

# Soil Testing for Vineyards

What you need to know!

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Soil Analysis

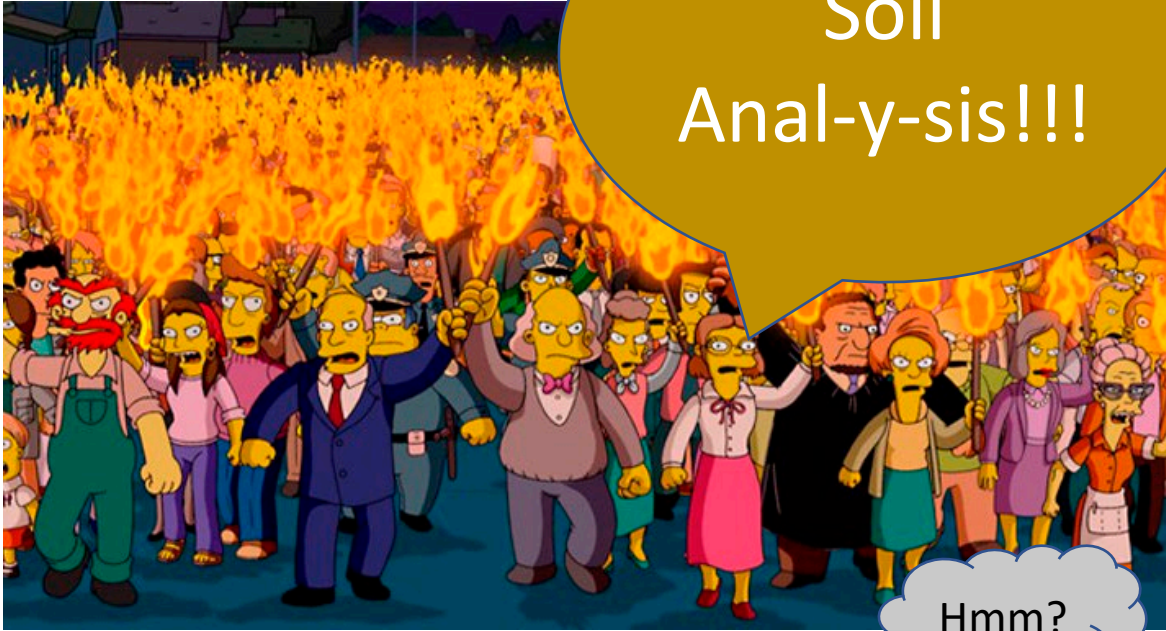
or/and

Tissue Analysis



The 600-lb (272 kg) gorilla in the room

Soil, Soil,  
Soil  
Anal-y-sis!!!



Hmm?



*Leaf Analysis  
Rules!*

Petiole  
samples  
forever!!!



Hmm?



# Outline for Today's Talk

- When are soil tests useful?
- Approaches to sampling soil
- Interpreting results of soil analysis
- Uncertainty in Soil Testing results

# Times when soil testing is useful...

**When...** there are no grape tissues to test.

Preplant and dormant season.

**We want to know chemical properties not revealed in foliar tests**

Soil organic matter, pH, buffer pH, Cation Exchange capacity, base saturation,

**When we want to know about the root environment.**

Acidity, alkalinity, salinity, sodicity, toxic metal levels, dispersed soils

**Baseline (time capsule) for soil nutrients and chemistry.**

Compare to future samples, improvement or degradation, and to untangle uncertainty in foliar test results, evaluate our management.

**Managing sister crops**

cover crops, soil organisms, livestock helpers.

