Overhaul of Potassium Recommendations in North Dakota

Advanced Crop Advisor Workshop, 2018

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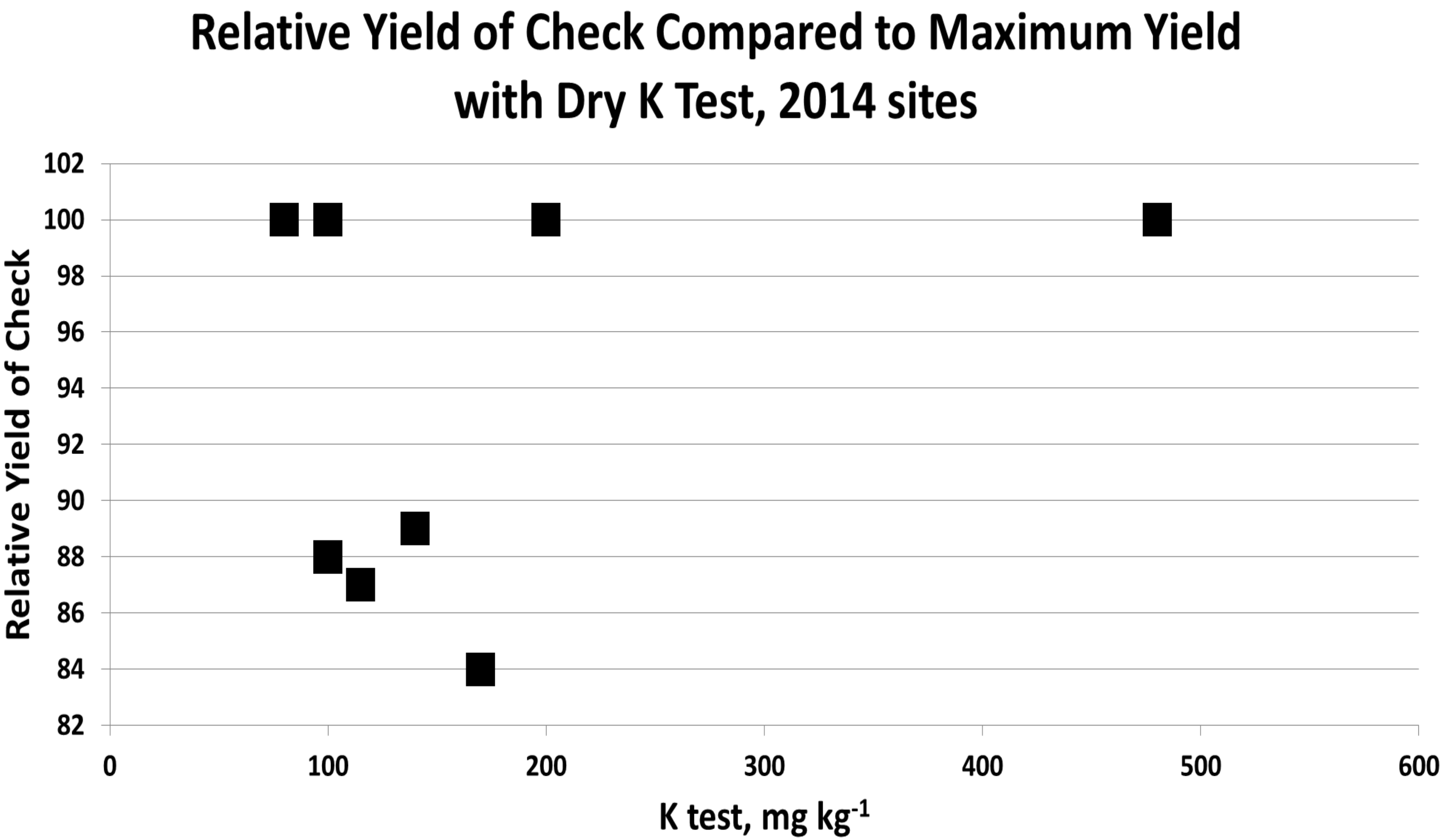
K study started 2014 season

Response to decline in K soil test levels in SE North Dakota as a result of rotation change from wheat/barley/sugar beet, which do not result in high K removal to corn and soybean which removes much K.

Common K soil tests in SE ND are 100-200 ppm.

The dry K test was best of all, but was only predictive of response 50% of time



Site, Year	K test, ppm	Expected Yield Increase	Actual Yield Increase
Buffalo, 2014	100	Y	N†
Walcott E, 2014	100	Y	Y
Wyndmere, 2014	100	Y	N
Milnor, 2014	100	Y	N
Gardner, 2014	115	Y	Y
Fairmount, 2014	140	Y	N
Walcott W, 2014	80	Y	N
Arthur, 2014	170	N	Y
Valley City, 2014	485	N	N
Page, 2014	200	N	N
Absaraka, 2015	113	Y	N
Arthur, 2015	125	Y	Y
Barney, 2015	170	N	N
Casino, 2015	120	Y	Y
Dwight, 2015	110	Y	N
Fairmount1, 2015	188	N	Y
Fairmount2, 2015	118	N	Y
Leonard N, 2015	380	N	N
Leonard S, 2015	190	N	N
Milnor, 2015	118	Y	Y
Prosper, 2015	205	N	N
Valley City, 2015	200	N	N
Walcott, 2015	109	Y	Y
Absaraka, 2016	160	N	Y
Valley City, 2016	226	N	Y
Gardner, 2016	60	Y	Y
Lisbon, 2016	78	Y	Y
Mooreton, 2016	70	Y	N
Colfax, 2016	54	Y	Y

An Historical Perspective on the Chemistry and Mineralogy of Soil Potassium

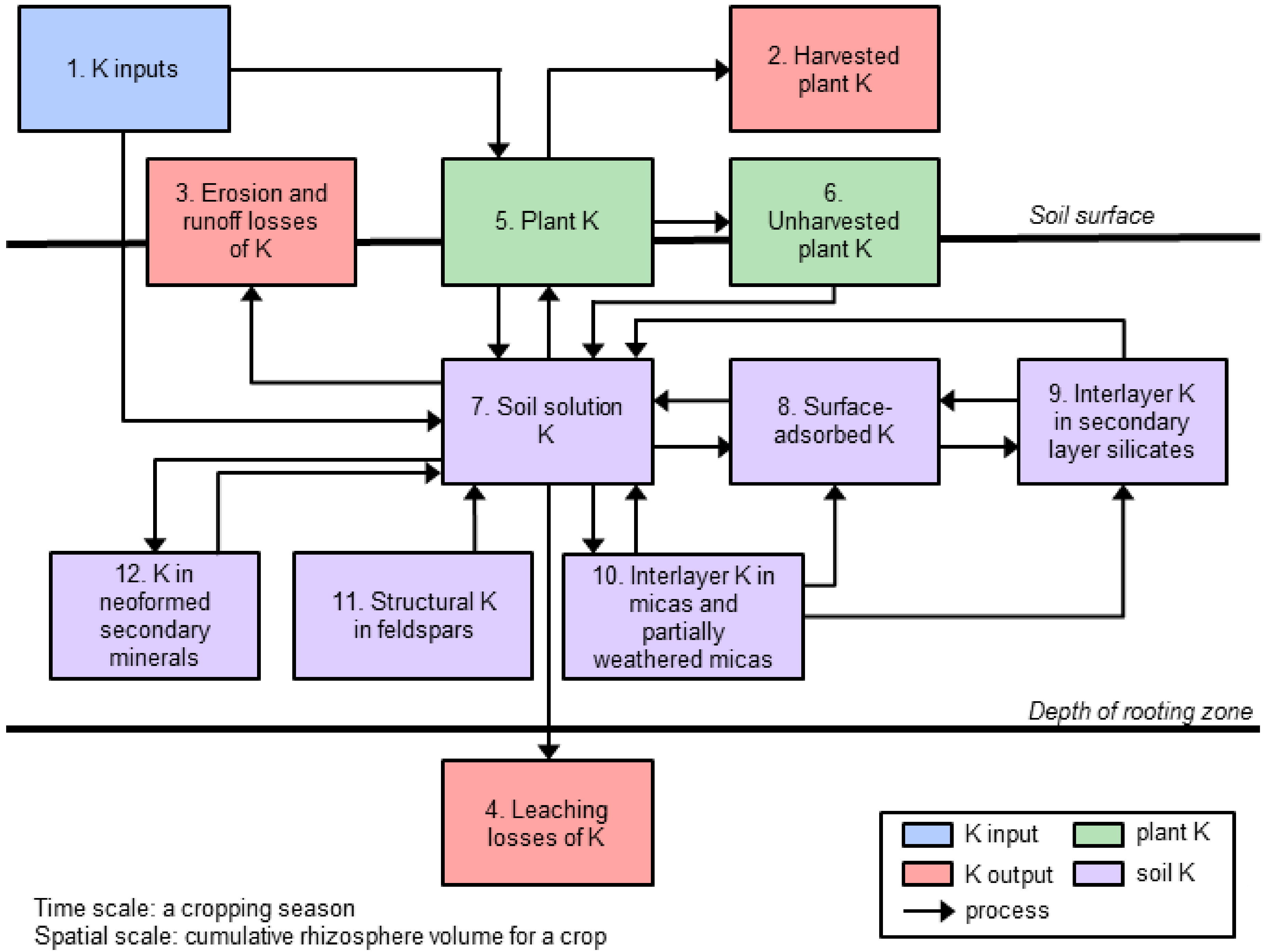
Symposium - Soil Potassium Tests and Their Relationship to Plant Availability and Native Mineralogy

