Taking the Burn Out of Acid Soils

Part 3- Lime sources and Strategies to Remediate Stratified Acidity in No-till

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Intensive crop growth, application of any ammonia-based fertilizer, including manure, results in surface soil acidification.

The remedy is 'liming', which is the application of any amendment that reacts with H^+ ions to form CO_2 and water.

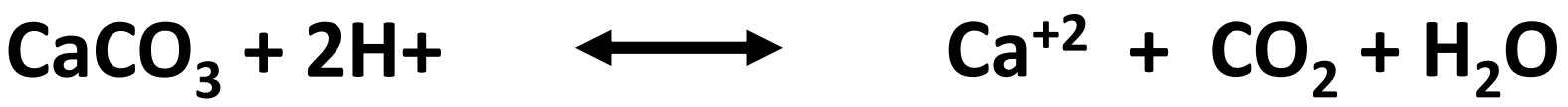
In conventional till systems, the liming material is incorporated into the soil during tillage passes.

Limestone Quarry, Illinois

Water treatment Lime Sludge

(image Burch Hydro)

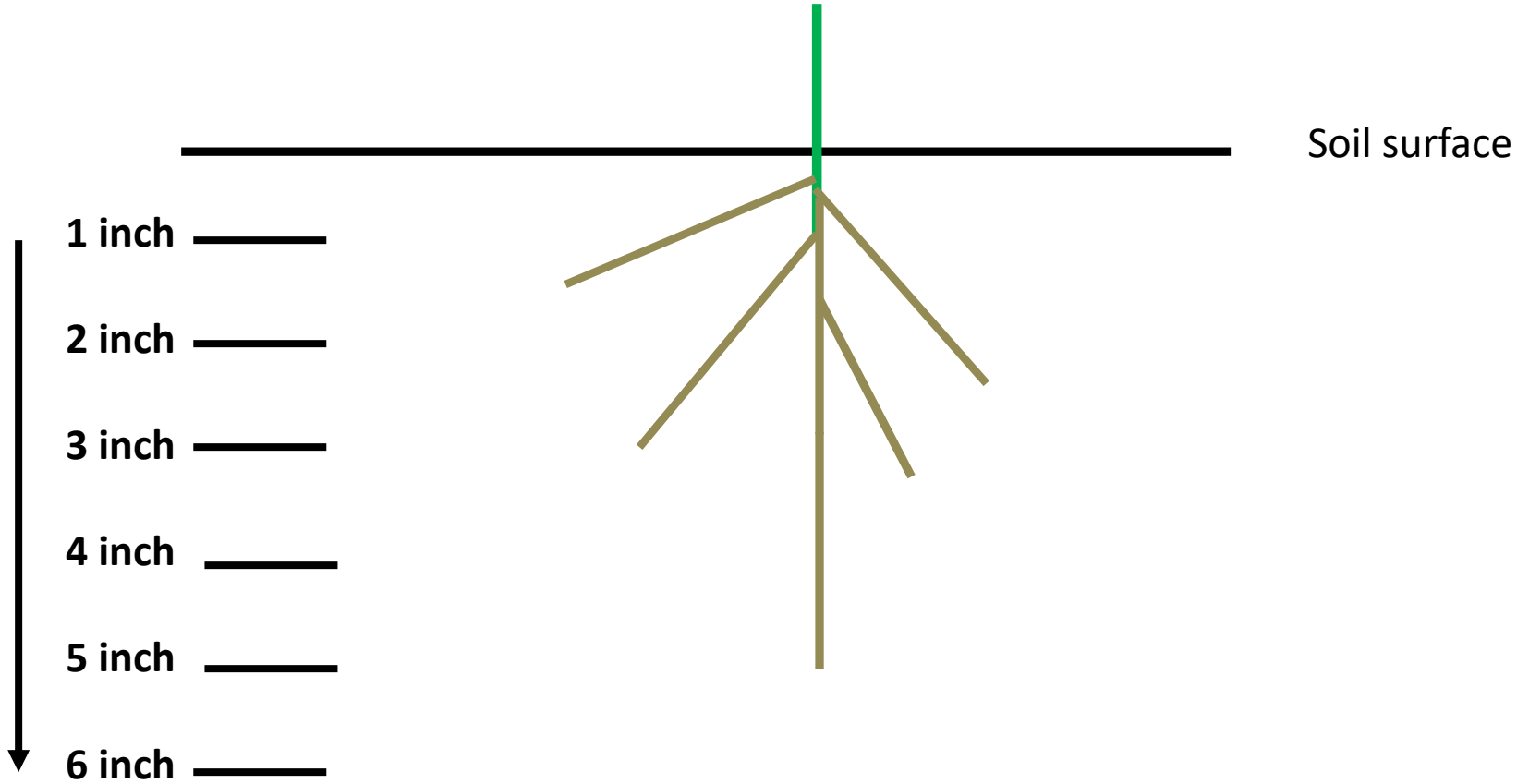
Sugar beet waste lime (Versa-Lime)


