PERSISTENCE
DATA MINING

SCALABLE & EFFICIENT AGRICULTURE TESTING SOLUTIONS

ALTA Presentation
JULY 2022

OUR MISSION

Cost-Efficient, Automated, and Scalable Agriculture Testing That Improves Farm Productivity, Reduces Waste, and Enhances Soil Fertility

"Visible and near-infrared (vis-NIR) and mid-infrared (MIR) reflectance spectroscopy has emerged and developed as an important method for quantitative soil analysis, with a potential to become an alternative to the conventional lab-based, wet-chemistry analysis for several soil properties."

GLOBAL SOIL PARTNERSHIP

Food and Agriculture Organization of the United Nations

UNITED NATIONS' 17 SUSTAINABLE DEVELOPMENT GOALS

DEDICATED TO GOALS HIGHLIGHTED BELOW

1 No Poverty	2 Zero Hunger	3 Good Health & Well-Being	4 Quality Education	5 Gender Equality	6 Clean Water & Sanitation
7 Affordable & Clean Energy	8 Decent work & Economic Growth	9 Industry Innovation & Infrastructure	10 Reduced Inequalities	11 Sustainable Cities & Communities	12 Responsible Consumption & Production
13 Climate Action	14 Life Below Water	15 Life on Land	16 Peace, Justice & Strong Institutions	17 Partnerships for the Goals	

LABS-NEED

Chemical Processing is Expensive and Labor Intensive

	OM
Revenue	$6.50
Cost	$5.00
ROI	$1.50
Accuracy	Moderate

HOW SOILYTICS WORKS

Scan → Upload → Analyze → Report → Apply

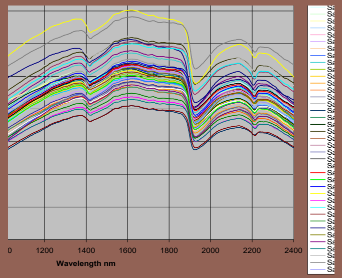
Scan

Fast Scanning In Seconds

Upload

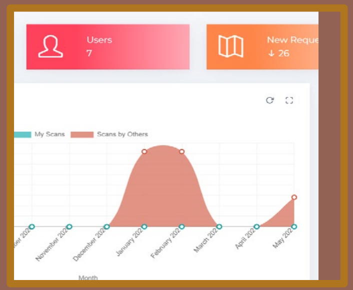
Upload Results To Cloud

Analyze



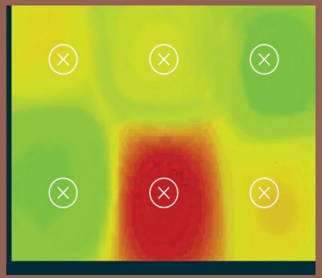
Analyze Image Scans For Nutrient Contents

Report



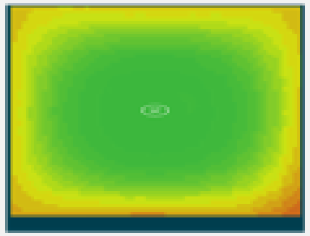
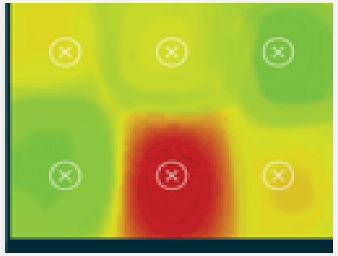
Display Results And Manage Farming Portfolio

Apply



Provide Actionable Data for Precision Agriculture (i.e. Fertilization Prescription Maps)

METHOD COMPARISON

	CHEMICAL LABS	SOILYTICS
PROCESS	Intensive, Manual Samples Sent To Labs	Automated On-Site Testing
SPEED	Slow 1-2 Weeks	Fast Near Real-Time
ACCURACY	Inherently Inaccurate Due To: • Chemical Changes During Handling/Transit • High Probability of Human Error	High Accuracy Machine learning algorithms
EXPENSE	$8-12 Basic Soil Test $25-$125 For Additional Tests (i.e. Nitrogen)	$3-5 (Comprehensive Nutrient Test)
PRECISION	 Less Granular (Every 2.5 - 4 acres)	 More granular (Every Acre for Same Cost)

COMPETITIVE ADVANTAGE

BEST HYPERSPECTRAL SCANNING SOLUTION IN THE INDUSTRY

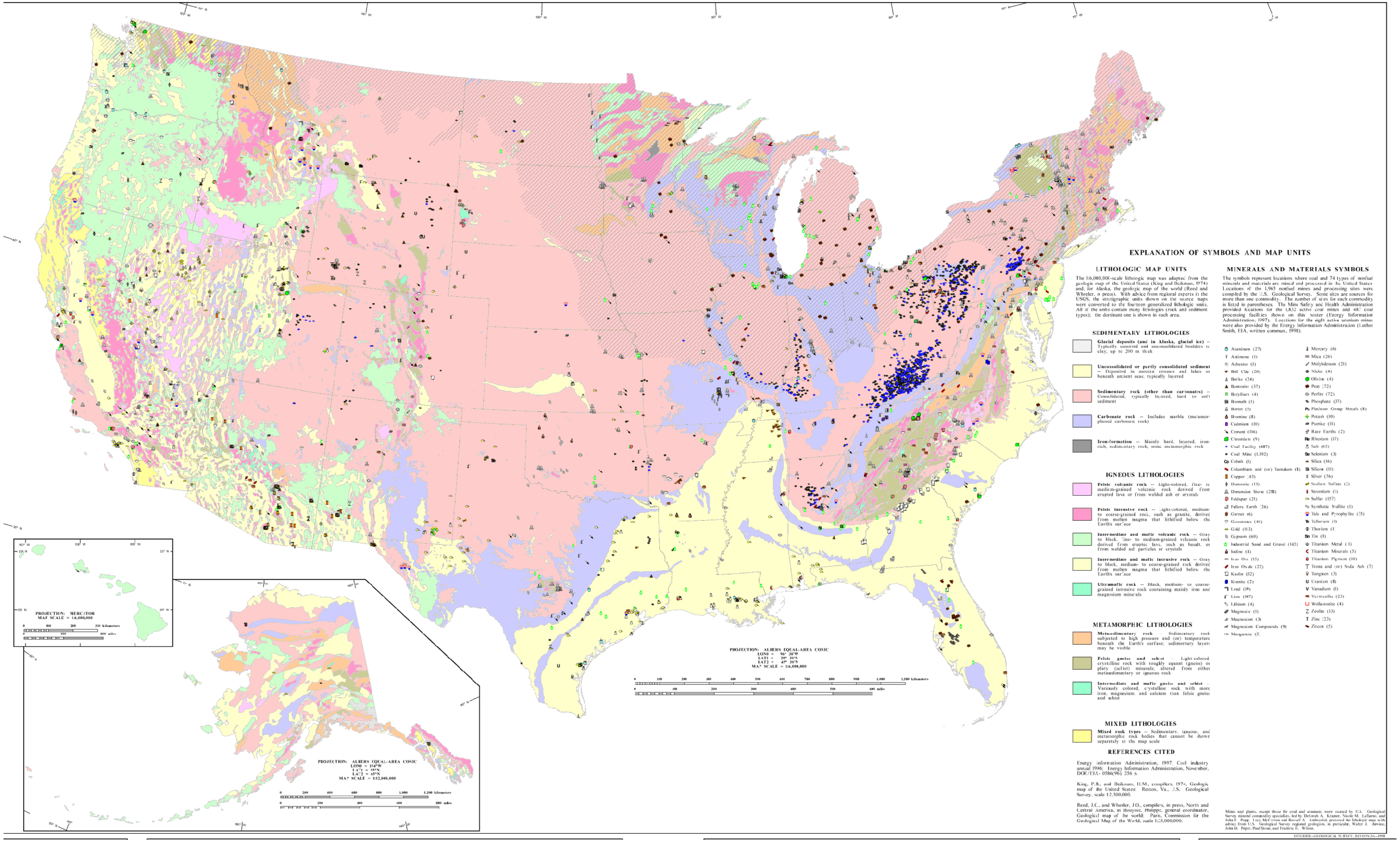
✓ Highly Accurate ✓ Fast, Actionable Data ✓ Scalable

Other Technologies: Current Aerial & Satellite Systems Do Not Test At Surface Level And Do Not Provide Actionable Data

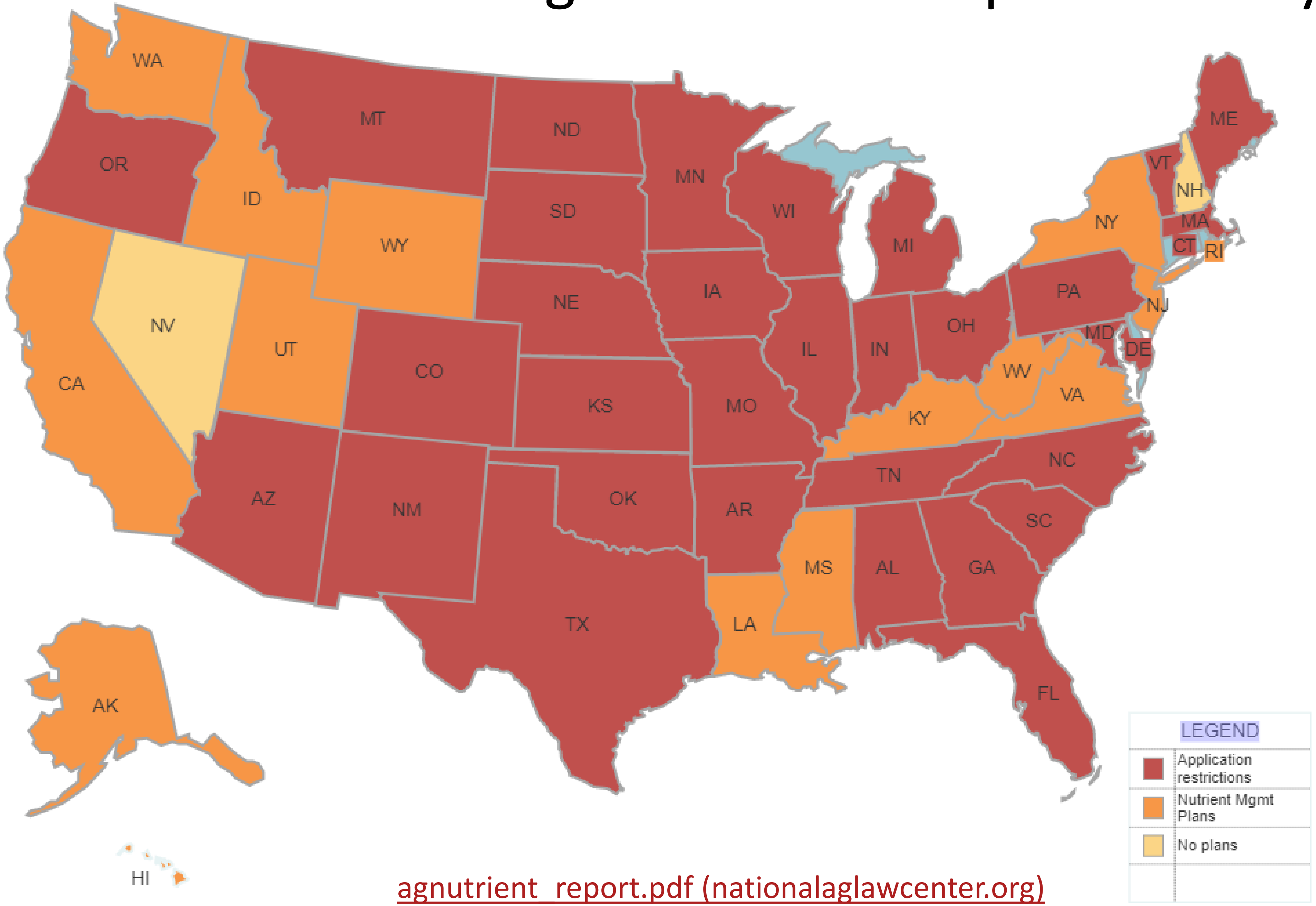
- High Resolution Scanning Bandwidth (350 2500 nm)
- Ongoing Data Integrity
- Comparison Of Authoritative Data Sources
- Continually Improving Algorithms Based on Machine Learning

