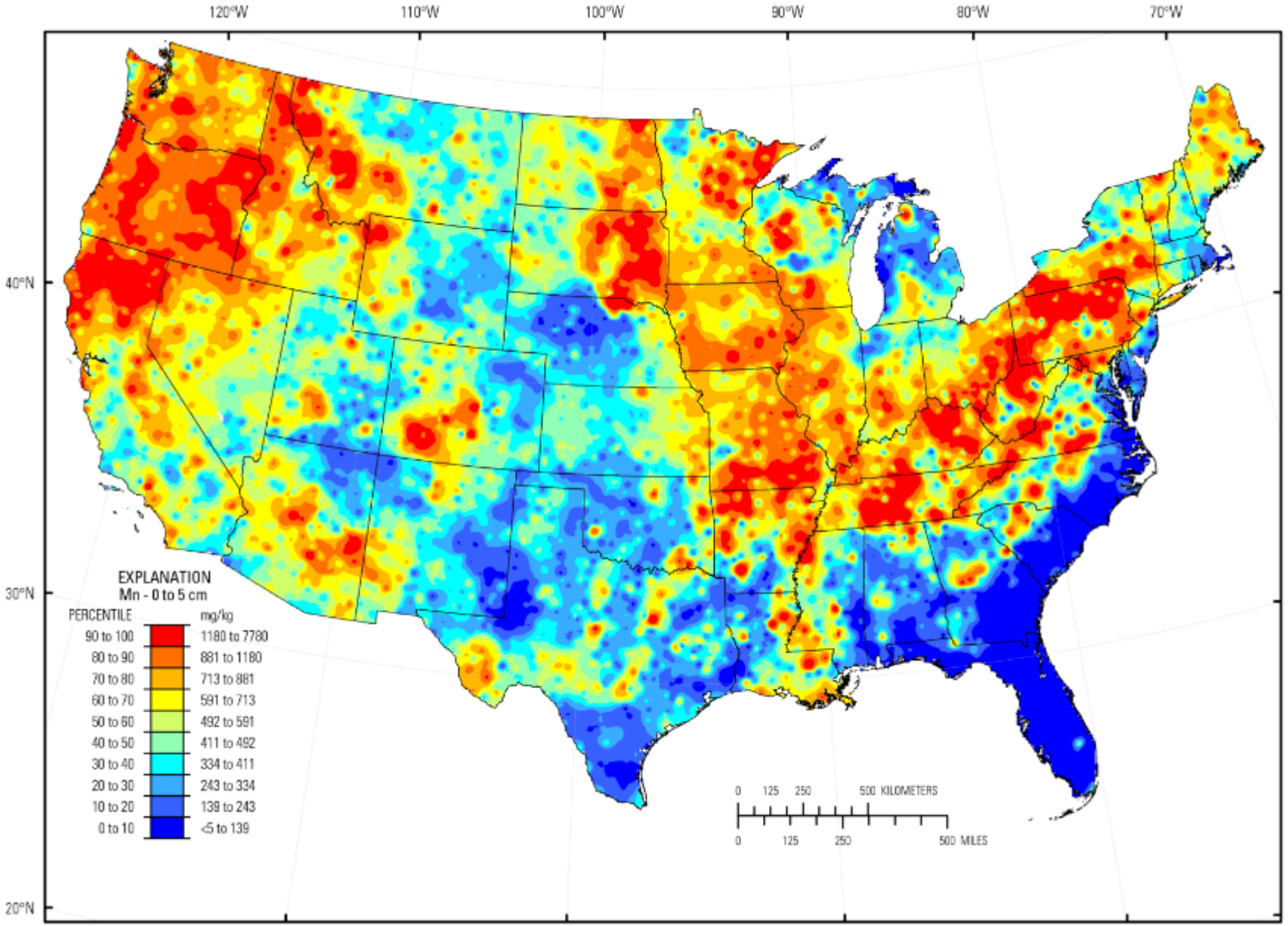


RESIDUAL

EXCHANGEABLE (KCl)

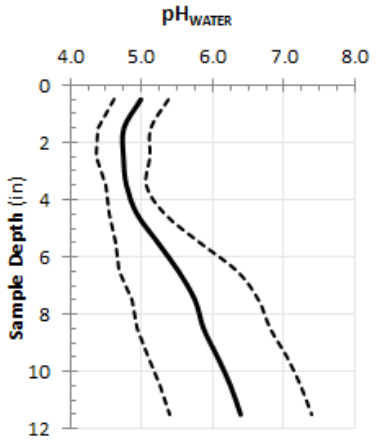


“A” horizon residual. *Manganese [Mn]*



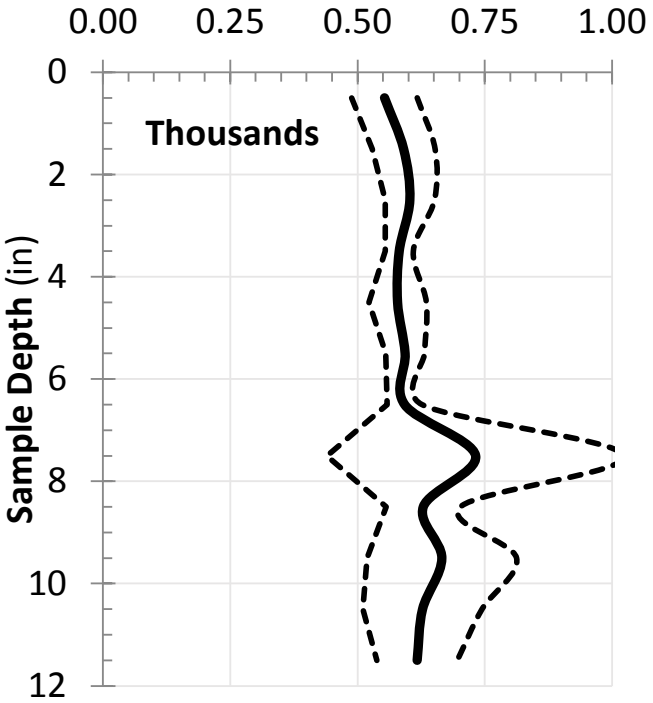
Manganese [Mn]

Mn = Acid-forming cation. essential plant nutrient (MICRO), decreases microbial activity, binds phosphorus under acid conditions



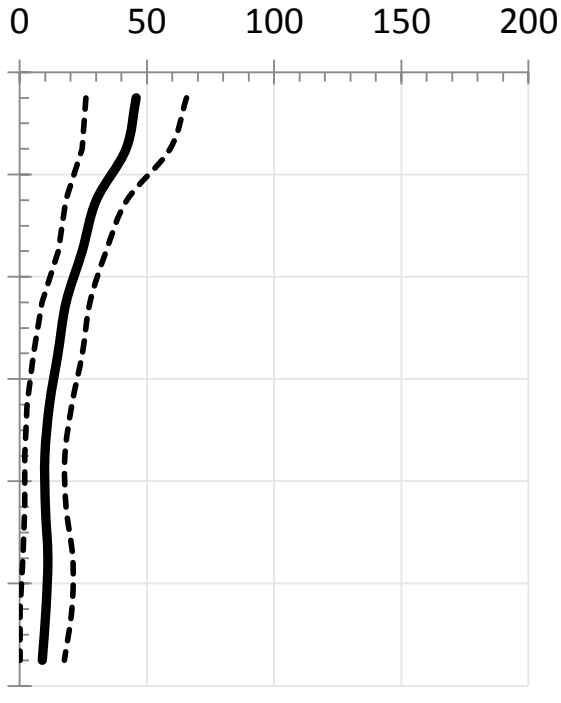
RESIDUAL

Manganese (mg kg^{-1})

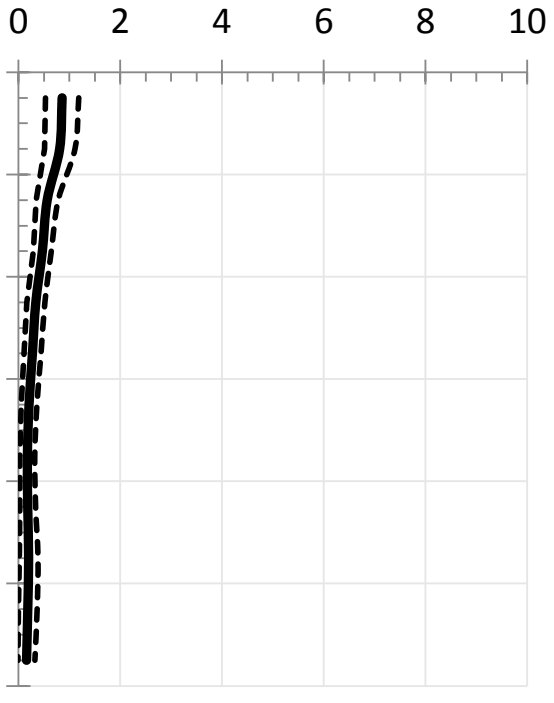


EXCHANGEABLE (DTPA)