CaCO3 + 2H+
Ca+2 + CO2 + H2O

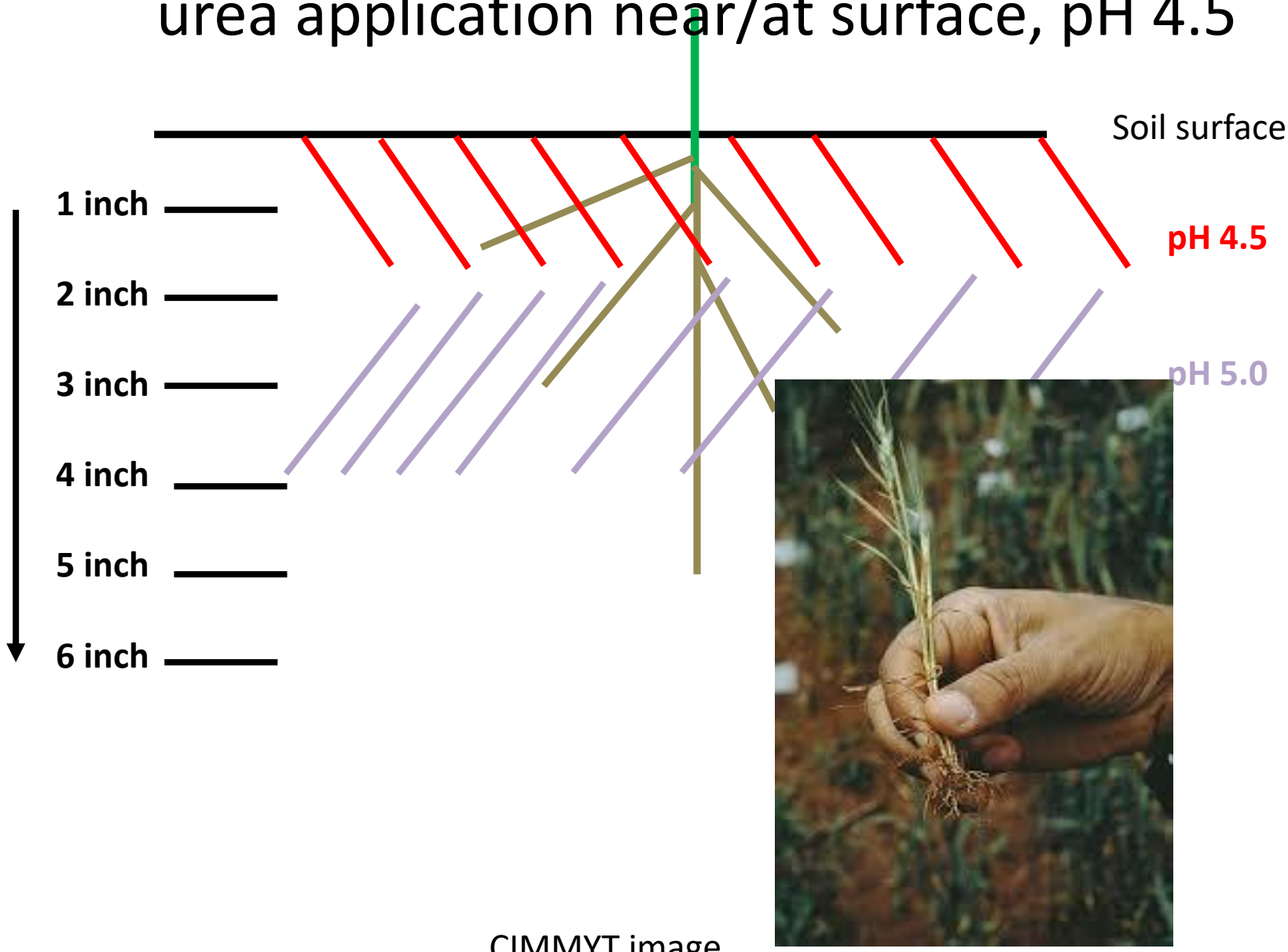
Erosion is an ever-lurking danger to continued soil productivity.

