Soil Fertility Short Course

Arnall

- Inter-relationships between N P K
- Role of Soil pH on Nutrients
- Role of Micro Nutrients
- Soil Fertility Amendments, dry/liquid

Number 1 Rule

- My number one rule for this Presentation

- ASK QUESTIONS

Law of the Minimum

- von Liebig postulated that the yield of a plant would be directly proportional to the most limiting growth factor, even if several other growth factors might be limiting to a lesser degree. His "Law of the Minimum" = water barrel made up of different length barrel staves. Each stave represents the existing level of a growth factor, such as light, heat, nutrients, etc.
  The level of water in the barrel (yield) is limited to the height of the shortest barrel stave
  (most limiting growth factor).

Father of Agricultural Chemistry

SCIENCE-WORLD

Yield Potential

- According to the Law of the minimum given the following growth factors what would the maximum level of yield be for the situation? ________________________
- *Light 120 bushel* *Water 60 bushel* *Nutrient 100 bushel* *Heat 85 bushel*.

Yield Potential

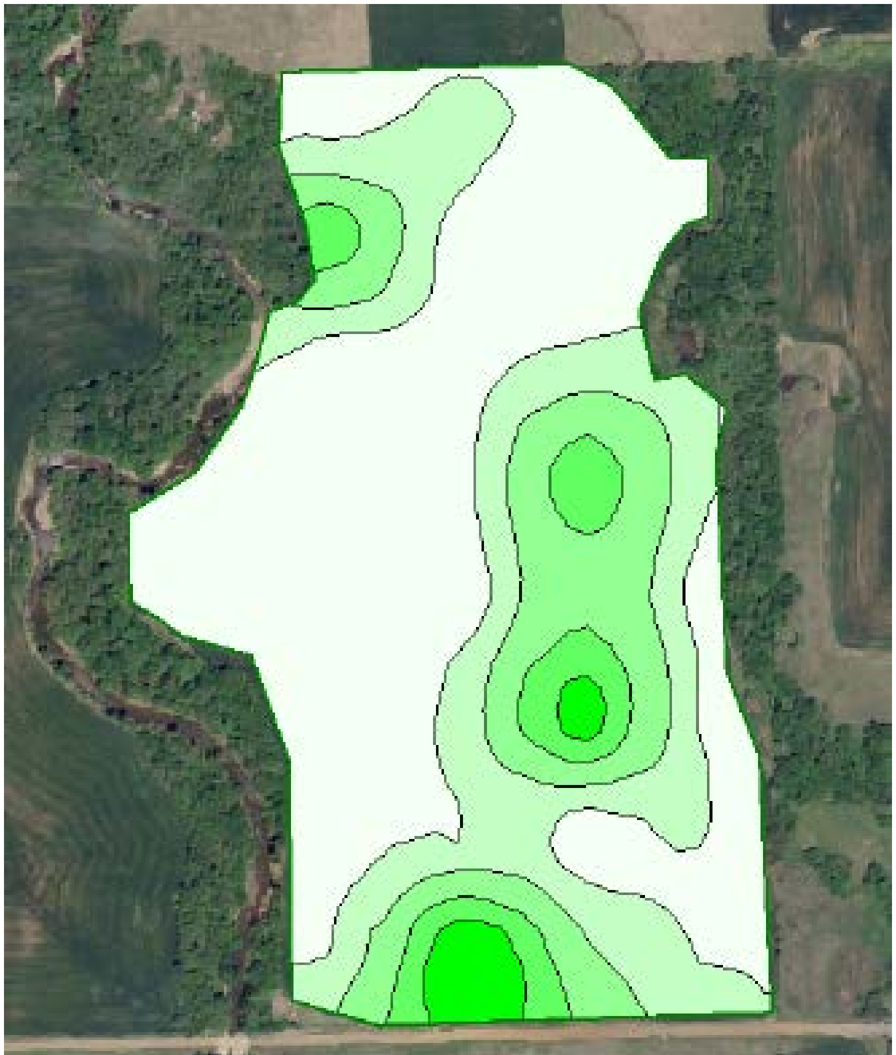
- **Given:**
- Genetic Potential **170 bu/ac**
- Environmental Potential **110 bu/ac**
- Water Potential **90 bu/ac**
- Residual Nitrogen Potential **60 bu/ac**
- Phosphorus Sufficiency **35%**
- Potassium Sufficiency **70%**

Doing the Math and Fertilizing

- 60 * (.35*.7)
- 60 * .25 = 15
- What if applied 60 lbs
- 90 * .25 = 22.5 + 7.5 bu
- What if 60 lbs N and 30 lbs P_2O_5
- 90 * .7 = 63 + 48
- So $30 on N resulted in $45 increase yield
- And $50 spent on NP resulted in $288

