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

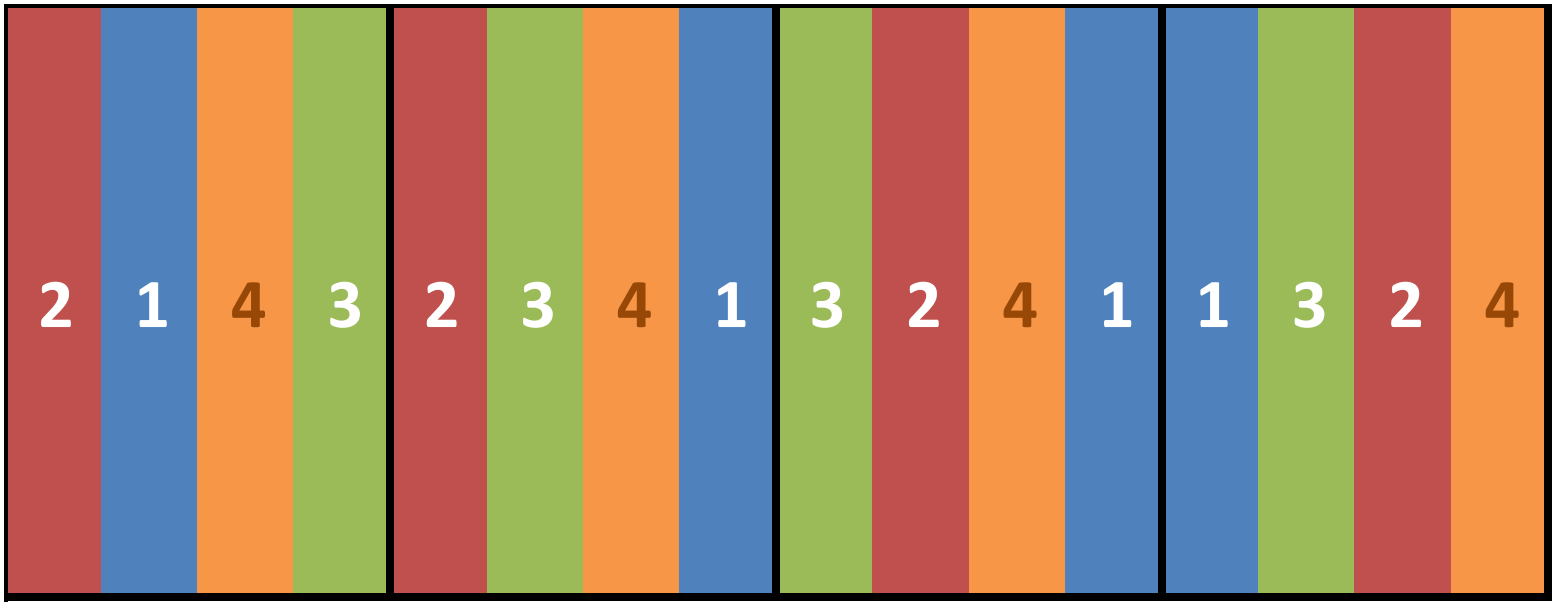
2015 Yields

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 Spot

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

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

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

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	.

Nutrient Status on Soil ?

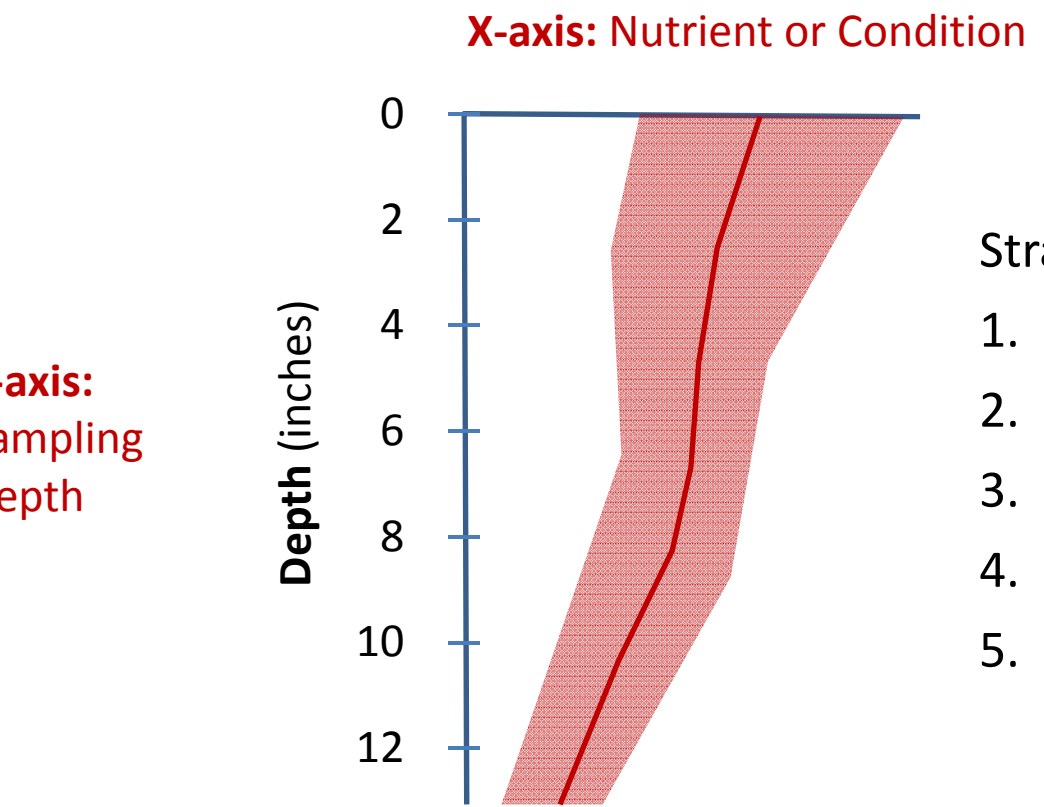
Trt Effects on nutrient status

- By site replication and treatment

Examples

Tillage Effects on Stratification

One-foot soil profile chart …

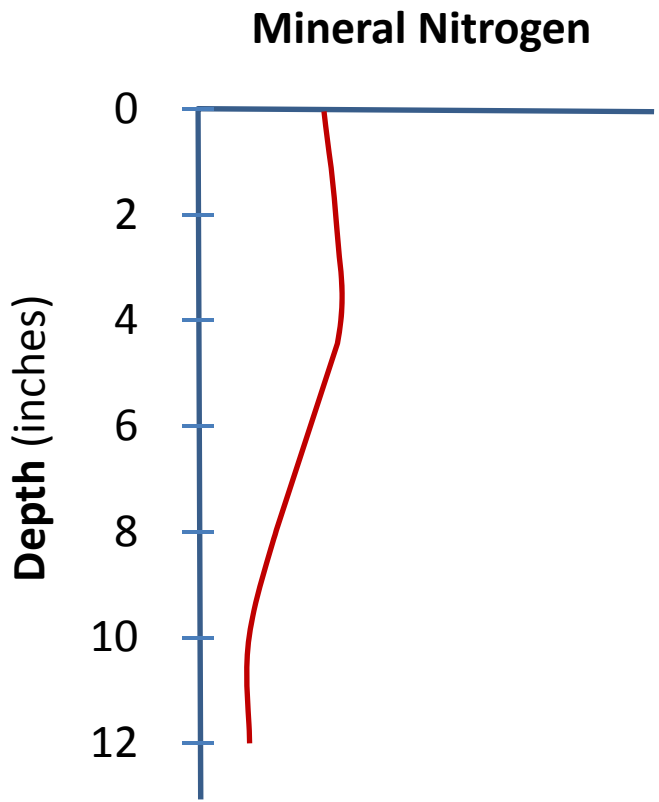


Stratification can affect:

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

Tillage Effects on Stratification

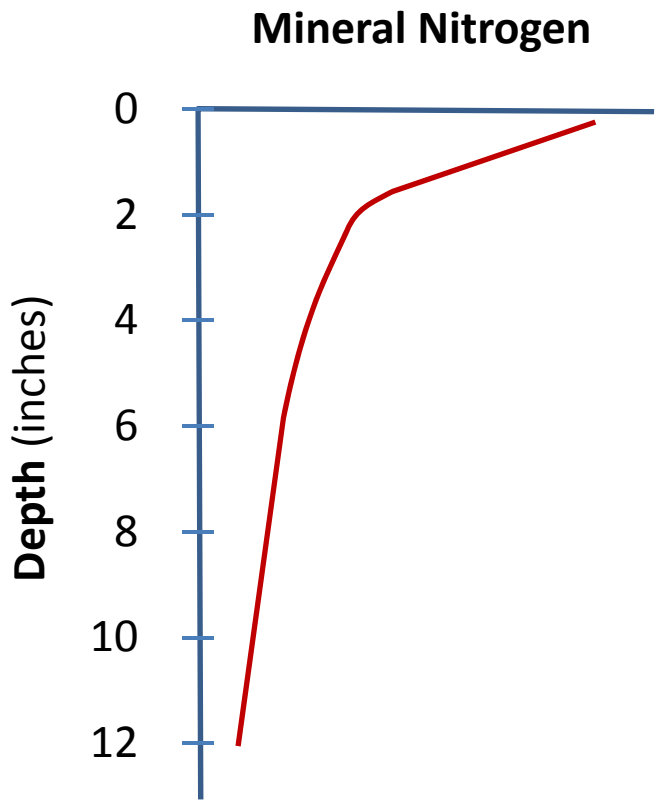
Soil profile chart format … *Conventional*