Continuous no-till can have nutrient-efficiency benefits to grower profit and deep tillage (deeper than 3 inches) can eliminate any no-till benefit for several years.

Wheat growing in pH > 5.2



Wheat growing in soil after 20 years urea application near/at surface, pH 4.5



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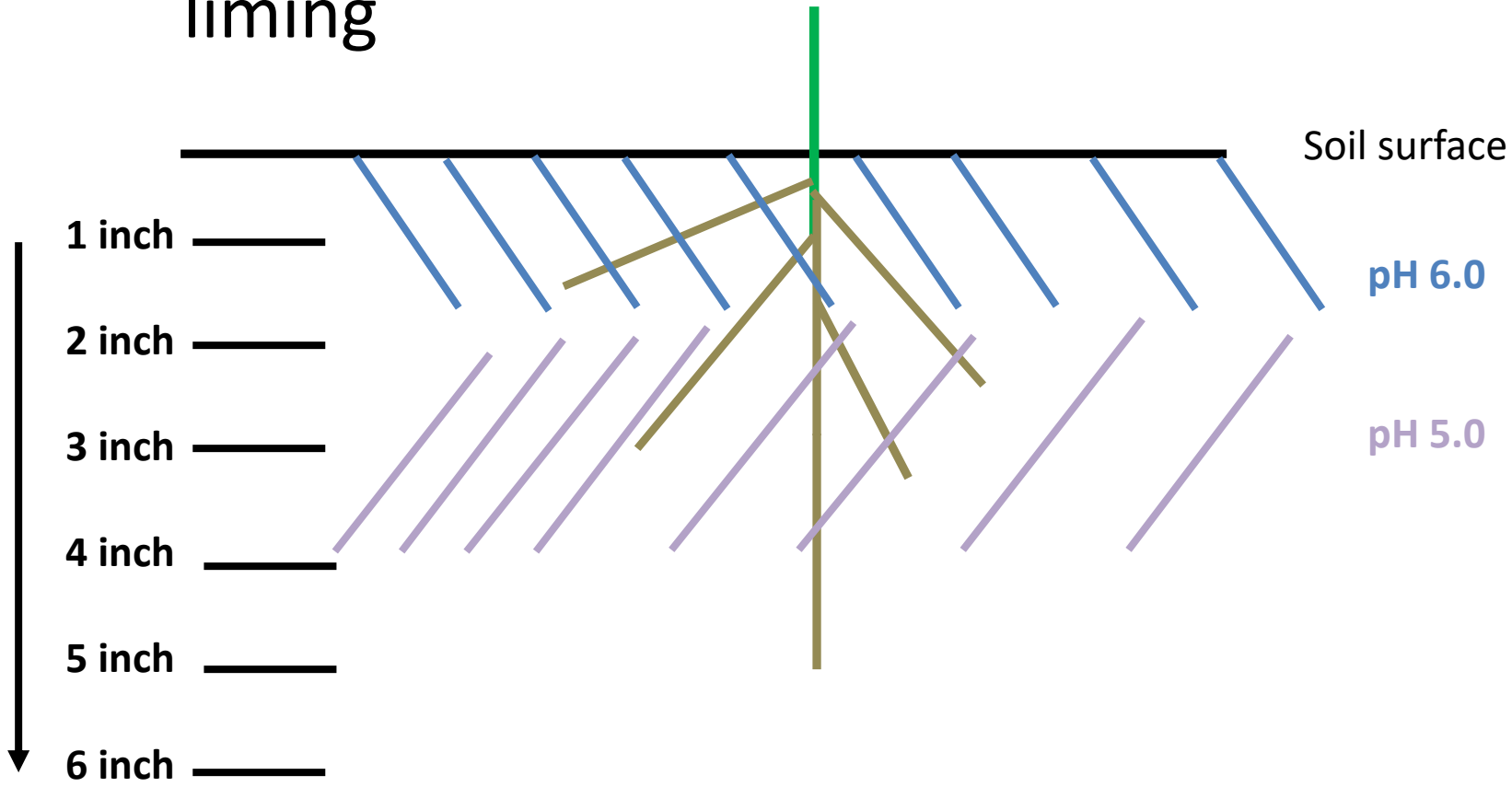
Wheat growing in soil after 1 year surface liming



Lime effects, no-till surface application, after 4 years, Kansas

Agronomy Journal Godsey et al., 2007

Depth inch	pH	0.5t/a Pellet Lime	2T	4T
0-1	5.8	6.1	6.7	7.3
1-2	5.5	5.8	6.1	6.6
2-3	5.7	5.8	6.0	6.2
3-4	5.8	5.8	6.0	6.1
4-5	5.9	5.9	5.9	6.0
5-6	5.9	5.9	6.0	6.0

Pennsylvania- Beegle

Initial pH 0-6 inches was 5.1
Initial pH 0-2 inches was 4.5

3 T/acre CCE lime increased pH in 0-2 in 2 months to 6.2 2-4 and 4-6 inch depths also increased.

Winter wheat yield increased from 52 bu/a to 71 bu/a in first year.