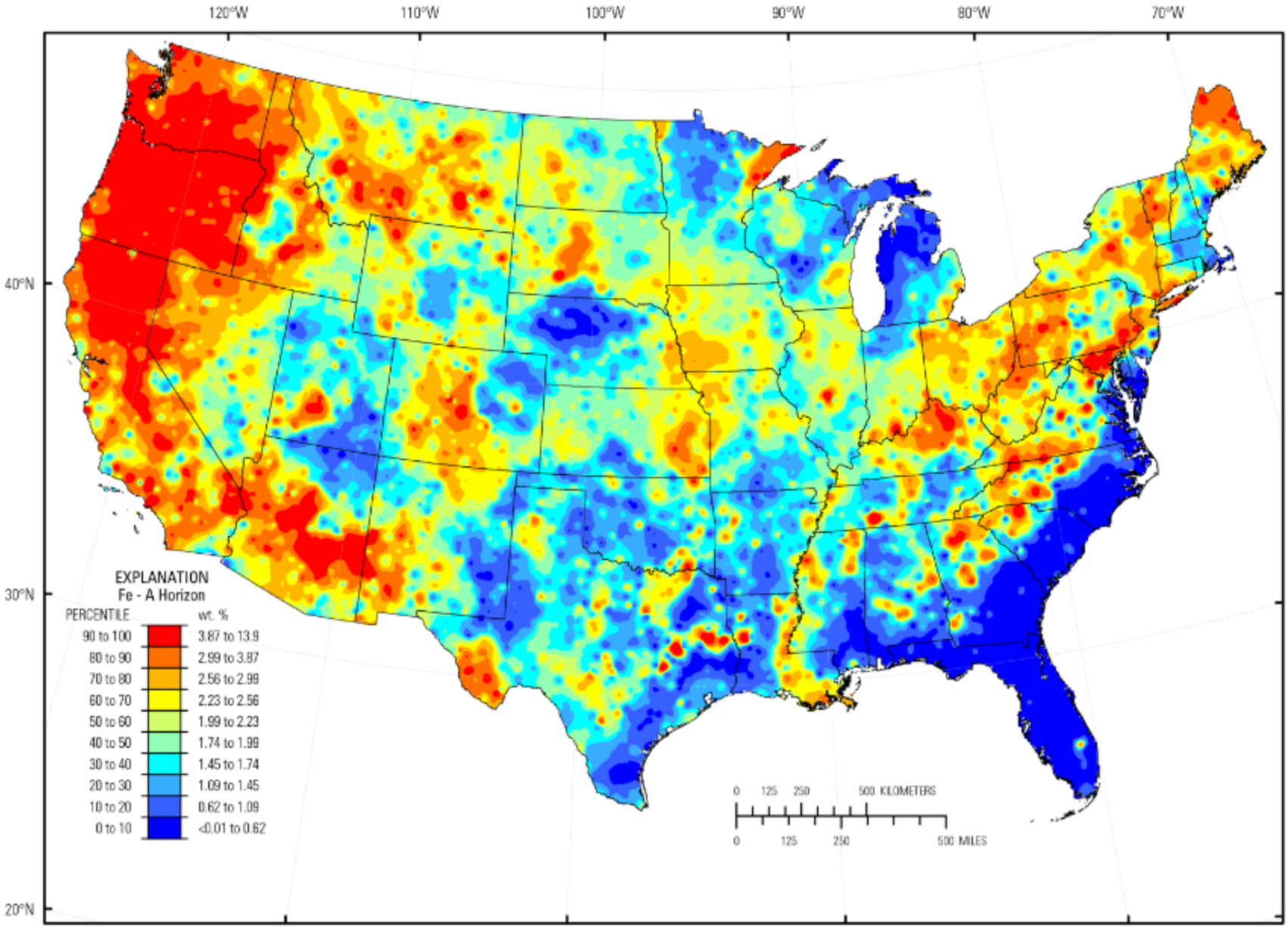
Manganese (mg kg^{-1})



Manganese (% CEC)

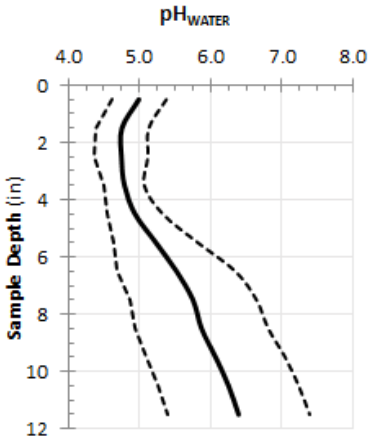


“A” horizon residual. *Iron [Fe]*



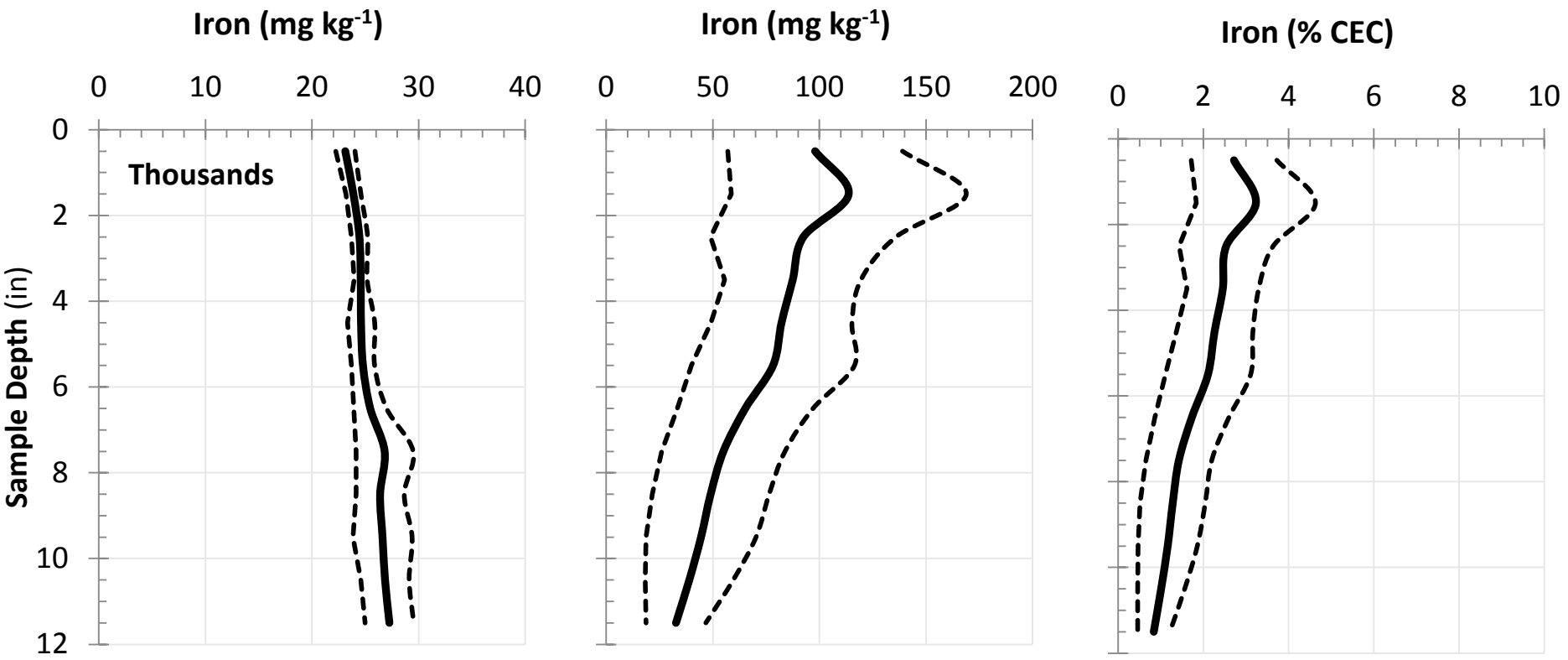
Iron [Fe]

Fe = Acid-forming cation. Essential plant nutrient (MICRO), binds phosphorus

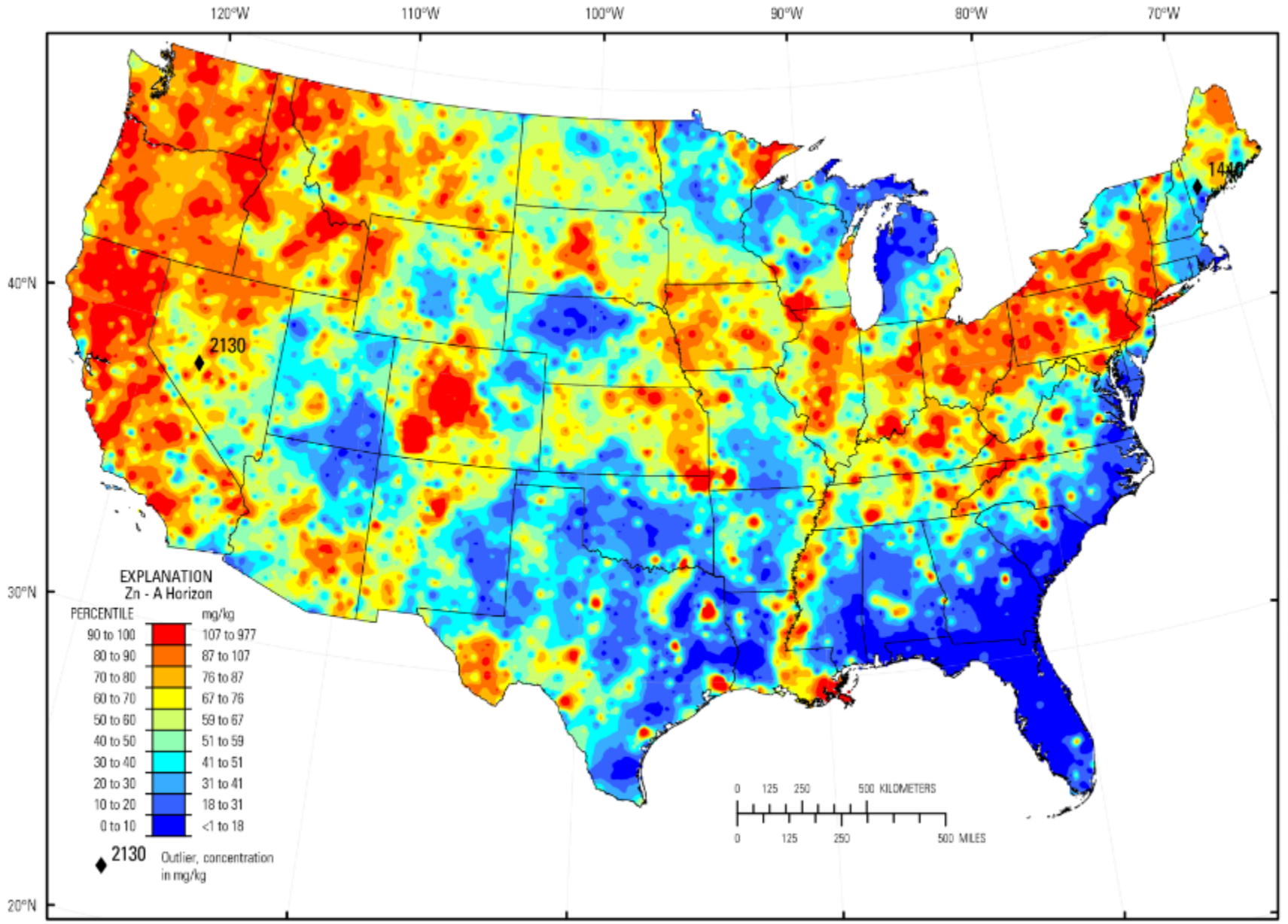


RESIDUAL

EXCHANGEABLE (DTPA)

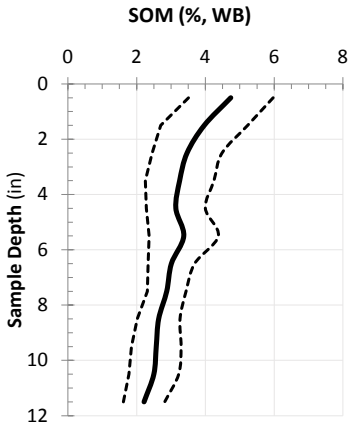


Zinc [Zn]