Thorough mixing action

Tillage Effects on Stratification

Soil profile chart format … *No-Till*



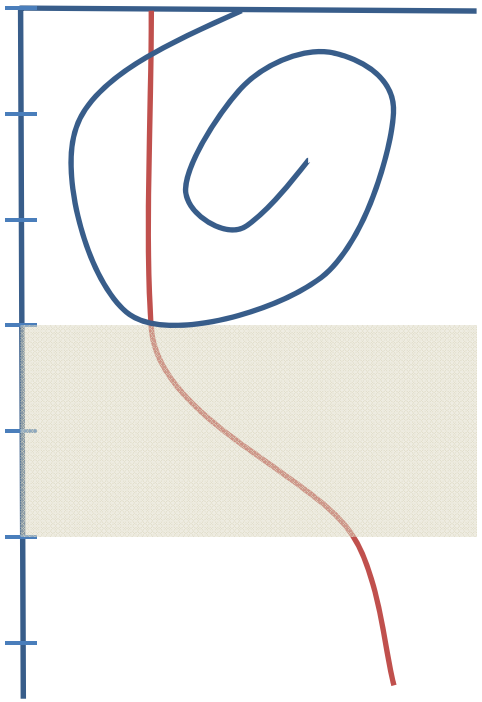
Minimal mixing action

Patterns of Stratification. *Tillage*

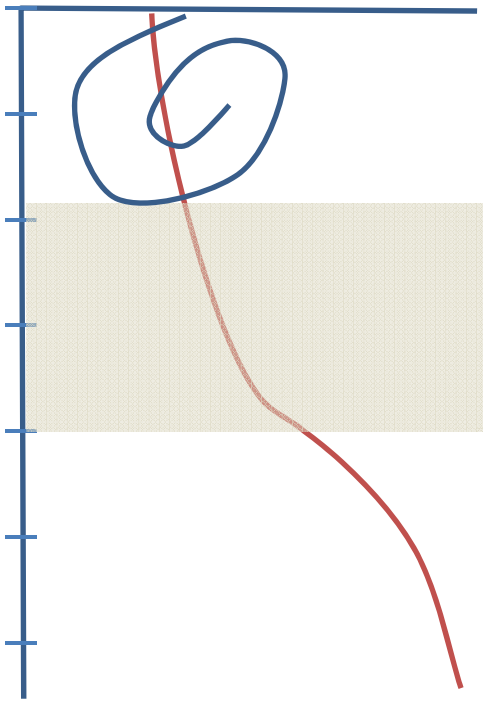
Zones of soil compaction

Soil mixing

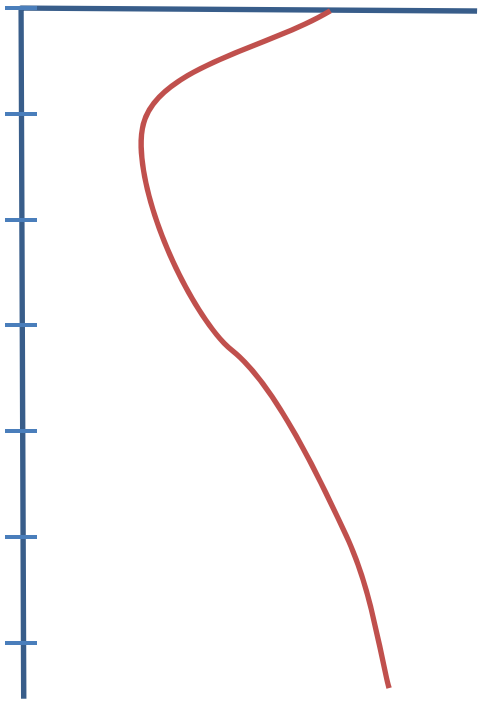
DEEP TILLAGE



CONSERVATION



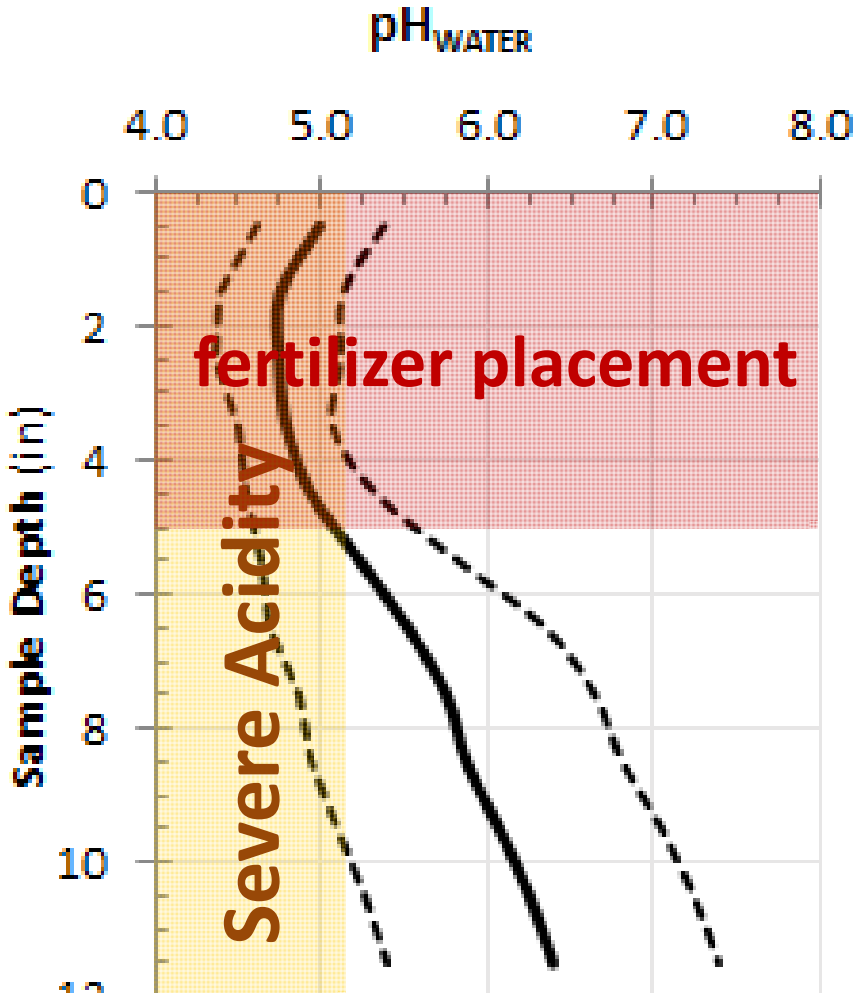
DIRECT SEED



Soil pH (H_2O)

Soil pH below 5.2 is considered severe, a sign of soil degradation

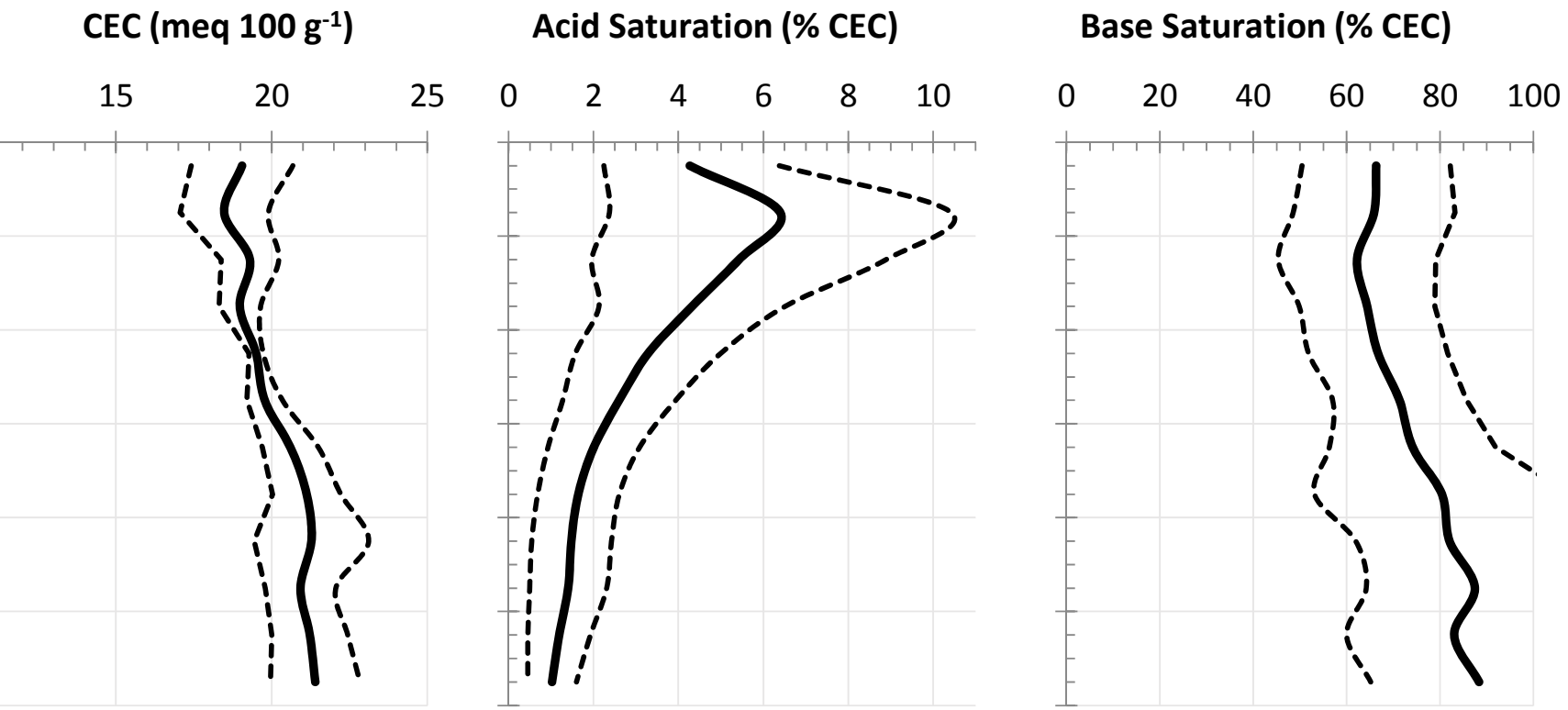
Nitrogen- and sulfur-based fertilizers acidify soil



Cation Exchange

([Al] + [Mn] + [Fe]) ÷ CEC

([Ca] + [Mg] + [Na] + [K]) ÷ CEC



Nutrients

Residual nutrients are strongly held inside of soil particles – high concentrations

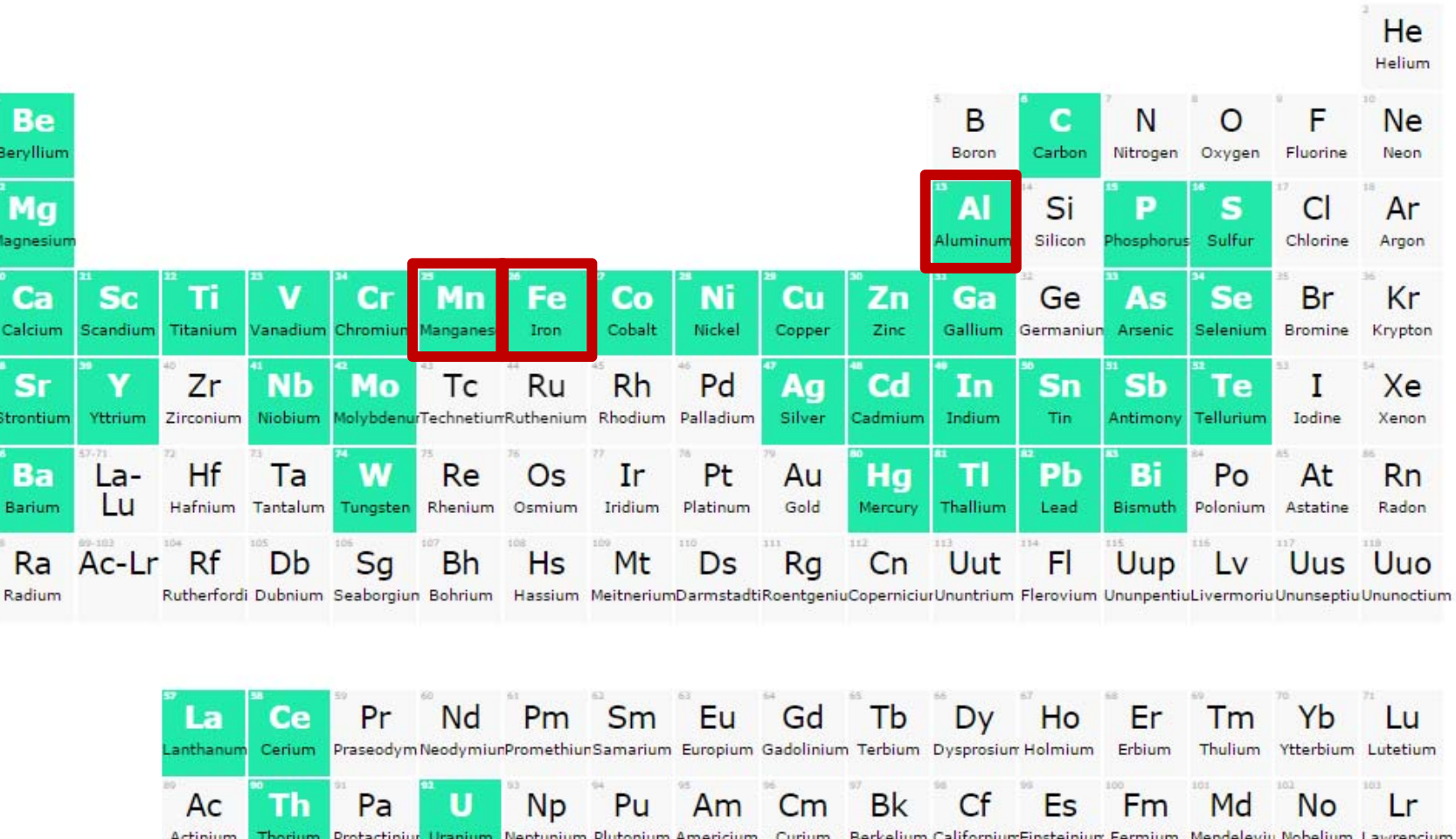
Exchangeable nutrients occupy exchange sites at or near surfaces of soil particles – lower concentrations

How is the CEC affected by changes in soil pH?

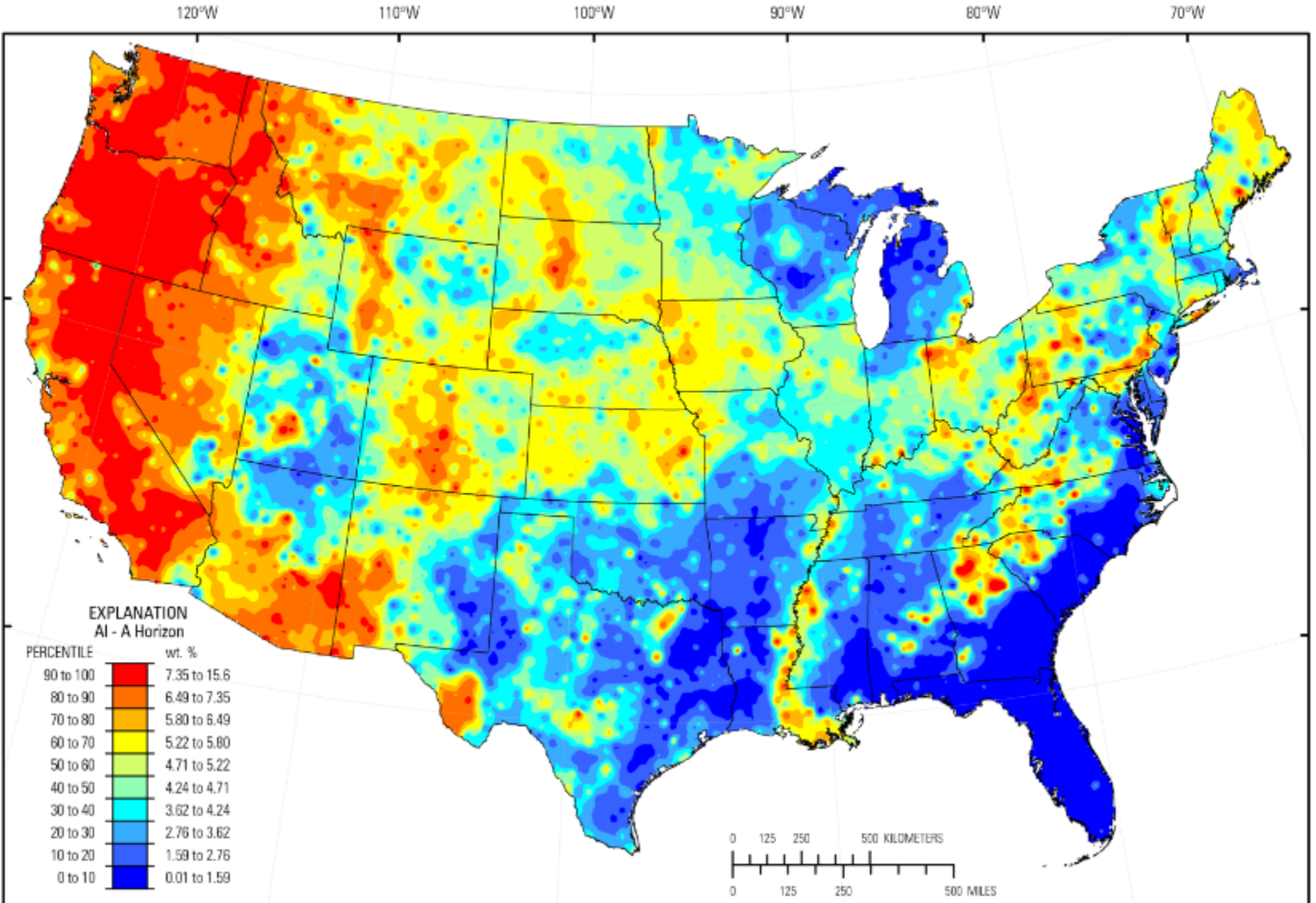
- Consider exchangeable acidity
- Consider base saturation