DELAWARE ENVIRONMENTAL INSTITUTE
UNIVERSITY OF DELAWARE

Donald L. Sparks

S. Hallock du Pont Chair

Director, Delaware Environmental Institute



1. K inputs
2. Harvested plant K
3. Erosion and runoff losses of K
5. Plant K
6. Unharvested plant K
Soil surface
7. Soil solution K
8. Surface-adsorbed K
9. Interlayer K in secondary layer silicates
12. K in neoformed secondary minerals
11. Structural K in feldspars
10. Interlayer K in micas and partially weathered micas
Depth of rooting zone
4. Leaching losses of K
K input
plant K
K output
soil K
process
Time scale: a cropping season
Spatial scale: cumulative rhizosphere volume for a crop

The dry K test is only an index-

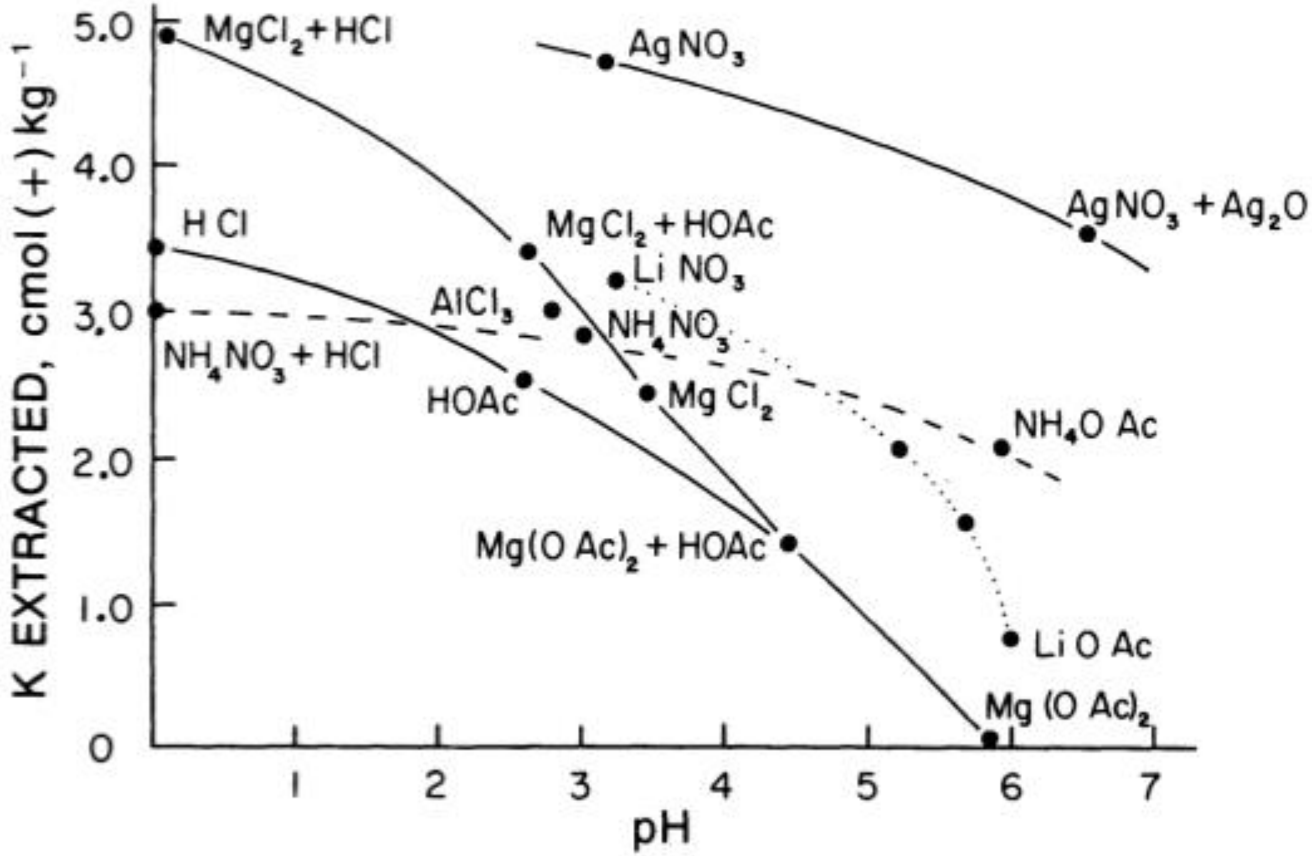


Fig. 9–25. Displacement of K from Nason B3 soil as affected by pH and extracting solution. All solutions are normal with respect to the component indicated (Rich, 1964).

From Sparks and Huang 1985

Soils Sparks worked on were very sandy, low CEC, slam-dunk for K studies, right?

Table 1. Selected physical, chemical, and mineralogical properties of Dothan soils from Greensville and Nottoway Counties.

Horizon	Depth	Soil separates: Sand	Soil separates: Silt	Soil separates: Clay	Organic matter	Soil pH	CEC	Exchangeable bases: Ca	Exchangeable bases: Mg	Exchangeable bases: Na	Clay mineral suite†
	cm	%					meq/100 g				
Greensville County											
Ap	0–20	66.6	24.4	9.0	0.5	6.1	4.2	0.74	0.12	0.04	VC_1,‡ GI_2, QZ_3, KK_4
A2	20–31	77.0	16.0	7.0	0.3	5.8	4.0	1.03	0.21	0.03	VC_1, KK_2, QZ_3, GI_4
B21t	31–41	65.9	23.8	10.3	0.3	4.8	4.8	0.85	0.27	0.02	VC_1, KK_2, GI_3, MI_4
Nottoway County											
Ap	0–15	81.6	15.0	3.4	1.2	5.8	5.8	1.72	0.85	0.01	VC_1, KK_2, QZ_3, GI_4
A2	15–33	70.8	20.1	9.1	0.2	5.2	3.4	0.24	0.13	0.03	VC_1, VR_2, KK_3, MI_4
B21t	33–58	69.1	19.1	11.9	0.2	4.7	4.0	0.26	0.06	0.03	VC_1, KK_2, GI_3, MI_4

† GI = gibbsite; KK = kaolinite; MI = mica; QZ = quartz; VC = chloritized vermiculite; VR = vermiculite.
‡ Subscript 1 = most abundant, 4 = least abundant.

From Sparks et al., Agron. J. 1980

Very little exchangeable K
Most K in feldspar

Table 2. Forms of K in Dothan soils from Greensville and Nottoway Counties.

Horizon	Depth	Dilute $HCl\text{-}H_2SO_4$ Ext. K	Exchange-able K	Non-exchange-able K	Primary mineral K		Total K	Total K		
					Feldspar	Mica		Sand	Silt	Clay
	cm	meq/100 g								
				Greensville County						
Ap	0–20	0.11	0.11	0.17	5.4	0.8	6.5	0.3	3.7	2.5
A2	20–31	0.06	0.11	0.19	5.7	0.9	6.9	0.4	3.4	3.1
B21t	31–41	0.10	0.22	0.38	5.1	3.6	9.3	0.2	1.4	7.7
				Nottoway County						
Ap	0–15	0.07	0.10	0.22	11.3	0.4	12.0	2.5	4.1	5.4
A2	15–33	0.03	0.09	0.19	8.2	2.3	10.8	2.0	5.5	3.3
B21t	33–58	0.08	0.13	0.24	5.4	5.6	11.4	1.8	4.7	4.9

From Sparks et al., Agron. J. 1980

Table 1. Effect of K applications on corn grain yields at four sites over three growing seasons. Yield was not significantly ($p \leq 0.05$) affected by treatment for any year-site combination.

Annual K Application†	Soil: Rumford	Kenansville	Matapeake	Sassafras
kg K ha^{-1}	yield, Mg ha^{-1}			
		1982		
0	13.1	12.4	12.1	13.1
94	13.4	12.3	11.3	12.9
94S	14.0	12.3	11.7	13.0
282	13.5	11.4	11.1	13.1
282S	13.8	11.4	11.2	12.2
SEM‡	0.3	0.5	0.4	0.4
		1983		
0	8.9	—	12.7	9.2
94	9.4	—	12.5	9.1
94S	8.5	—	12.1	7.6
282	11.5	—	11.8	6.9
282S	11.5	—	12.2	6.9
SEM	0.9	—	0.4	1.2
		1984		
0	9.8	—	8.7	—
94	10.1	—	9.2	—
94S	10.3	—	9.8	—
282	10.0	—	9.4	—
282S	10.5	—	9.3	—
SEM	0.2	—	0.4	—

† S indicates K was applied in three equal portions to give the total rate indicated.