120°W
110°W
100°W
90°W
80°W
70°W
40°N
30°N
20°N
2130
1440
EXPLANATION
Zn - A Horizon
PERCENTILE
mg/kg
90 to 100
107 to 977
80 to 90
87 to 107
70 to 80
76 to 87
60 to 70
67 to 76
50 to 60
59 to 67
40 to 50
51 to 59
30 to 40
41 to 51
20 to 30
31 to 41
10 to 20
18 to 31
0 to 10
<1 to 18
2130
Outlier, concentration in mg/kg
0 125 250 500 KILOMETERS
0 125 250 500 MILES

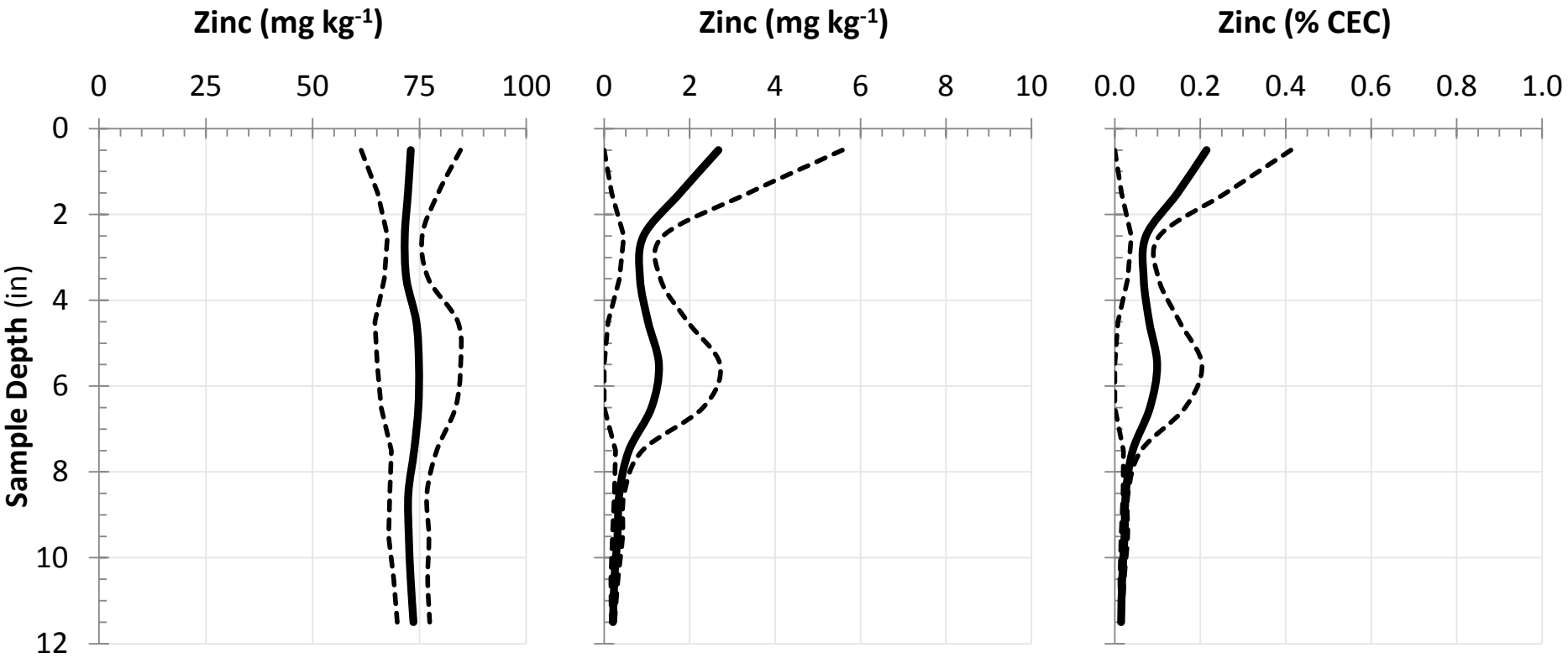
Zinc [Zn]

Zn = Base-forming cation. Essential plant nutrient (MICRO). In plant constituent of three or more enzymes, and plays role in plant hormone synthesis (auxin).



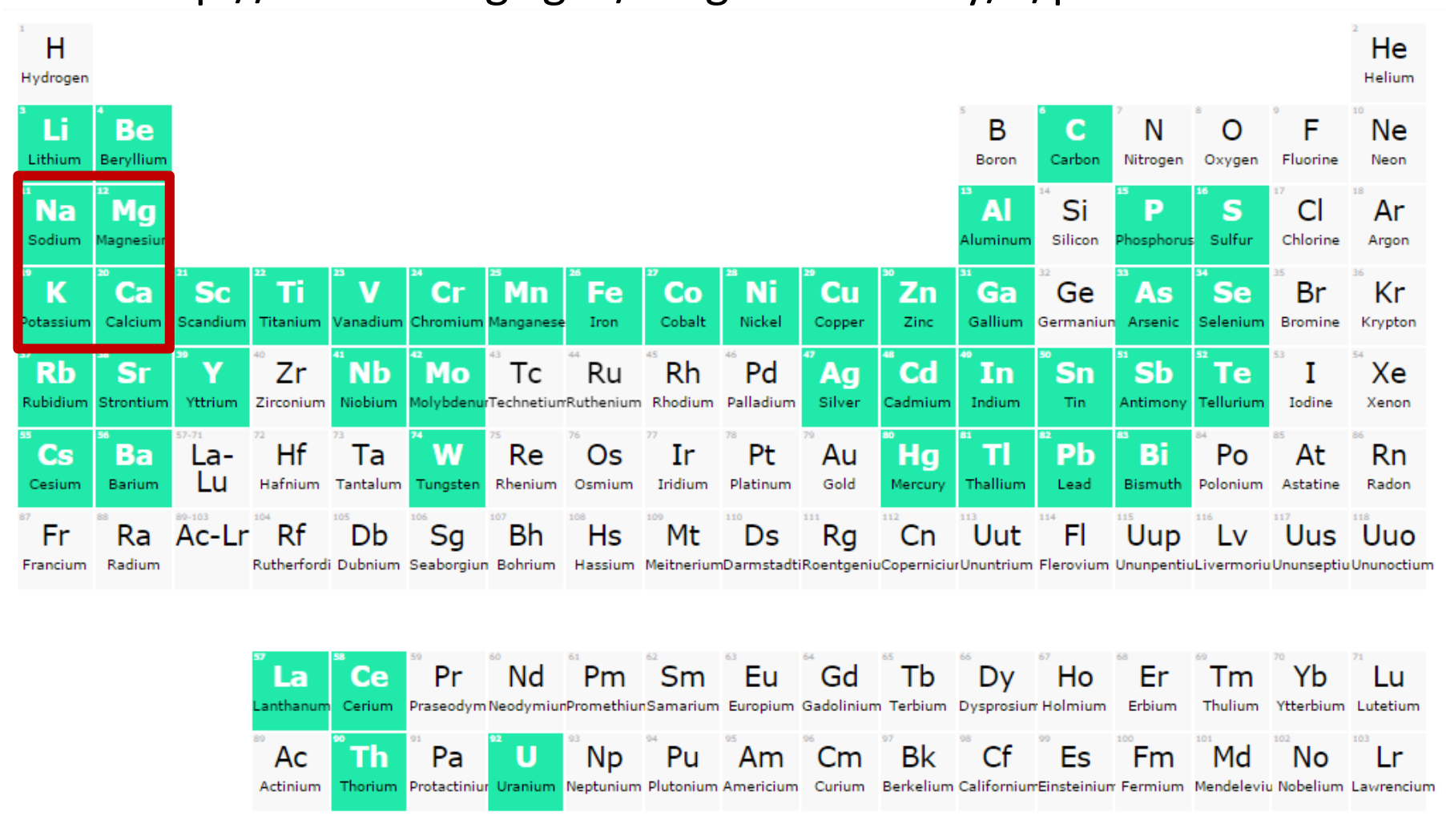
RESIDUAL

EXCHANGEABLE (DTPA)