Residual Nutrients. *Soil Profile Survey*

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

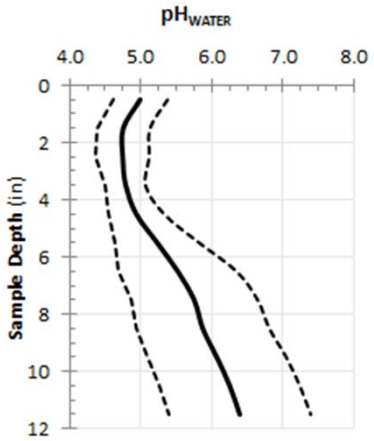


“A” horizon residual. *Aluminum [Al]*

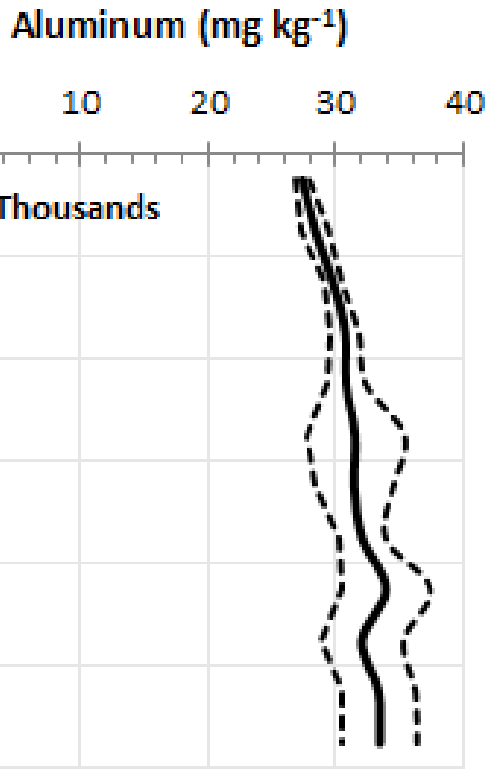


Aluminum [Al]

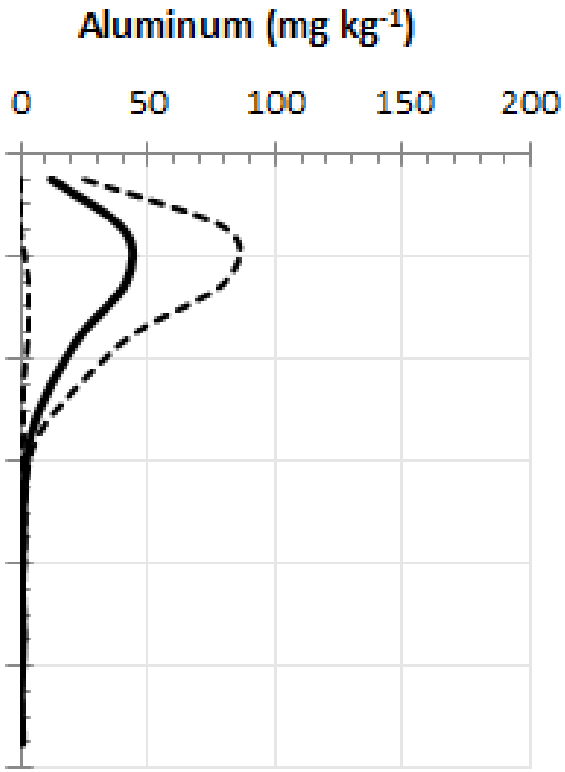
Acid-forming cation. Causes root stunting under acid conditions, can obstruct nutrient and water uptake, decreases microbial activity, binds phosphorus under acid conditions

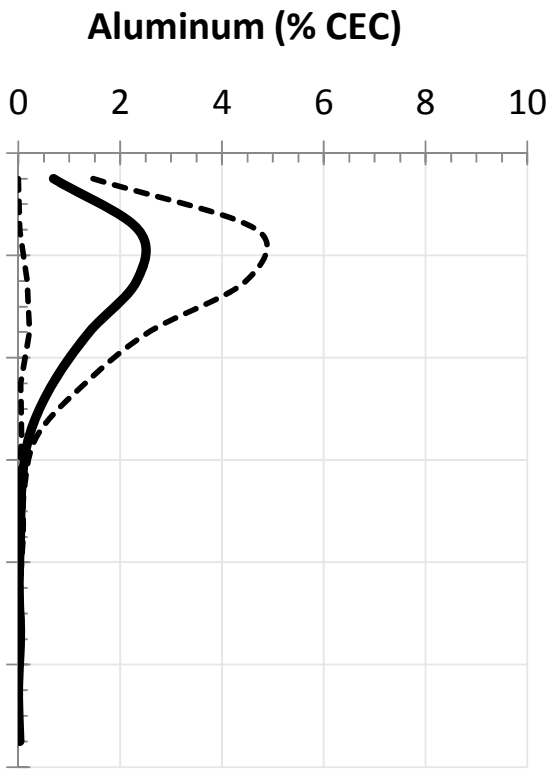


RESIDUAL

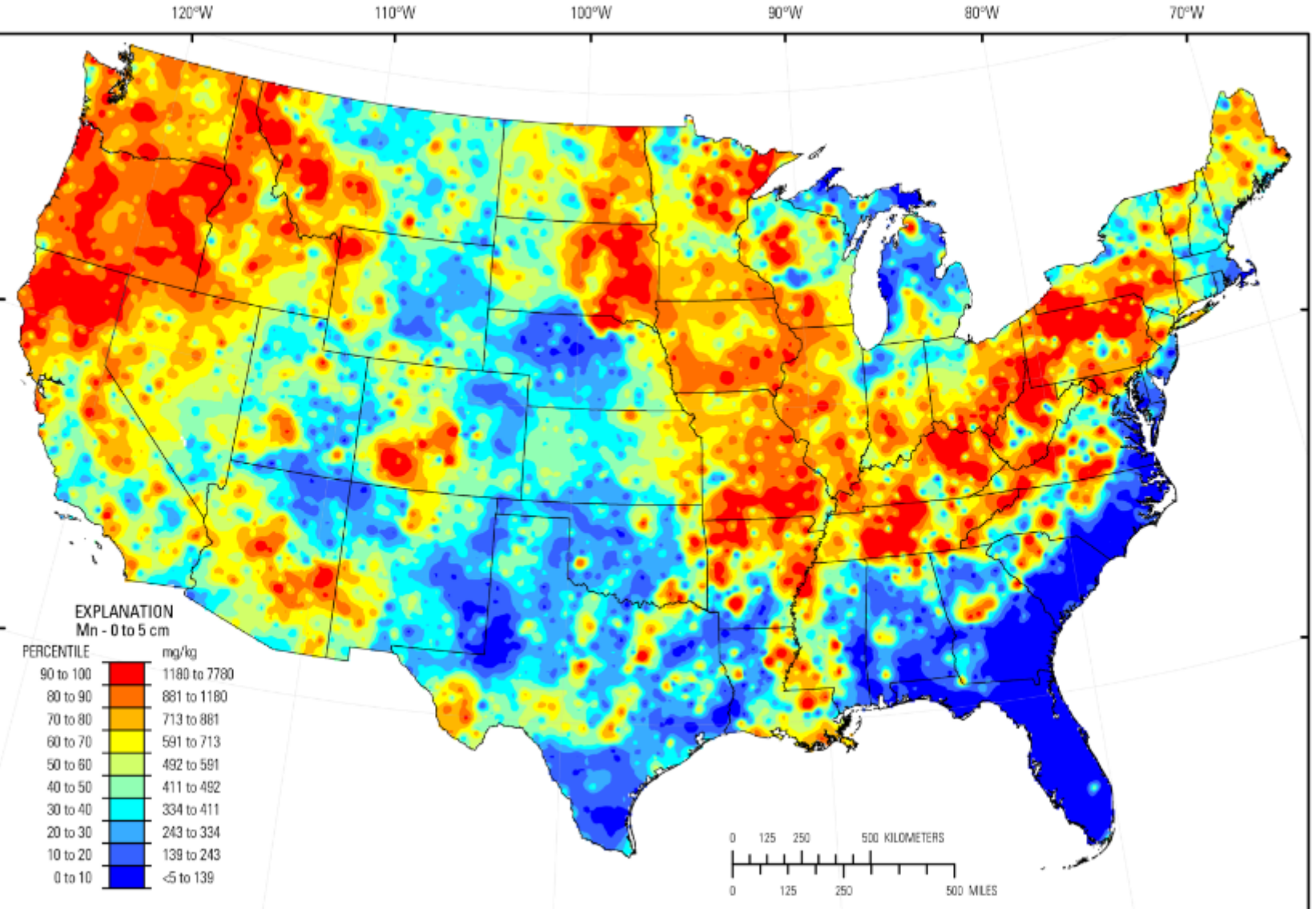


EXCHANGEABLE (KCl)



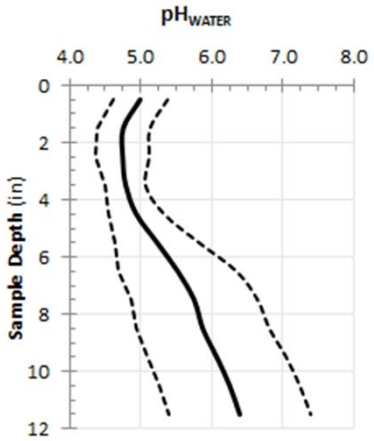


A” horizon residual. *Manganese [Mn]*



Manganese [Mn]

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

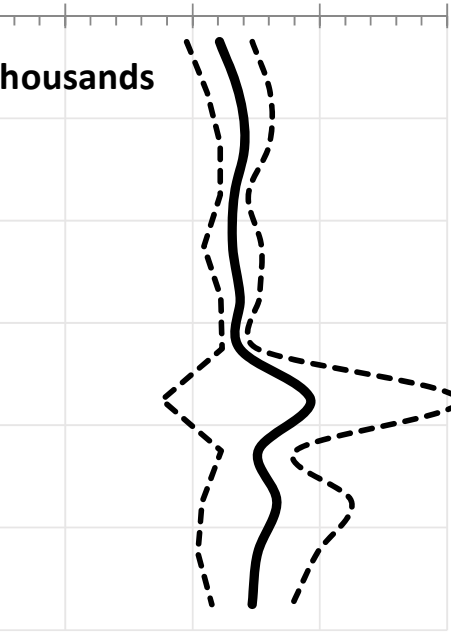


RESIDUAL

Manganese (mg kg^{-1})

0.25 0.50 0.75 1.00

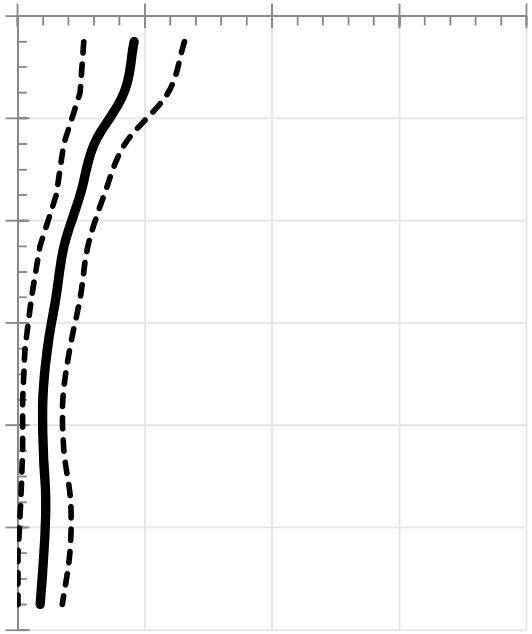
housands



EXCHANGEABLE (DTPA)

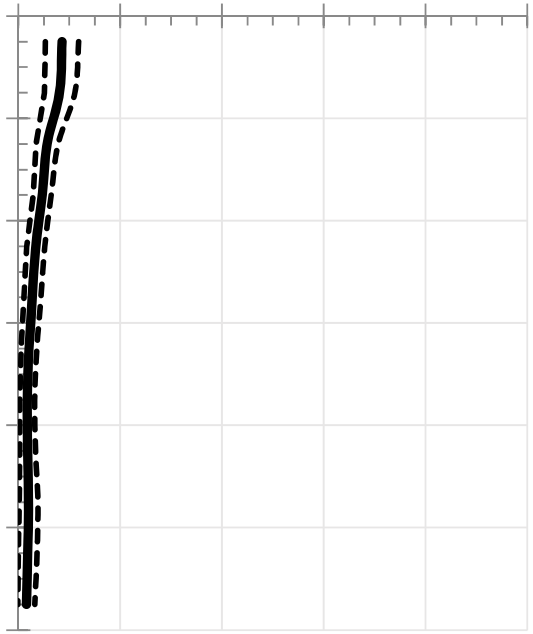
Manganese (mg kg^{-1})