# Cost of Soil testing

\$100 or less  
per sample

Double this for surface + subsoil



# Cost of Not soil testing

No info about pH, lime requirement CEC,  
OM

Uninformed rootstock selection

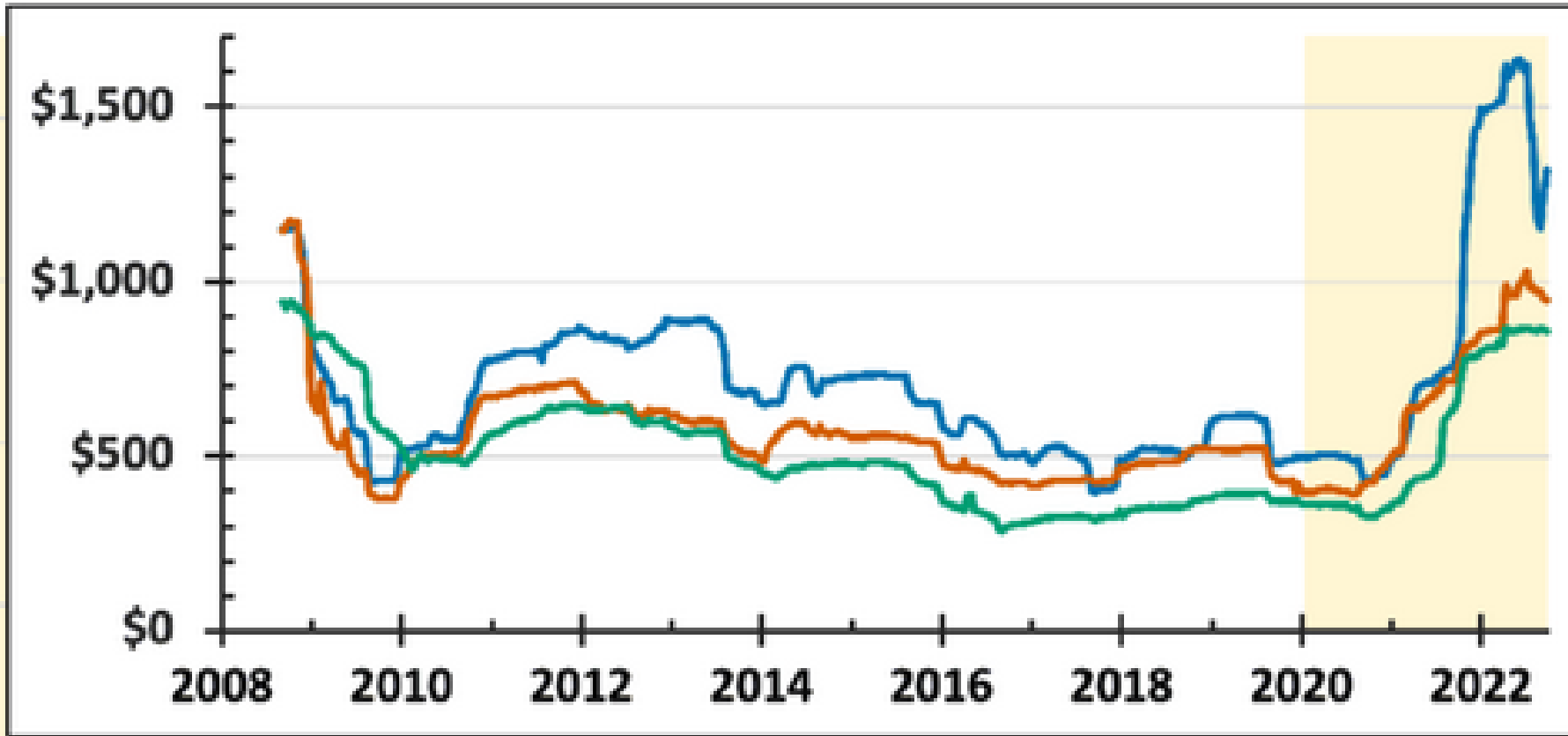
Undiscovered soil toxicity

Soil structure and drainage issues  
Not addressed.

Over amend or under amend

Fertilizer Cost Increases (\$/ton for 2020 to 2022)

— N  
— P  
— K



# Soil analysis for sister crops and soil health

**Cover Crop.** In preplant and in newly established vineyards the main crop is the cover crop. Liming and soil amendments to get a good stand of cover crop is a top priority. Use soil test to select for cover crop for example soil pH, SOM