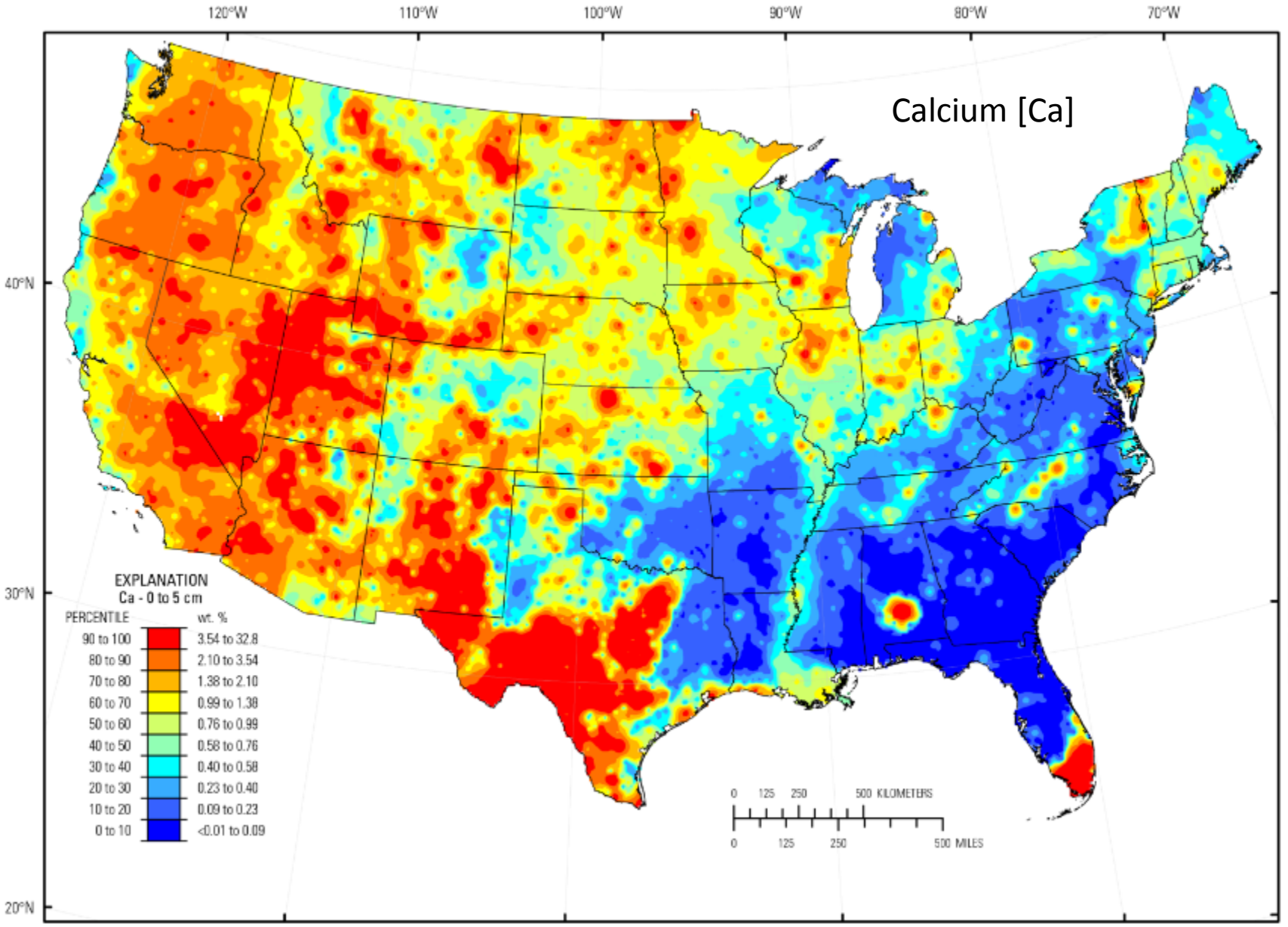


Residual Nutrients. *Soil Profile Survey*

http://mrdata.usgs.gov/soilgeochemistry/#/periodictable

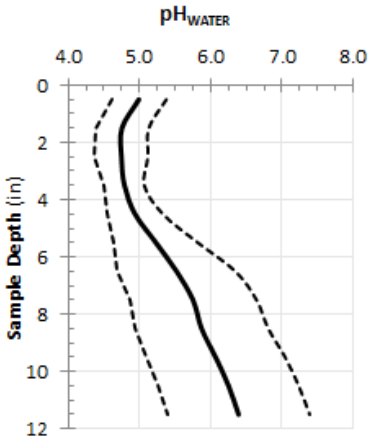


Calcium [Ca]


120°W
110°W
100°W
90°W
80°W
70°W
40°N
30°N
20°N
Calcium [Ca]
EXPLANATION
Ca - 0 to 5 cm
PERCENTILE
wt. %
90 to 100
3.54 to 32.8
80 to 90
2.10 to 3.54
70 to 80
1.38 to 2.10
60 to 70
0.99 to 1.38
50 to 60
0.76 to 0.99
40 to 50
0.58 to 0.76
30 to 40
0.40 to 0.58
20 to 30
0.23 to 0.40
10 to 20
0.09 to 0.23
0 to 10
<0.01 to 0.09
0 125 250 500 KILOMETERS
0 125 250 500 MILES

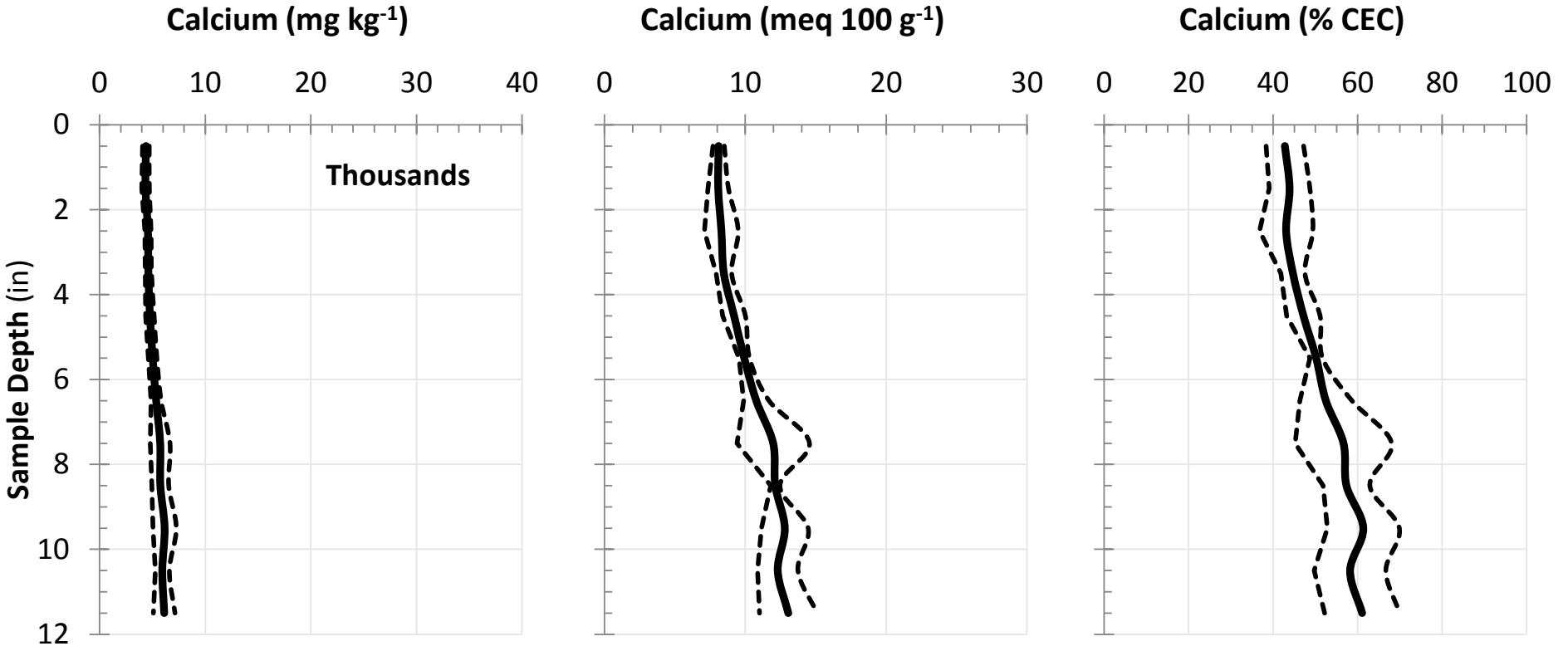
Calcium [Ca]

Ca = Base-forming cation. Essential plant nutrient (MACRO), in plant regulates ion exchange and important for cell structure. In soil binds phosphorus under alkaline conditions

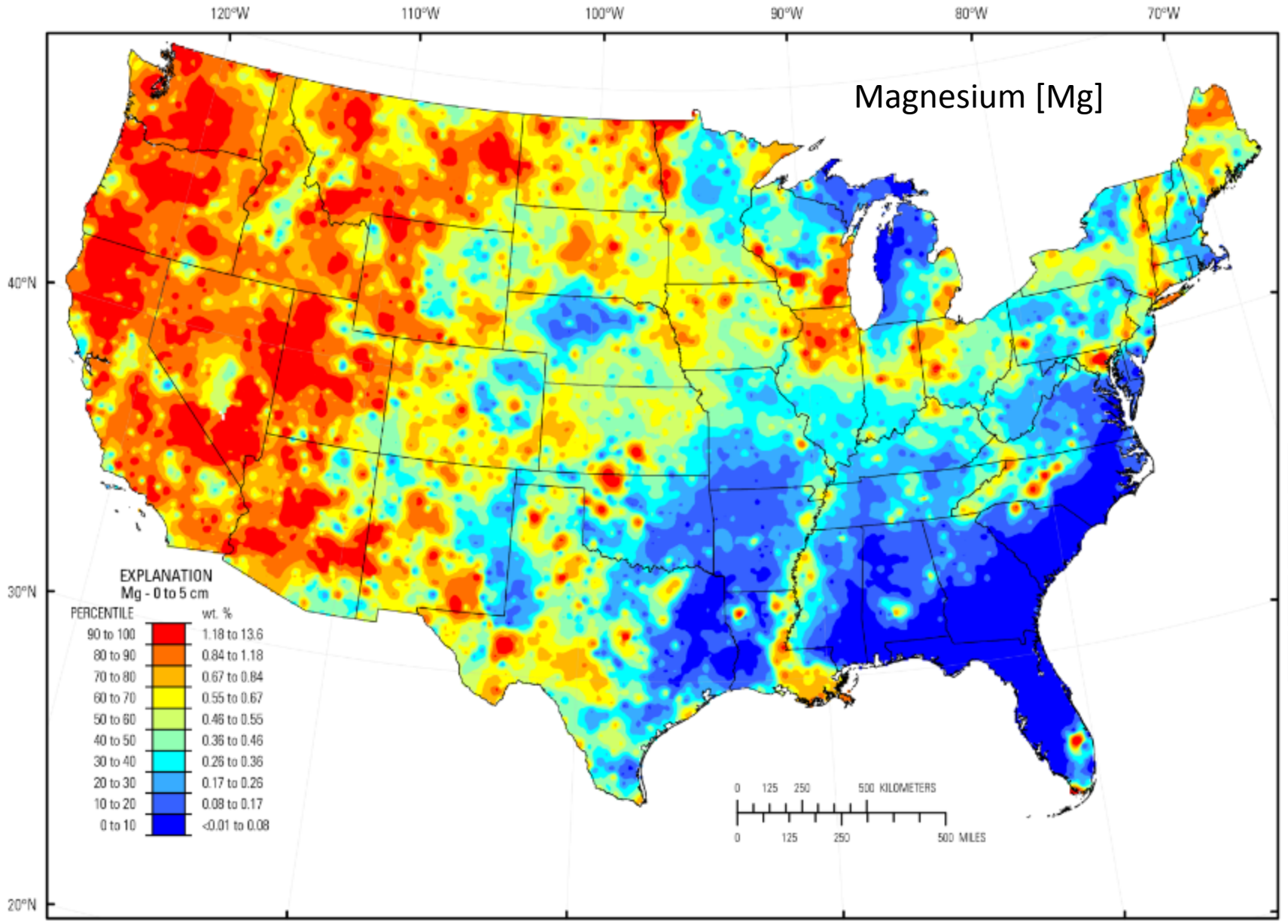


RESIDUAL

EXCHANGEABLE (KCl)

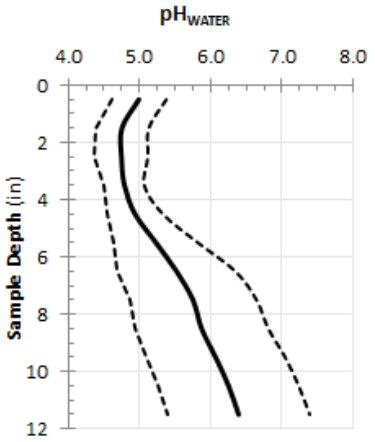


Magnesium [Mg]