‡ Standard error of the mean.

From Parker et.al., SSSAJ 1989b

Table 3. Potassium release from soils using a H-resin and oxalic acid.†

Horizon	Depth	H-resin	Oxalic acid
	cm	cmol kg^{-1}	
	Kenansville loamy sand		
Ap	0–23	0.199	1.97×10^{-3}
Bt2	89–118	0.251	2.97×10^{-3}
	Runford loamy sand		
Ap	0–25	0.172	1.41×10^{-3}
BC	89–109	0.231	1.97×10^{-3}
	Sassafras fine loamy sand		
Ap	0–20	0.235	5.64×10^{-4}
C1	84–99	0.246	1.69×10^{-3}

† These values represent amounts of K released at 30 d.

AP Kenansville = 85 lb K_2O per acre

From Sadusky et.al., SSSAJ 1987

Table 12. Potassium release from sand fractions of a Delaware soil using a H-resin and oxalic acid[a]

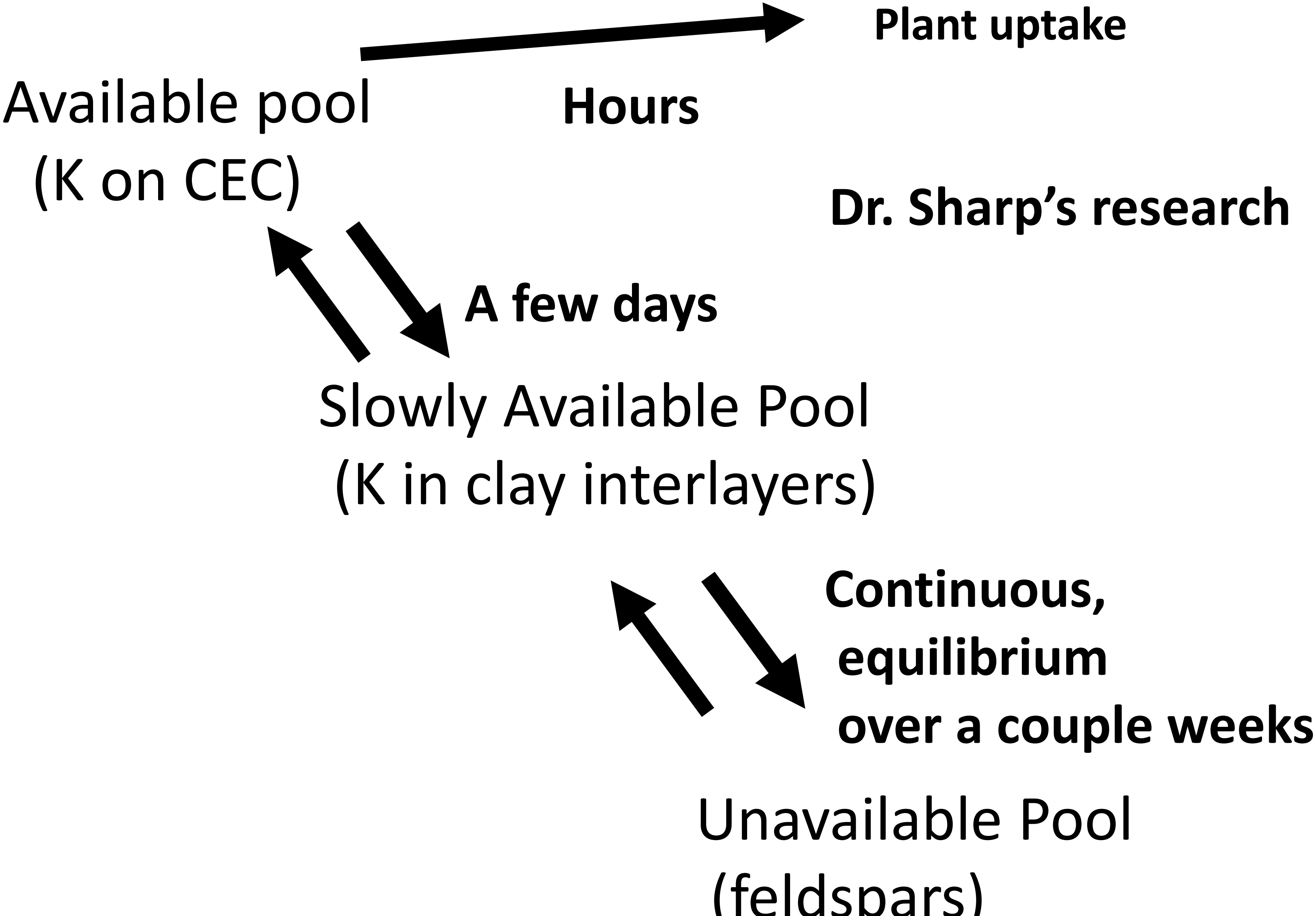
	K Released from Sand Fractions mg kg^{-1} [b]					
	Coarse (0.50–1.00 mm)		Medium (0.25–0.50 mm)		Fine (0.10–0.25 mm)	
Horizon	H-resin	Oxalic acid	H-resin	Oxalic acid	H-resin	Oxalic acid
Ap	53.5	0.50	65.0	0.72	71.5	1.05
E	53.5	0.55	58.0	0.72	87.5	0.99
Bt2	76.0	1.06	69.5	1.05	99.5	1.10
C	87.5	1.27	88.5	1.27	99.5	1.76

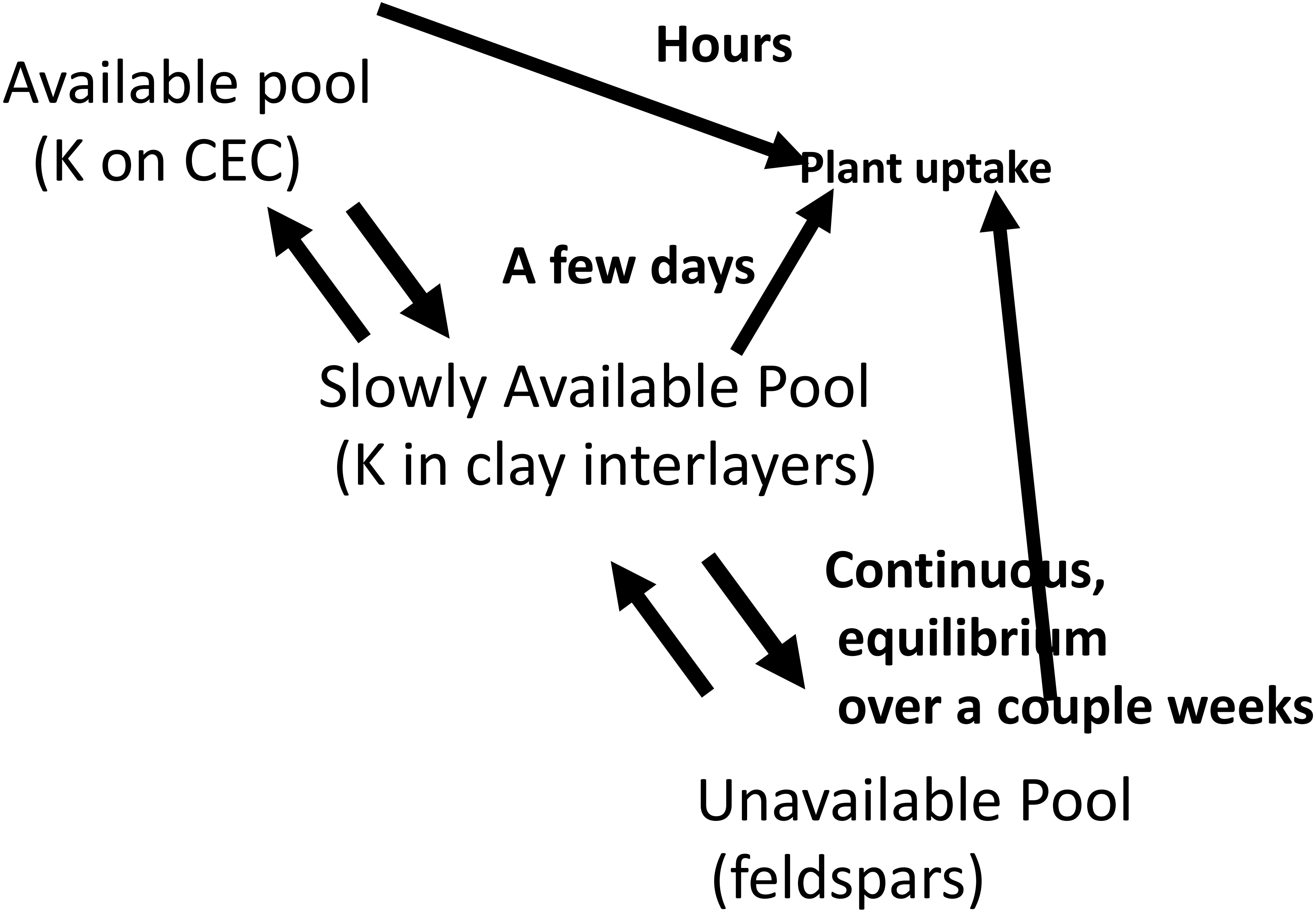
[a] Sadusky and Sparks (1985).