**Soil Biology.** Soil pH for N-fixation, SOM for food web.

**Livestock Helpers.** Monitor nutrient loading from manure or to improve forage nutrition.

**Environmental concerns.** Monitor nutrients to reduce nonpoint pollution.

# Soil Sampling

## How, where, when to sample soils?

Depth of sampling? Picture of Deep core

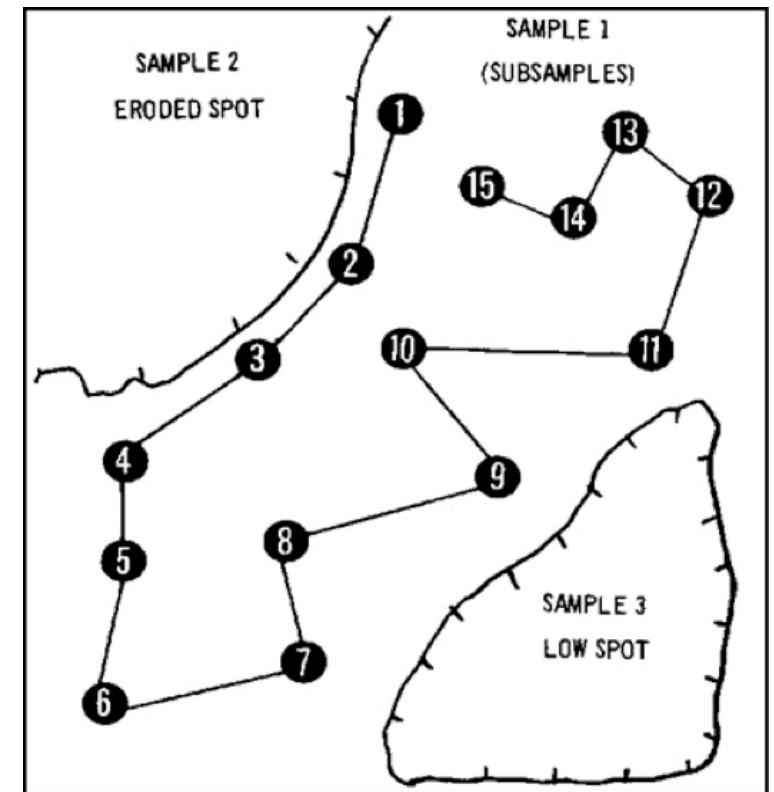


Location and number of samples? Gridding  
(Composite samples versus spot samples?)

Use GPS or other coordinate system.

Season of year?

How often?



# Soil Sampling Depth

- Surface sampling -- Plow Layer usually around 7 to 9 inches
- Subsoil sampling Depends on soil morphology but I typically collect a sample from 24 to 36 in depth. Vineyards are perennial deep rooting, and many are grown without irrigation so the surface layer is often dry by late June and early July. Conditions differ in subsoil.
- Substrata sampling Can sample as deep as your sampling equipment will allow. I only do this if I have a suspicion of a problem.

# Location and number of samples?

For Preplant I take a “reasonable number”, which is usually one pedon per soil series. Budget consideration,  
Ask: what is the benefit of doing more sampling?

**Look at variability in initial sampling**, determine if more is warranted. I usually collect more samples than I have analyzed, just in case.

## Composite samples versus spot samples?

I sample from the points where I have test holes for soil mapping.  
GPS location. This allows you to return to the same spot in the future.

*You may want to follow advice of nearly every extension publication ever written and do composite samples, I do not do this. I want to see the range not the average.*

## SOIL ANALYSIS REPORT

SAMPLE ID	LAB NUMBER	Organic Matter		Phosphorus		Potassium	Magnesium	Calcium	Sodium	pH		Hydrogen	Cation Exchange Capacity	PERCENT CATION SATURATION (COMPUTED)				
		*	**	P1 (Weak Bray)	NaHCO <sub>3</sub> -P (Olsen Method)	K	Mg	Ca	Na	Soil pH	Buffer Index	H		C.E.C. meq/100g	K %	Mg %	Ca %	H %
		% Rating	ENR lbs/A	**** *	**** *	**** *	*** *	*** *	*** *	*** *	meq/100g	meq/100g						
16B	59452	3.4M	97	4VL	6**	62L	252M	848L	18VL	5.0	6.6	4.5	11.1	1.4	18.7	38.2	41.0	0.7
22B	59453	3.4M	99	4VL	8**	100M	261M	996L	20VL	5.3	6.5	3.4	10.8	2.4	19.9	46.0	31.0	0.8
23B	59454	3.2M	94	4VL	17**	50L	360H	984L	25VL	5.1	6.5	5.0	13.1	1.0	22.6	37.6	38.0	0.8
28B	59455	4.3H	116	4VL	7**	151M	190M	1247L	20VL	5.2	6.6	4.3	12.6	3.1	12.4	49.4	34.5	0.7
29B	59456	4.3H	117	5VL	7**	182M	213M	1054L	11VL	5.1	6.4	4.6	12.1	3.8	14.4	43.3	38.0	0.4