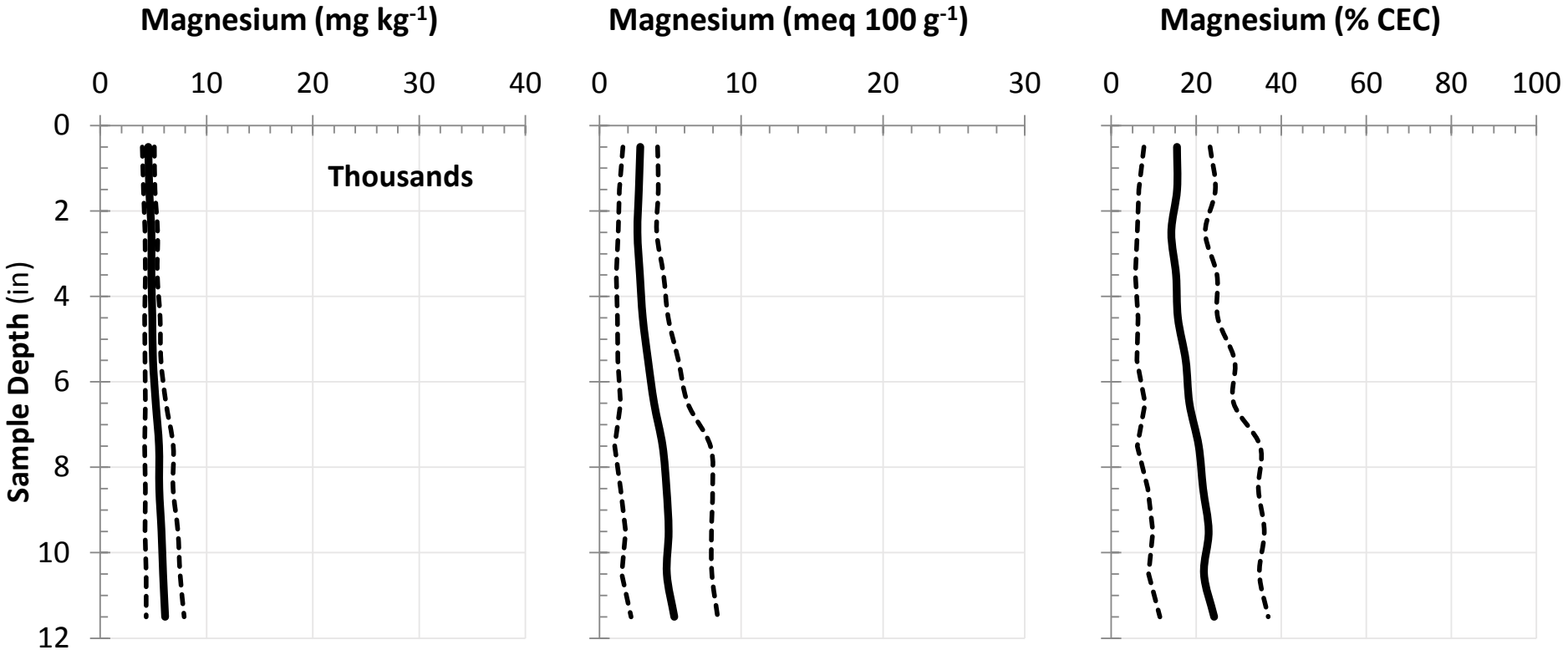
Magnesium [Mg^{+}]

Mg = Base-forming cation. Essential plant nutrient (MACRO), in plant key element in chlorophyll. In soil, binds phosphorus under alkaline conditions, relatively soluble under acid conditions

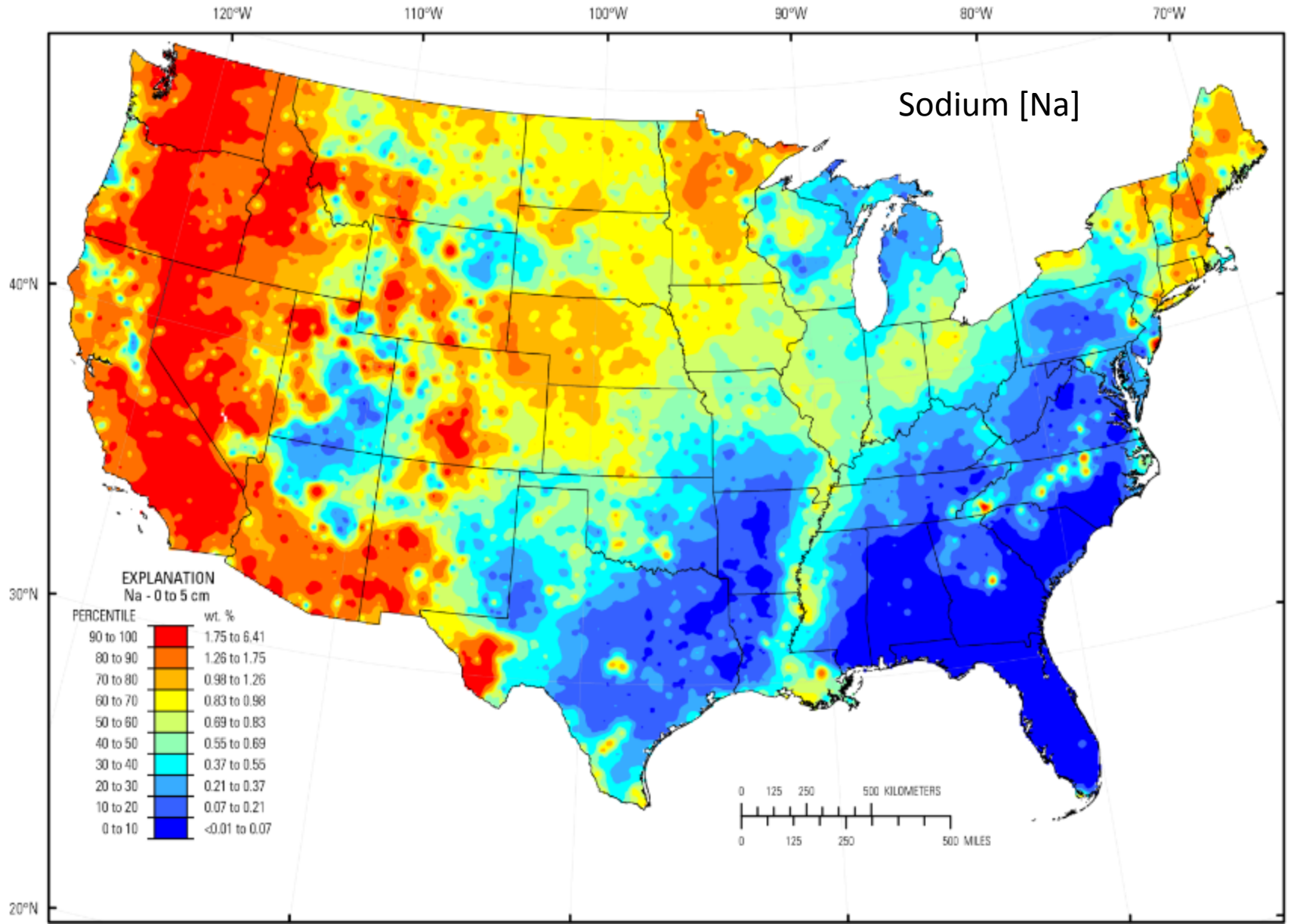


RESIDUAL

EXCHANGEABLE (KCl)

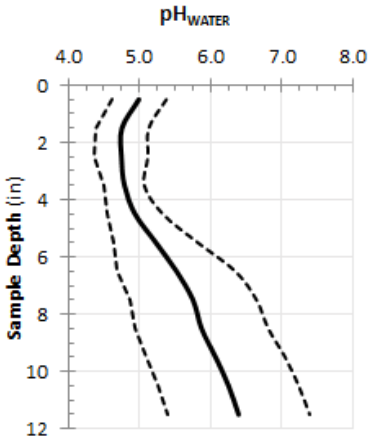


Sodium [Na]


120°W
110°W
100°W
90°W
80°W
70°W
40°N
30°N
20°N
Sodium [Na]
EXPLANATION
Na - 0 to 5 cm
PERCENTILE
wt. %
90 to 100
1.75 to 6.41
80 to 90
1.26 to 1.75
70 to 80
0.98 to 1.26
60 to 70
0.83 to 0.98
50 to 60
0.69 to 0.83
40 to 50
0.55 to 0.69
30 to 40
0.37 to 0.55
20 to 30
0.21 to 0.37
10 to 20
0.07 to 0.21
0 to 10
<0.01 to 0.07
0 125 250 500 KILOMETERS
0 125 250 500 MILES

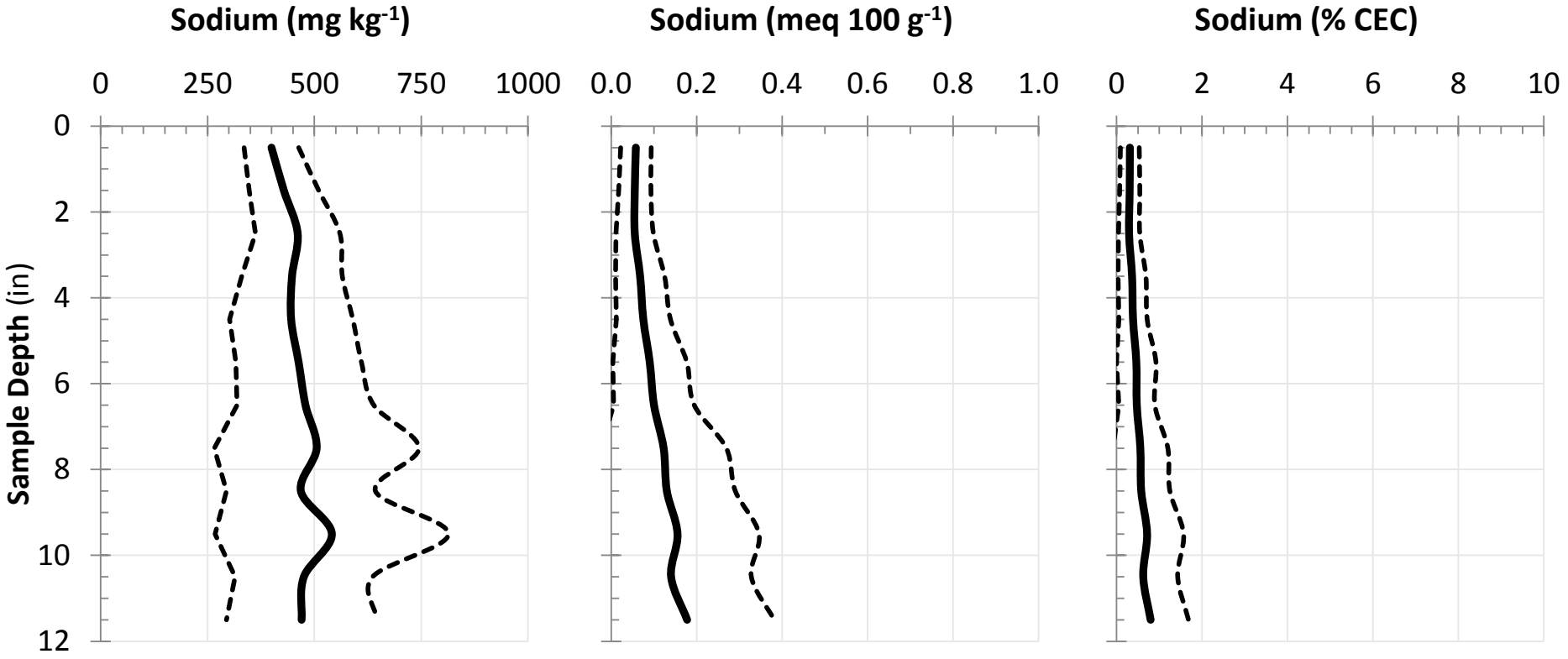
Sodium [Na]