[b] These values represent amounts of K released at 30 days.

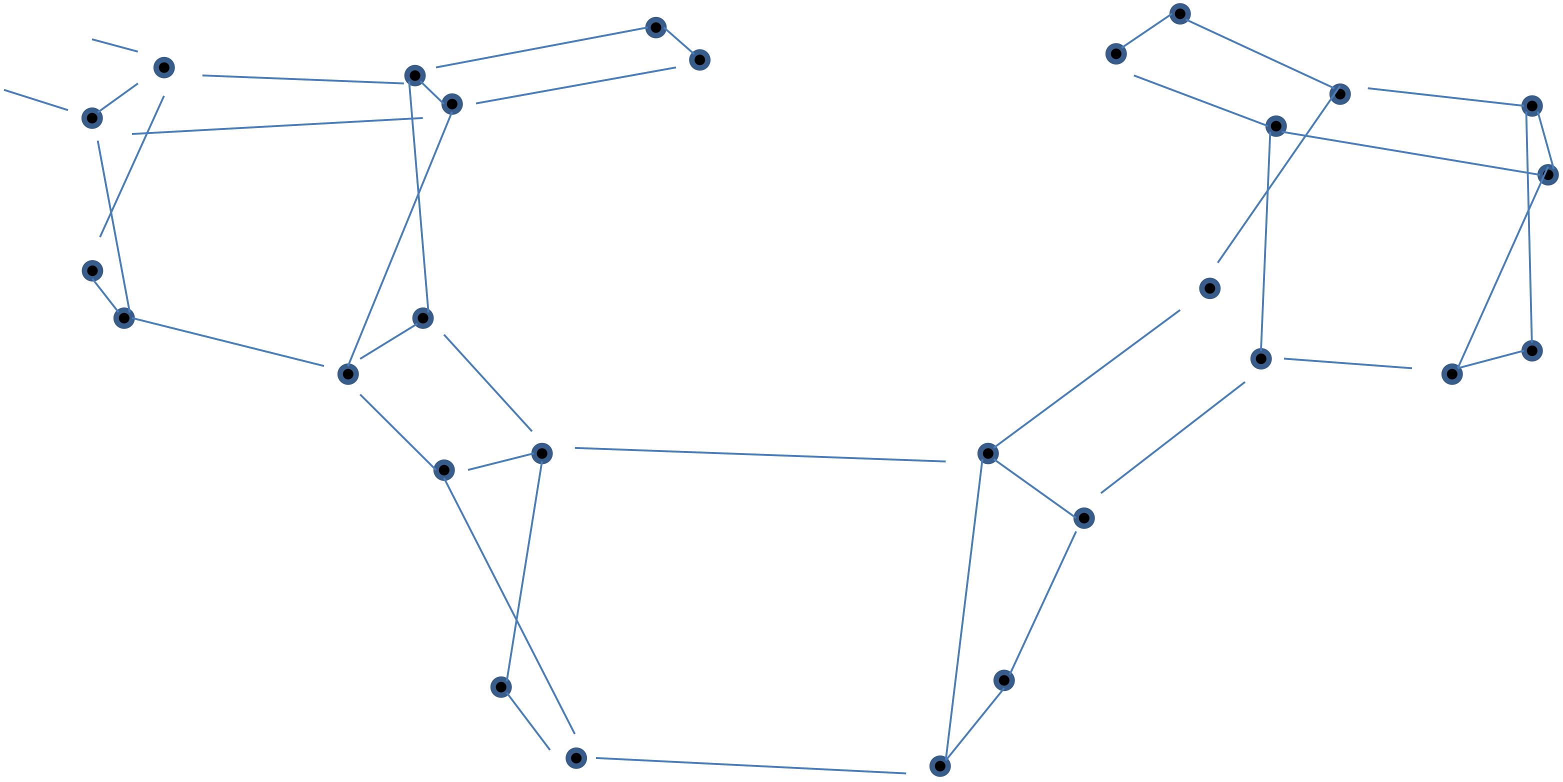
1 mg/kg = 2 lb/acre

From Sparks 1987

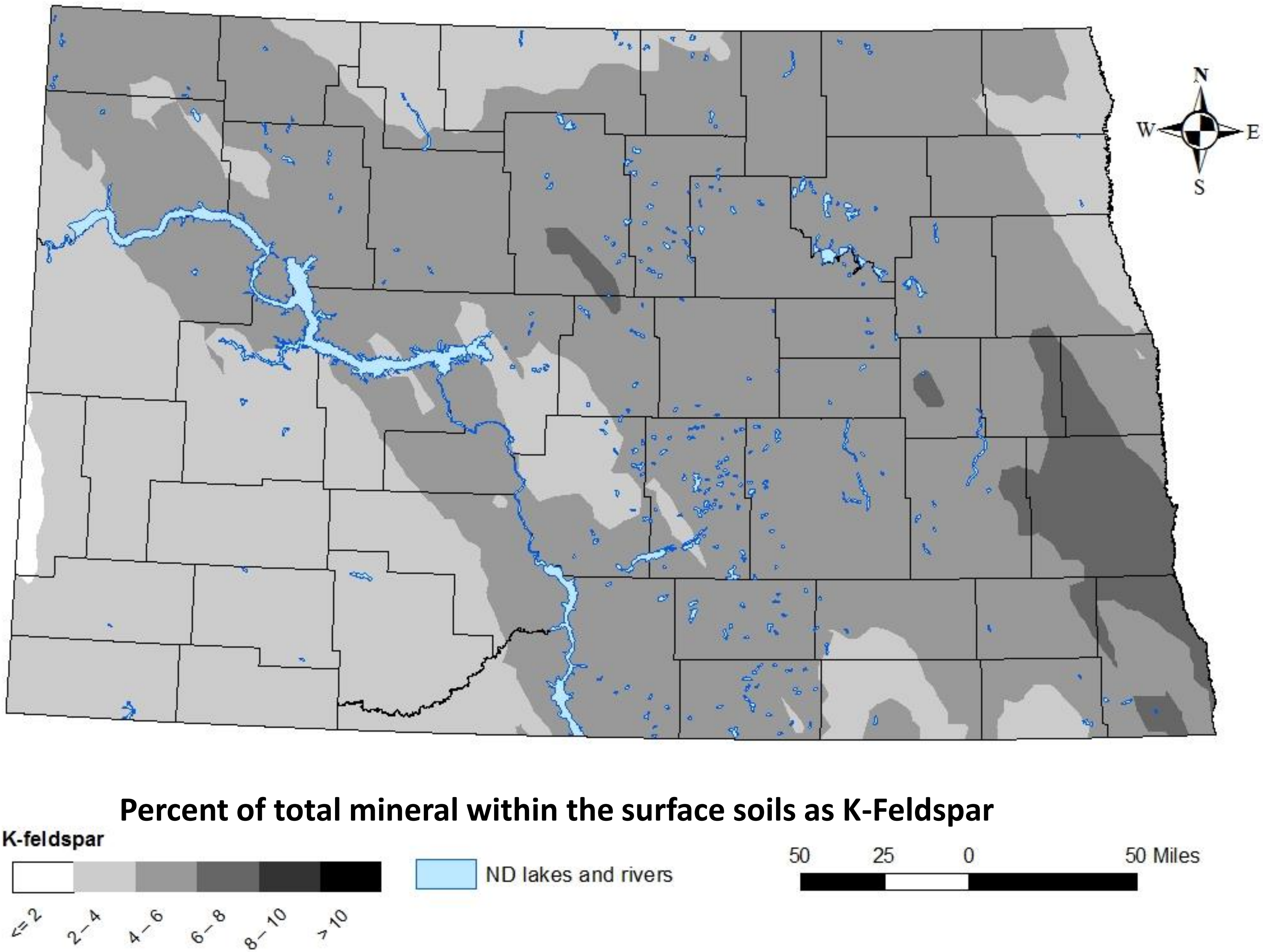

Plant uptake
Available pool
(K on CEC)
Hours
Dr. Sharp's research
A few days
Slowly Available Pool
(K in clay interlayers)
Continuous,
equilibrium
over a couple weeks
Unavailable Pool
(feldspars)


Available pool
(K on CEC)
Hours
Plant uptake
A few days
Slowly Available Pool
(K in clay interlayers)
Continuous,
equilibrium
over a couple weeks
Unavailable Pool
(feldspars)

Potassium feldspar-



3-D framework of SiO_4 and Al_2O_3 tetrahedrals isomorphous substitution of Al for Si ~ ¼ of the time results in significant negative (-) charge. Potassium within the open spaces helps balance charge.