	SOILYTICS	Soiloptix	SoilCares
Subsurface Testing	✓	✓	✓
Actionable Data	✓	✓	✓
Methodology	Hyperspectral (IR, NIR, SWIR) 350-2500 nm	Gamma Rays	Hyperspectral (Near IR) 1300 – 2550 nm
Resolution	**Very High**	Low	Medium
Accuracy	**Very High**	Medium	Medium

USGS MINERALOGY MAP OF USA

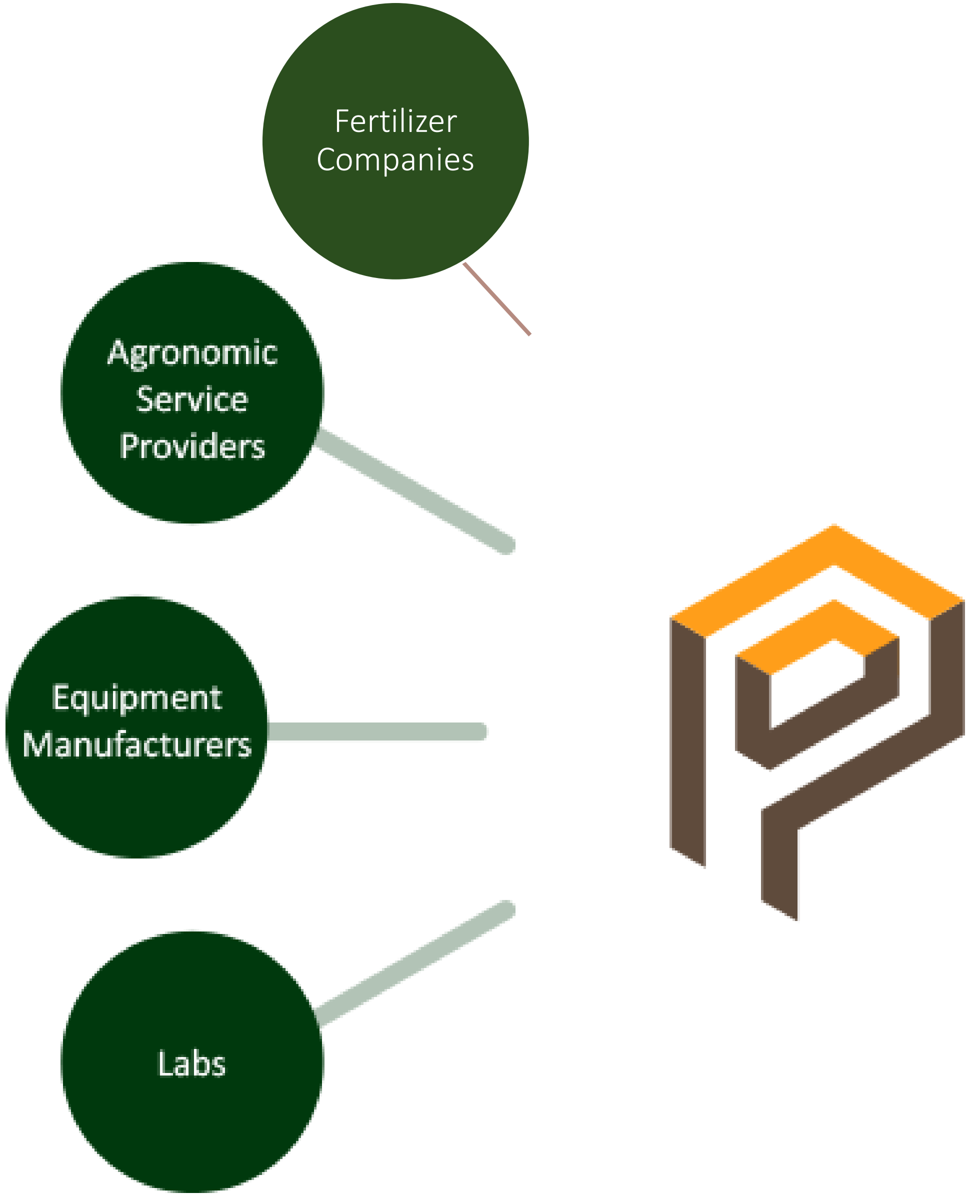


Nutrient Management Plan Requirement by States

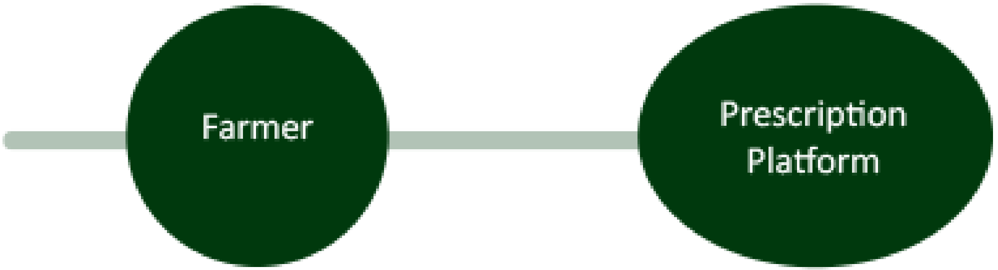


agnutrient_report.pdf (nationalaglawcenter.org)

OUR STRATEGY



We are currently working with a number of large Equipment Manufacturers, Labs and Agronomic Service Providers to test and deploy services. We will provide better data to the users, more quickly.



Our method makes it easier, faster, and less expensive for labs to process samples while increasing granularity for higher profits for the Farmer,

MILESTONES: Case Study History

2015 November- Acquired FAR 333 to fly SUAS commercially
2015 June-Registered ARMDS as an aircraft
2016 August- Wrote the standard for commercial flight of sUAS at night
2016 May- Spectral Lab results with promising accuracy from Illinois field
2017 July- In field analysis at 1 foot height discovered sUAS would not work
2017 May Infield work using 400-1700 NM spectrometer in South
2018 March India samples
2018 June USDA ARS Collaboration
2018 June Solum
2018 Dec Montana
2019 May Oklahoma multiple lab comparison
2019 June Full season hemp study
2019 Sept In lab collaboration
2020 March continued in lab collaboration
2020 Sept Multiple state multiple lab study
2021 Jan- USDA NRCS data share
2021 November completed 4-year study in Montana with cost and yield analysis

MILESTONES: Technology Buildout

- 2016 Built ARMDS for remote
- 2017 February Version 1 of acquisition software was built for 1st sensor
- 2018 December SoilHawk integration began
- 2019 January Version 2 of acquisition software was built for high performance sensor
- 2020 January Version 1 of Portal was built
- 2021 February Backend processor and database integration
- 2021 March version 2 of portal was programmed
- 2021 June Version 3 of acquisition software started
- 2022 February proprietary sensor buildout started

QUIT TREATING YOUR SOIL LIKE DIRT!!

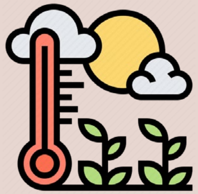
Improving soil health through hyperspectral soil analysis

"If you can't measure, you can't manage it."

Reliable data is essential to manage performance and identify areas of improvement.

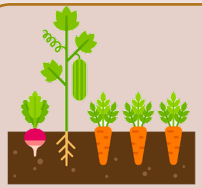
How good are your metrics?