\*\* NaHCO<sub>3</sub>-P unreliable at this soil pH

SAMPLE NUMBER	Nitrogen NO <sub>2</sub> -N ppm	Sulfur SO <sub>4</sub> -S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Excess Lime Rating	Soluble Salts mmhos/cm	Chloride Cl ppm	PARTICLE SIZE ANALYSIS				
											SAND %	SILT %	CLAY %	SOIL TEXTURE	
16B	4VL	4L	0.2VL	12M	13M	0.2VL	0.1VL	L	0.1VL						
22B	1VL	2VL	0.2VL	6M	16M	0.2VL	0.1VL	L	0.1VL						
23B	1VL	2VL	0.3VL	9M	21H	0.5L	0.1VL	L	0.1VL						
28B	1VL	1VL	0.4VL	13H	19H	0.3VL	0.1VL	L	0.1VL						
29B	2VL	1VL	0.4VL	20H	27VH	0.7L	0.1VL	L	0.1VL						

# Soil Organic Matter (SOM)

One of the most important analytics, soil organic matter improves soil physical properties, provides habitat and food for soil biology, acts as a nutrient pool, adds to cation exchange capacity of the soil, cycles carbon and many other benefits.



# Soil Organic Matter (SOM)

The amount of SOM shows the state of the soil, its history and potential for improvement.

Provides a benchmark of SOM to evaluate vineyard practices over time.

Say “When”, when you have enough.

SAMPLE ID	LAB NUMBER	Organic Matter	
		* % Rating	** ENR lbs/A
16B	59452	3.4M	97
22B	59453	3.4M	99
23B	59454	3.2M	94
28B	59455	4.3H	116
29B	59456	4.3H	117

# Soil pH

Soil pH is a measure of the acidity or alkalinity in the soil, also called soil reaction.

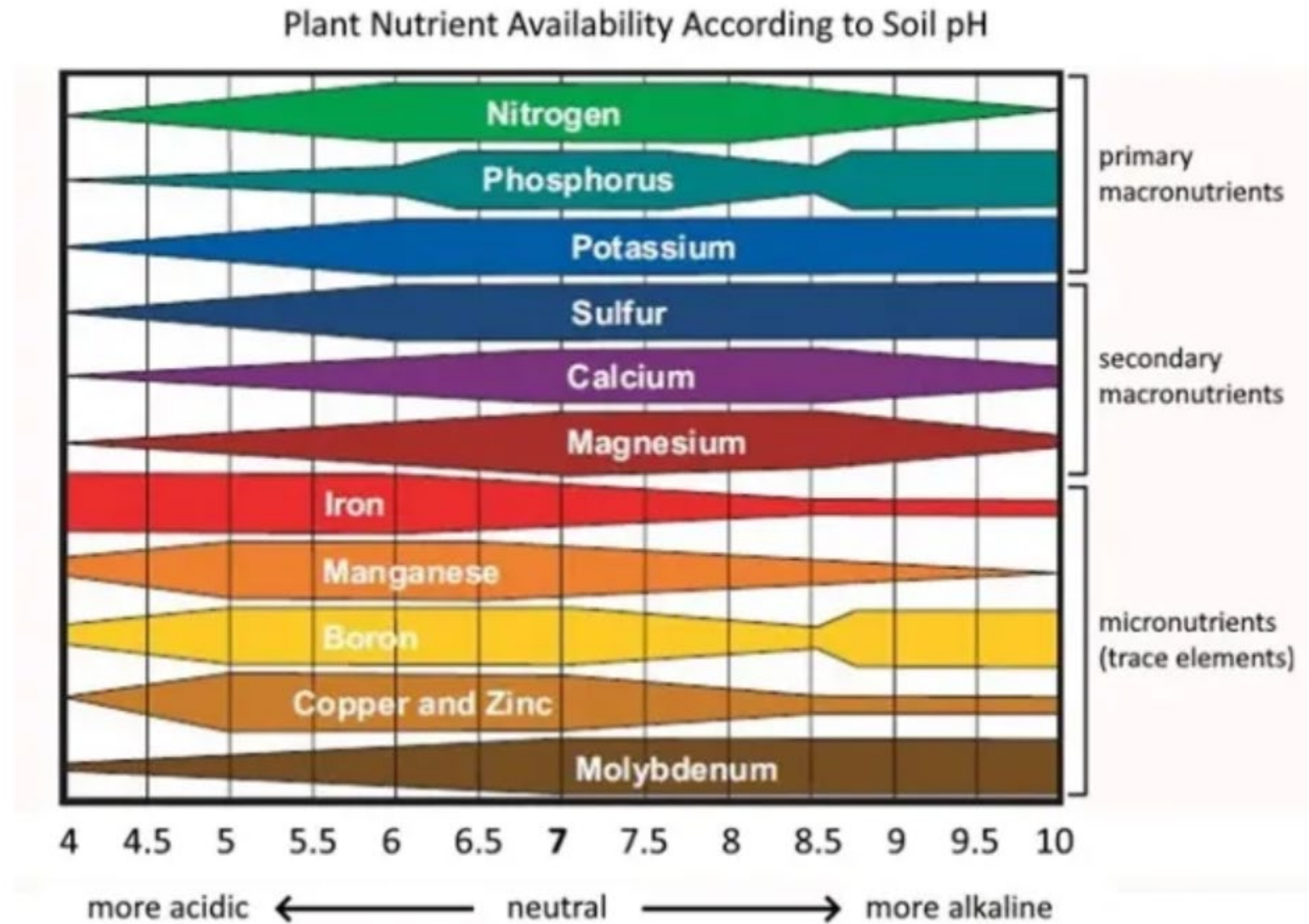
pH		Hydrogen
Soil pH	Buffer Index	H meq/100g
5.0	6.6	4.5
5.3	6.5	3.4
5.1	6.5	5.0
5.2	6.6	4.3
5.1	6.4	4.6