Washington State, Palouse Region

Brown et al. 2008

Depth, inches	pH	Exchangeable Al, ppm
0-2	5.1 ± 0.8	28
2-4	4.7 ± 0.5	55
4-6	5.5 ± 0.3	7
6-8	5.9 ± 0.3	5

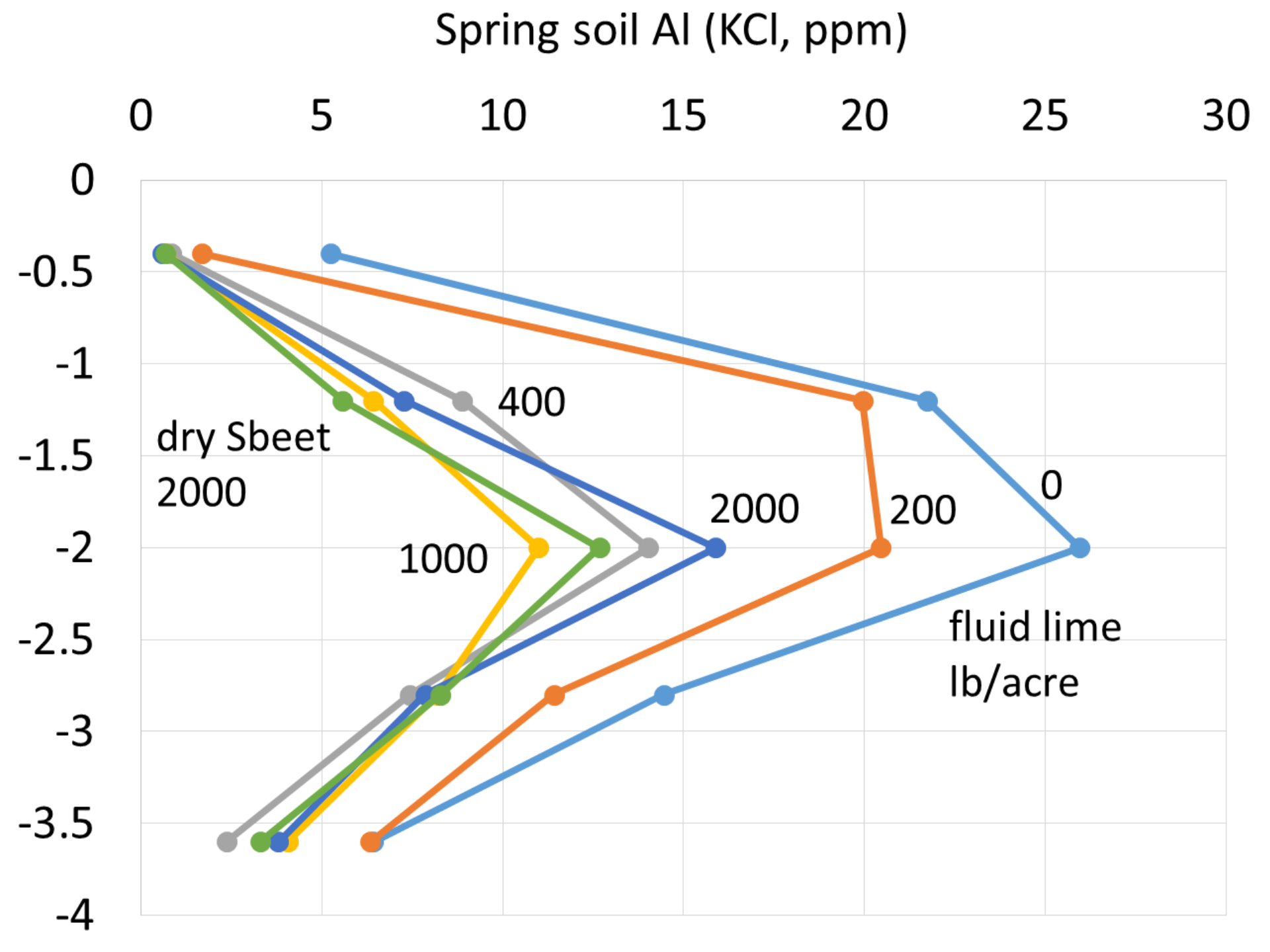
Washington State, Palouse Region

Brown et al. 2008 2 years after broadcast lime 3 T/a CCE lime

Depth, inches	pH w/lime	Al activity after lime	Al in check
0-2	7.0	10^{-14}	10^{-7}
2-4	5.2	10^{-8}	10^{-7}