BENEFITS OF IMPROVING SOIL HEALTH



ENVIRONMENT & CLIMATE

ECONOMIC SECURITY

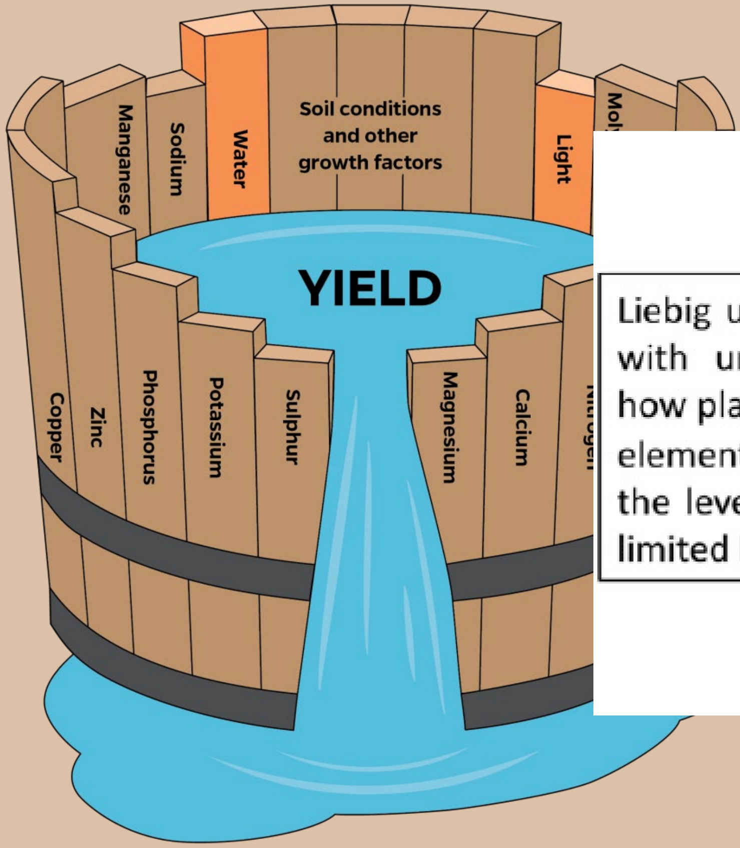


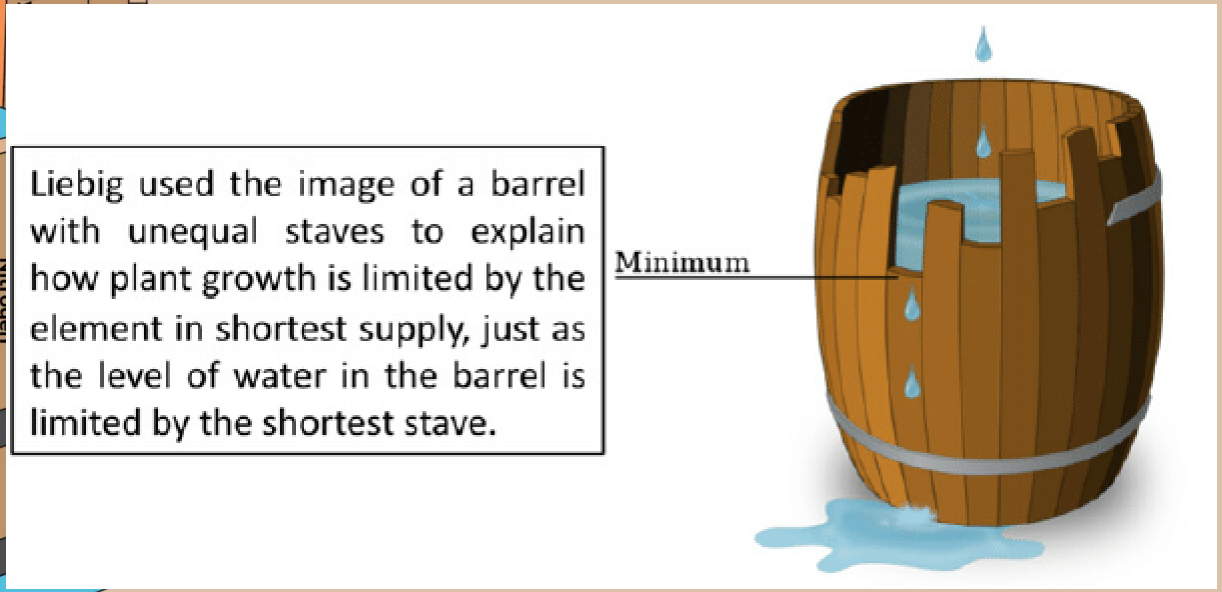
NUTRITIOUS FOOD

WATER SUSTAINABILITY

Actionable and accurate soil testing is essential to address soil nutrient deficiencies and help restore soil fertility.

Liebig’s Law of the Minimum



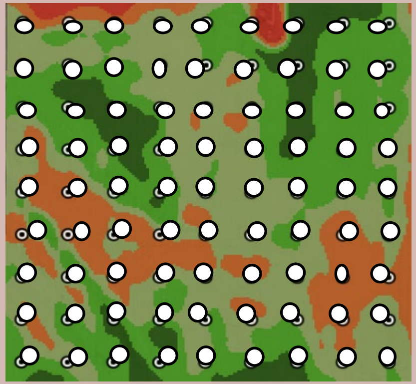


PILOTS

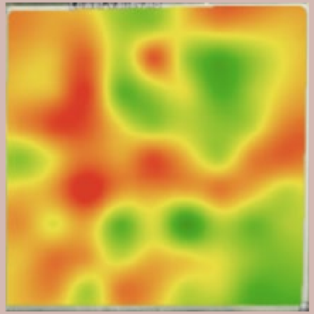
Marshall Field - Hay Crop in Montana (160 acres)

Soilytics

81 samples across field
Cost: $207



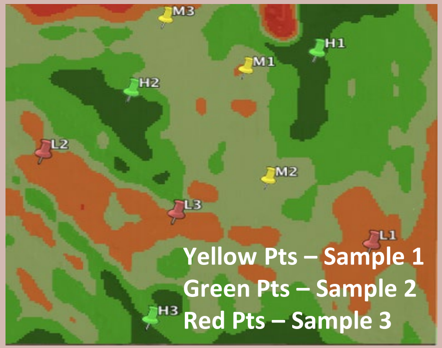
Zoned mapping results for 81 pts
(pH Results)



Prescription Map for
Sulfur (to treat pH)

Chemical Lab

3 samples from 9 data points
Cost: $150



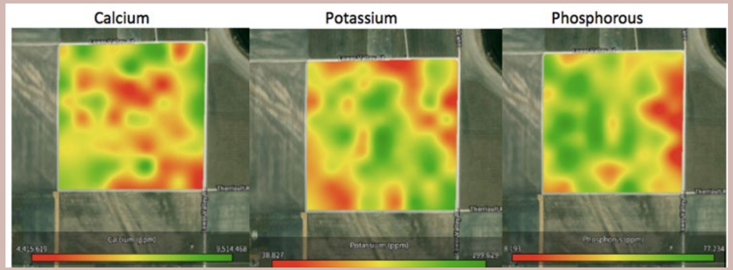
No zone mapping from test
Average Value Assigned to Each Location

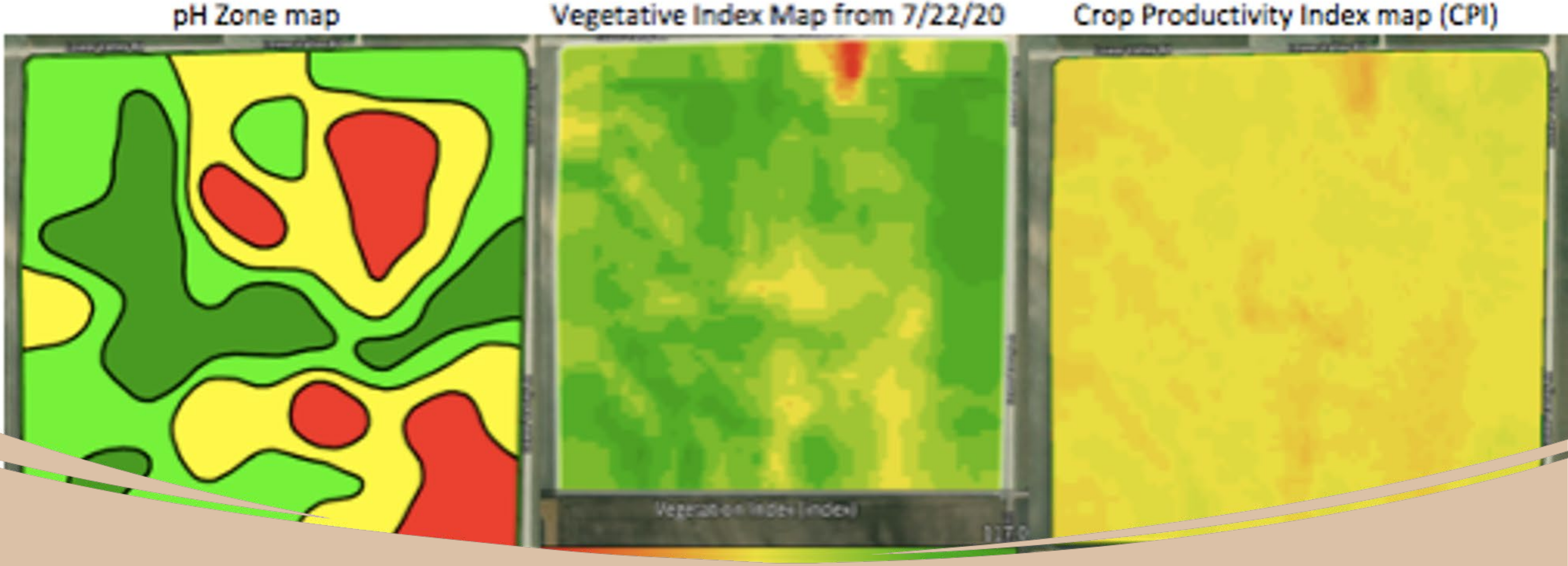
Results

- 27x data points @ similar cost
- Enabled variable rate fertilizer for field
- Saved $ 1,310 in input costs and decreased 3.7 tons in fertilizer volume