Classes	soil pH:
Extremely acid	3.5 – 4.4
Very strongly acid	4.5 – 5.0
Strongly acid	5.1 – 5.5
Moderately acid	5.6 – 6.0
Slightly acid	6.1 – 6.5
Neutral	6.6 – 7.3
Slightly alkaline	7.4 – 7.8
Moderately alkaline	7.9 – 8.4
Strongly alkaline	8.5 – 9.0

# Benefits of Liming Acidic Soils

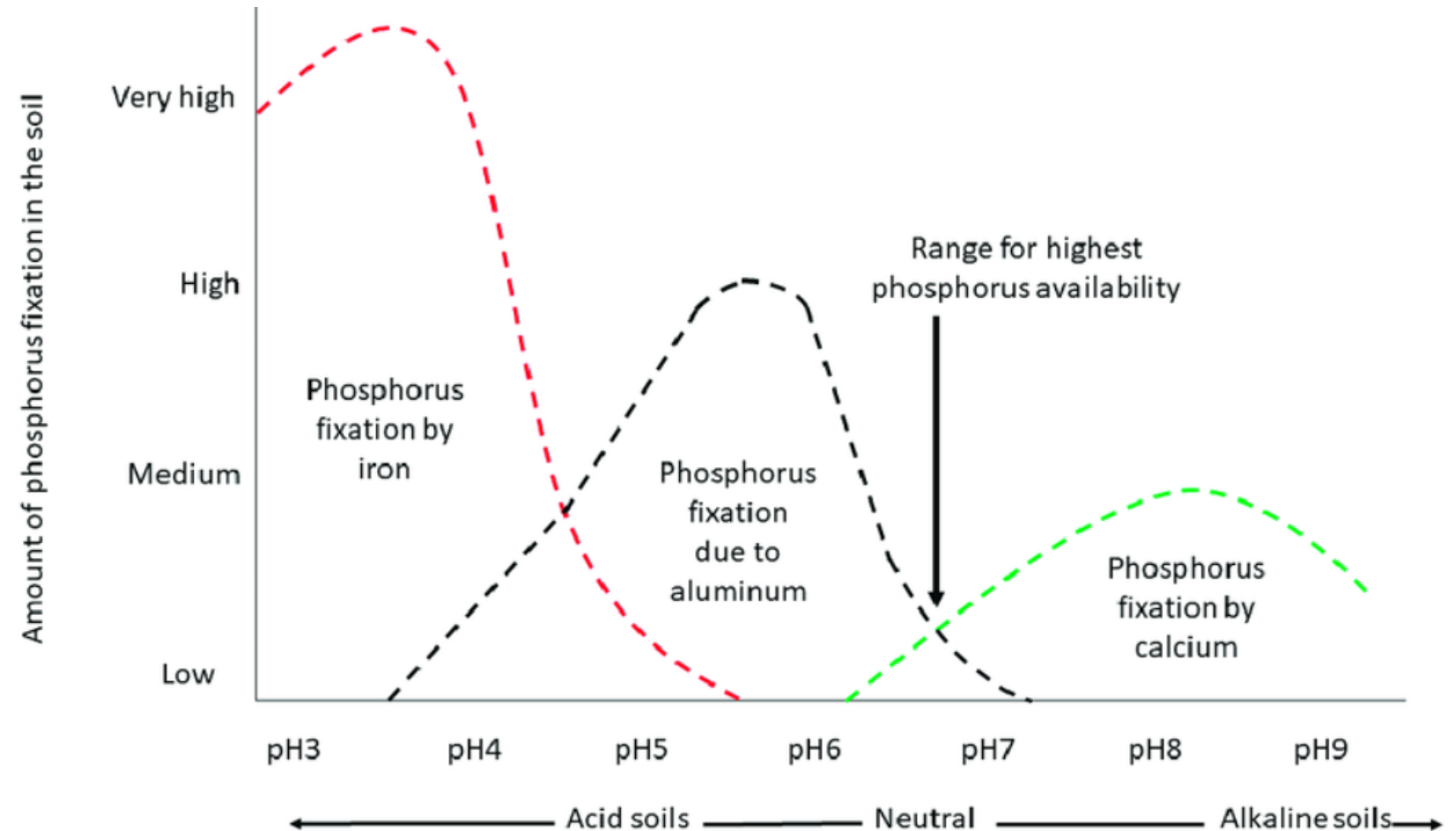
- Correct a low pH
- Improve crop growth and health
- Increased nutrient availability in your soil
- Manage microorganism community