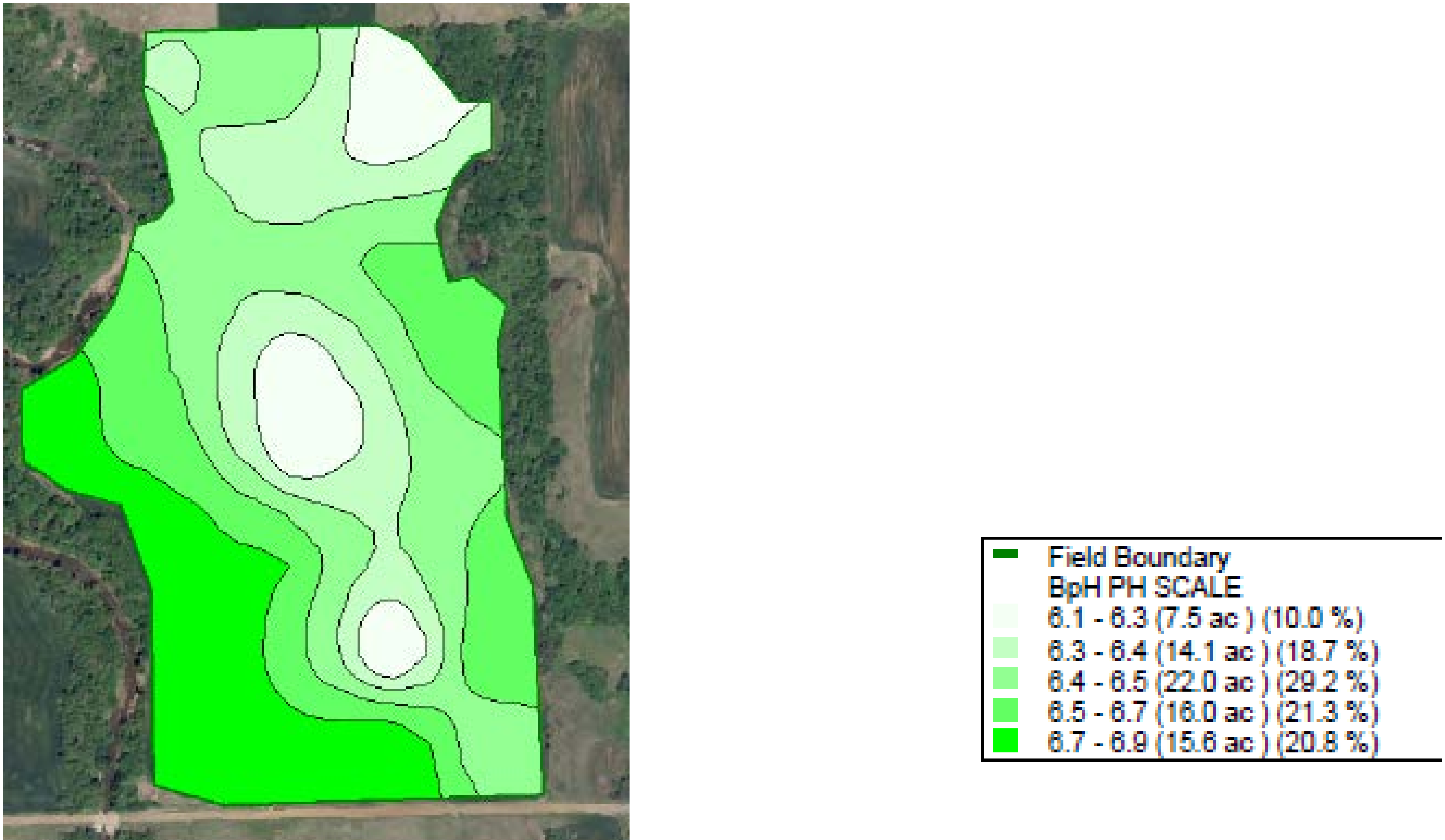
Example Field

pH

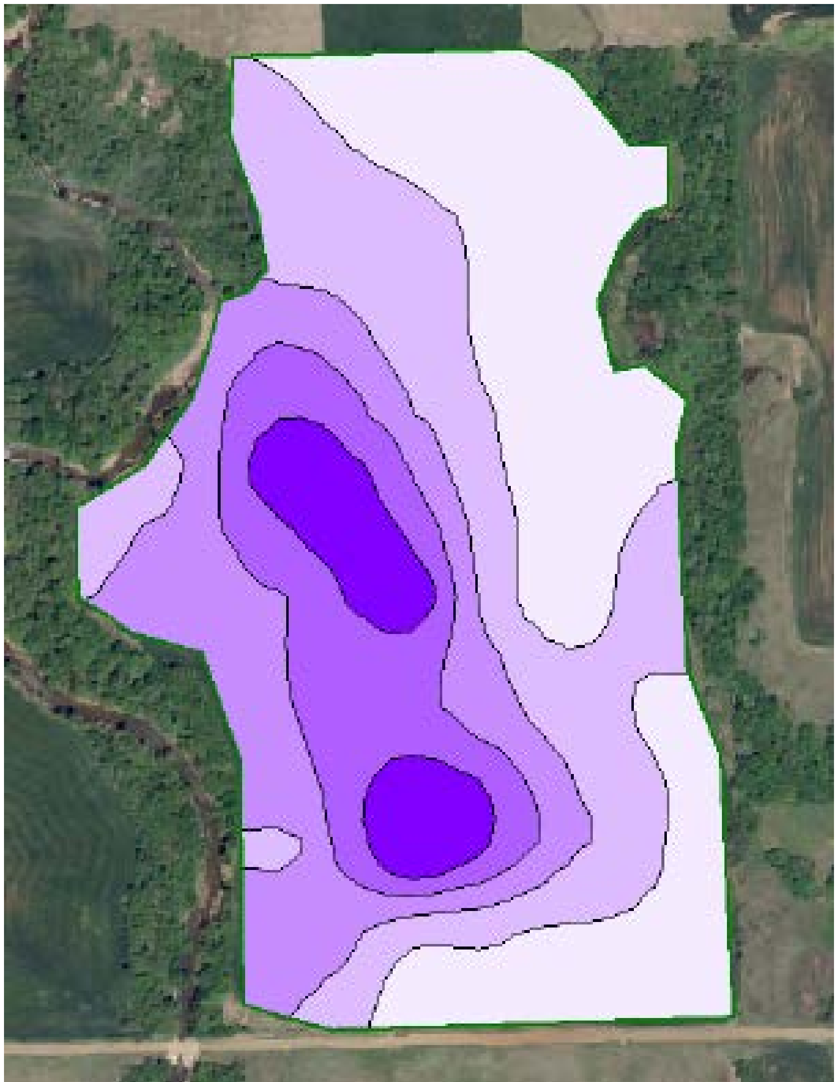


Field Boundary
pH PH SCALE
4.4 - 5 (39.9 ac) (53.0 %)
5 - 5.6 (17.5 ac) (23.3 %)
5.7 - 6.3 (11.3 ac) (15.0 %)
6.4 - 7 (4.4 ac) (5.9 %)
7 - 7.9 (2.1 ac) (2.8 %)