Noteworthy

- Zone maps vary significantly for each nutrient





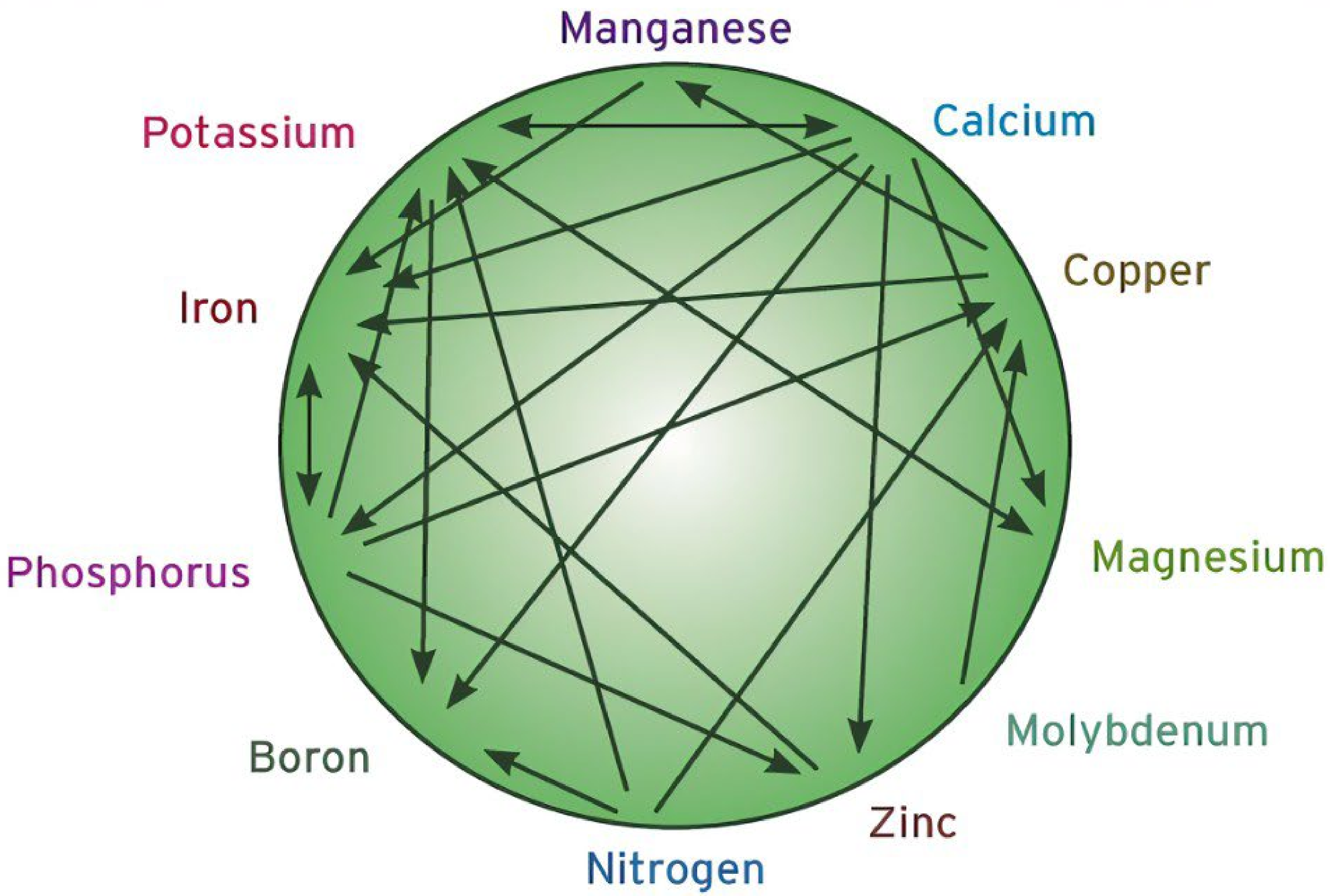
Zone set created for VR Elemental Sulfur Application

- Variable rate application vs. applying flat-rate saved the grower $13.06/ac

Mulder's Chart

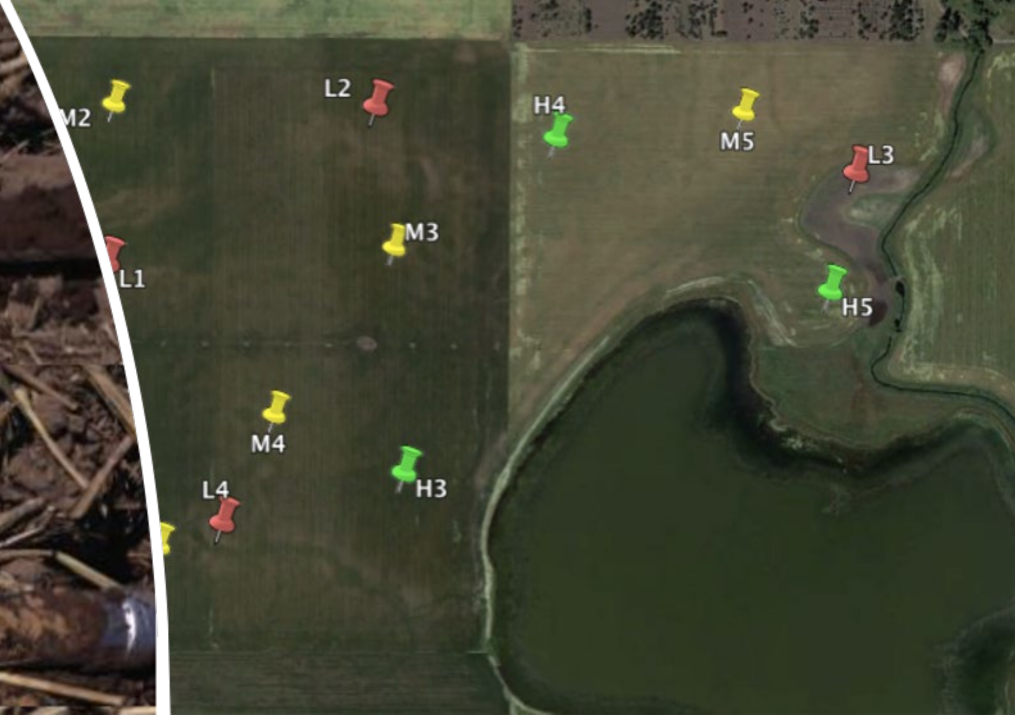
Antagonism →
The decreased availability of the plant nutrient due to the action of another nutrient.

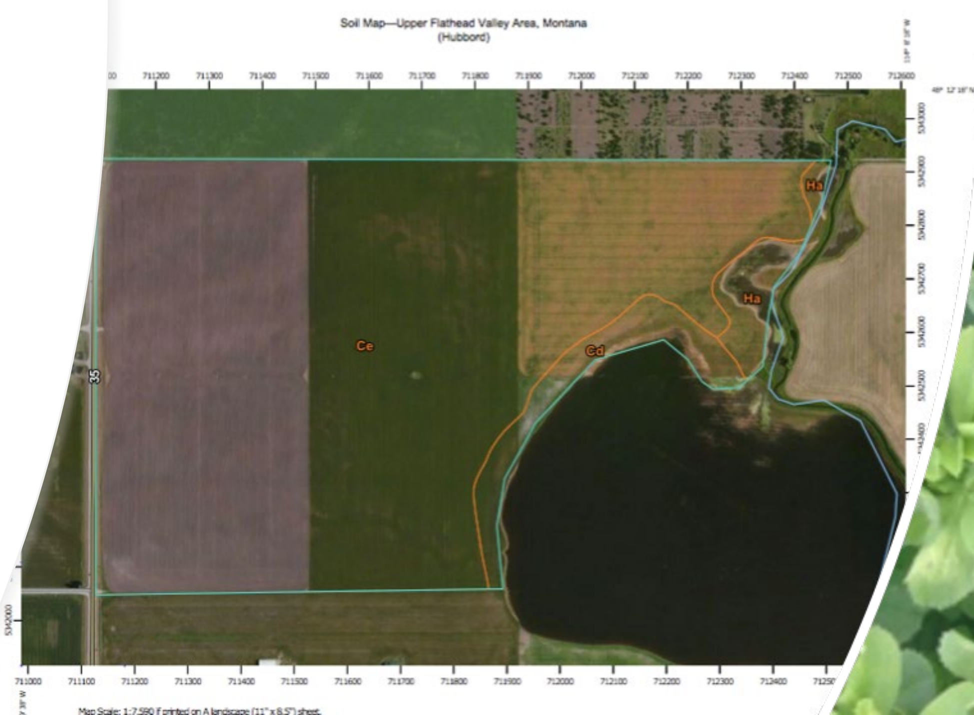
← **Synergism**
Increased availability of a nutrient to the plant due to the increase in the level of another nutrient.



What's the big deal with Acidity?

- Newly Acquired Field
  - Creston Silt Loam "Prime Farmland"
  - Pivot Installed with VR capabilities
  - Goal – High quality, high yielding Alfalfa
  - Powerzones Ordered, Ground Truthing
  - Soil sampled by zone
    - Every zone came back in the 5 pH range





pH Matters

Yield Loss Due To Low pH

Crop	pH 4.7	pH 5.0	pH 5.7	pH 6.8
Corn	66%	27%	17%	0%
Soybeans	35%	21%	20%	0%
Wheat	32%	24%	11%	0%
Alfalfa	98%	91%	58%	0%