McFarland, Washington State 2015

Depth	Check	2 T/a beet lime	2 T/a fluid lime	½ T fluid lime
	pH			
0.5 in	5.2	6.8	6.6	6.0
1 in	4.9	5.6	5.6	5.4
1.5 in	4.9	5.0	5.0	5.1
2 in	4.9	4.9	4.9	5.0
3 in	5.0	5.0	5.0	5.0


Spring soil Al (KCl, ppm)
0
5
10
15
20
25
30
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
dry Sbeet
2000
400
1000
2000
200
0
fluid lime
lb/acre

Cyril Hopkins- “Wheat from Stones” about 1910, Illinois Exp Sta Bull.

Calcium Carbonate Equivalent (CCE) of pure general materials

Source	Chemical Formula	CCE
Gypsum	$CaSO_4$	0
Calcitic Lime	$CaCO_3$	100
Magnesium Carbonate	$MgCO_3$	119
Dolomite Limestone	$Ca/MgC0_3$	101-118
Burned/Quick Lime	CaO	179
Hydrated/Slaked Lime	$Ca(OH)_2$	136

CCE $CaCO_3$

Atomic wt (g/mole) Ca = 40

C = 12

O = 16

so 40 + 12 + 16 + 16 + 16 = 100

CCE $MgCO_3$

Mg = 24

C = 12

0 = 16

so 24 + 12 + 16 + 16 + 16 = 84

100/84 = 119 so CCE $MgCO_3$ = 119

Effective Neutralizing Power (ENP)

Fineness Index (FI)

(% passing 8 mesh, remaining on #20) X 0.2
+ (% 20 mesh, remaining on #60) X 0.6
+ (% passing 60 mesh) X 1.0

% ENP = %CCE X FI

Tons material needed =

(2000 lb/ton X %ENP/100) X (% DM/100)

Limestone sources are seldom (never?) pure

Name	Site	#8	#20	#60	CCE %	ENP %
Caledonia Quarry	Houston Co.	98	90	77	99	85
Black Hammer Quarry	Houston Co.	89	68	54	99	66
Eitzen Quarry	Houston Co.	89	68	56	96	65
Stoffel Quarry	Blue Earth Co.	100	100	100	87.2	87
Grabau Quarry	Fillmore Co.	87.9	66.8	56	97.6	64.5
Syverson Quarry	Goodhue Co.	97	74	56	82	58
Koch, Inc.	Mower Co.	100	90	68	95	79
Milestone Materials (pit run)	Winona Co.	94	70	56	96	66
Milestone Materials (cyclone fines)	Winona Co.	100	100	100	97	97

Just a random sampling of Minnesota Quarries
(not an endorsement**)**

Sugarbeet waste lime is closest and cheapest lime source many have in the region.

Site	#8 %	#20 %	#60 %	CCE %	Effective Neutralizing Power % (ENP)	Moisture %
Crookston	100	100	100	73	76	30.3
Drayton	99.9	99.9	99.9	71.6	68.4	27
E. Grand Forks	100	100	99.9	74.7	74.4	33.5
Hillsboro	99.5	99	97.8	76.1	72.3	28.5
Sidney, MT	99	99	99	60.5	~55	26.5

The Ca/Mg ratio of the liming material is NOT important in this region.

Spreading sugarbeet waste lime after spring wheat harvest-

Image by Mike Metzger, Minn Dak Sugarbeet Cooperative with permission.

Costs?

Sugarbeet lime is free (at least it has been to date)

Needs to be stockpiled

The applicators need an end-loader capable of reaching over the side of the application unit.

The sugarbeet lime is always 20-30% moisture, so steep sided boxes and taking raising dividers in the box would be necessary. Graphite coated sides wouldn't be a bad idea.

Calibrate swath using pans to minimize streaking.

Steps to acid surface pH-

Sample 0-2 inches and 2-6 inches

Have lab run pH/buffer pH on both depths

Line up lime source and schedule application- fall best to avoid compaction.

Apply before freeze-up