0 50 100 150 200

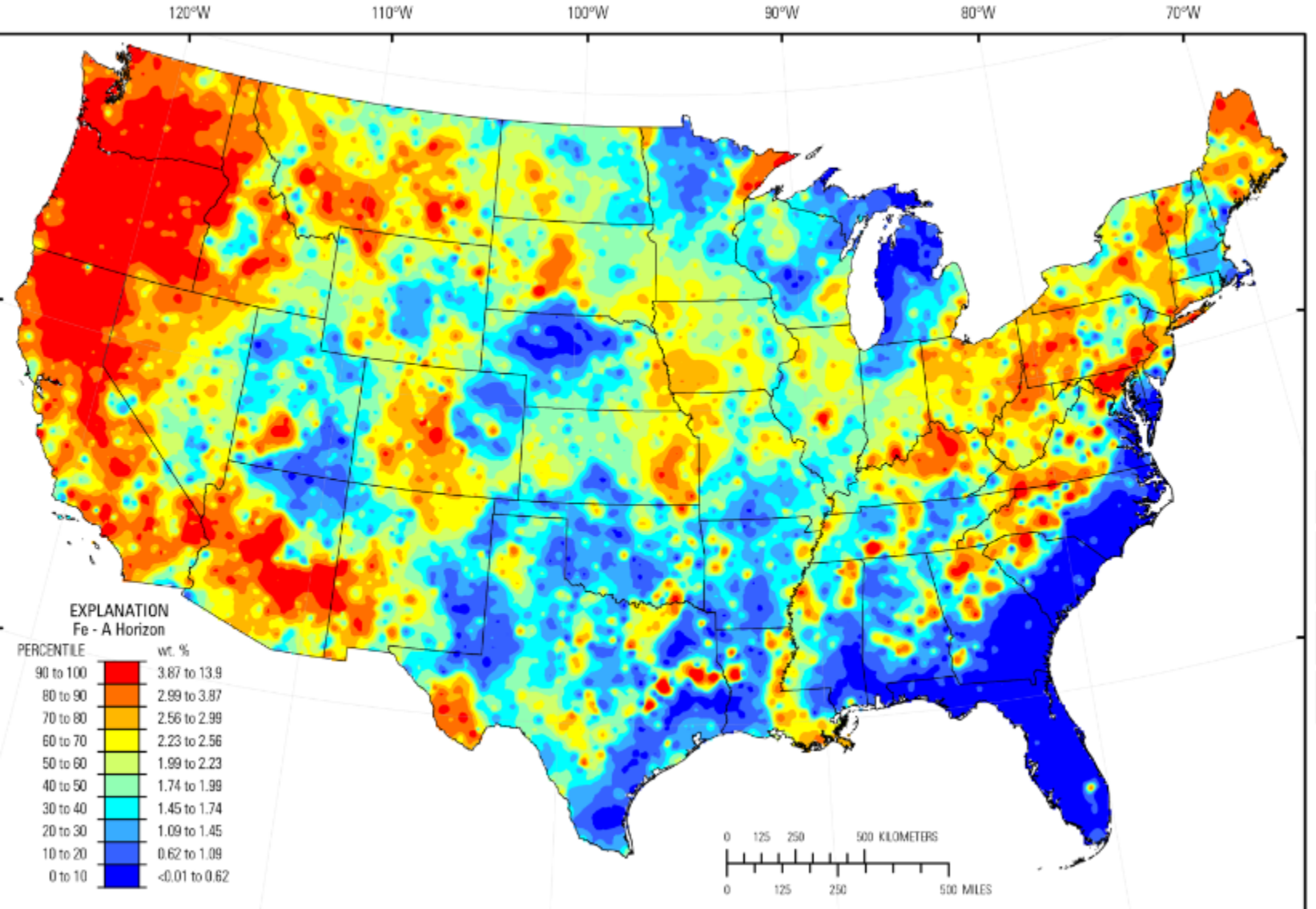


Manganese (% CEC)

0 2 4 6 8 10

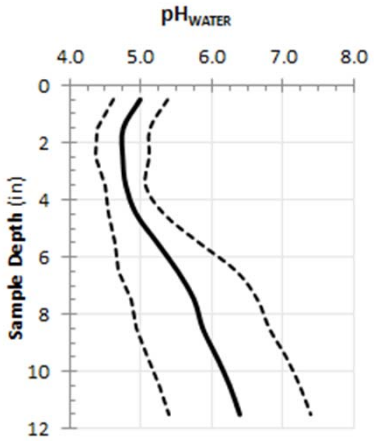


“A” horizon residual. *Iron [Fe]*

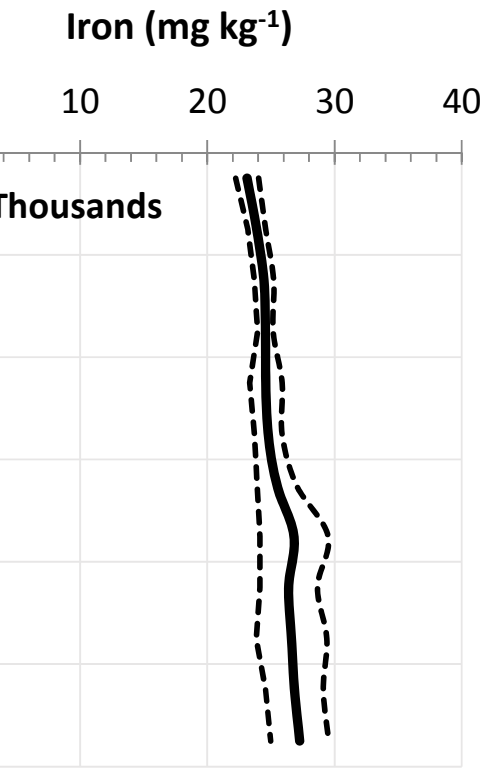


Iron [Fe]

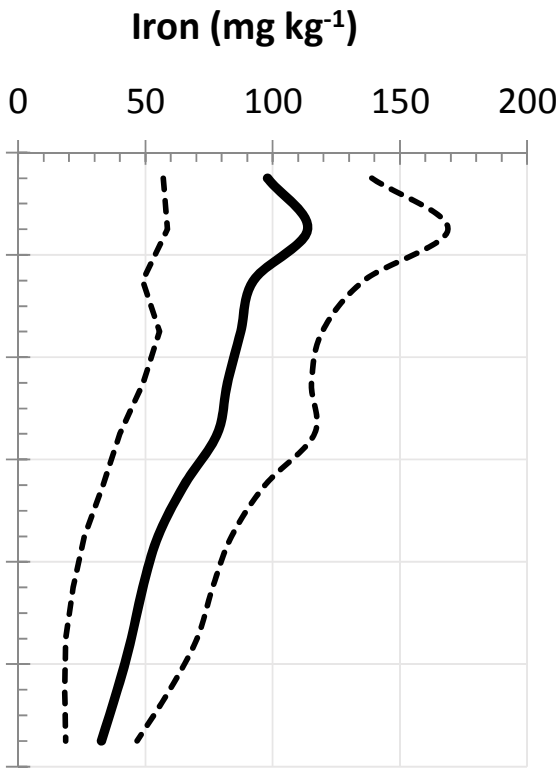
Acid-forming cation. Essential plant nutrient (MICRO), binds phosphorus

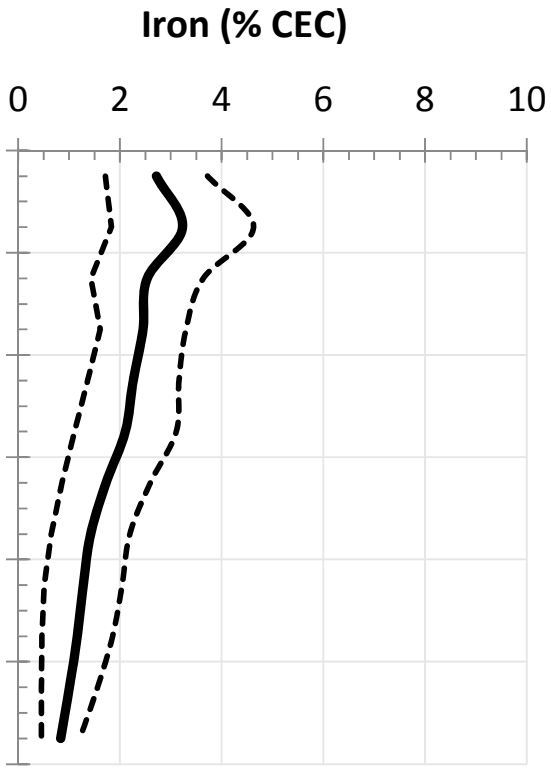


RESIDUAL

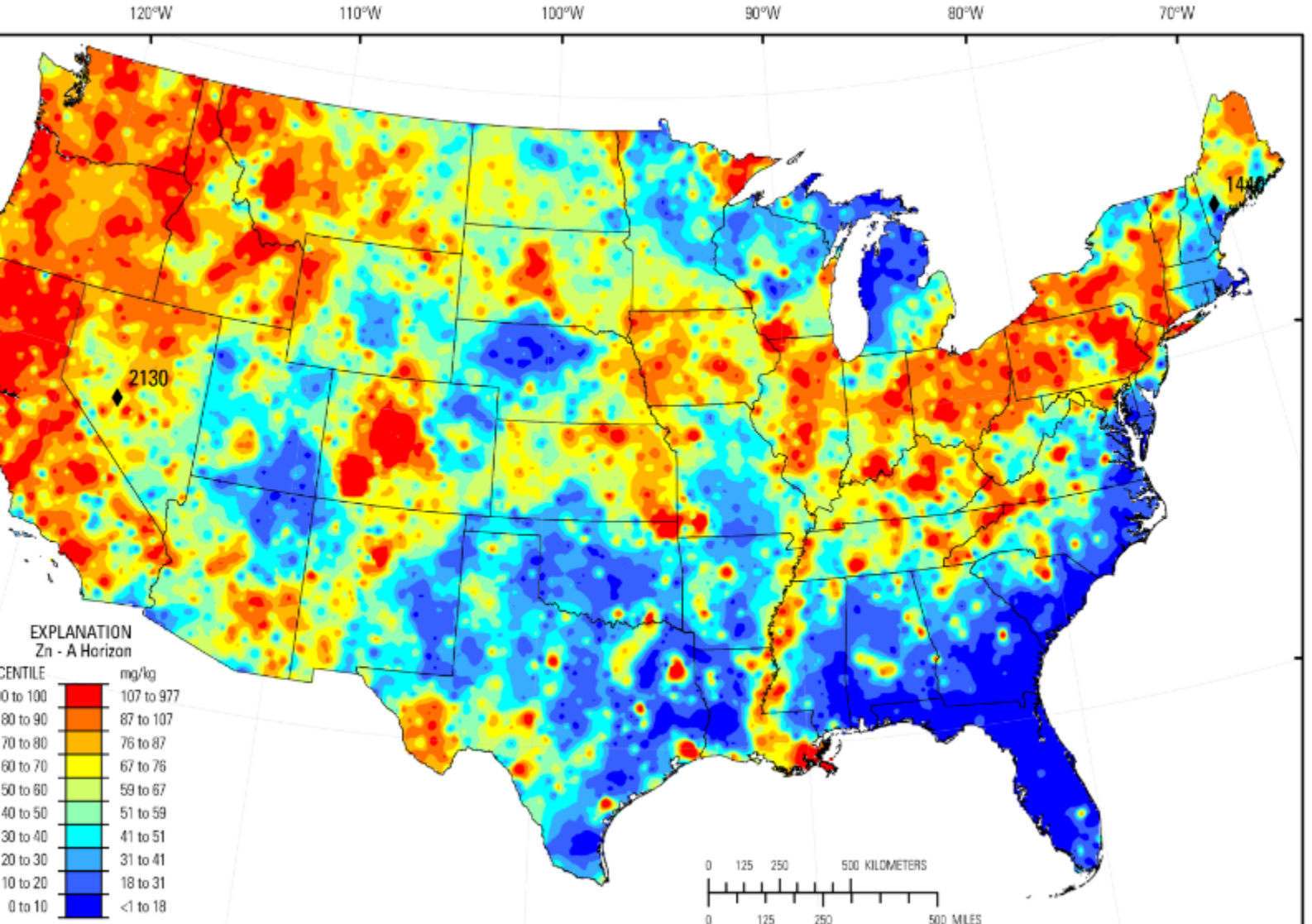


EXCHANGEABLE (DTPA)



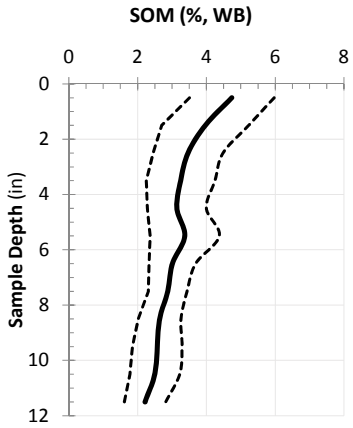


Zinc [Zn]