* Adapted from Smith & Doran 1996

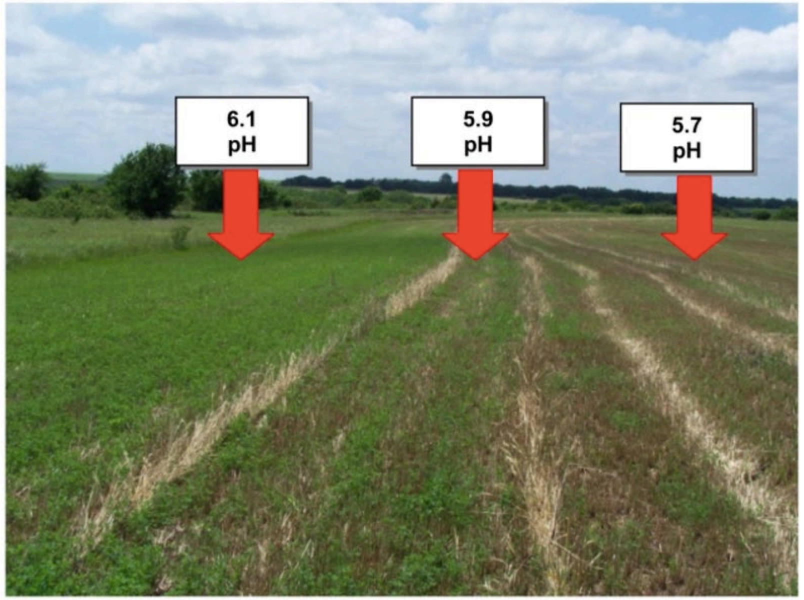
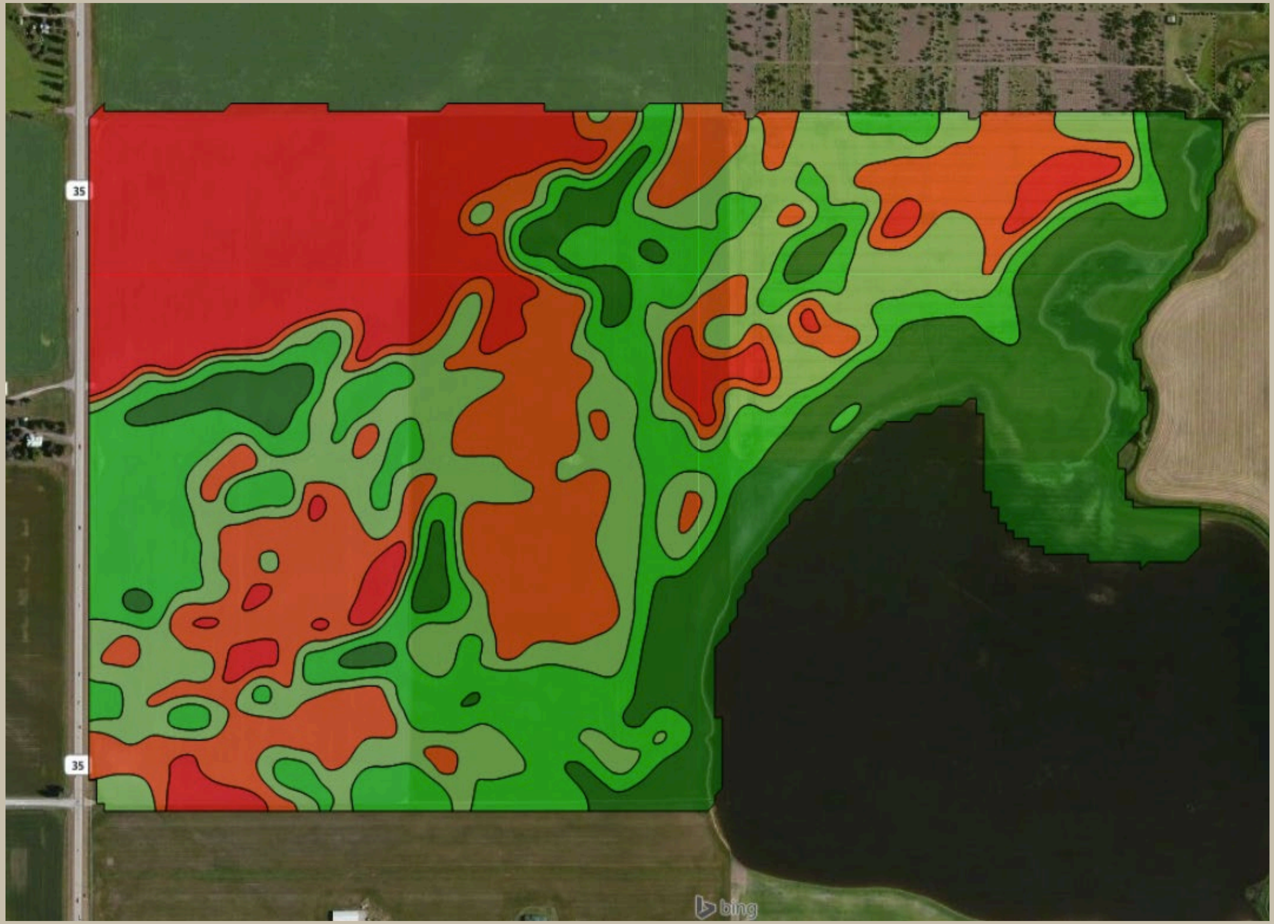


Figure 2. Differences in establishment of alfalfa based on differences in soil pH measured with a hand-held pH meter.

Soil pH	% Fertilizer Efficiency			% Fertilizer Wasted
	N	P	K	
5.0	53	34	52	54
5.5	77	48	77	33
6.0	89	52	100	20
7.0	100	100	100	0



Bulk Lime Rate

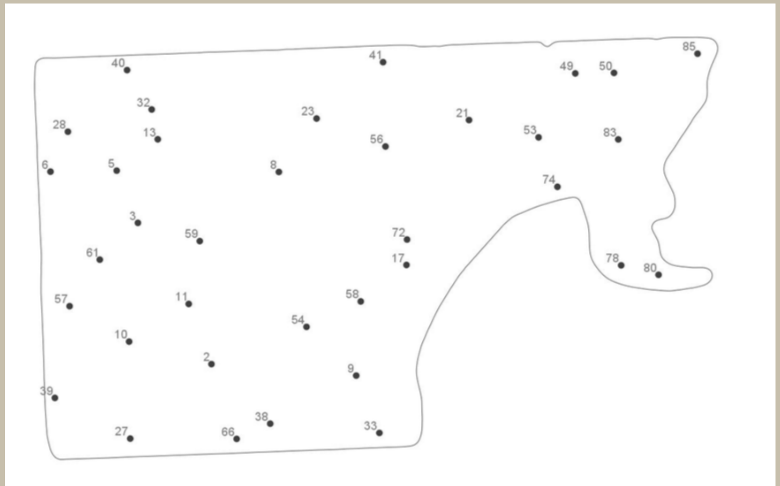
~1 - 2Tn/Ac to move pH to 6.8 applied by zone

Lime Cost: $230/Tn

Total Cost 134Ac Field: $51,060

+ ph_SURF

Zone ID	Zone Name	Acres
5.5000	5.5000	43.04
5.9500	5.9500	44.98
6.2000	6.2000	45.93
6.6000	6.6000	44.9
7.2500	7.2500	43.52



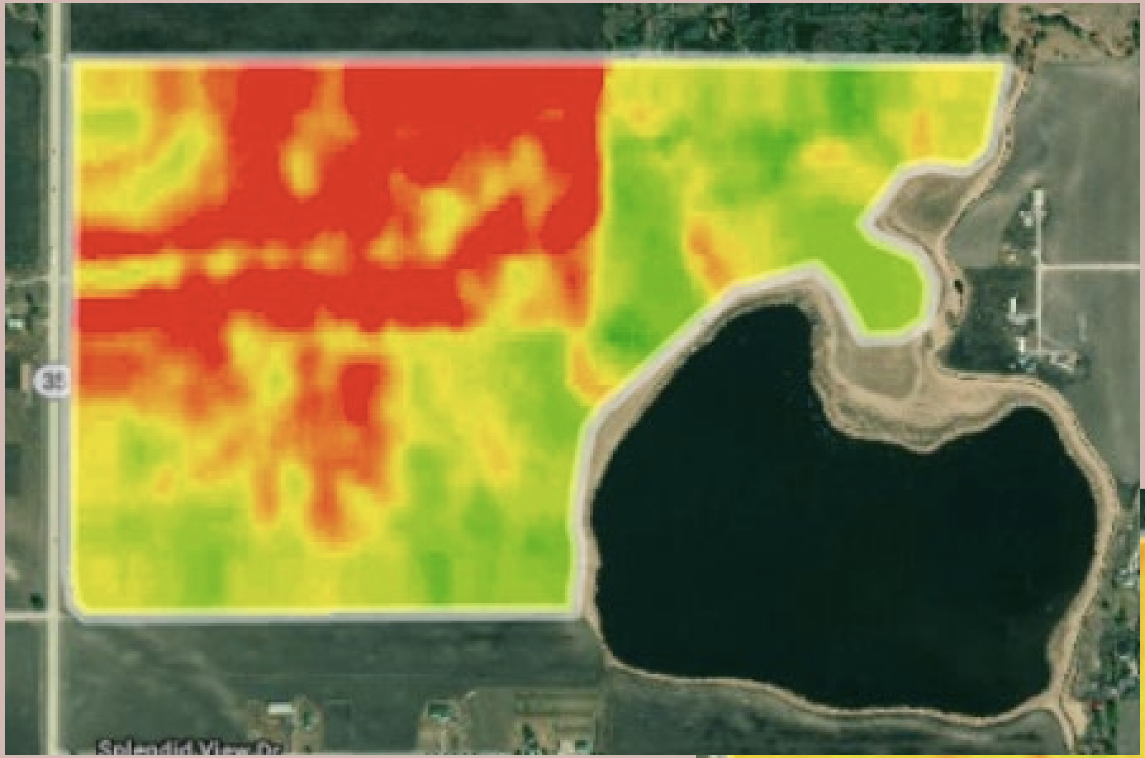
Trimble SIS

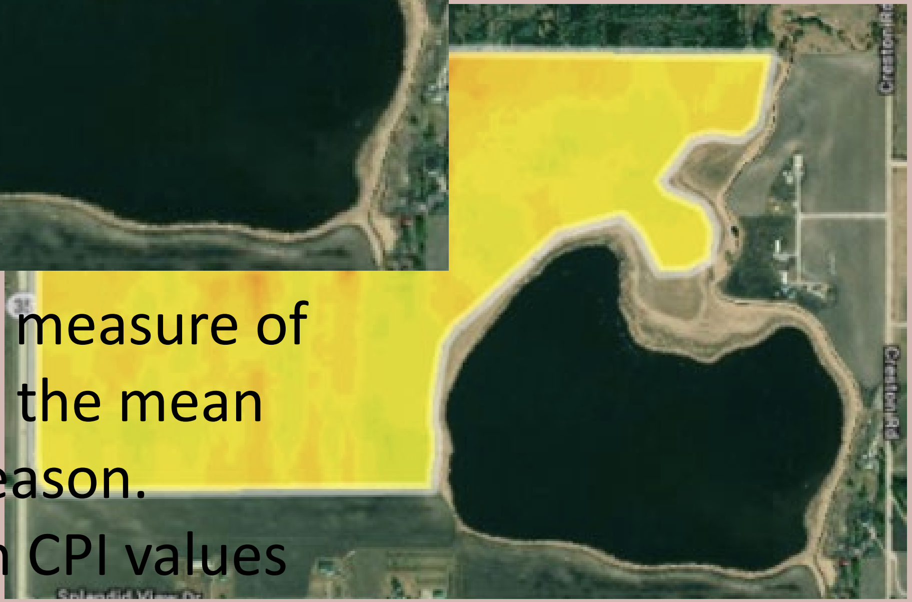
SOILYTICS

2nd VR Lime App

- Applied on 107 acres vs 220
- Sourced lime for $100/tn less
- Savings by using HSA data = $21,879
- Saved $1739.75 in lab savings.
- Received 69 sample pts rather than 37