Buffer Index

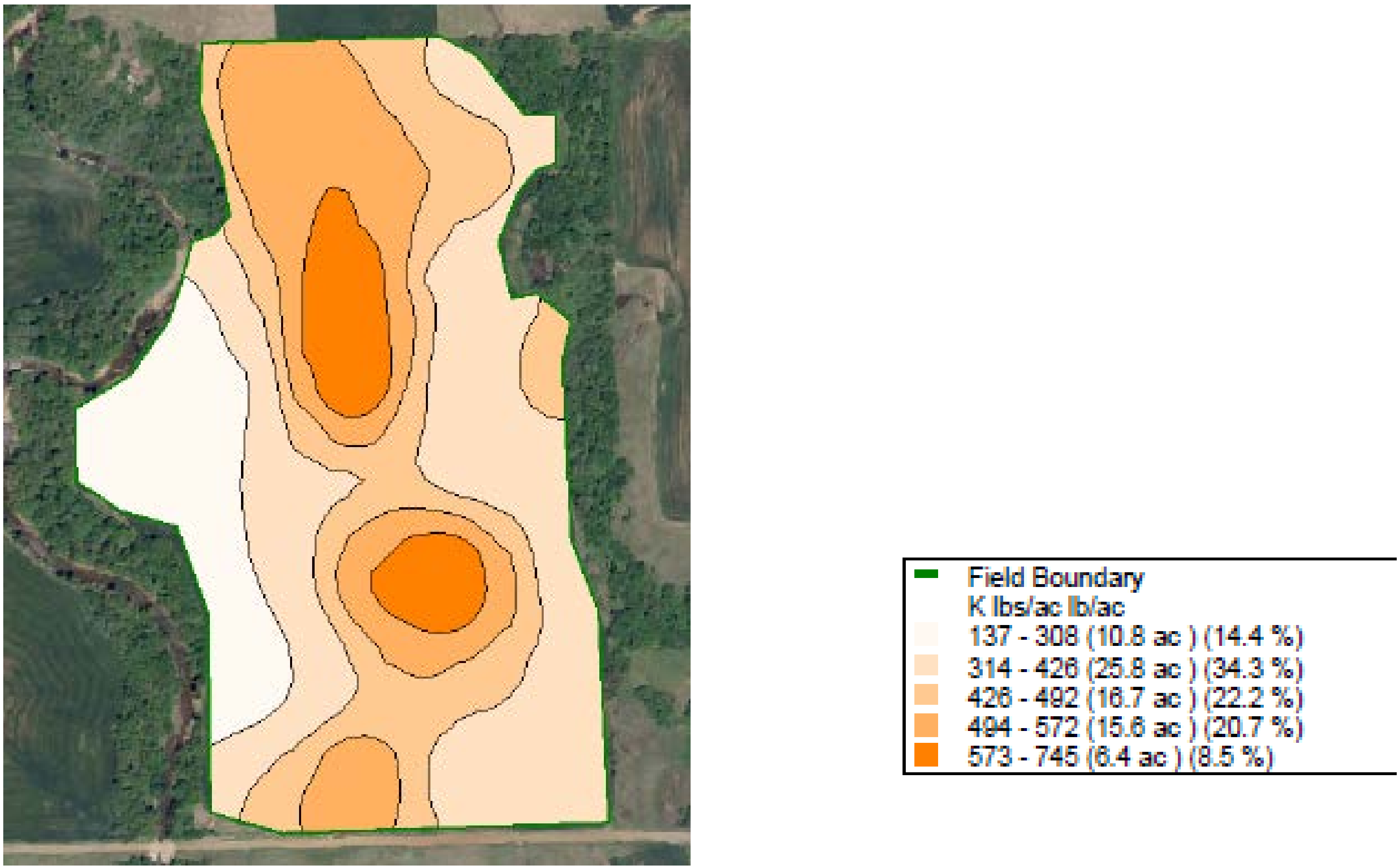


STP



- Field Boundary
- P Mehlich III lbs/ac lb/ac
- 5 - 28 (25.5 ac) (33.8 %)
- 28 - 52 (19.0 ac) (25.2 %)
- 53 - 73 (15.3 ac) (20.3 %)
- 73 - 92 (10.1 ac) (13.4 %)
- 92 - 131 (5.5 ac) (7.2 %)

STK


Field Boundary
K lbs/ac lb/ac
137 - 308 (10.8 ac) (14.4 %)
314 - 426 (25.8 ac) (34.3 %)
426 - 492 (16.7 ac) (22.2 %)
494 - 572 (15.6 ac) (20.7 %)
573 - 745 (6.4 ac) (8.5 %)