N
W
E
S
Percent of total mineral within the surface soils as K-Feldspar
K-feldspar
<= 2
2 – 4
4 – 6
6 – 8
8 – 10
> 10
ND lakes and rivers
50
25
0
50 Miles

Clays measured in survey-

Smectite- (includes montmorillonite/beidelite)
(Crisp leaf-lettuce sandwich w/o mayo)

Illite- 2-1 limited expanding clay
(peanut butter sandwich)

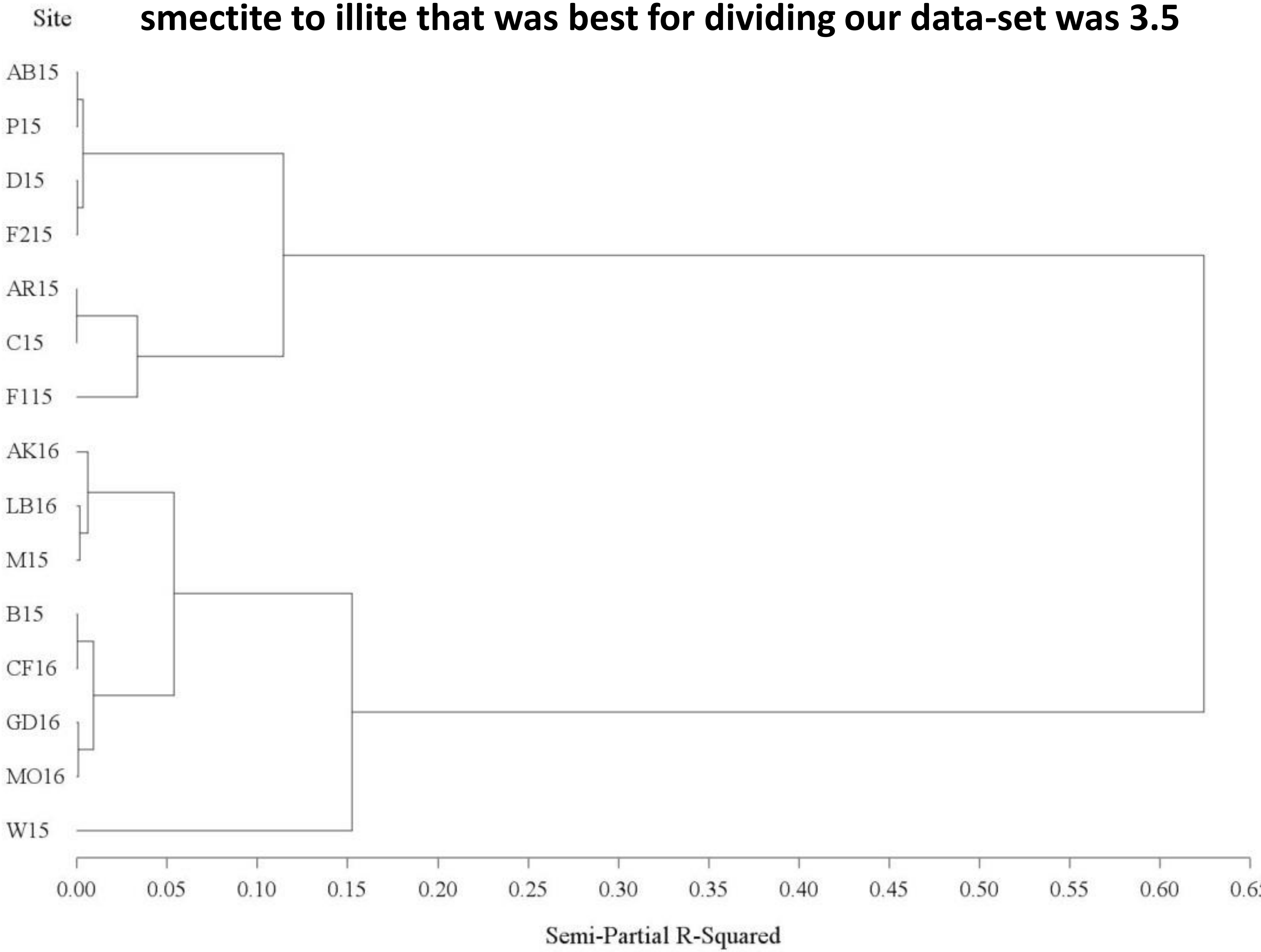
Kaolinite (1-1 non-expanding clays)

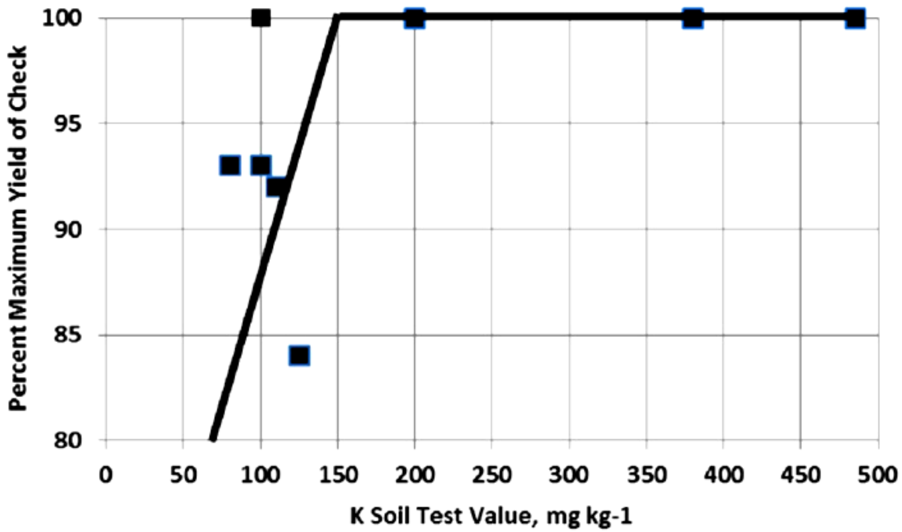
Chlorite (3-1 non-expanding clays)

Smectites ‘fix’, or temporarily retain K when soil is dry

Illites do not ‘fix’ K when dry

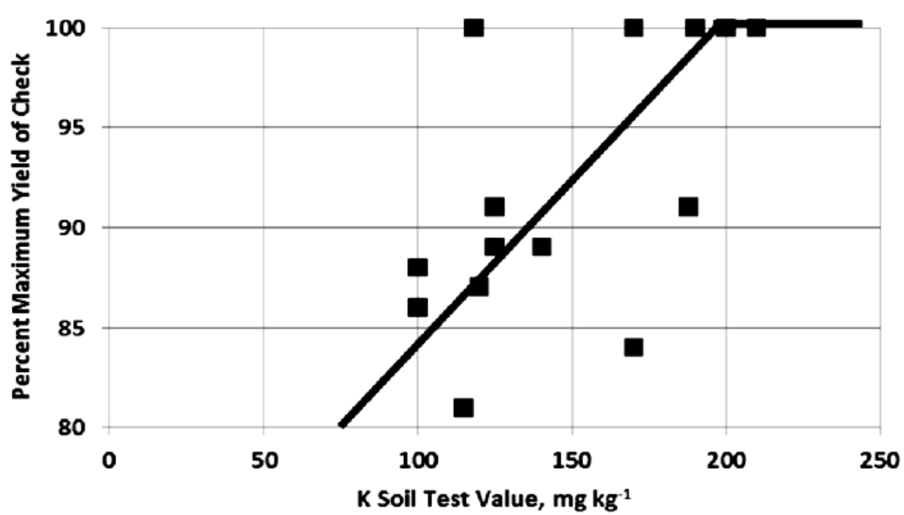
Used statistics to cluster the sites into two groups. The ratio of smectite to illite that was best for dividing our data-set was 3.5