Reducing Variability





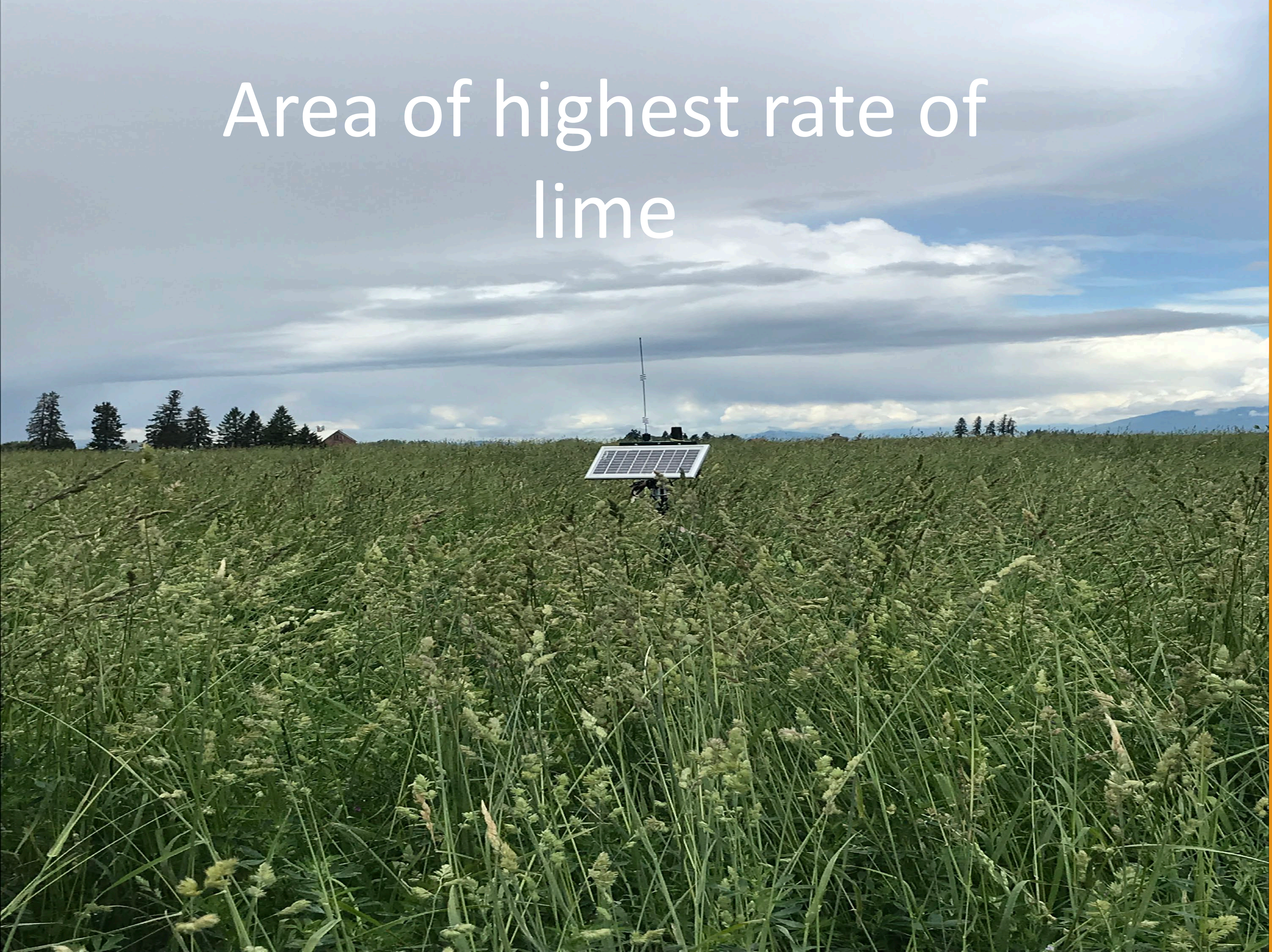
Crop Productivity Index – measure of variability with 100 being the mean value for that cropping season.

2018 – 24 pt difference in CPI values

2021 – 4 pt difference in CPI values

Went from over 47% of the field with below optimal pH in 2016 to 1.6% of the field below optimal this season.

Area of highest rate of lime



We have improved fertilizer efficiency by over 34% by improving our pH levels. This is an anticipated savings of $9,080.72 this last season.

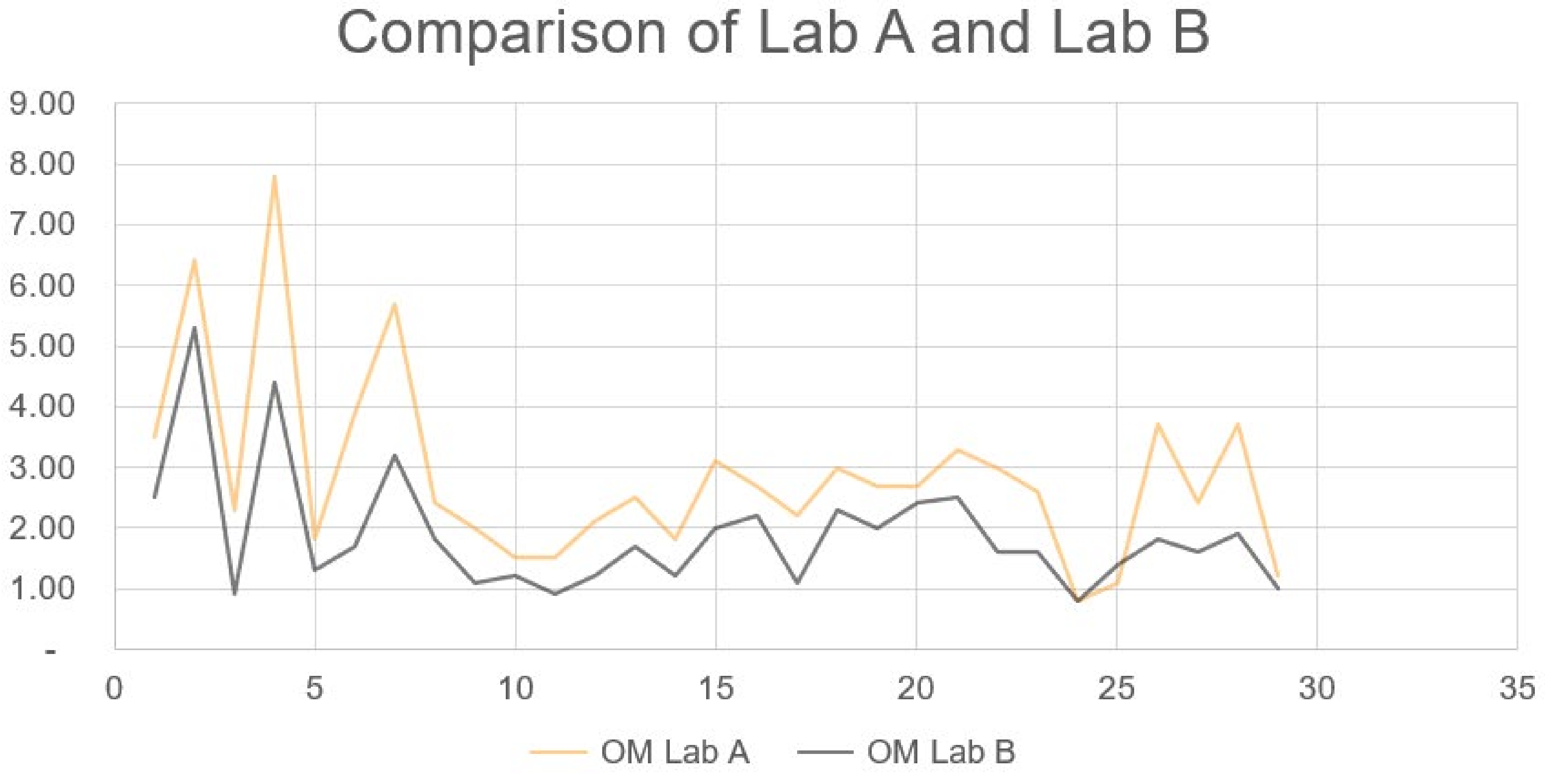
We have increased alfalfa yields by over 40%. This amounts to over $88,000 on this one field last season.