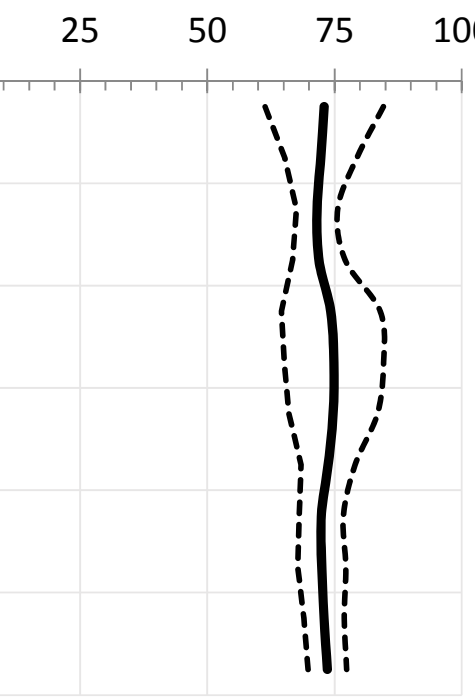

120°W
110°W
100°W
90°W
80°W
70°W
2130
1440
EXPLANATION
Zn - A Horizon
CENTILE
mg/kg
90 to 100
107 to 977
80 to 90
87 to 107
70 to 80
76 to 87
60 to 70
67 to 76
50 to 60
59 to 67
40 to 50
51 to 59
30 to 40
41 to 51
20 to 30
31 to 41
10 to 20
18 to 31
0 to 10
<1 to 18
0 125 250 500 KILOMETERS
0 125 250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

Zinc [Zn]

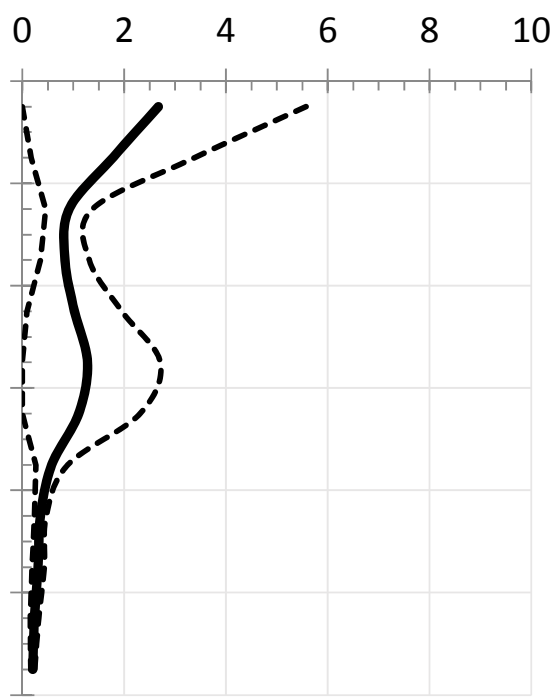
Base-forming cation. Essential plant nutrient (MICRO). In plant constituent of three or more enzymes, and plays role in plant hormone synthesis (auxin).

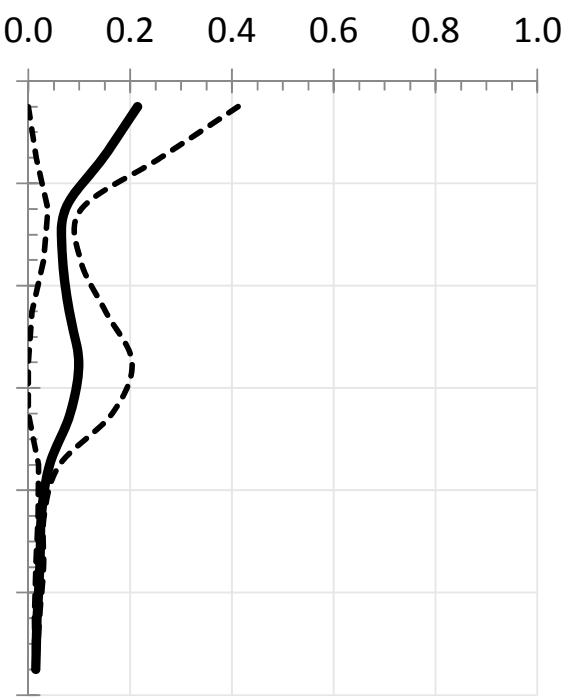


RESIDUAL



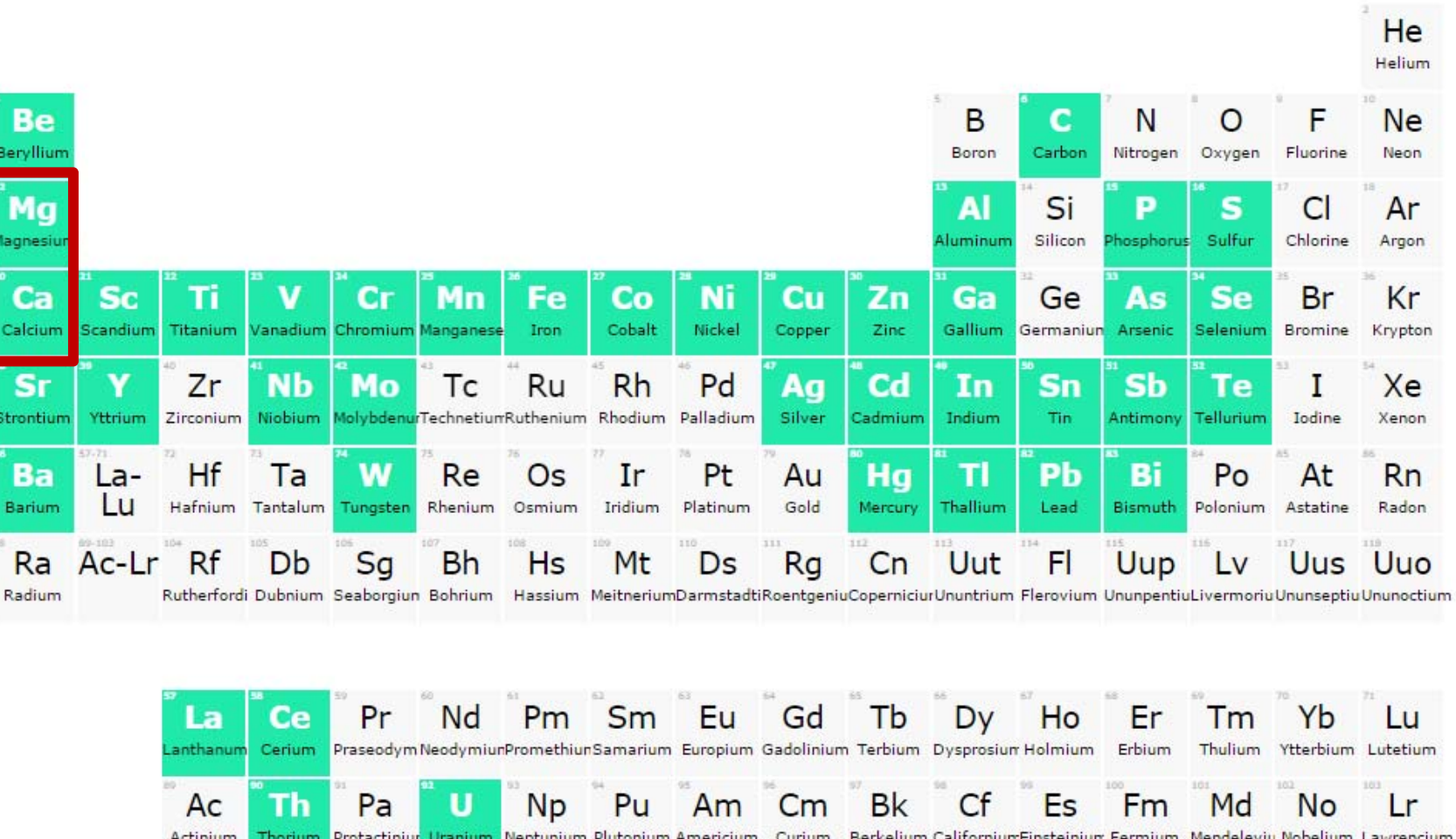
EXCHANGEABLE (DTPA)



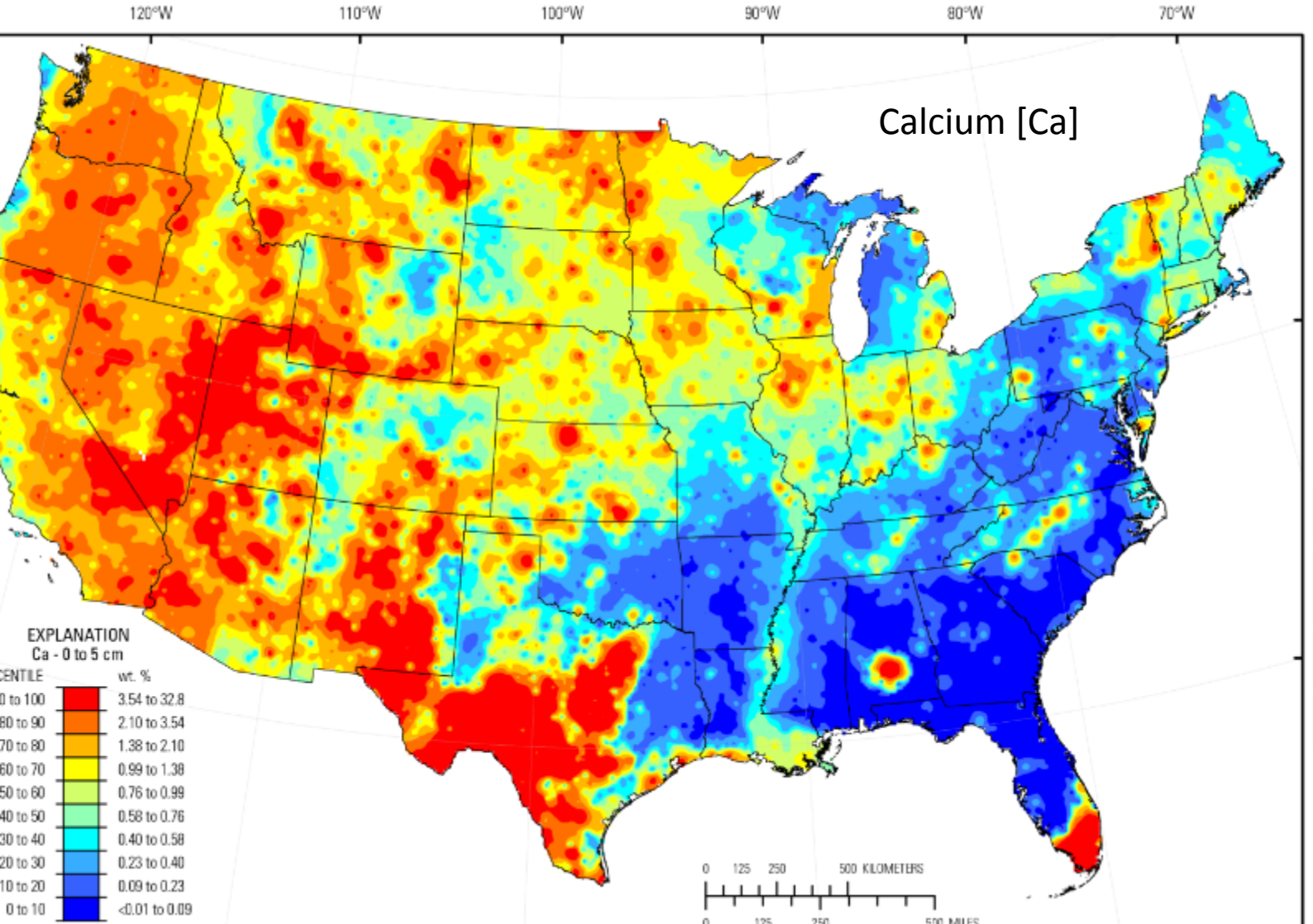


Residual Nutrients. *Soil Profile Survey*

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

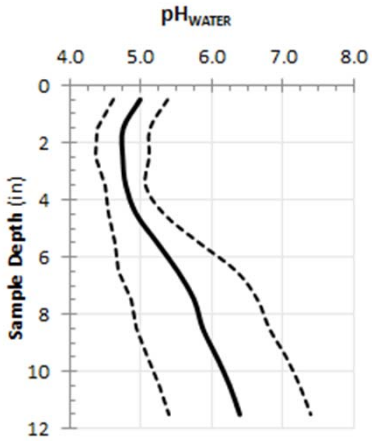


Calcium [Ca]


120°W
110°W
100°W
90°W
80°W
70°W
Calcium [Ca]
EXPLANATION
Ca - 0 to 5 cm
CENTILE
wt. %
0 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

Calcium [Ca]

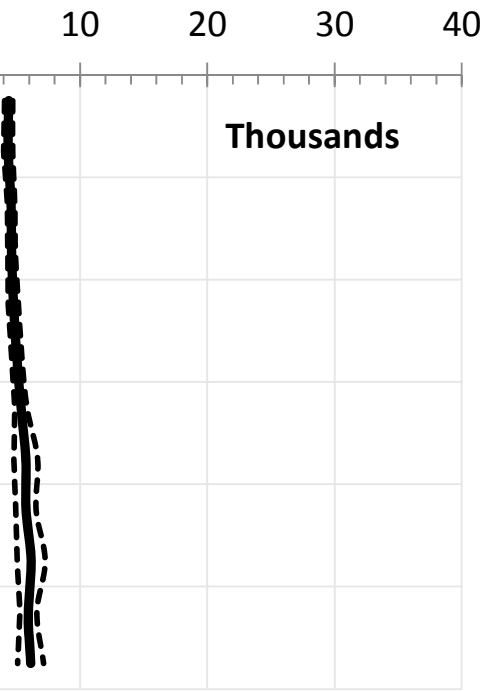
Base-forming cation. Essential plant nutrient (MACRO), in plant
regulates ion exchange and important for cell structure. In soil
binds phosphorus under alkaline conditions