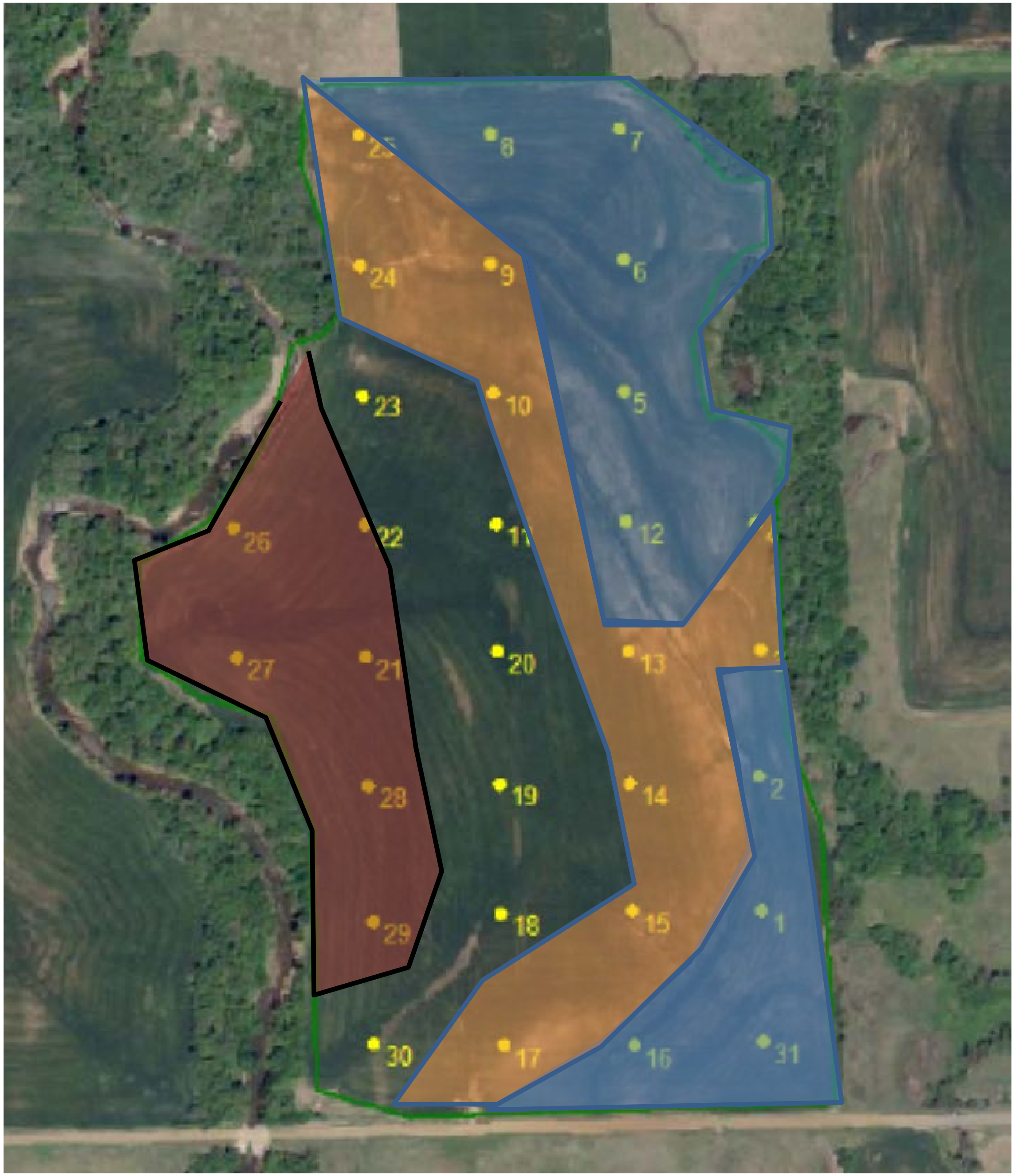
STP

75% suff

90% Suff

STK

80-90%



STP

75% suff

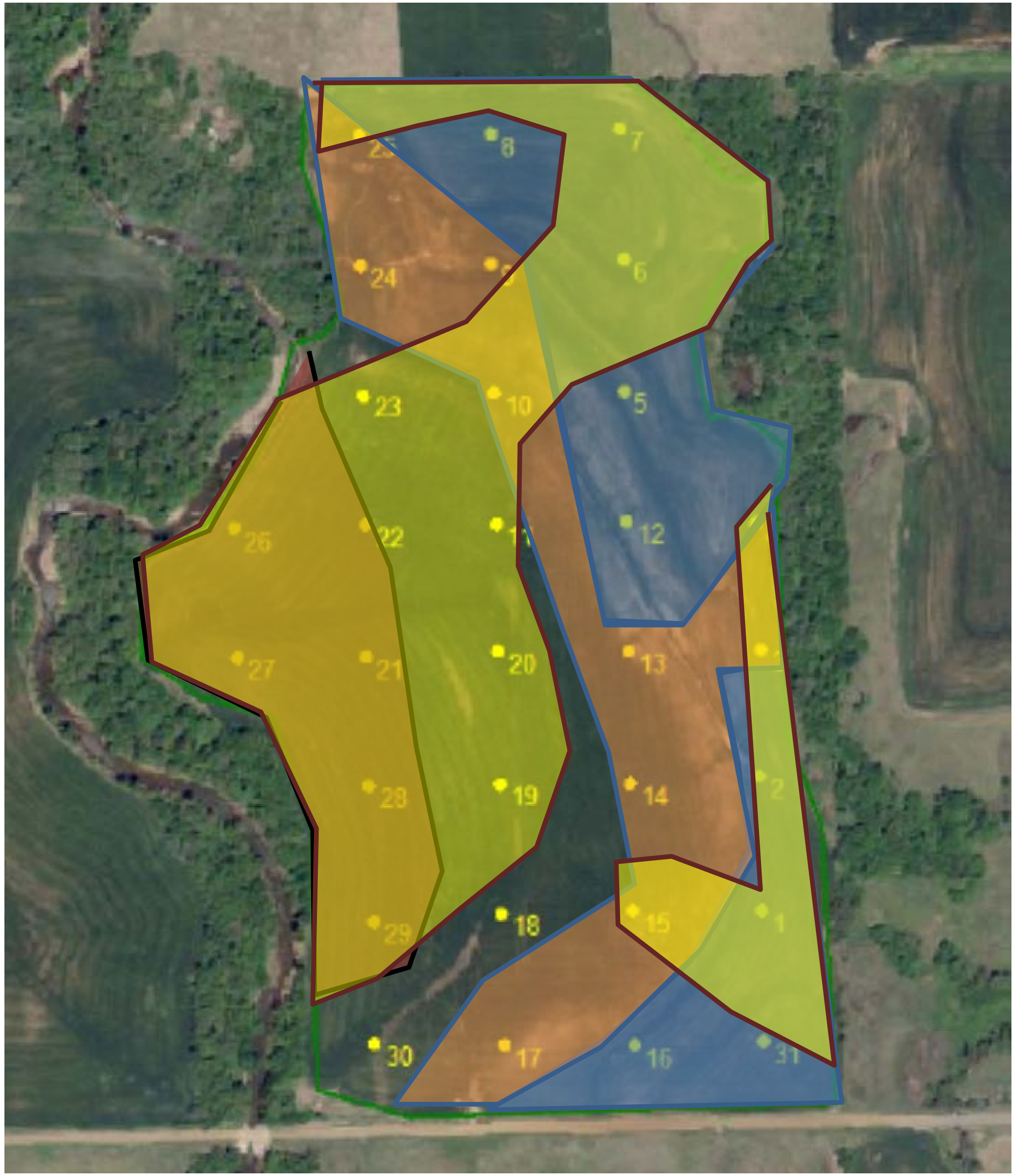
90% Suff

STK

80-90%

pH

<5.0



Soil pH Impacts

- It is more than Aluminum toxicity.
- Nutrient Availability is greatly influenced by pH
- Some herbicides are pH “sensitive”
- Physiological impact.