CASE STUDIES

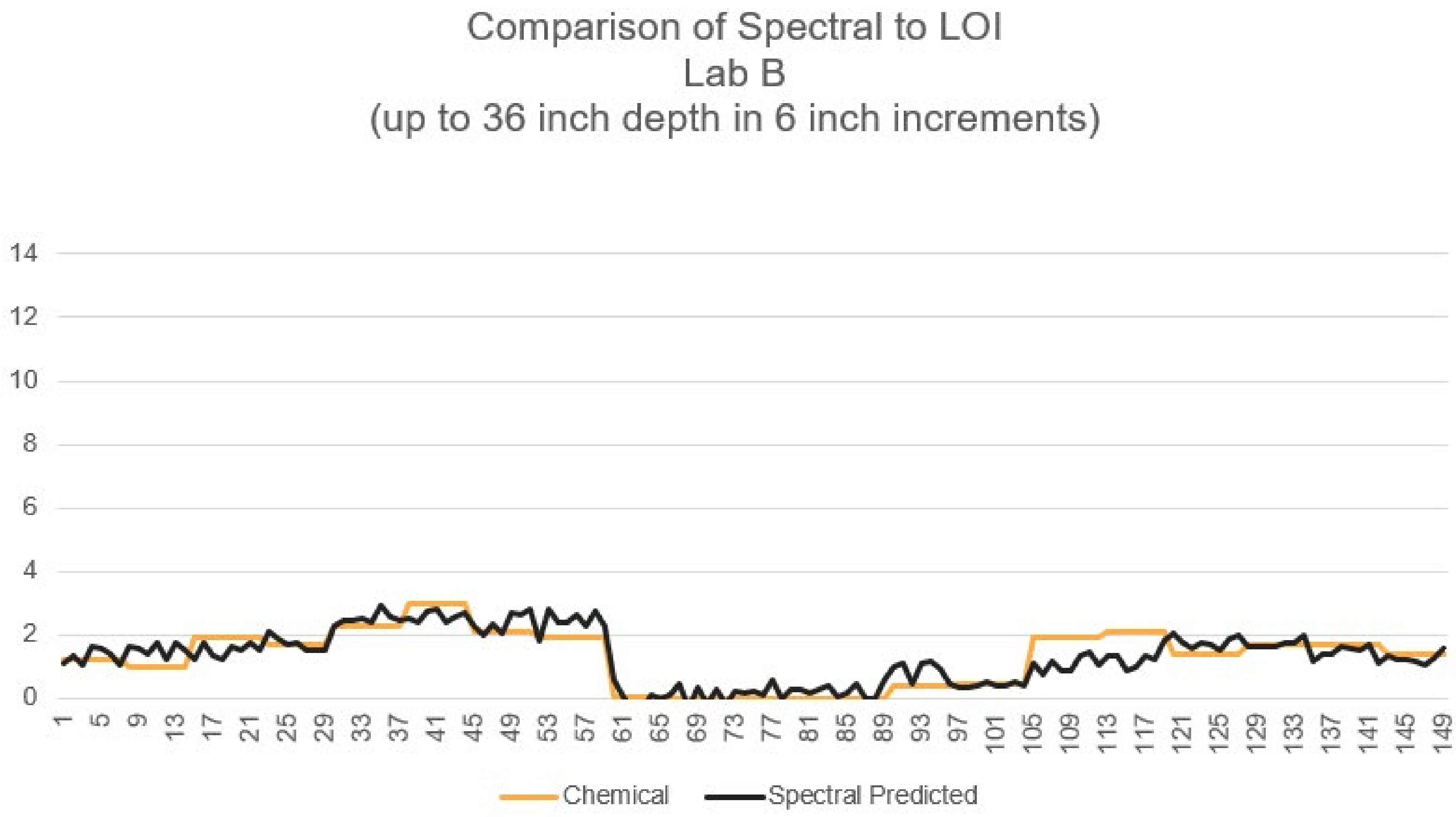
Soilytics™ Solution

	Traditional	SOILYTICS	Cost Difference	SOILYTICS Savings
Field A	$5,635.50	$5,441.97	$193.53	3%
Field B	$3,628.34	$2,573.59	$1,054.75	29%
Field C	$17,804.75	$10,967.91	$6,836.84	38%
Field D	$11,498.96	$11,330.60	$168.36	1%
Field E	$6,800.98	$6,233.16	$567.82	8%
Field F	$10,100.04	$8,992.49	$1,107.55	11%
Field G	$62,411.98	$51,233.48	$11,178.50	18%

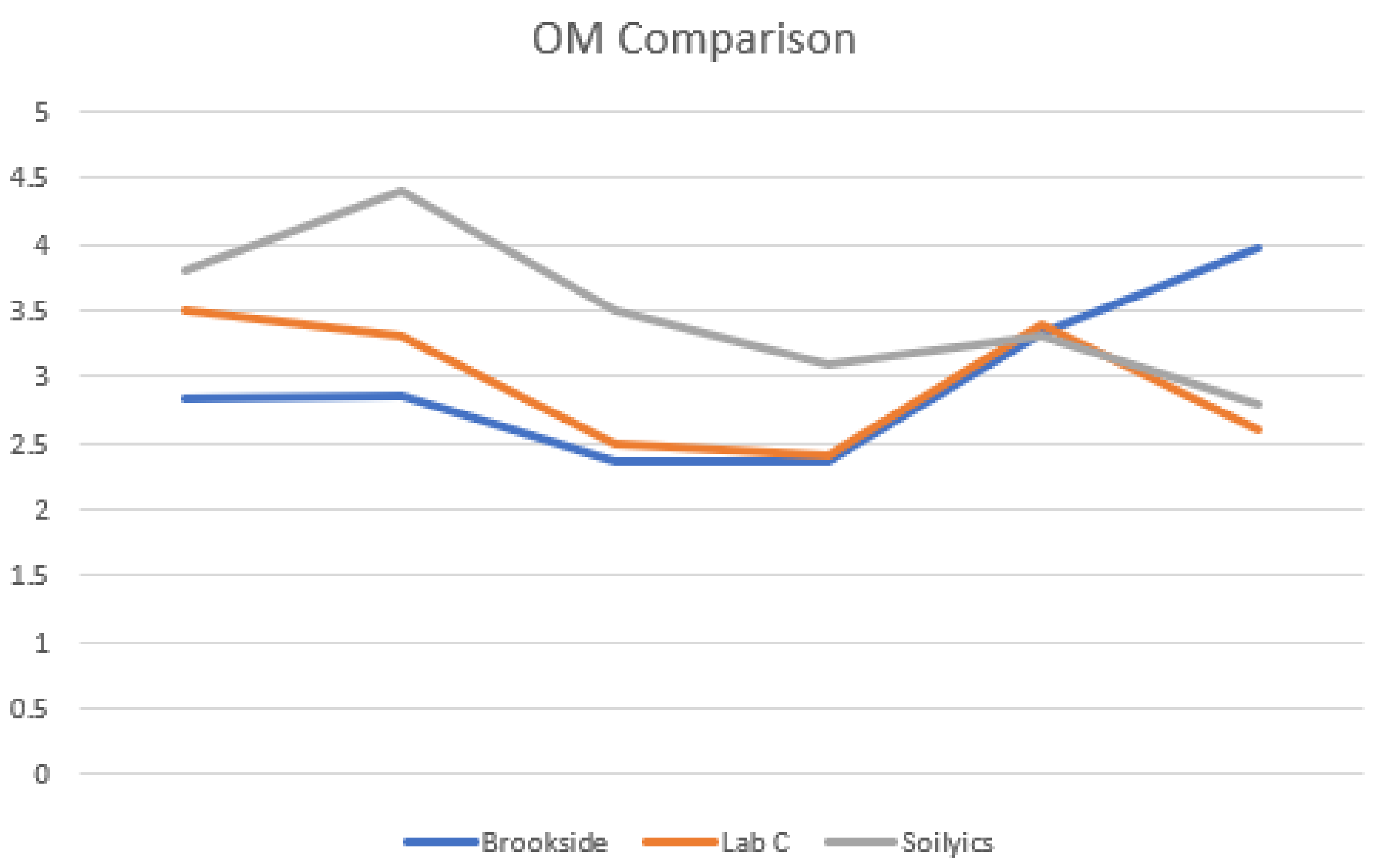
COMPARISON OF LAB RESULTS



COMPARISON OF LAB TO SPECTRAL RESULTS



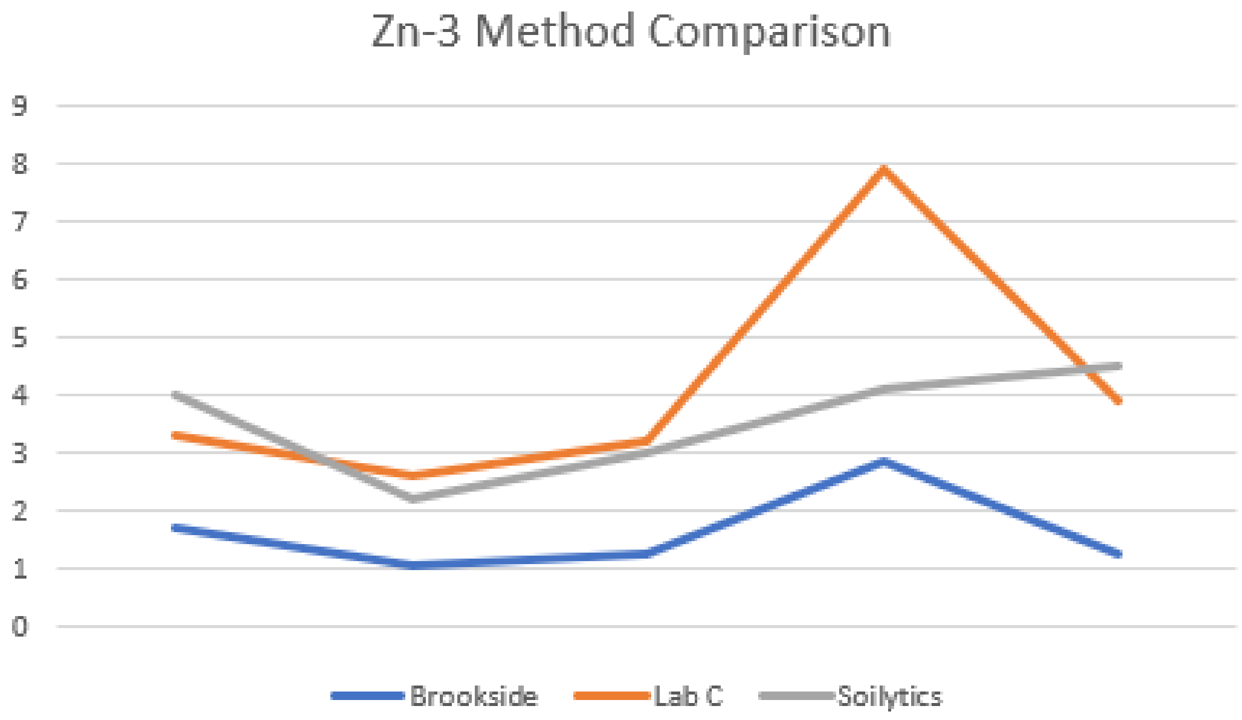
3 METHOD COMPARISON-OM



OM	Lab D	Lab C	SOILYTICS
0162-1	2.83	3.5	3.8
0163-1	2.86	3.3	4.4
0260-1	2.37	2.5	3.5
0261-1	2.37	2.4	3.1
0502-1	3.33	3.4	3.3
1907-1	3.96	2.6	2.8