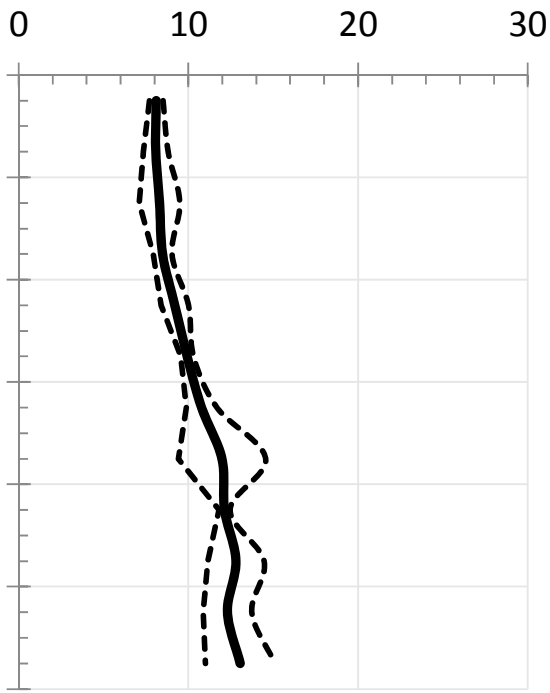
RESIDUAL

EXCHANGEABLE (KCl)

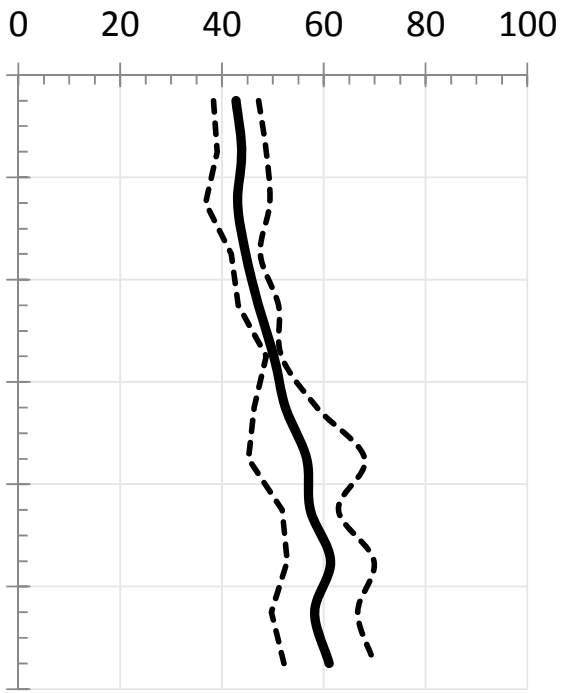
Calcium (mg kg^{-1})



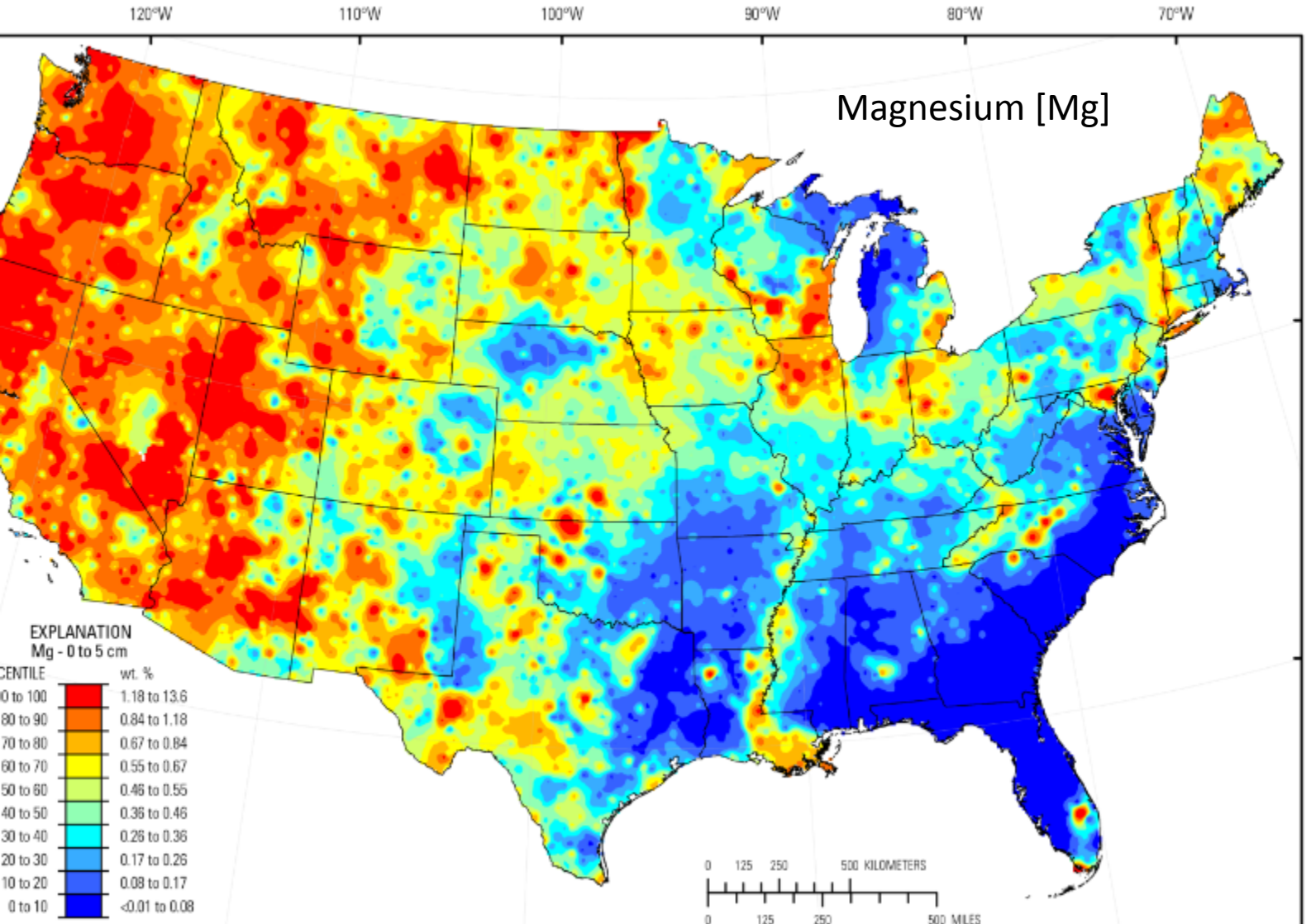
Calcium (meq 100 g^{-1})



Calcium (% CEC)

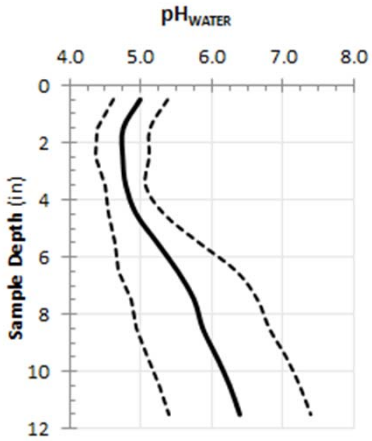


Magnesium [Mg]



Magnesium [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)

Magnesium (mg kg^{-1})

10 20 30 40

Thousands

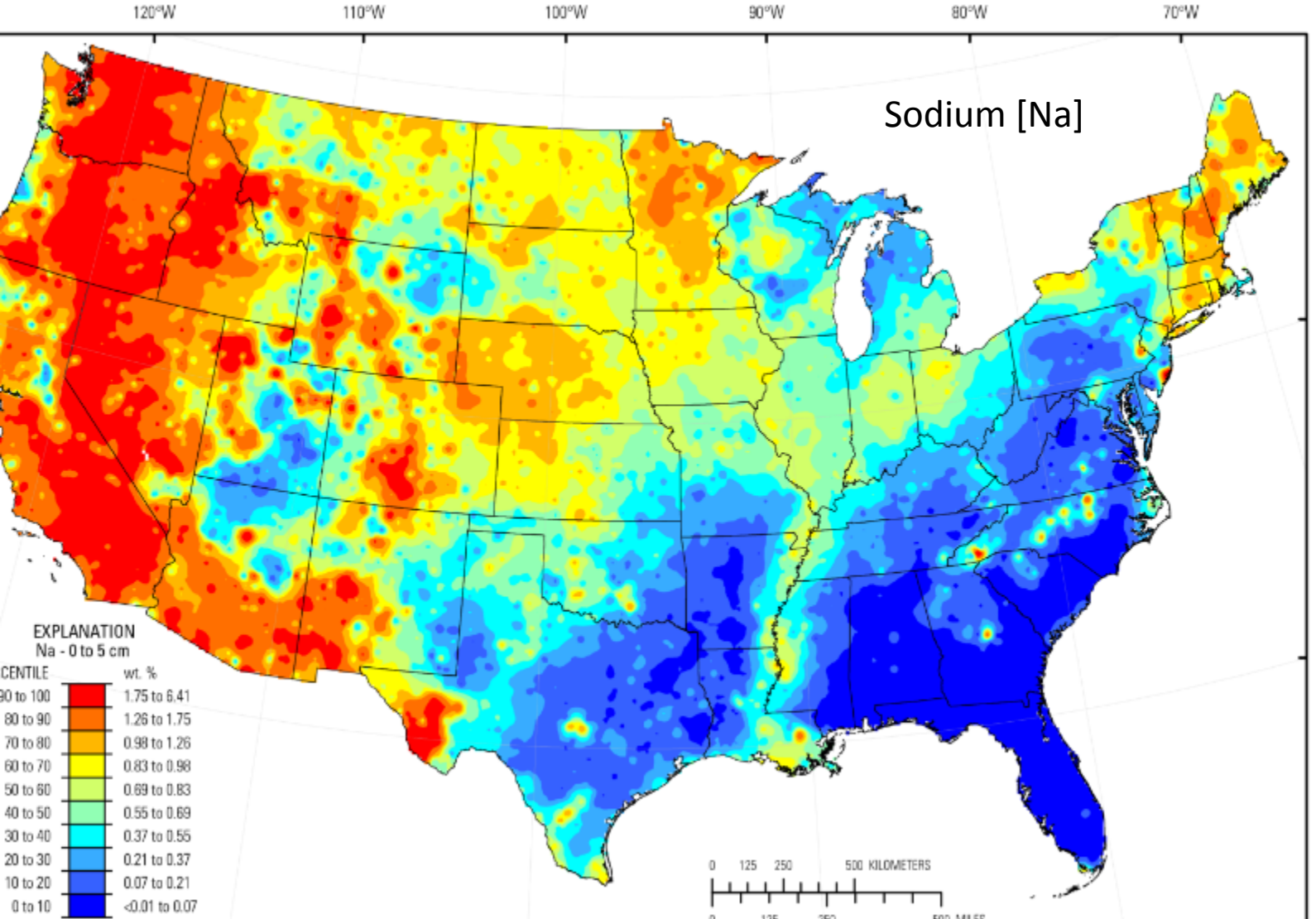
Magnesium (meq 100 g^{-1})

0 10 20 30

Magnesium (% CEC)

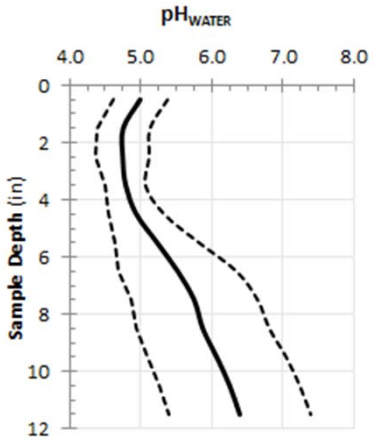
0 20 40 60 80 100

Sodium [Na]


120°W
110°W
100°W
90°W
80°W
70°W
Sodium [Na]
EXPLANATION
Na - 0 to 5 cm
CENTILE
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

Sodium [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)

Sodium (mg kg^{-1})

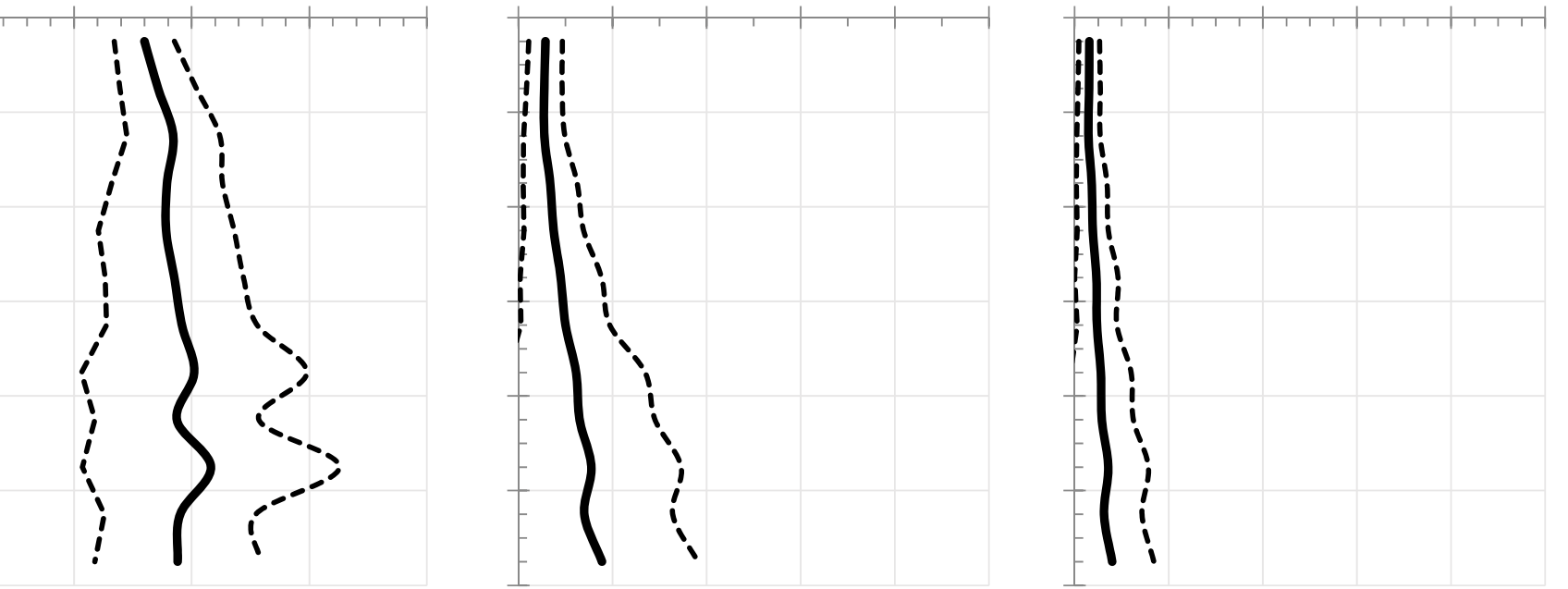
250 500 750 1000

Sodium (meq 100 g^{-1})