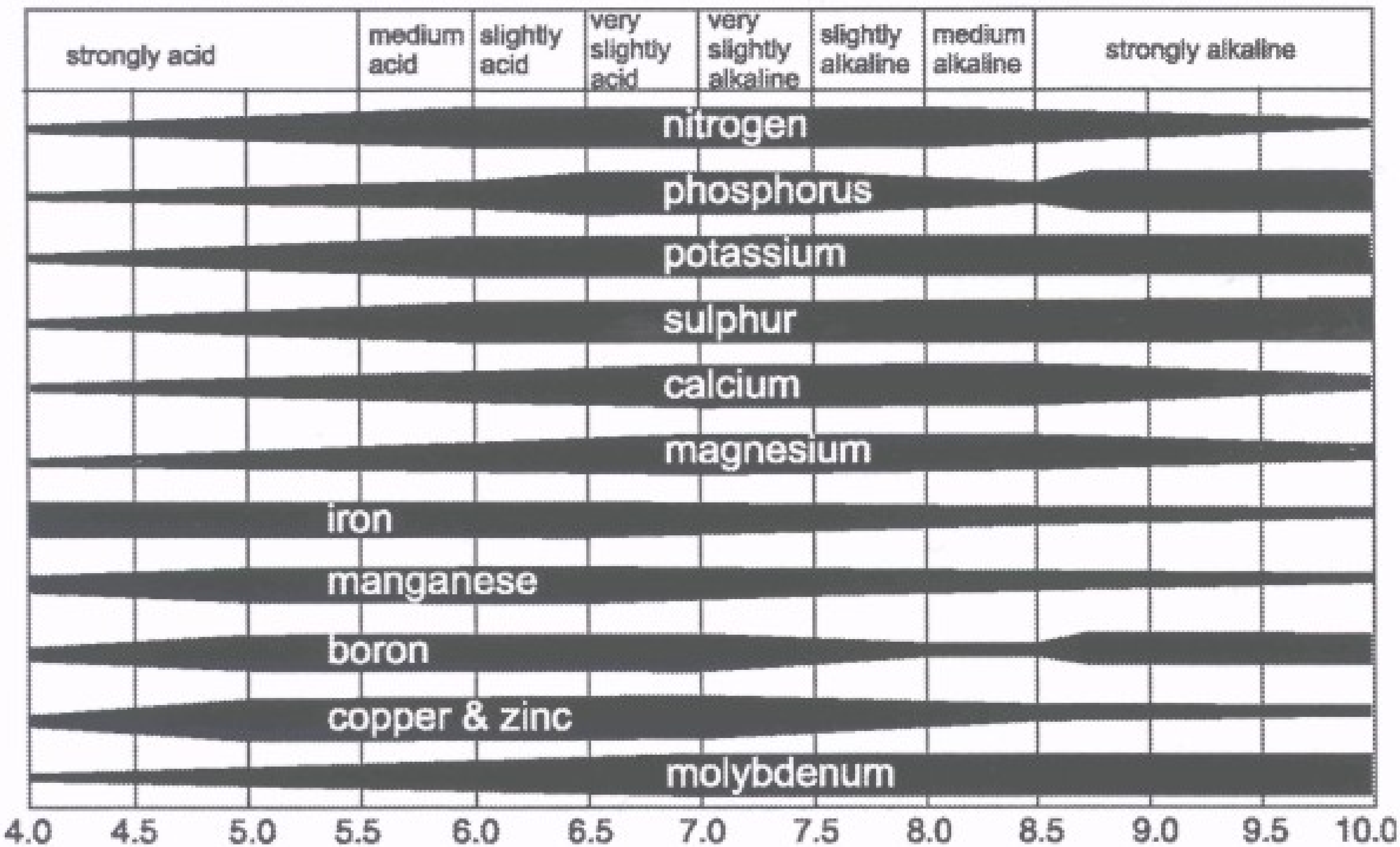





Soil pH of 4 and 6

pH 4.0 Tol and non tol

Nutrient Availability



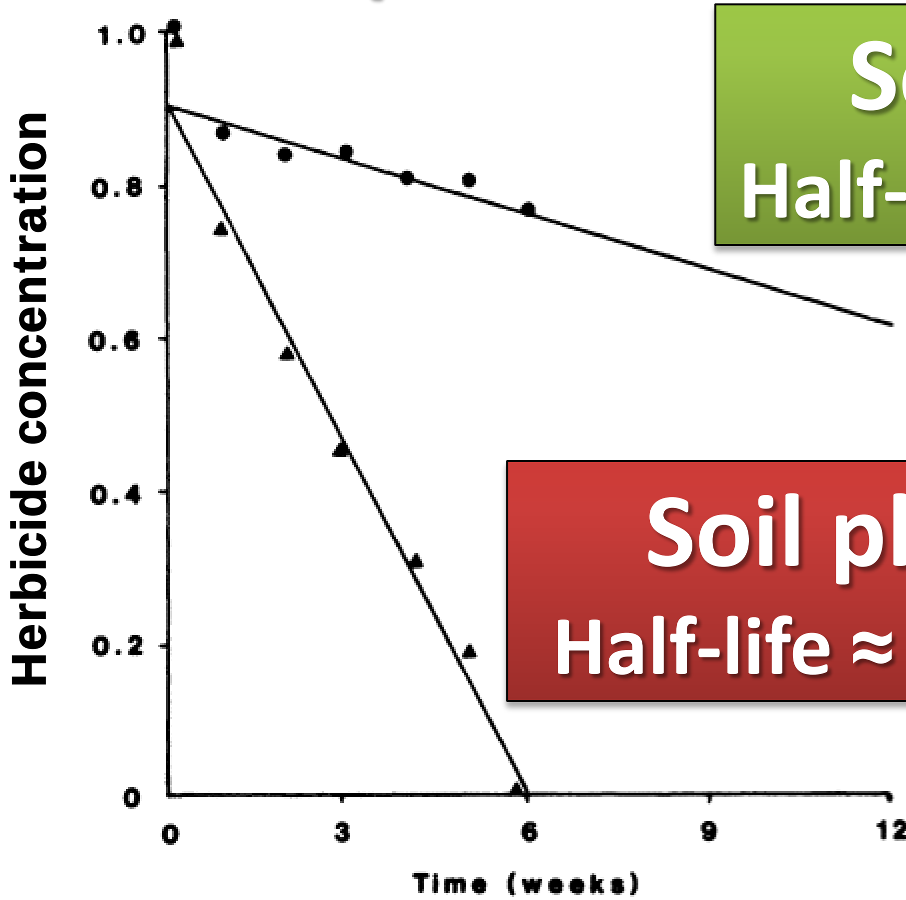
ALS inhibitors

Group 2

- ***Imi*dazolinones**
  - –Pursuit
  - –Raptor/Beyond
- ***S*ulfonyl*u*reas**
  - Maverick
  - Osprey
  - Classic
- **Sulfonanilides**
  - –PowerFlex
  - –FirstRate
  - –Python
- **Sulfonylaminocarbonyl-triazolinones**
  - –Olympus
  - –Everest

SUs are more persistent at *higher* soil pH

Glean (chlorsulfuron)