South Dakota sample presented largest trend variation

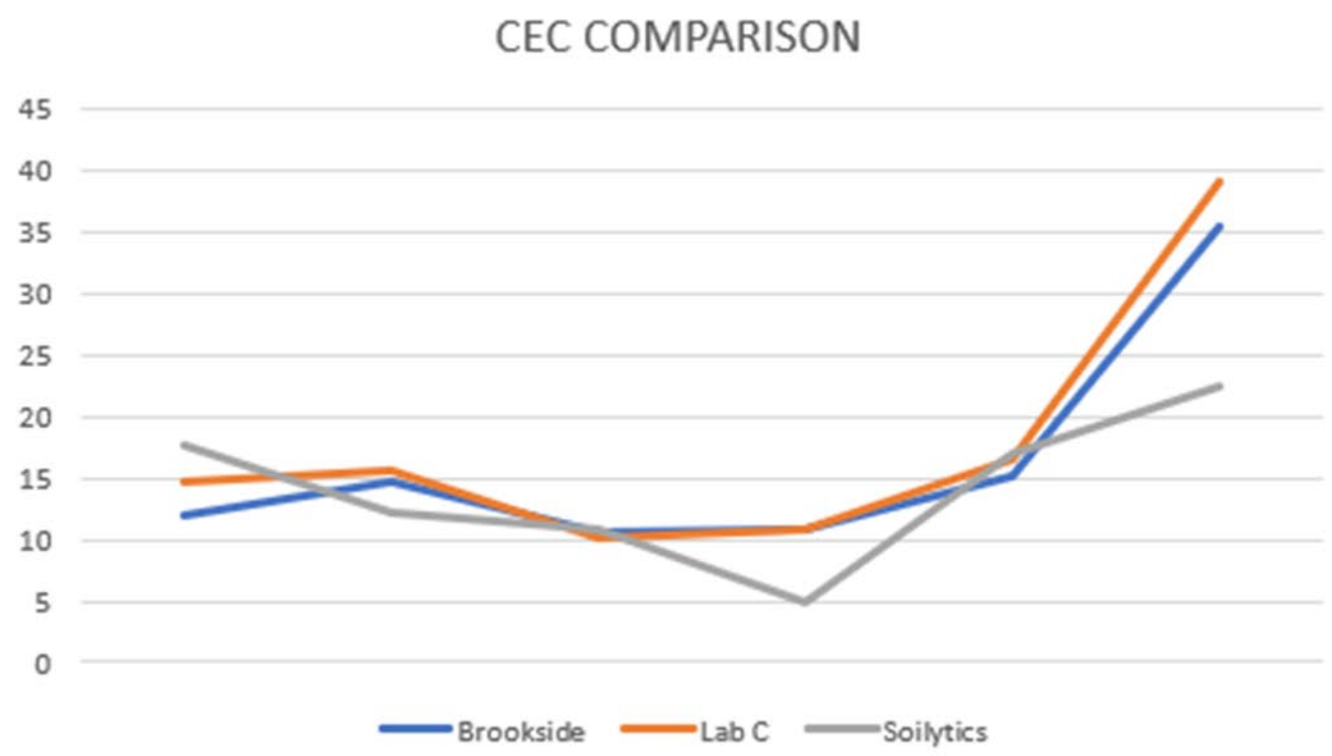
3 METHOD COMPARISON-Zn



Lab D	Lab C	SOILYTICS
1.71	3.3	4
1.03	2.6	2.2
1.22	3.2	3
2.83	7.9	4.1
1.21	3.9	4.5

South Dakota sample presented largest trend variation

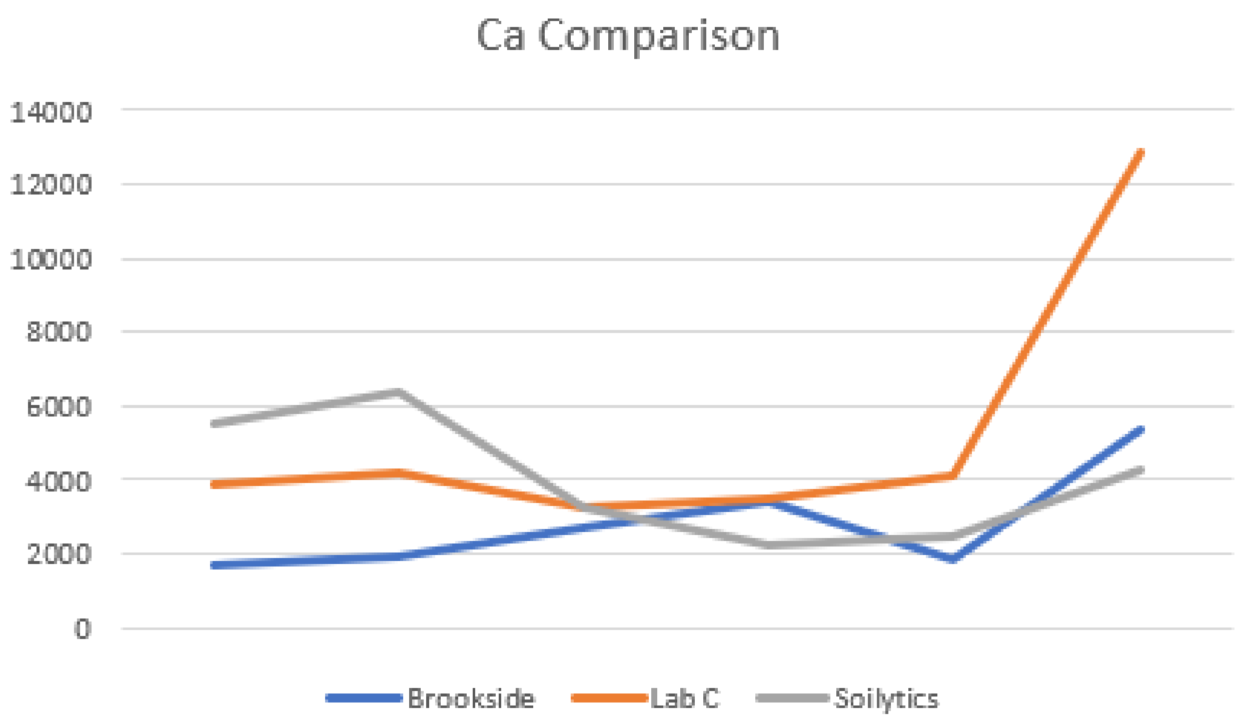
3 METHOD COMPARISON-CEC



Lab D	Lab C	SOILYTICS
11.98	14.8	17.7
14.62	15.6	12.2
10.67	10.2	10.8
10.76	10.8	5
15.18	16.5	16.9
35.37	39.2	22.4

South Dakota sample presented largest trend variation

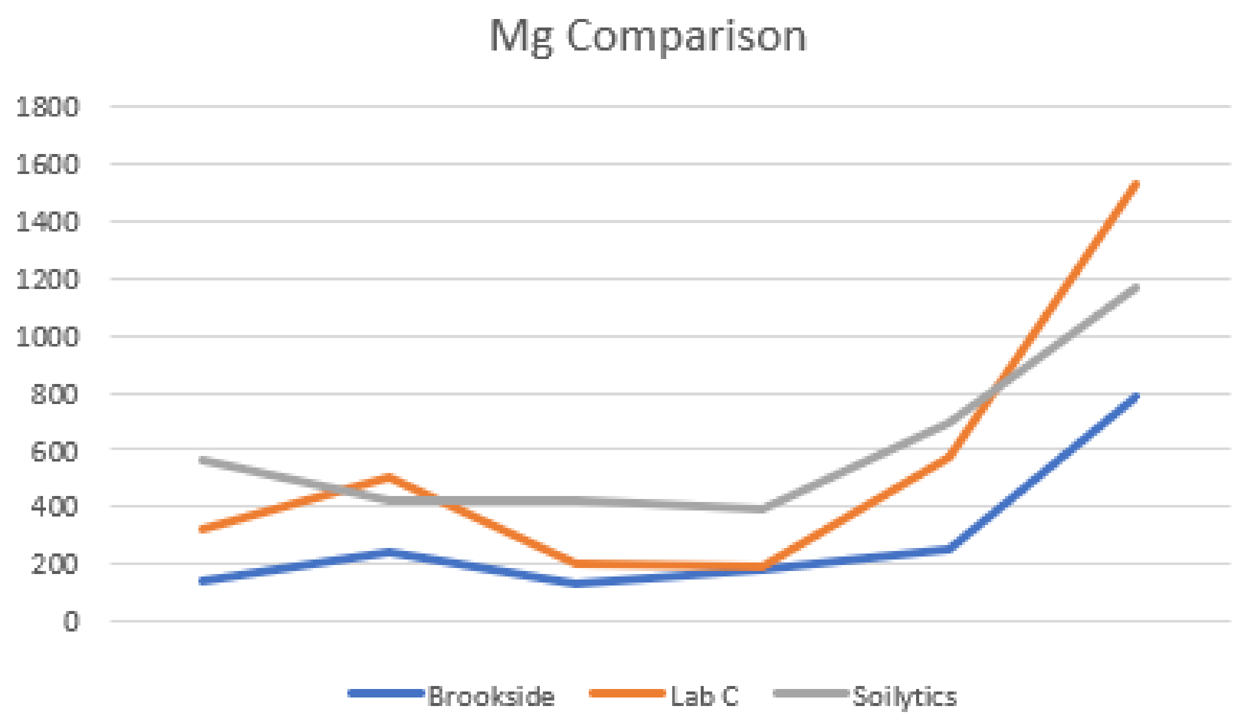
3 METHOD COMPARISON- Ca



Lab D	Lab C	SOILYTICS
1710	3891	5525.7
1966	4189	6385.6
2736	3237	3233
3384	3487	2211.2
1836	4148	2456.6
5342	12864	4307.6

South Dakota sample presented largest trend variation

3 METHOD COMPARISON-Mg



Lab D	Lab C	SOILYTICS
139	326	560.2
242	500	421.2
130	204	420
184	191	395.7
251	573	690.5
781	1525	1170.6

Conclusion

Receiving 20+ times the data for same analytical cost.

More granular data than ever before, thus more precise management than ever before.

Better able to place the right nutrients, in the right place, at the right time, at the right rate.

Increasing yields and decreasing input costs.

Growing more profitable bushels!

PARTNERSHIPS

HARDWARE

STANDARDIZATION

STRATEGICS

DATA INTEGRITY

ASSOCIATIONS / ACADEMIA

SOFTWARE INTEGRATION

CONTACT US

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Nutrient (PPM except where noted)	LOD	LOQ
Nitrogen	1	2
Phosphorous	1	1.5
Potassium	1	20
Zinc	1	6
Iron	0.1	2
Manganese	0.1	0.25
Copper	0.1	0.05
Boron	0.1	0.125
Magnesium	1	5
Calcium	1	50
Sulfur	1	4.5
Chloride	1	7.5
pH (scale of 0 to 14)	0.1	0.25
CEC (meq/100 g)	1	2
OM (%)	0.5	1
Carbon	0.2	0.5

Element	Low Wavelength [nm]	High Wavelength [nm]	RMSE good
OM	350	2500	<1 or 0.5
CEC	350	2500	<3
pHw	350	2500	<1 or 0.4
Potassium	350	2500	<1 or 0.4
Copper	350	2500	<1 or 0.9
Boron	350	2500	<1 or 0.4
Sulfur	350	2500	<1 or 0.9
Zinc	350	2500	<2