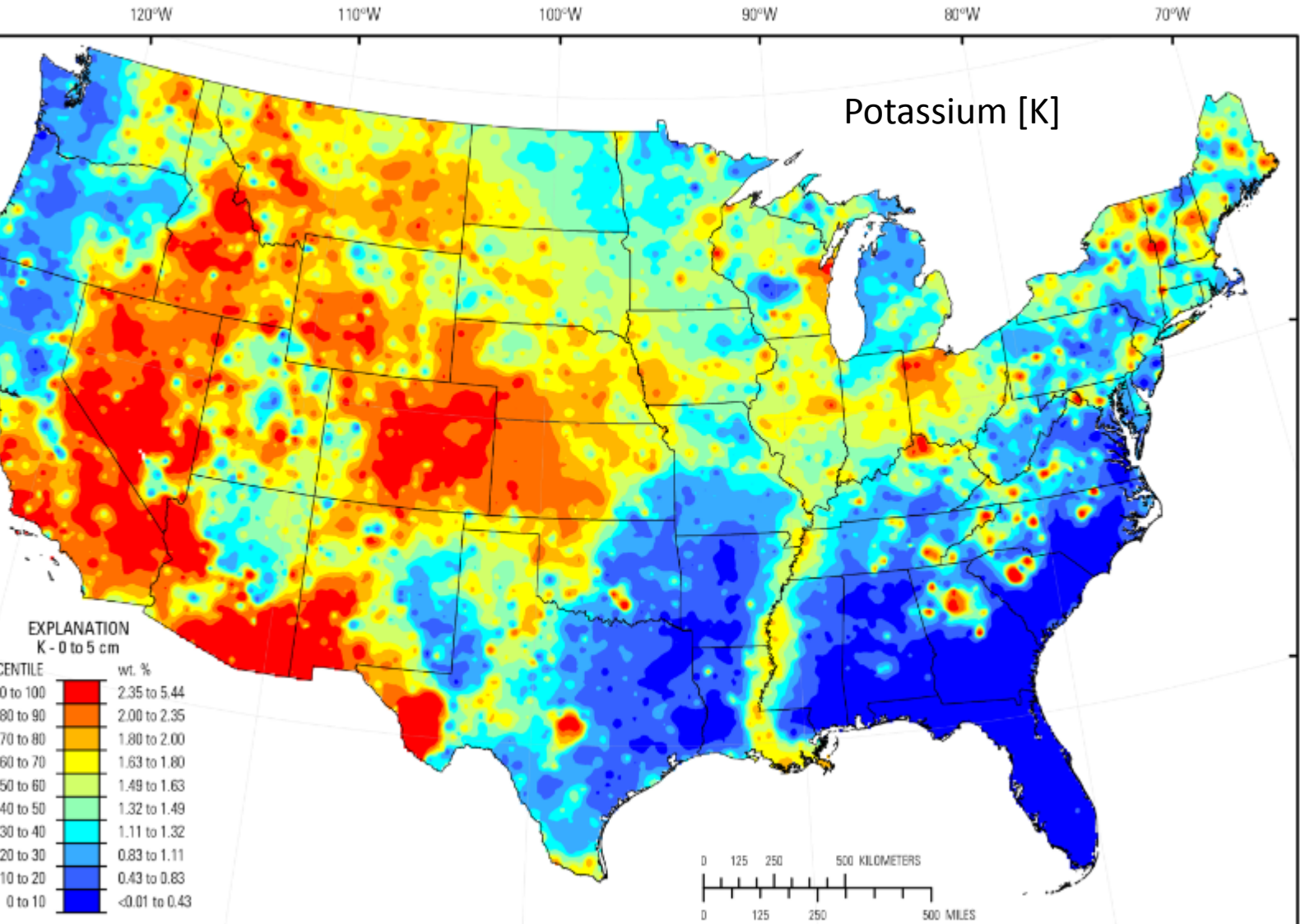
0.0 0.2 0.4 0.6 0.8 1.0

Sodium (% CEC)

0 2 4 6 8 10

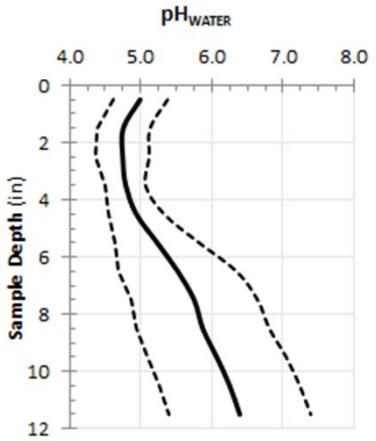


Potassium [K]


120°W
110°W
100°W
90°W
80°W
70°W
Potassium [K]
EXPLANATION
K - 0 to 5 cm
CENTILE
wt. %
0 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]

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



RESIDUAL

EXCHANGEABLE (KCl)

Potassium (mg kg^{-1})

2500 5000 7500

Potassium (meq 100 g^{-1})

0 2 4 6 8 10

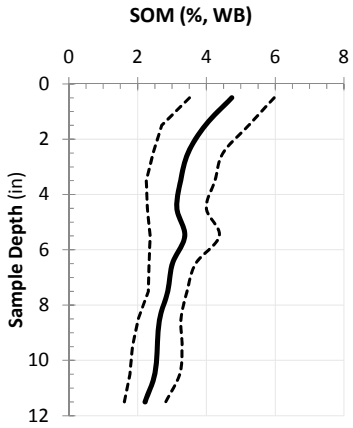
Potassium (% CEC)

0 20 40 60 80 100

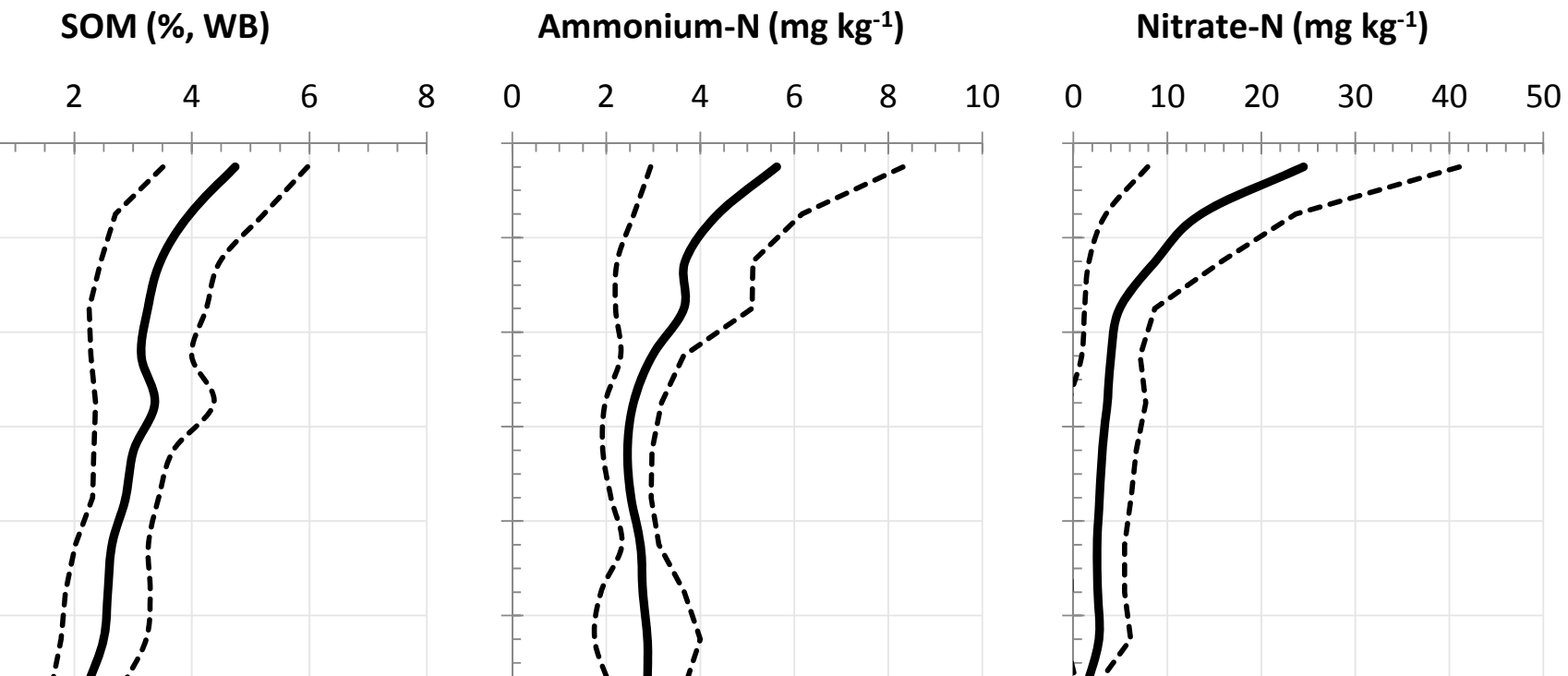
Mineral N [NO_3] and [NH_4]

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

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



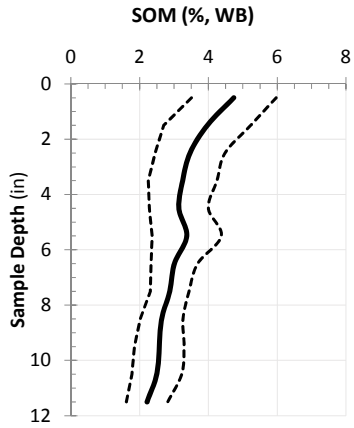
OIL ORGANIC MATTER

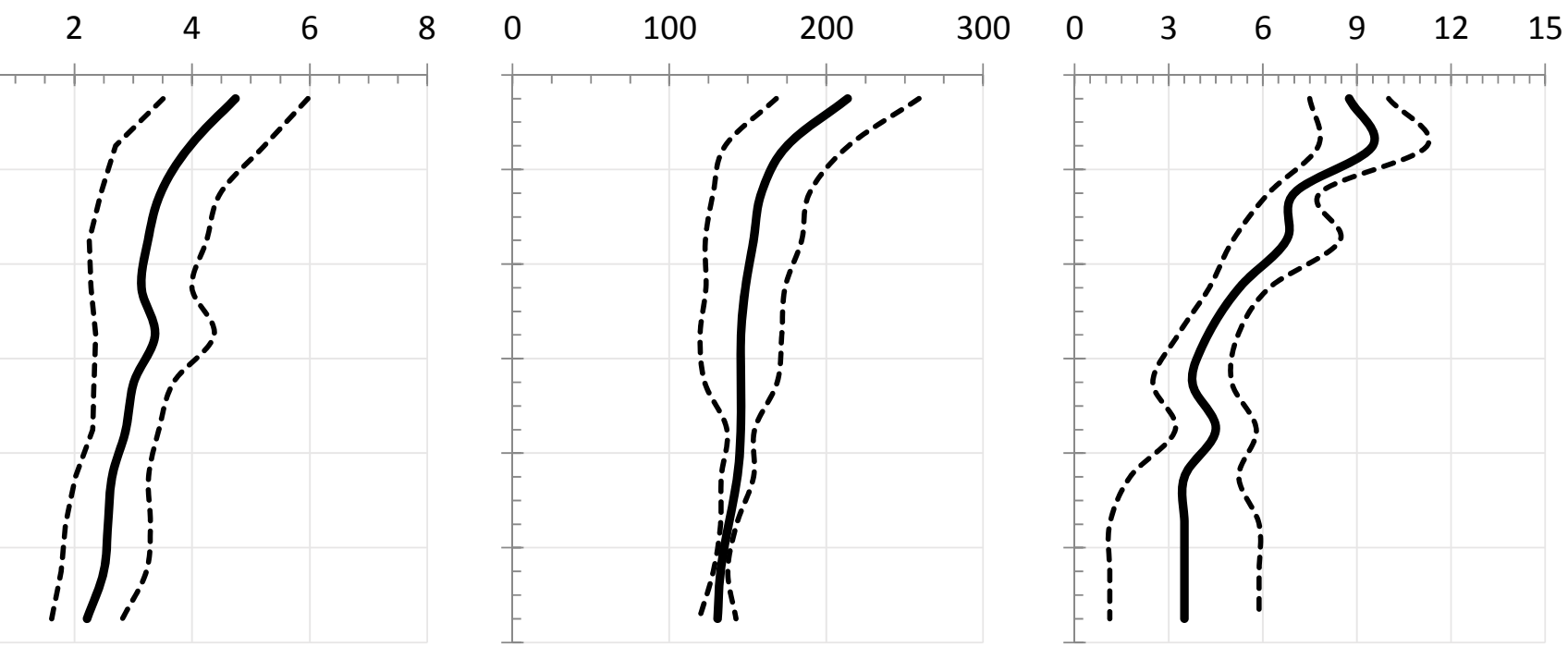


Sulfur [S]

ssential plant nutrient (MACRO). In plant main component of proteins.