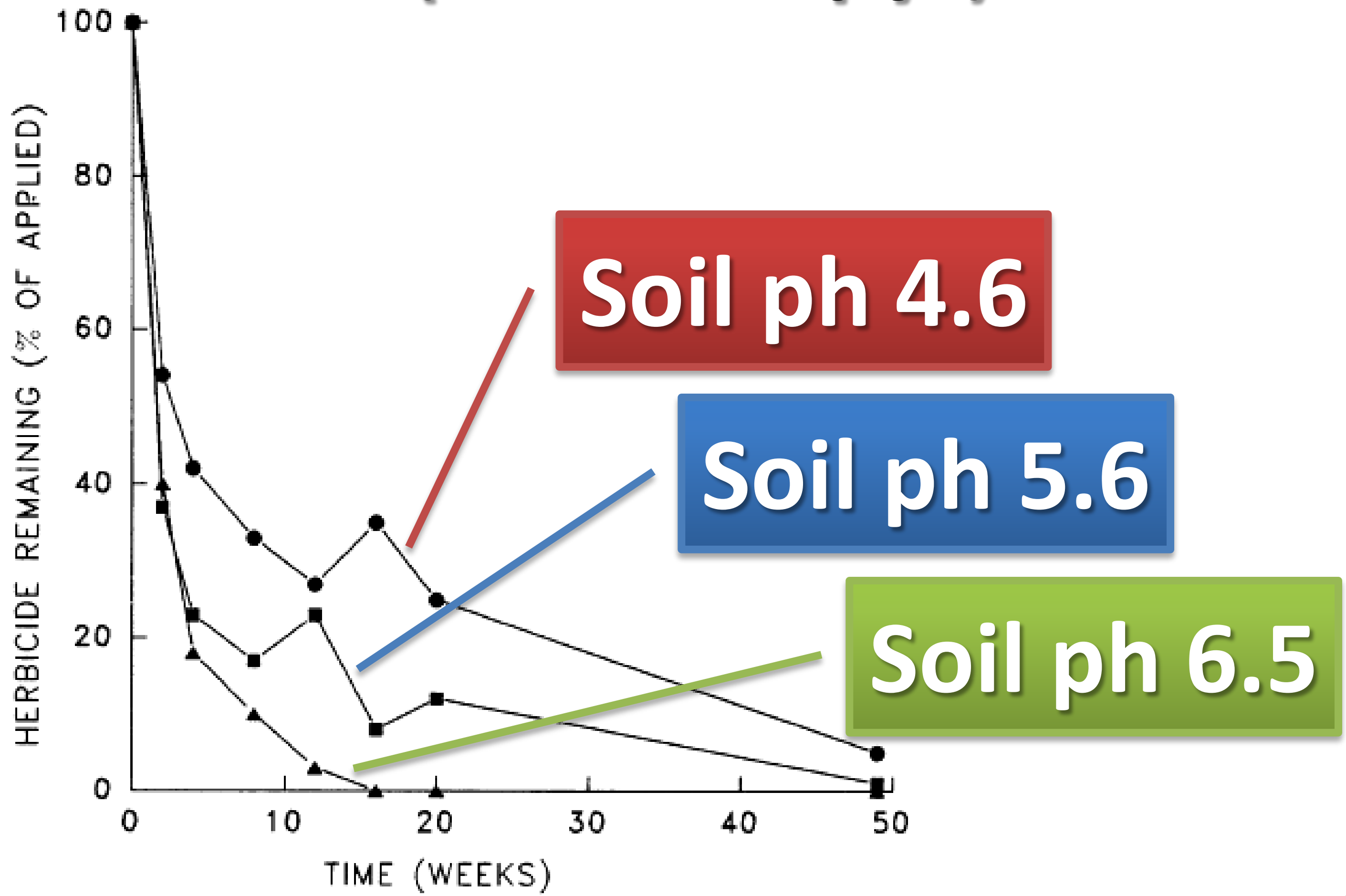
Soil pH 7.5
Half-life ≈ 10 weeks

Soil ph 5.6
Half-life ≈ 2 weeks

Frederickson and Shea, Weed Sci. 34:328-332

IMIs are more persistent at *lower* soil pH

Pursuit (imazethapyr)