# pH and Nutrient Availability



# Example: Phosphorus fixation and availability with pH

Nutrient species vary with pH and so does availability to plants.



General qualitative representation of soil phosphorus availability as impacted by pH. Redrawn from Price [1].

# Buffer pH and Lime Requirement



Buffer pH measures the exchangeable acidity. The farther away from 7 the more exchangeable acidity and greater lime requirement to raise pH.

Lime requirement test value	New Sikora Recommendations			New SMP Recommendations		
	Target soil pH			Target soil pH		
	pH 5.6	pH 6.0	pH 6.4	pH 5.6	pH 6.0	pH 6.4
	<b>Recommended lime application to attain target soil pH<sup>b</sup> (t/a)</b>					
6.7	0	0	0	0	0	0
6.6	0	0	0	0	0	0
6.5	0	0	0.5	0	0.5	0.5
6.4	0.5	0.5	1.0	0.5	1.0	1.2
6.3	0.8	1.0	1.7	0.9	1.5	1.9
6.2	1.2	1.6	2.3	1.3	2.1	2.6
6.1	1.6	2.1	3.0	1.7	2.6	3.3
6.0	1.9	2.6	3.7	2.1	3.1	4.0
5.9	2.3	3.1	4.3	2.4	3.7	4.7
5.8	2.6	3.6	5.0	2.8	4.2	5.3
5.7	3.0	4.1	5.7	3.2	4.7	6.0
5.6	3.4	4.7	6.3	3.6	5.2	6.7
5.5	3.7	5.2	7.0	3.9	5.8	7.4
5.4	4.1	5.7	7.6	4.3	6.3	8.1
5.3	4.5	6.2	8.3	4.7	6.8	8.8
5.2	4.8	6.7	9.0	5.1	7.4	9.5
5.1	5.2	7.2	9.6	5.5	7.9	10.2
5.0	5.6	7.8	10.3	5.8	8.4	10.8
4.9	5.9	8.3	11.0	6.2	9.0	11.5
4.8	6.3	8.8	11.6	6.6	9.5	12.2

# Lime Requirement -- Buffer pH Analysis

## How Does Lime Work?



Agricultural Lime is Calcium Carbonate (CaCO<sub>3</sub>). A low pH (acidic) in your soil is a result of hydrogen ions (H<sup>+</sup>). When lime is applied to the soil, it reacts with hydrogen ions to produce water (H<sub>2</sub>O), Carbon dioxide (CO<sub>2</sub>), and Calcium (Ca).

This reaction raises the pH of the soil. Water, Carbon dioxide and Calcium will be used by the plant and the Calcium will also help open up the soil structure.

Lime is not very soluble in the soil therefore it will only move slowly into the subsurface and subsoil. Working the lime into the ground will allow it to come in contact with more of the soil.