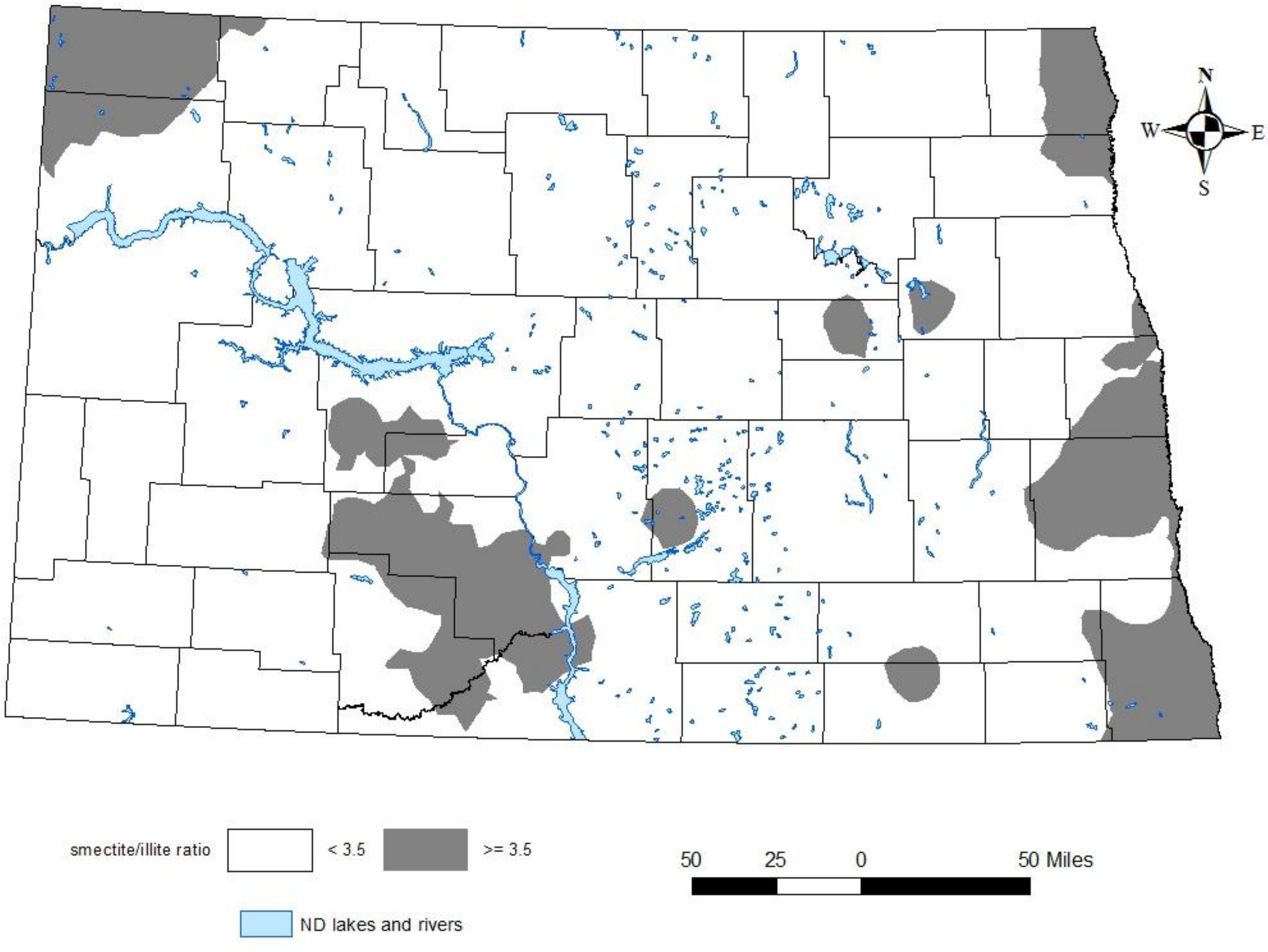




Smectite/illite ratio < 3.5

Smectite/illite ratio > 3.5





N
W
E
S
smectite/illite ratio
< 3.5
>= 3.5
50
25
0
50 Miles
ND lakes and rivers

Rates of K-

When there was a yield increase to K, yield increase was recorded up to 200 lb/acre 0-0-60 (120 lb K_2O)
Usually, yield decreased from the high yield when K rate was 250 lb/acre 0-0-60 (150 lb K_2O).

So- NDSU recommendations for any single year in corn are capped at 120 lb K_2O.