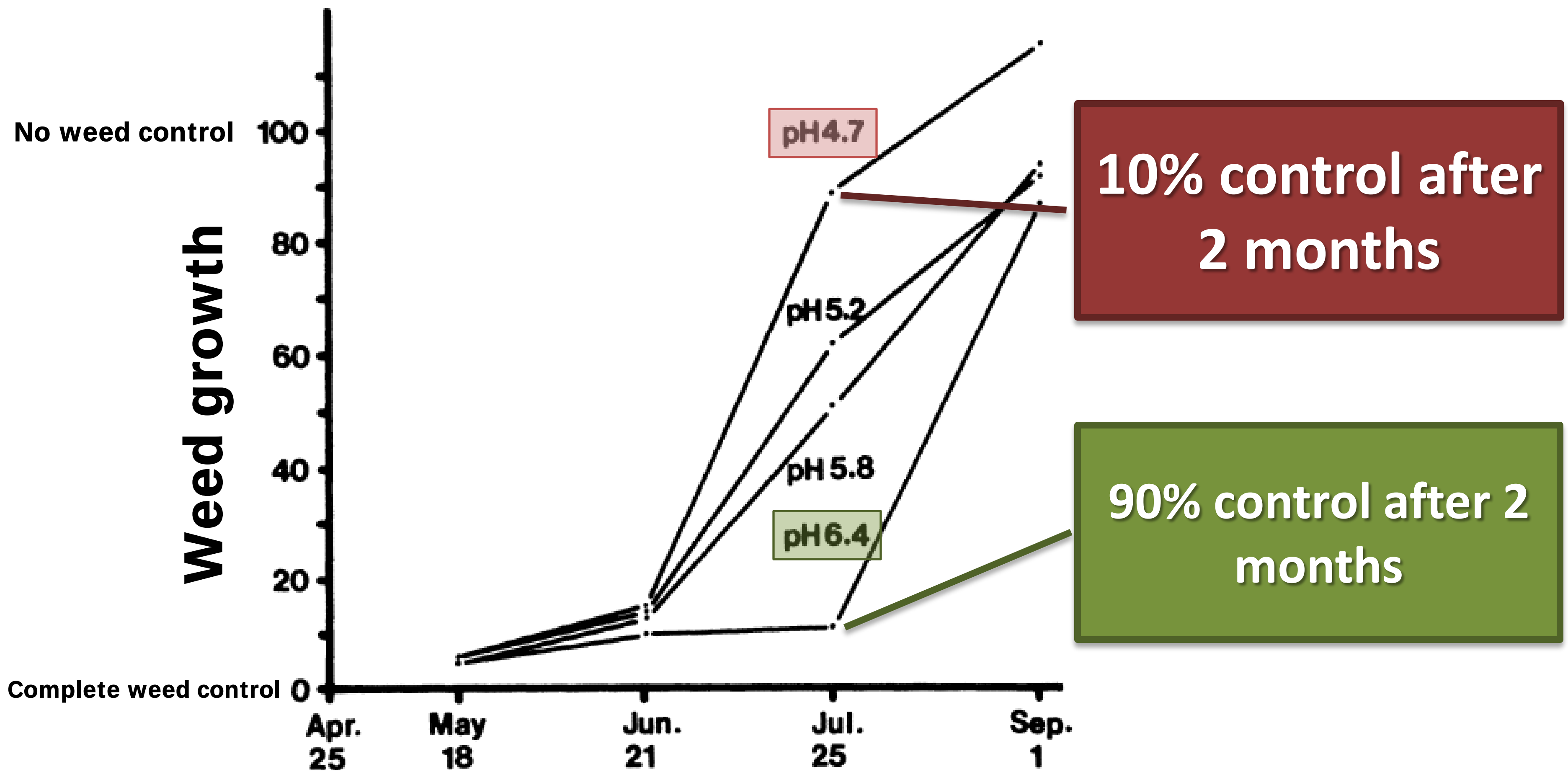


Loux and Reese, Weed Tech. 7:452-458

Effect of soil pH on herbicides

- **PSII inhibitors—atrazine, Sencor**
  - More persistent at high soil pH

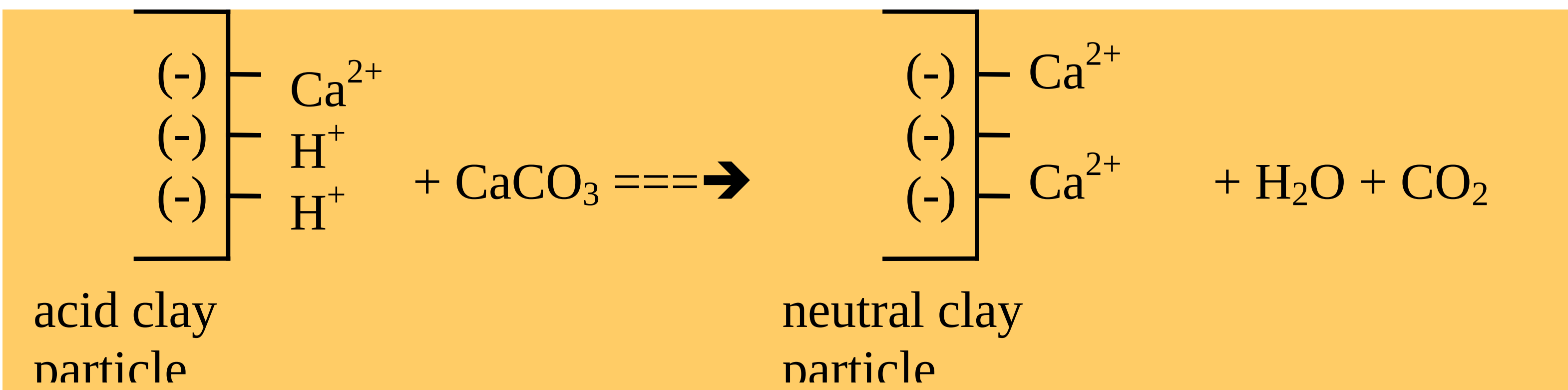
Atrazine is more persistent at *higher* soil pH



Hiltbold and Buchanan, Weed Sci. 25:515-520

How is soil acidity neutralized

Most effective way to neutralize soil acidity is by incorporation of aglime.



Neutralization of acid soil using aglime (CaCO3) resulting in increasing exchangeable Ca and formation of water and carbon dioxide.

Lime

- Aglime is effective because it is the salt of a relatively strong base (calcium hydroxide) and a weak acid (carbonic acid), and is therefore basic

- $Ca(OH)_2 + H_2CO_3 \text{ ===}\!\!\rightarrow CaCO_3 + H_2O$

carbonic acid

Lime needed to neutralize soil acidity

- Exchangeable acidity must be neutralized in order to change soil pH because it represents most (99 %) of the soil acidity. Since the amount of exchangeable acidity in the soil, at a given pH, depends on the soil CEC, the amount of lime required is a function of clay content, organic matter content, and soil pH.
- Lime requirements can be determined directly in a laboratory by quantitatively adding small amounts of a solution of known strength base (e.g. 0.1 normal NaOH), to a known amount of the acid soil mixed with water.

Special Formulations

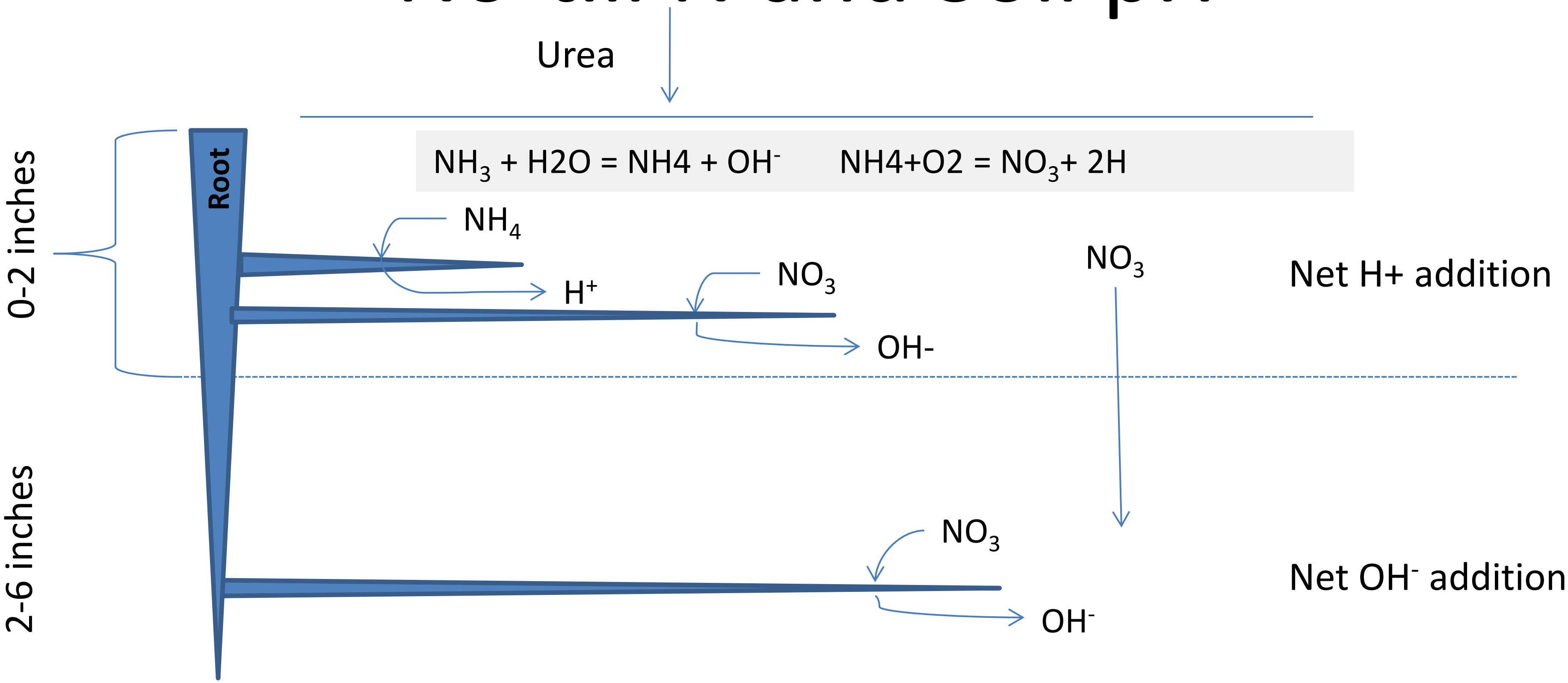
- **Liquid lime**

- Formulated by mixing finely ground limestone with water and a small amount of clay.
- Clay is added to help keep the lime particles suspended in the water during application.
- Since the solubility of $CaCO_3$ is low, most of the lime is present in solid form and will react like an application of solid lime. The ECCE of the formulation will be much less (depends on how much water was added) than that of the lime used in the mixture, even when the dry lime had a high ECCE.
- Typically the dry lime has an ECCE of nearly 100 % and the liquid lime is about 50 % because about ½ of it is water.