Na = Base-forming cation. Not essential plant nutrient. In plant can sometimes replace function of potassium. In soil at high concentration pull moisture away from plant roots

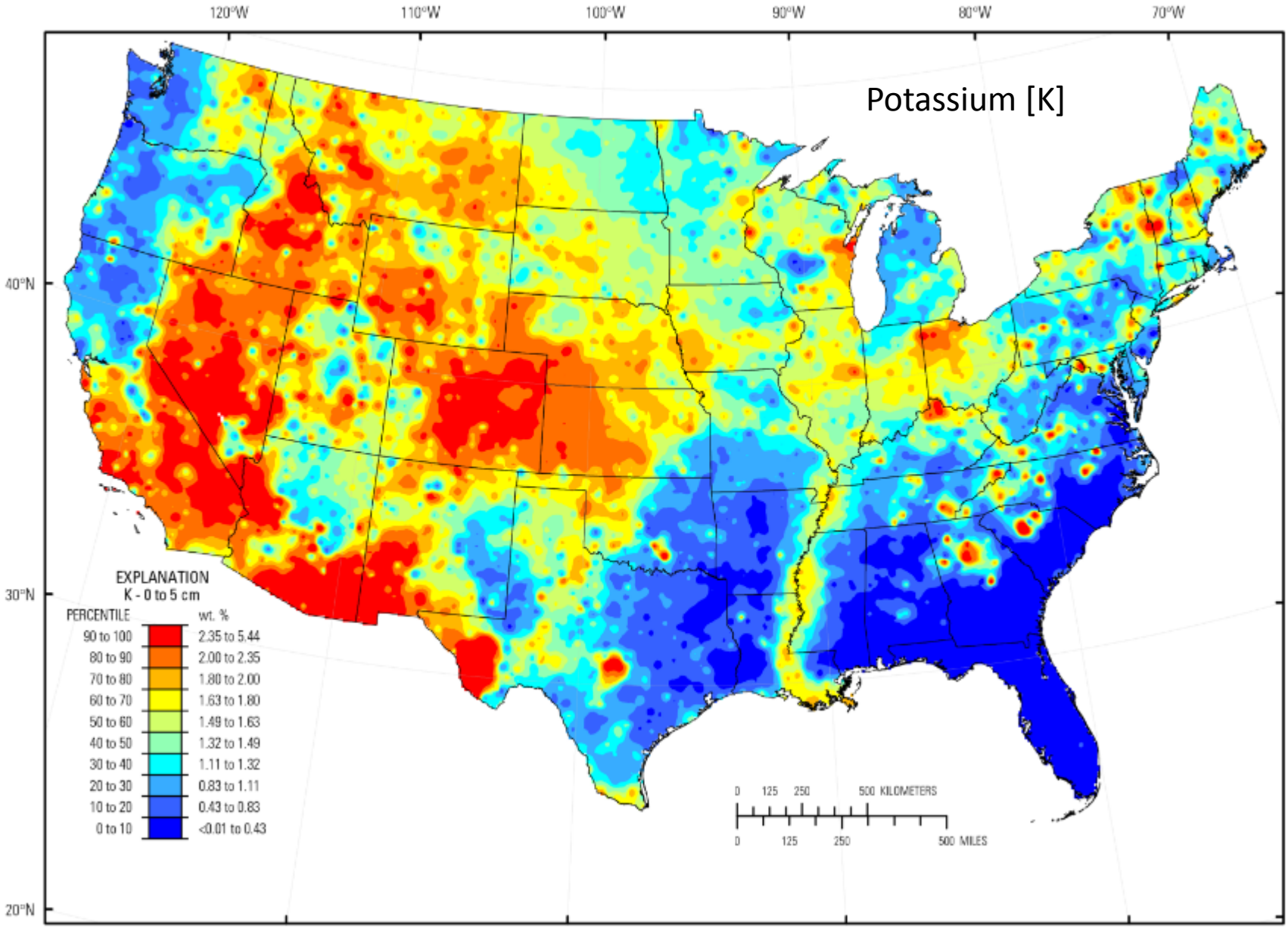


RESIDUAL

EXCHANGEABLE (KCl)

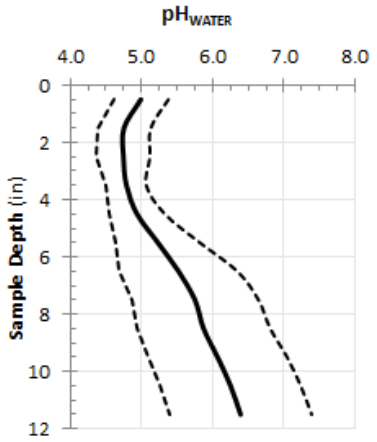


Potassium [K]


120°W
110°W
100°W
90°W
80°W
70°W
40°N
30°N
20°N
Potassium [K]
EXPLANATION
K - 0 to 5 cm
PERCENTILE
wt. %
90 to 100
2.35 to 5.44
80 to 90
2.00 to 2.35
70 to 80
1.80 to 2.00
60 to 70
1.63 to 1.80
50 to 60
1.49 to 1.63
40 to 50
1.32 to 1.49
30 to 40
1.11 to 1.32
20 to 30
0.83 to 1.11
10 to 20
0.43 to 0.83
0 to 10
<0.01 to 0.43
0 125 250 500 KILOMETERS
0 125 250 500 MILES

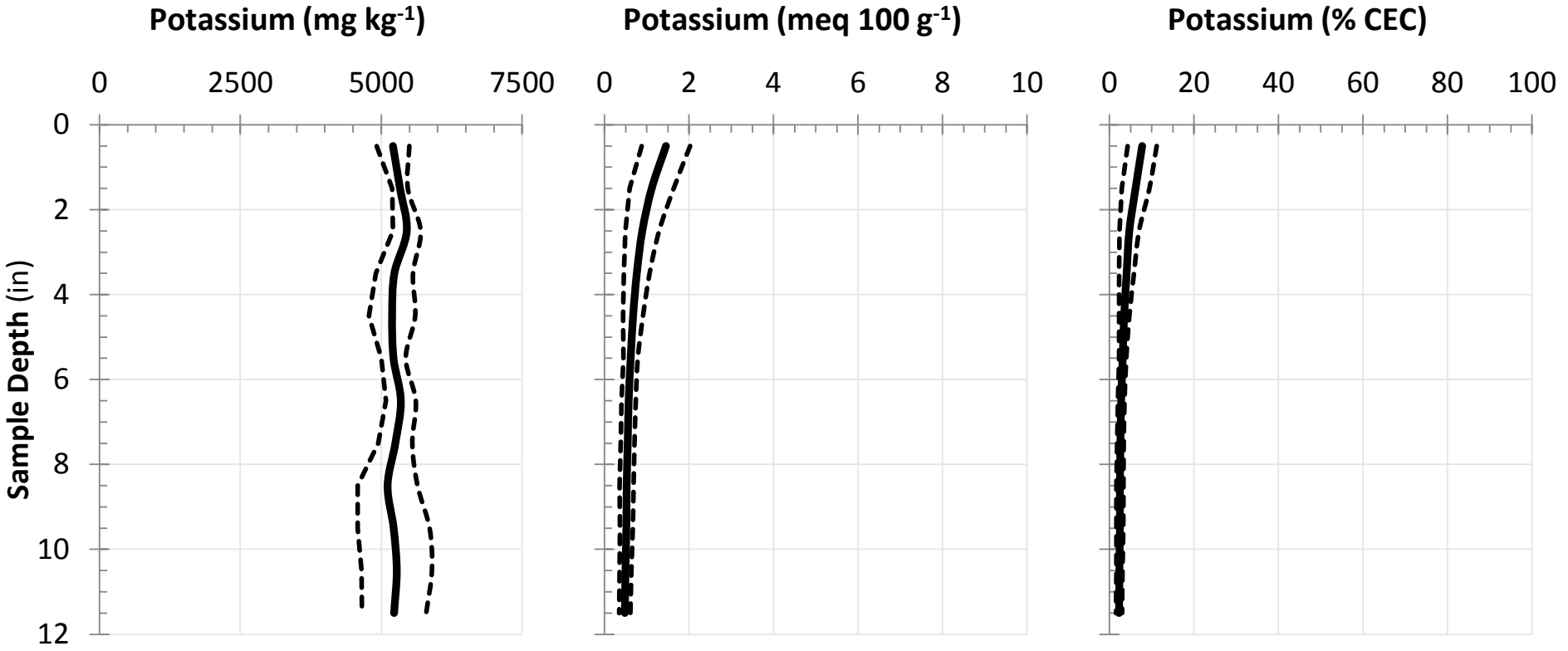
Potassium [K]

K = Base-forming cation. Essential plant nutrient (MACRO). In plant regulates water content



RESIDUAL

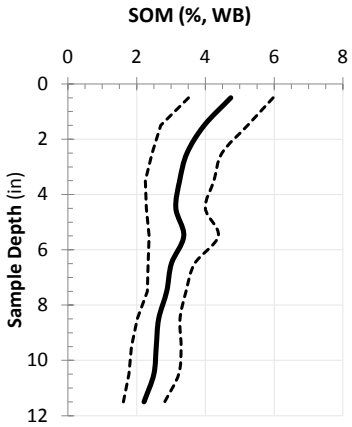
EXCHANGEABLE (KCl)