New North Dakota critical K levels-

For corn, alfalfa-

Smectite/illite > 3.5 200 ppm

Smectite/illite < 3.5 150 ppm

For sugar beet-

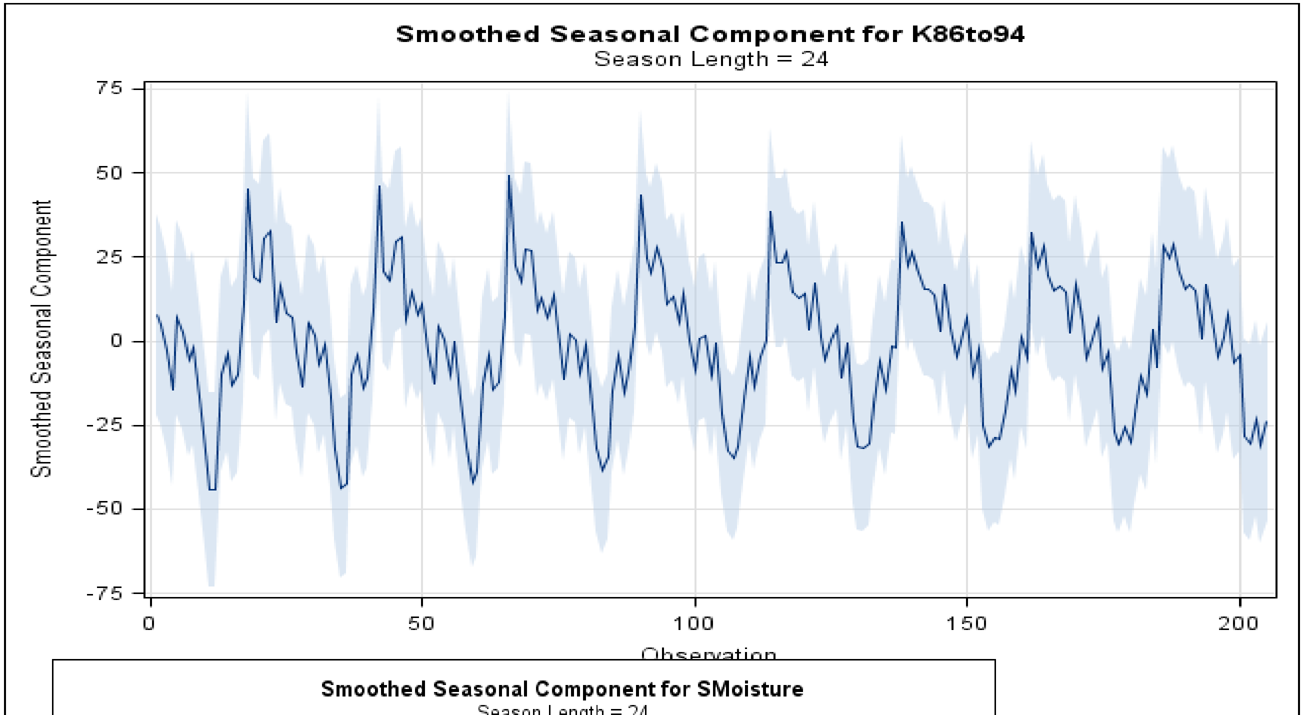
>3.5 150 ppm

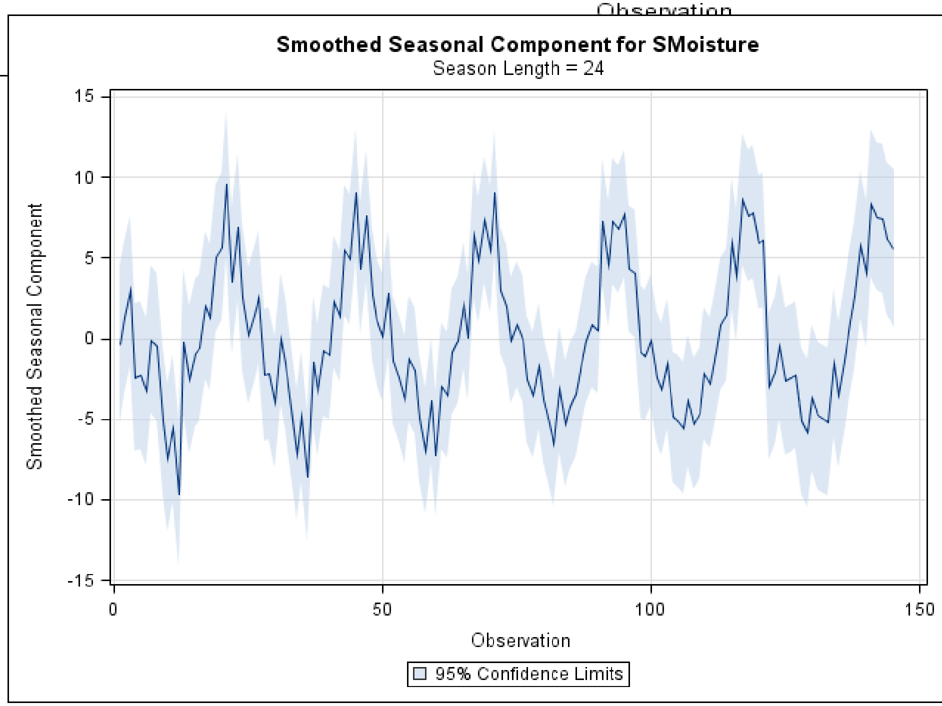
< 3.5 120 ppm

For spring wheat/durum/winter wheat

> 3.5 150 ppm

< 3.5 100 ppm

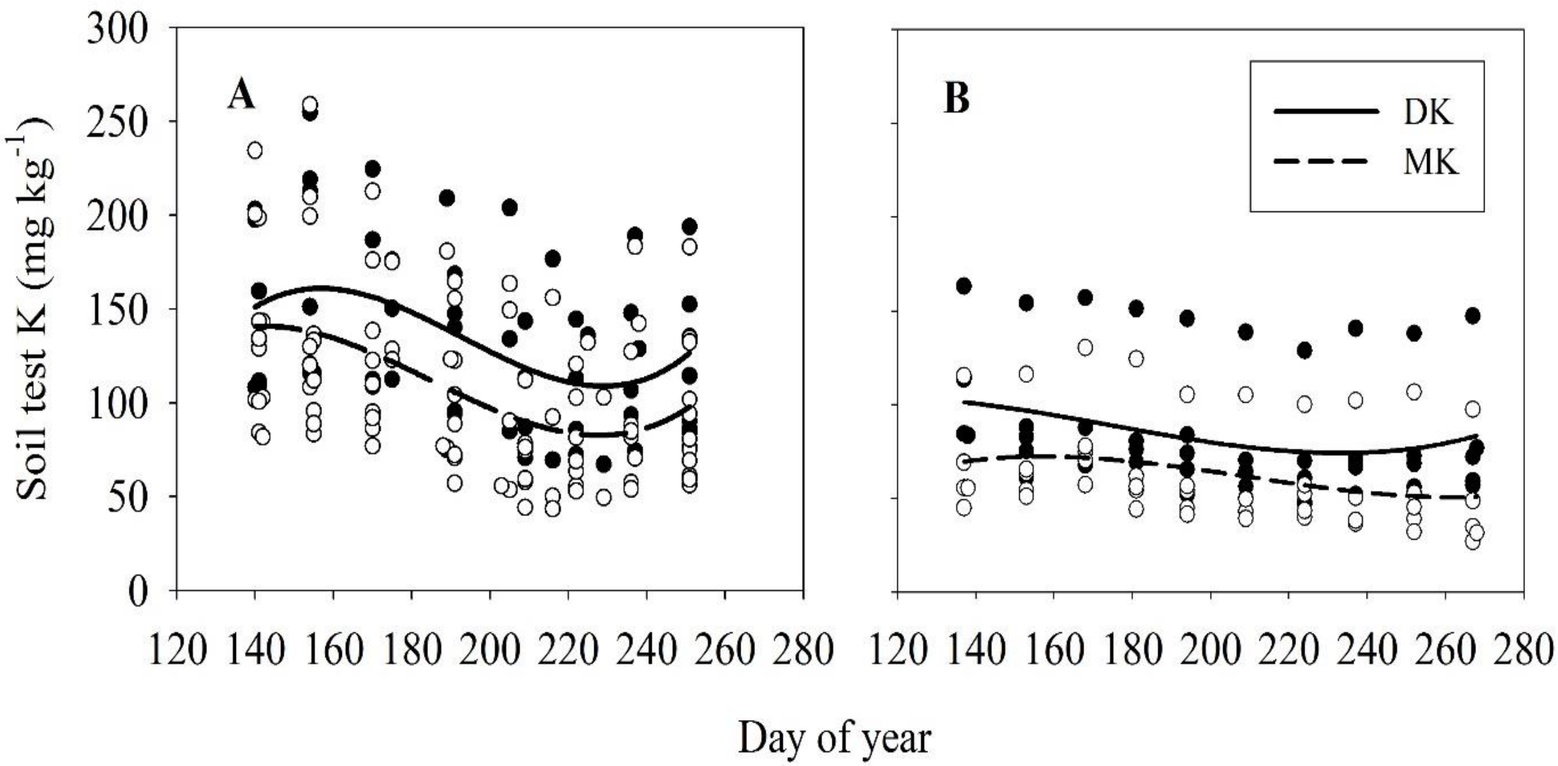




Seasonal variability in a smectite dominate Flanagan/Drummer soil near Urbana, IL over 9 complete years From Peck and Sullivan, 1995, IFCA proceedings Graphed by Franzen, 2011.

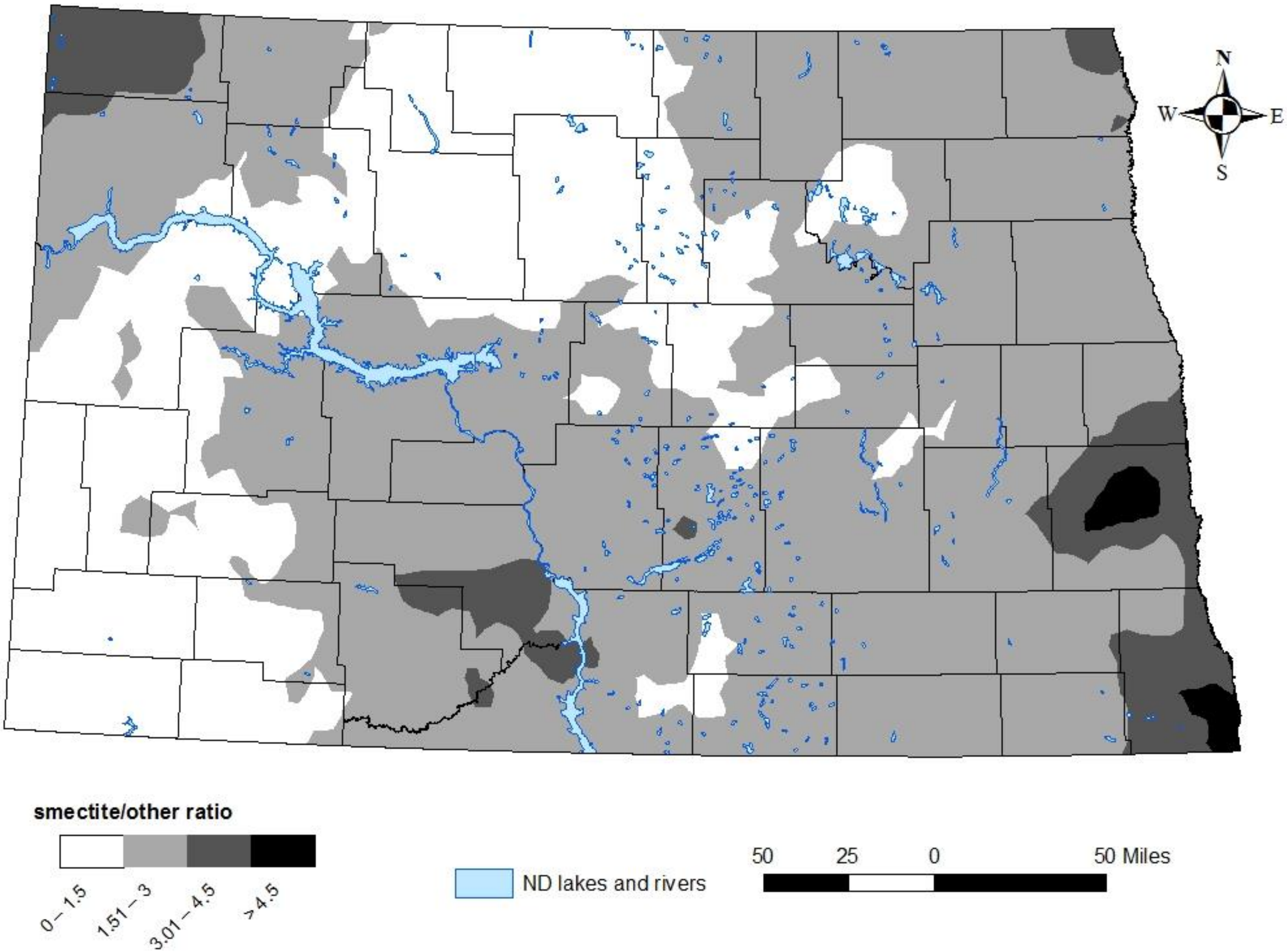
Variability of soil test dry and moist K in a year with greater beginning soil moisture (A) and a dryer beginning growing season year (B), North Dakota

(From Breker MS thesis, 2017)



North Dakota corn potassium recommendation app

Search for Corn K Calculator



N
W
E
S
smectite/other ratio
0 – 1.5
1.51 – 3
3.01 – 4.5
>4.5
ND lakes and rivers
50
25
0
50 Miles