- **Pelleted lime**

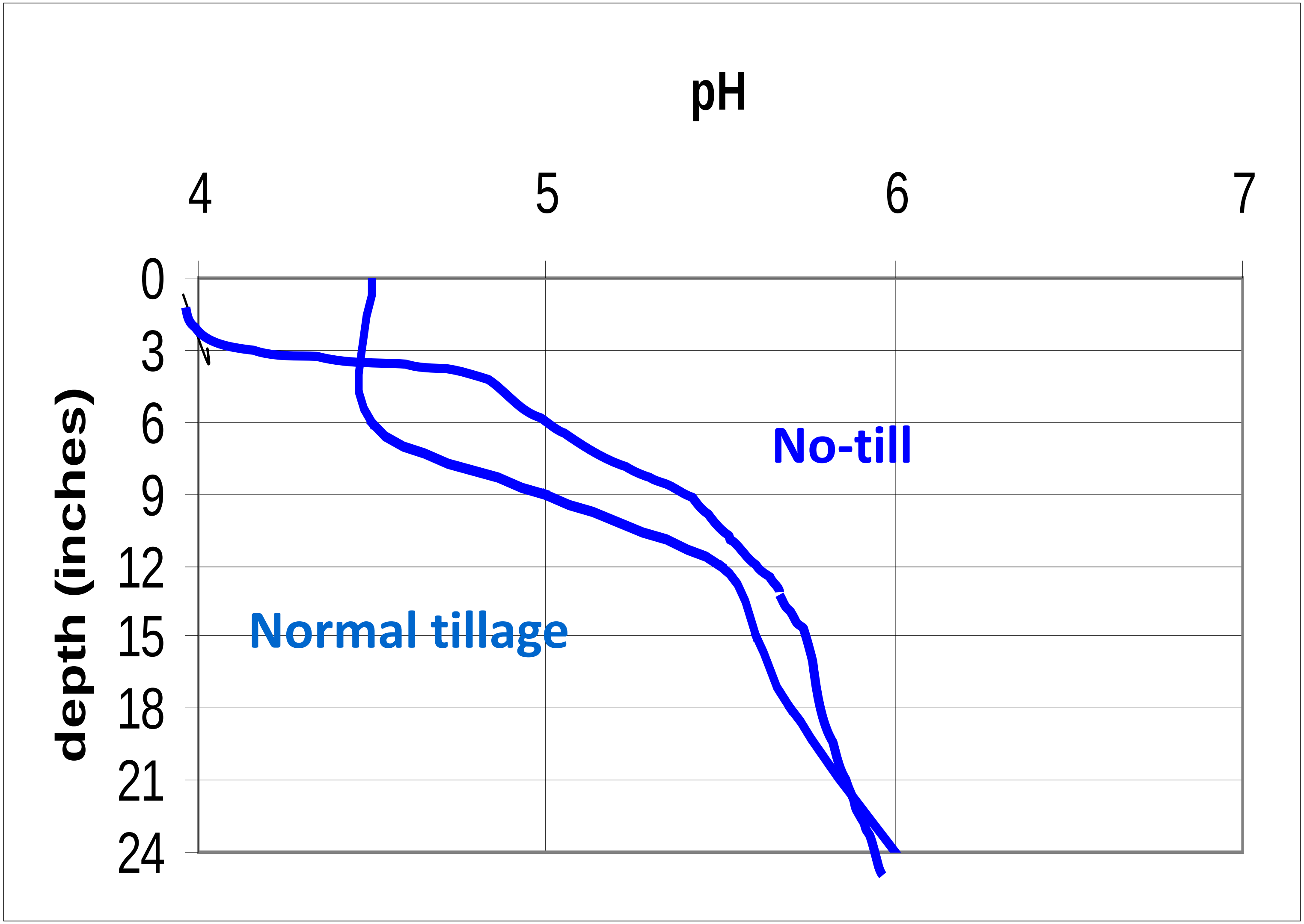
- Pelleted lime is created by compressing, or otherwise forming pellets out of finely ground, good quality $CaCO_3$.
- Neutralizing effectiveness of liming materials depends upon being able to maximize their surface contact with soil colloids.
- The advantage of liquid lime and pelleted lime compared to conventional aglime is to minimize dust. The disadvantage is they are usually much more expensive, on a cost per ton of ECCE, than conventional aglime.

No-till N and Soil pH



Assumption:
For each NH_4 or NO_3 take up by the plant 1 H^+ or OH^{-1} will be exchanged.
This is not the case.

Production Induced Soil Acidity



Lime required to neutralize the soil acidity produced by fertilizers if all ammonium-N is converted to nitrate-N.

Nitrogen source	Chemical Formula	*Composition*	*Lime required (lb $CaCO_3$ / lb N)*
Anhydrous ammonia	NH_3	82-0-0	1.8
Urea	$(NH_2)_2CO$	46-0-0	1.8
Ammonium nitrate	NH_4NO_3	34-0-0	1.8
Ammonium sulfate	$(NH_4)_2SO_4$	21-0-0-24	5.4
Monoammonium phosphate	$NH_4H_2PO_4$	10-52-0	5.4
Diammonium phosphate	$(NH_4)_2HPO_4$	18-46-0	3.6
Triple super phosphate	P_2O_5	0-46-0	0.0

Adapted from Havlin et al., 1999.

Role of Micro Nutrients

- Micros are only micros because
- The Quantity taken up by plant.
- However the natural quantity is typically high.

- Areas of Concern.
  - Low OM Sandy Irrigated soils.
  - No-till may reduce this.

STV from Oklahoma, Wheat and Canola 11

3325 under winter wheat crop code 98 Canola
266000 acres? 7840 acres?

Nut.	# Samples	100% STV	# < 100%	% <100%	STV Ave.	STV Med	STV Min	STV Max
N	3369	100	3049	90.5	50	39	0	480
P	3369	65	1922	59	76	57	2	1546
K	3369	250	360	10.7	504	447	56	2406
S	257	15	36	14	34	25	2	571
Ca	262	750	0	0	5147	3506	805	23767
Mg	261	100	0	0	747	691	139	1993
Fe	165	4.5	1	.6	40	36	3.7	140
Zn	165	.3	4	2	.8	.6	.225	6.7

NPKS Demo Soil Test

Typical Results for Immobile Nutrients and Base Cations
“A”Typical Results for Mobile Nutrients…

0-6”	Ave	Med	Min	Max
pH	6.0	5.8	4.4	8.2
NO3	35	28	6	112
P	72	56	19	183
K	460	442	244	903
SO4	25	21	9	62
Ca	3685	3031	873	16130
Mg	807	579	194	2177

6-18”	Ave	Med	Min	Max
pH	6.5	6.5	4.8	8.4
NO3	58.1	44	2	206
P	34.7	25	6	295
K	371	361	219	598
SO4	45	38	20	200
Ca	5050	3436	537	27497
Mg	1073	810	165	3057

Nutrient Removal

Crop	Unit	N	P	K	Ca	Mg	S
Wheat	Lb/bu	1.2	.52	.26	.16	.08	.18
Canola	Lb/bu	1.88	.4	.32	.125	.125	.17

Crop	Unit	Fe	Zn	Mn	Cu	B	Cl
Wheat	Lb/bu	.002	.0011	.0003	.0009	.0001	Na
Canola	Lb/bu	na	.001	.001	.0001	Na	Na

Soil Amendments

- What are the Amendments Major Co is Concerned with?

Thank you!!!

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