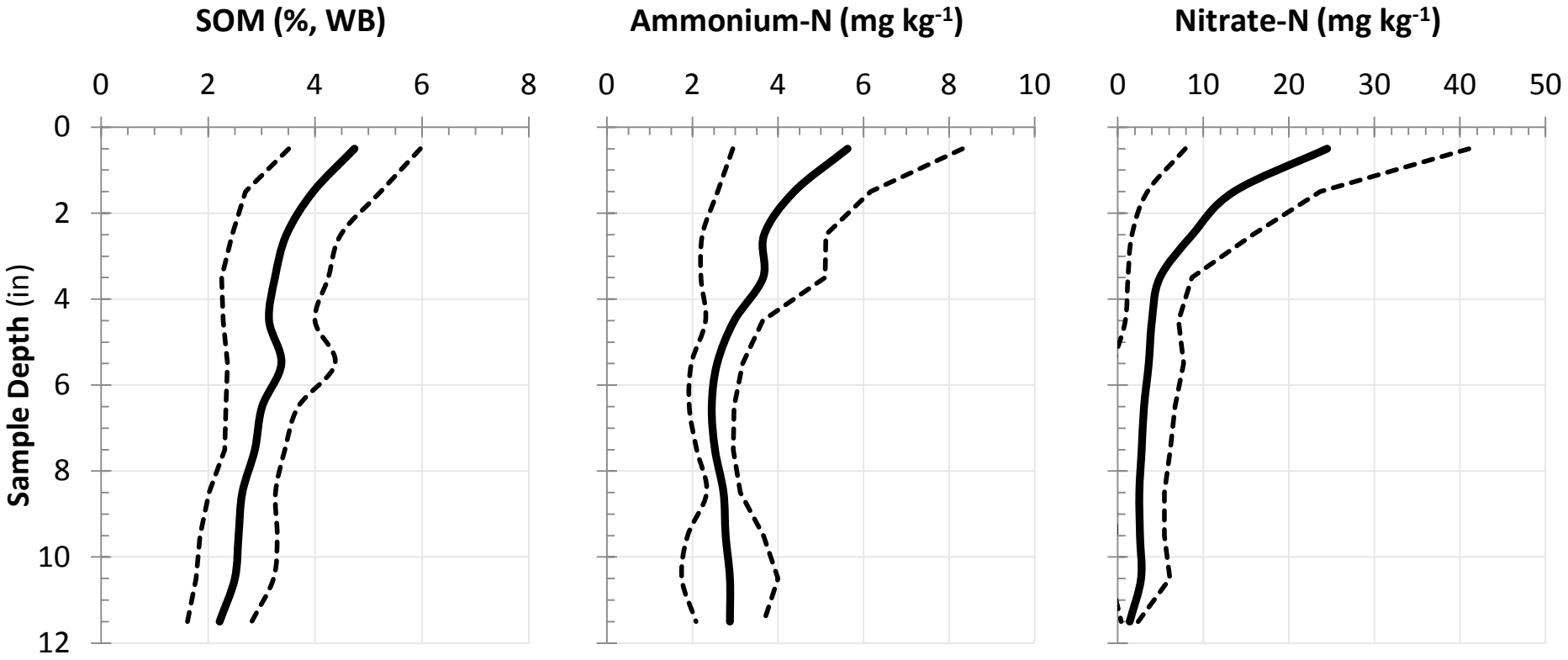
Mineral N [NO_3] and [NH_4]

NO_3-N = high concentrations leach through soil and drag base-forming cations to deeper soil strata

NH_4-N = denitrification releases H_3O into soil solution. Contributes to soil acidification.

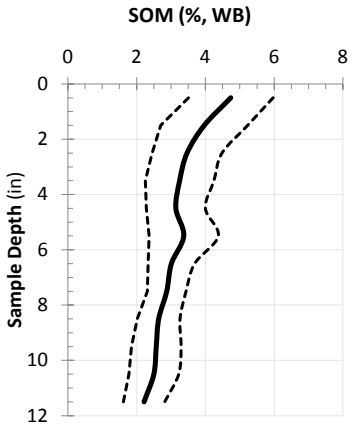


SOIL ORGANIC MATTER

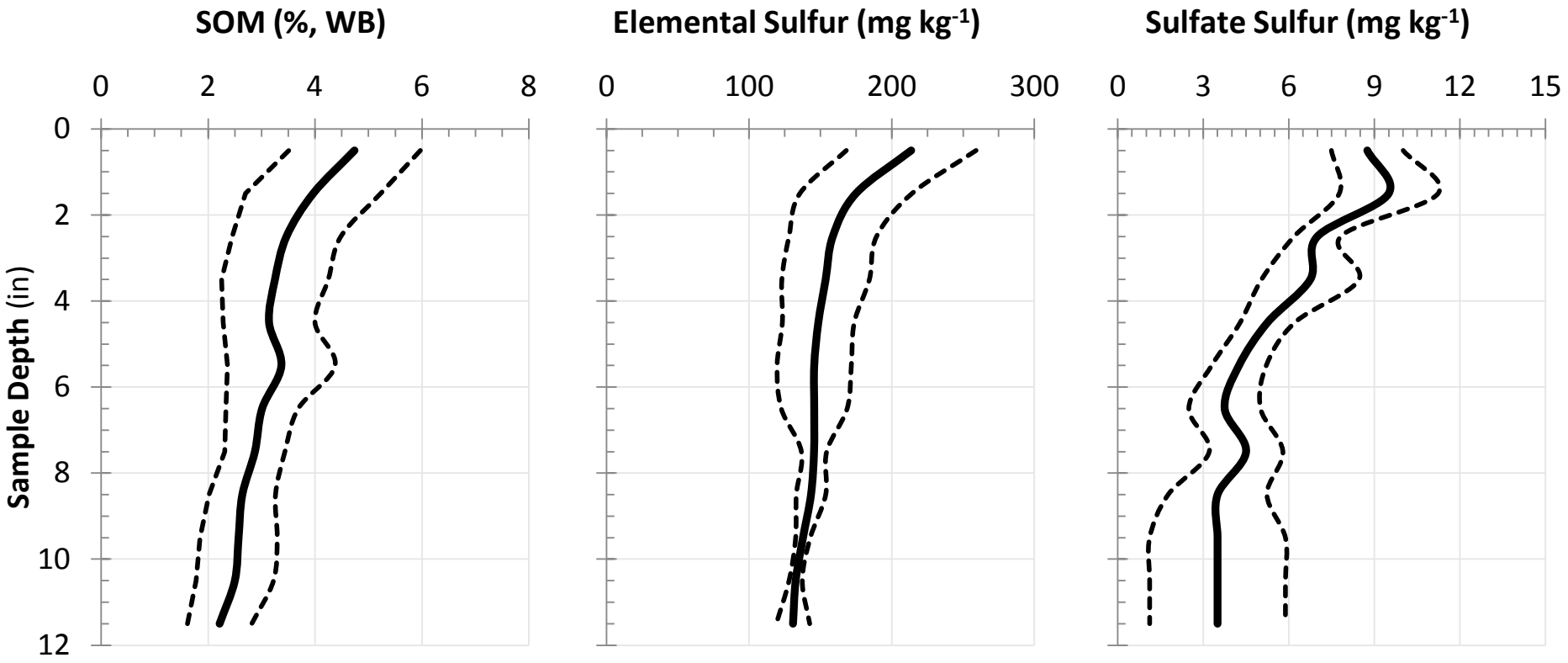


Sulfur [S]

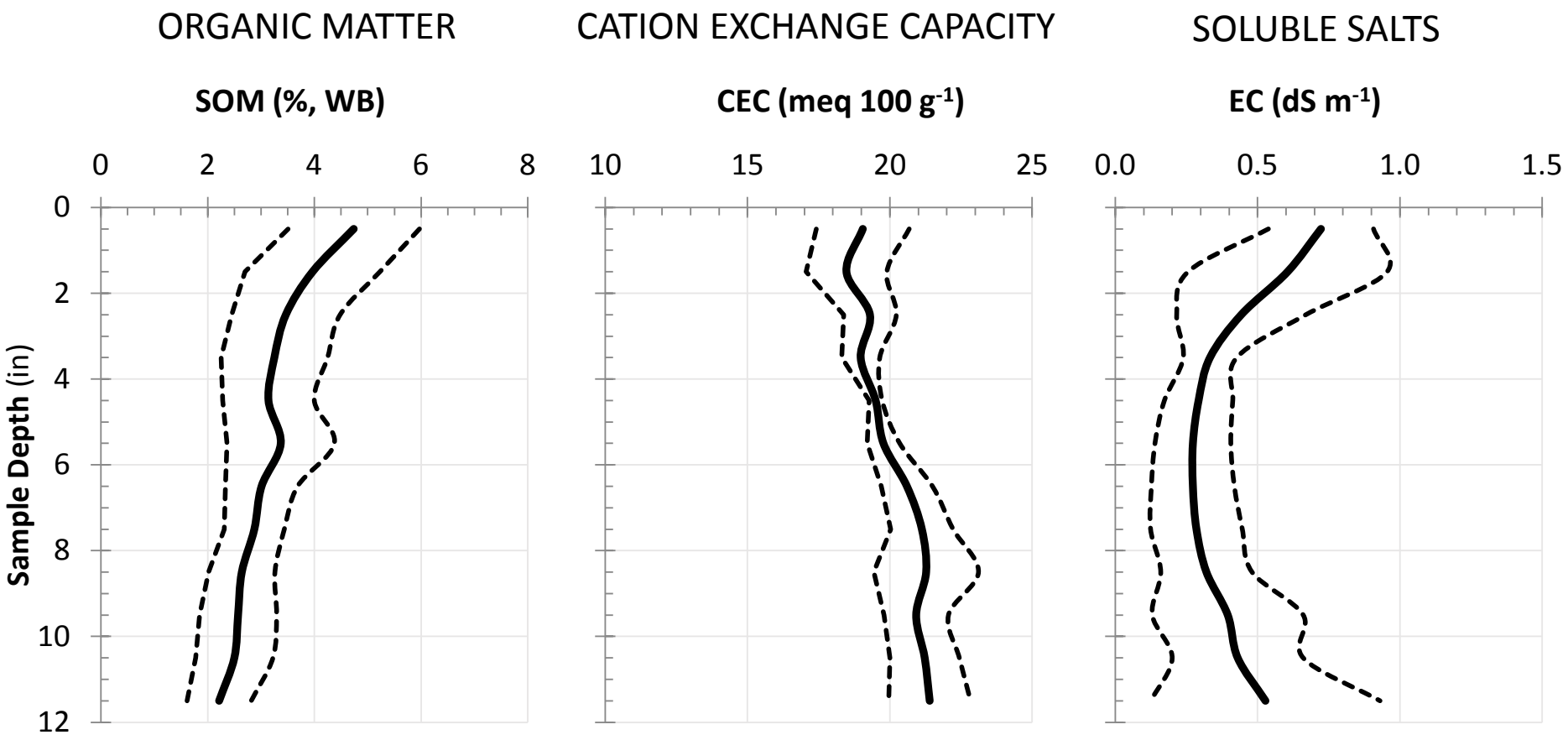
S = Essential plant nutrient (MACRO). In plant main component of proteins.