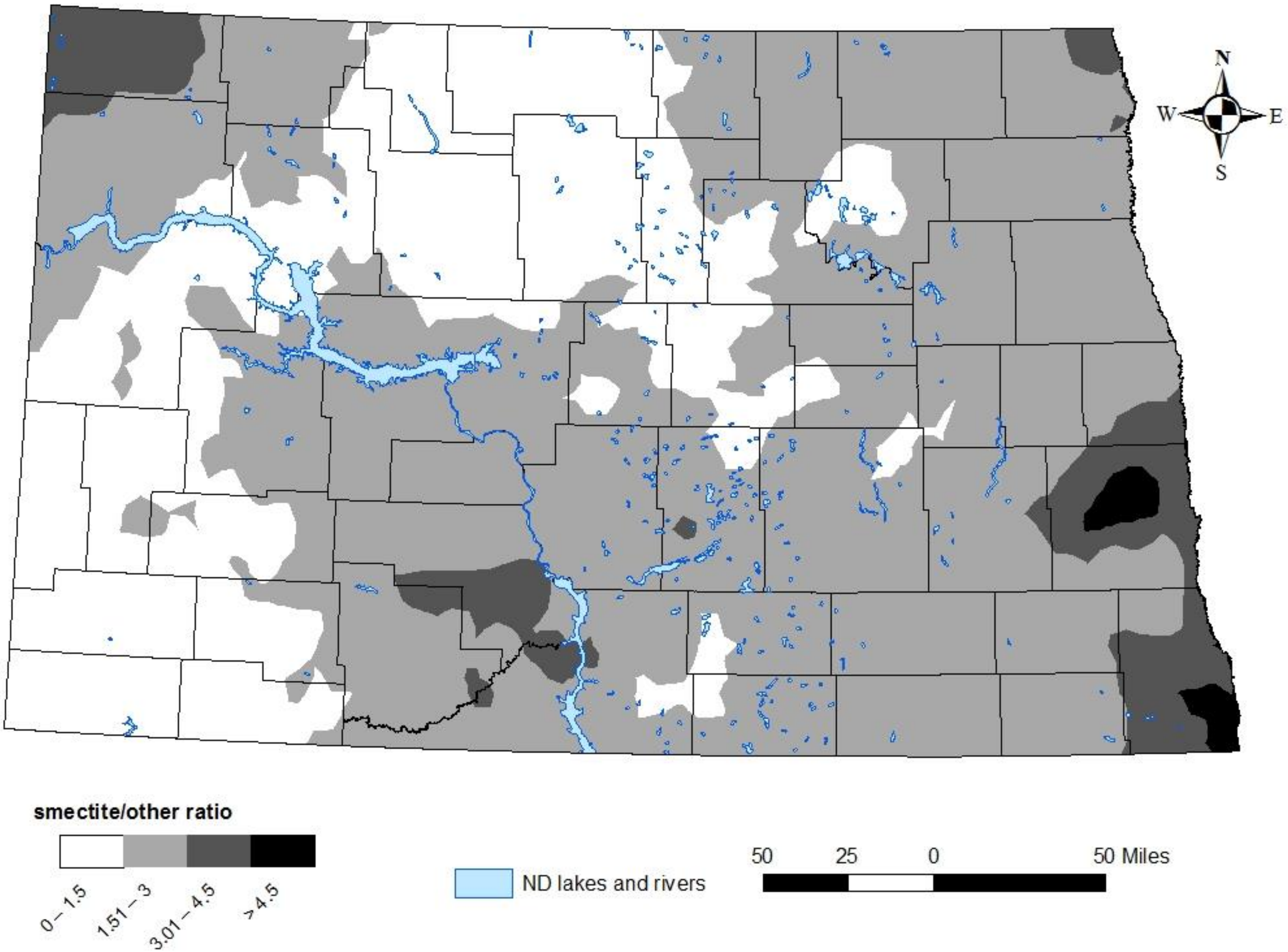
Tillage and clays?

Smectites shrink and swell

- **moisture**
- **freeze thaw (moisture more important)**

Illites only shrink and swell a little

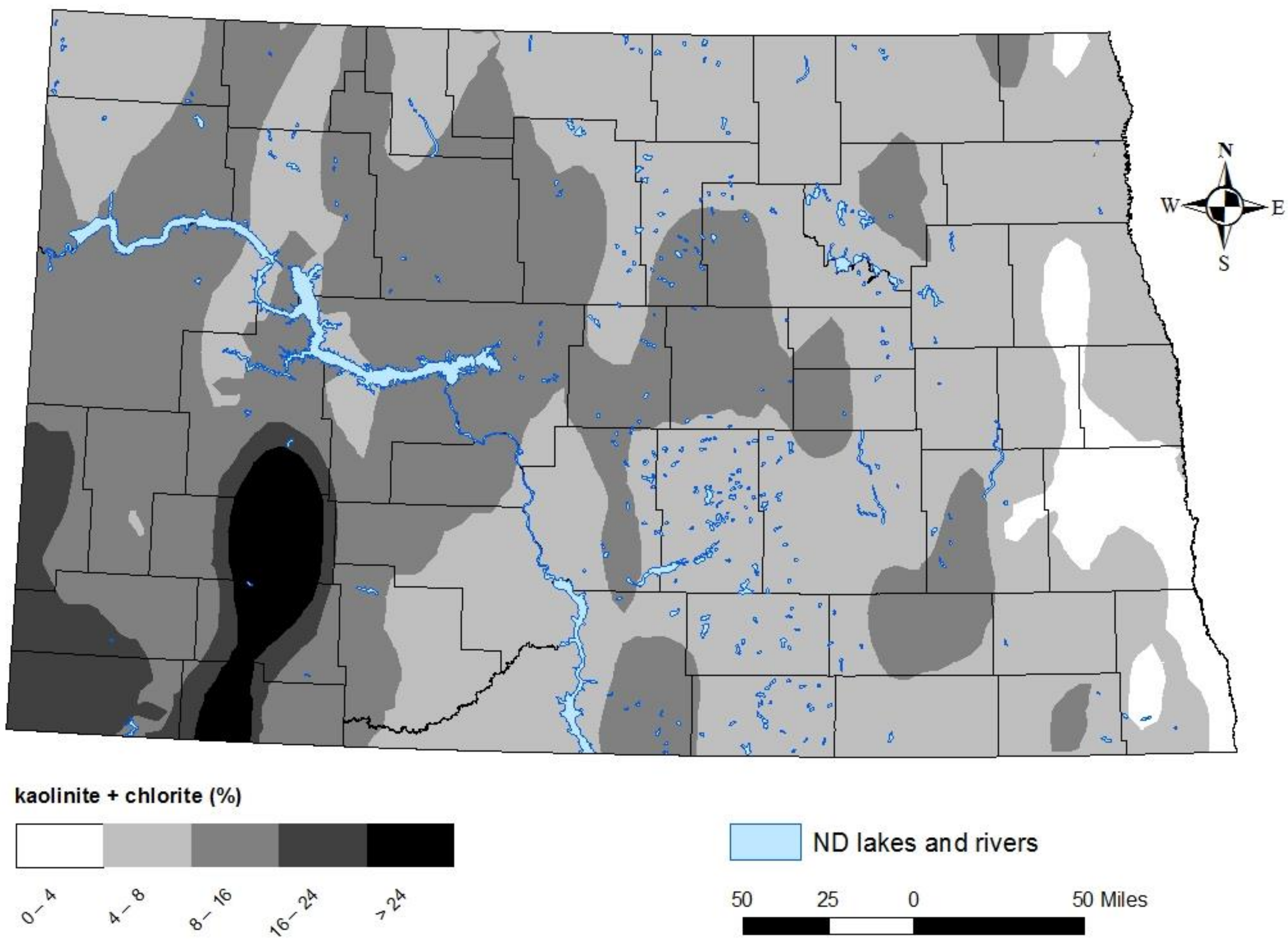
Kaolinite/Chlorite not at all



N
W
E
S
smectite/other ratio
0 – 1.5
1.51 – 3
3.01 – 4.5
>4.5
ND lakes and rivers
50
25
0
50 Miles

Smectite-dominant soils (S/other > 1.5) would have greatest ease of transition to no-till

Illite and other dominant soils (S/other <1.5) growers would need to be patient in spring field work, adopt controlled traffic management and grow a rotation incorporating different crop rooting depths.



N
W
E
S
kaolinite + chlorite (%)
0 – 4
4 – 8
8 – 16
16 – 24
> 24
ND lakes and rivers
50
25
0
50 Miles

Summary-

The dry soil 1-N Ammonium acetate extraction offered by NDSU and Agvise for decades is the best method for determining our K index most related to crop response,

but only if K chemistry is considered.

Summary-

Sampling the same time each year of K interest will best track K soil test increase or decrease over time.

New K recommendations for corn include an economic component based on K price and corn price.

K fertilizer rates are capped at 120 lb K_2O

Summary-

Kaolinite content of western counties is far higher than I would ever have envisioned. It is remarkable that no-till has worked extremely well in that region given the unforgiving nature of their clay mineral properties.

It is an encouragement to farmers to the east that they have been successful, and a sign that moving towards no-till should be easier in eastern ND soils.