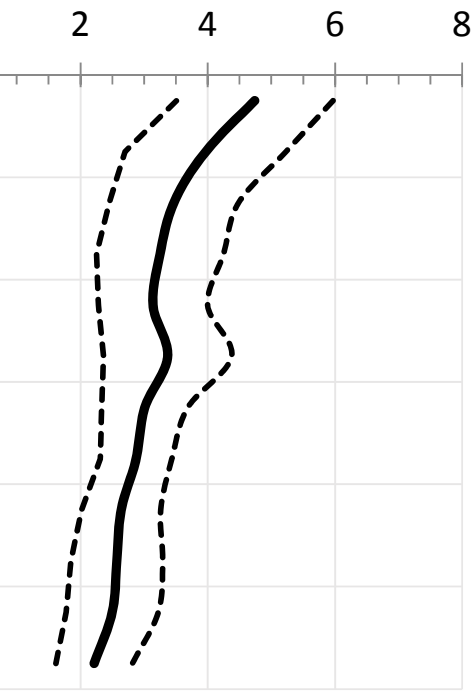
OIL ORGANIC MATTER



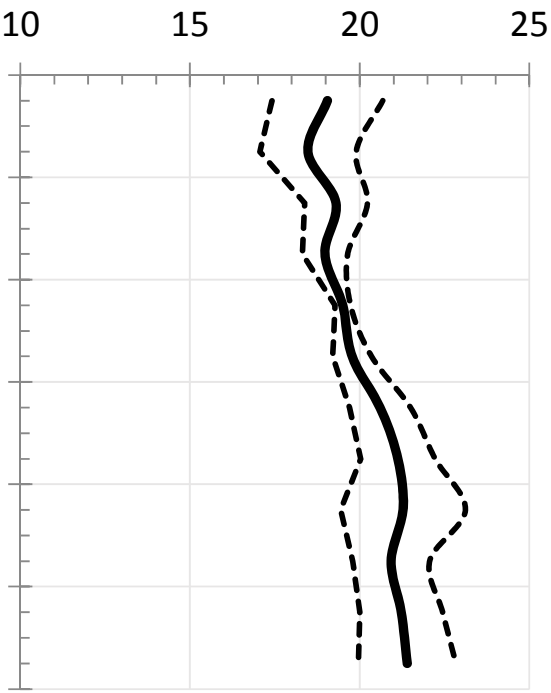


Indicator Tests for Soil Conditions

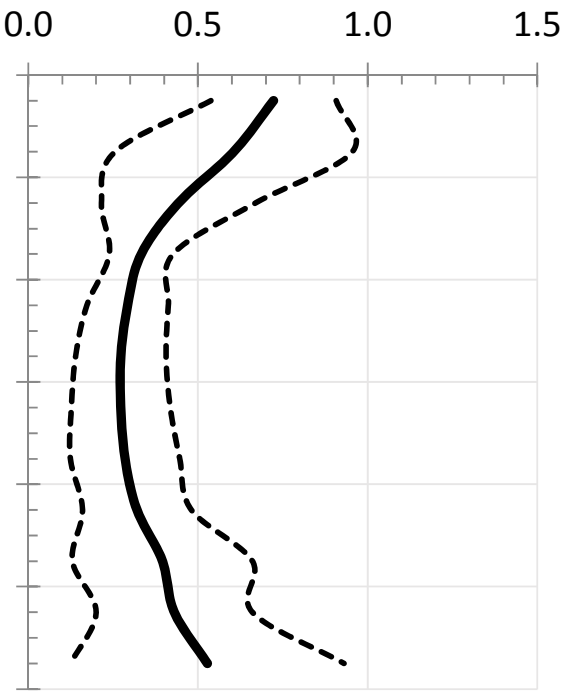
ORGANIC MATTER



CATION EXCHANGE CAPACITY



SOLUBLE SALTS



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

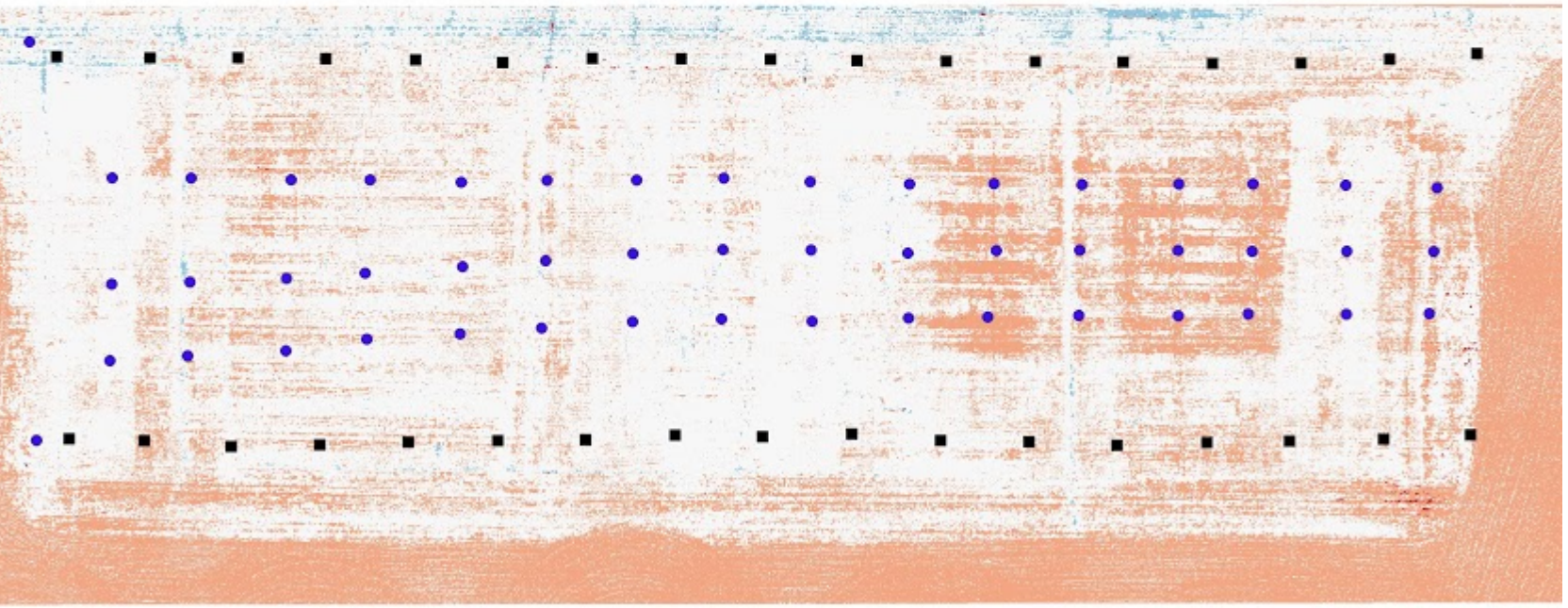
NDRE - Contrast

ASHINGTON 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, LLC
FAA Ex333#14051
(541)480-6903

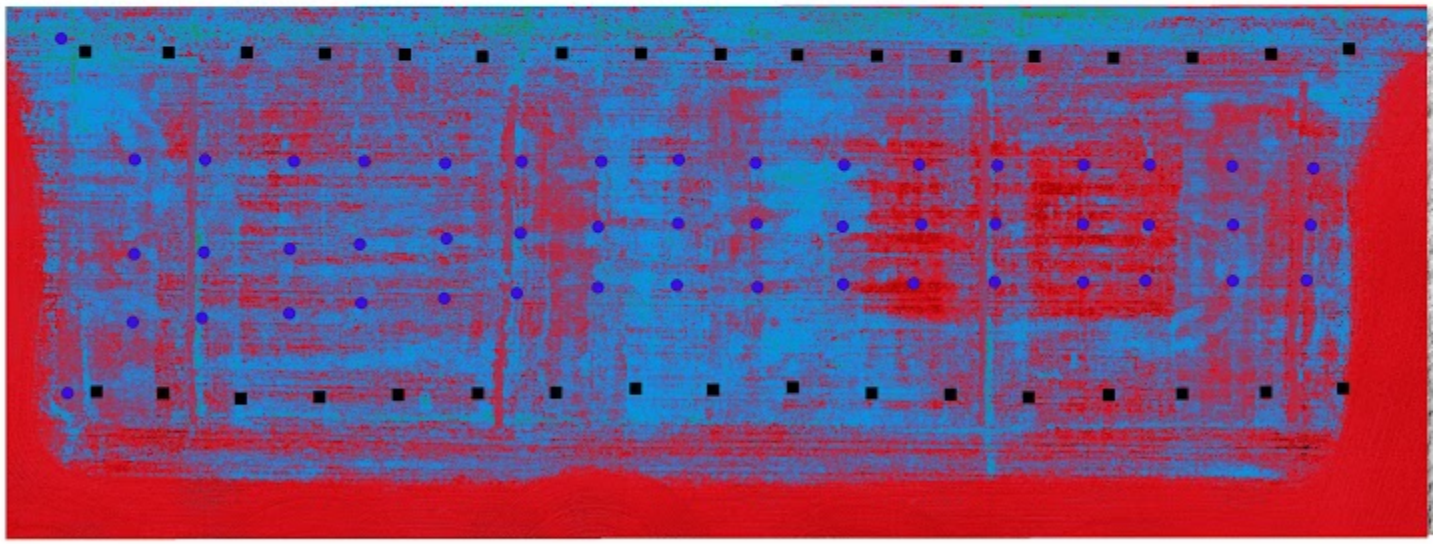
NDVI

SHINGTON STATE
UNIVERSITY

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

d
bplot Corners
ta Collection Points

00000
100000
200000
300000
400000
500000
600000
700000
800000



OmniFox Aerial, LLC
FAA Ex333#14051
(541)480-6903

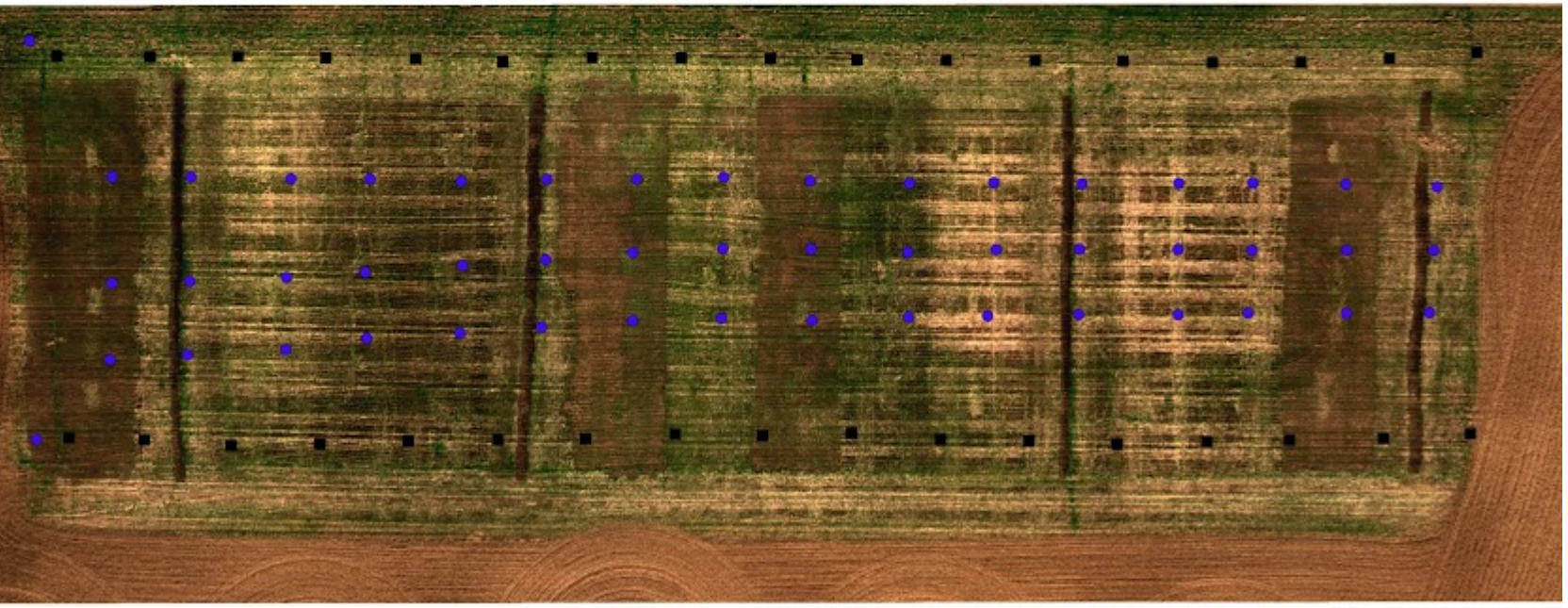
RGB - Visible

WASHINGTON STATE UNIVERSITY

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

Legend
- Subplot Corners
- Data Collection Points

Site EC16-RGB



OmniFox Aerial, LLC
FAA Ex333#14051
(541)480-6903

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