SOIL ORGANIC MATTER



Indicator Tests for Soil Conditions



Weed Interaction

- Pullman site
  - Effect of burn on weed seed
    - Minor (preliminary observation)
  - Drones to capture imagery (five bands)
  - No FAA permissions for Walla Walla site
- GIS support – Rick Rupp
  - Calibrations
    - Biomass yield
    - Differentiate weed versus crop
      - area and possible biomass

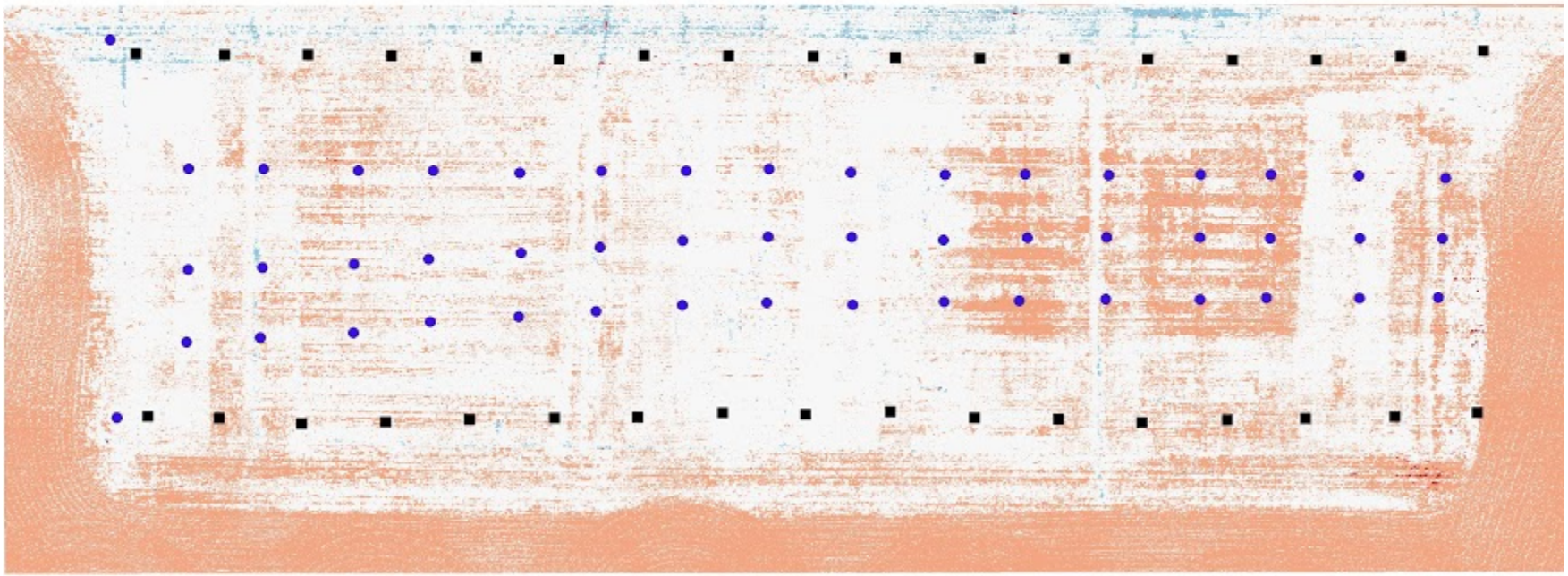
NDRE - Contrast

WASHINGTON STATE UNIVERSITY

Site: EC16
Date: 4/6/16
Method: sUAS
Sensor: Micasense RedEdge3

Legend
- Subplot Corners
- Data Collection Points

NDRE (contrast enhanced)
- 0.0
- 0.15
- 0.30
- 0.45
- 0.60



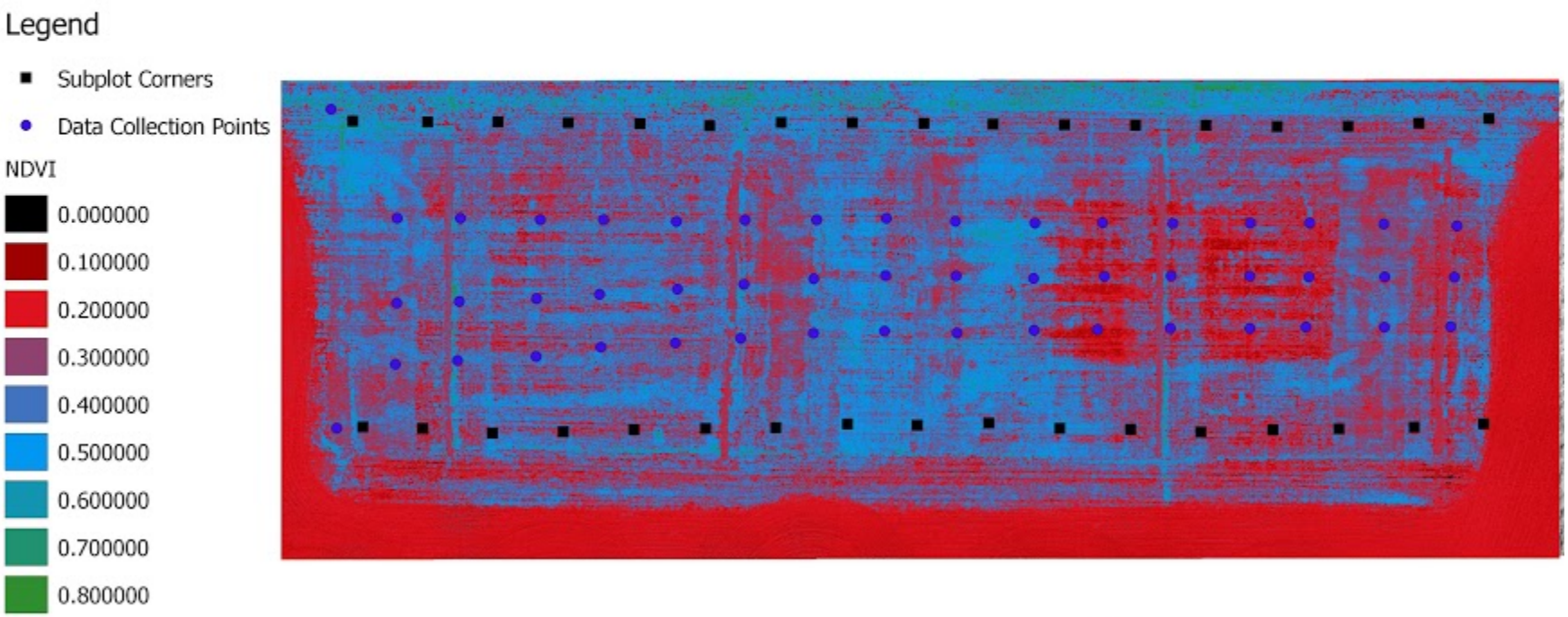
OMNIFOX AERIAL

OmniFox Aerial, LLC
FAA Ex333#14051
(541)480-6903
Pilot: Luke Henderson
VO: Zack Thorn
Data Processing: Derrick Westoby
Colormap - RdBu

NDVI

WASHINGTON STATE UNIVERSITY

Site: EC16
Date: 4/6/16
Method: sUAS
Sensor: Micasense RedEdge3



OMNIFOX AERIAL

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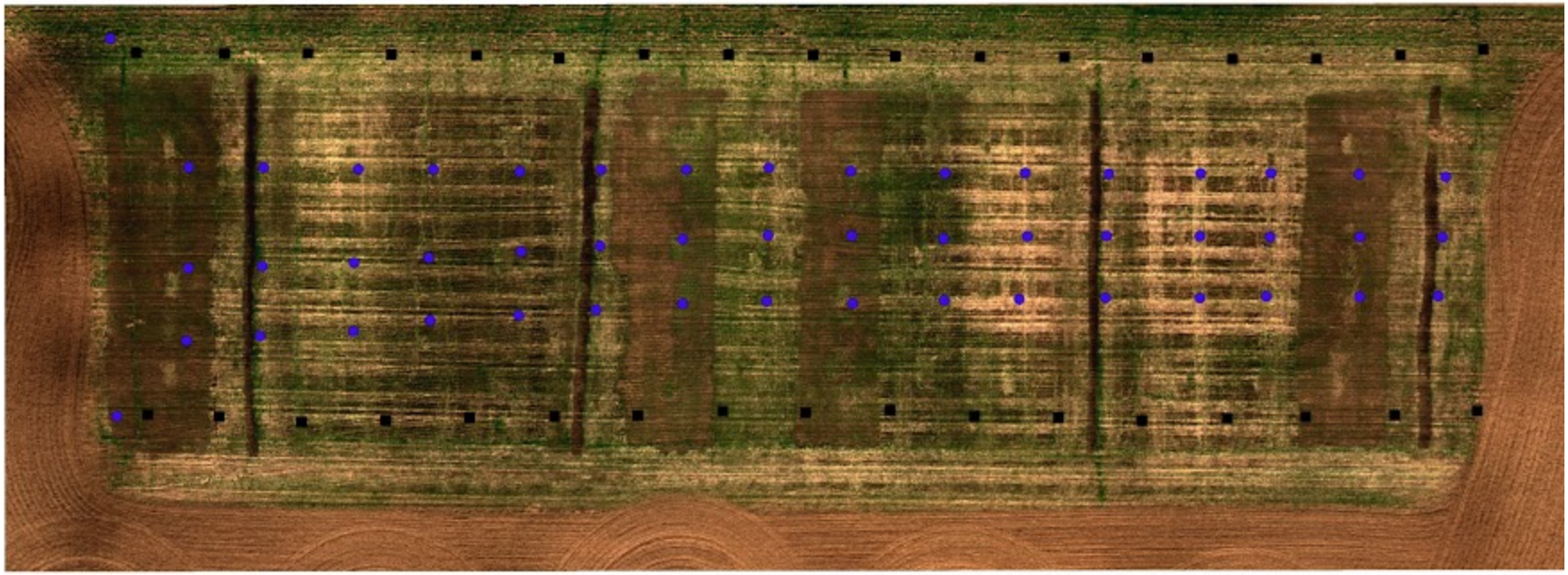
RGB - Visible

WASHINGTON STATE UNIVERSITY

Site: EC16
Date: 4/6/16
Method: sUAS
Sensor: Micasense RedEdge3

Legend
- Subplot Corners
- Data Collection Points

Site EC16-RGB



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Next Steps

- JULY – AUGUST 2016
  - Biomass and Grain yields
  - Residue management treatments
    - Harvest and Burn
  - stubble and ash samples
  - soil moisture samples
- FEBRUARY – MARCH 2017
  - soil moisture samples
  - Soil nutrient profiles
    - 0 to 12 inches, 1-inch increment
  - GIS analysis of drone imagery

Thank you

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  - Walla Walla WA 99362
  - 509-524-2691