Adding gypsum (calcium sulfate) at the same time will also help with the lime move \ into the soil profile. The calcium in gypsum will help open up the soil structure and it is more water soluble than lime.

# Subsoil acidity



Acid soils can limit root activity

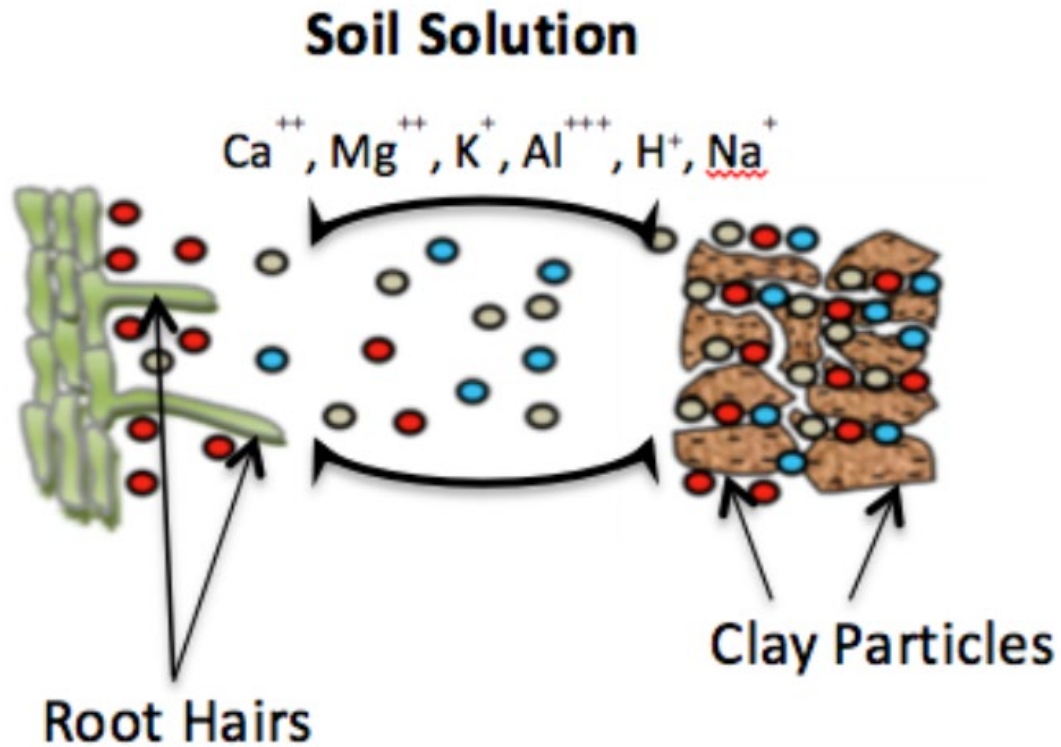
Subsoils become acid as result of natural weathering processes and though inputs of N-fertilizers and acid precipitation.

Lime moves too slowly and may take many years to raise pH in subsoil in a meaningful way.

Extremely acid subsoils can contain toxic levels of aluminum or deficient amounts of calcium and restrict root growth

And a major consequence of subsoil acidity manifests as drought stress.

# Cation Exchange Capacity



Cation Exchange Capacity C.E.C. meq/100g	PERCENT CATION SATURATION (COMPUTED)				
	K %	Mg %	Ca %	H %	Na %
11.1	1.4	18.7	38.2	41.0	0.7
10.8	2.4	19.9	46.0	31.0	0.8
13.1	1.0	22.6	37.6	38.0	0.8
12.6	3.1	12.4	49.4	34.5	0.7
12.1	3.8	14.4	43.3	38.0	0.4

Soil and Soil Components	CEC (meq/100 g)
<b>Clay Type</b>	
Kaolinite	3-15
Illite	15-40
Montmorillonite	80-100
<b>Soil Texture</b>	
Sand	1-5
Fine Sandy Loam	5-10
Loam	5-15
Clay Loam	15-30
Clay	>30
<b>Organic Matter</b>	<b>200-400</b>

# Base Saturation and Cation Balance

- Fertility of soil and balance of base cations
- Relative age or degree of weathering of a soil
- Influenced by parent material, climate, and soil age
- Indicator for certain soil conditions like serpentine, or sodium affected soils

# Nutrient Bases $K^+$ , $Ca^{2+}$ , $Mg^{2+}$ , $Na^+$

Look at relative abundance of bases in the exchange complex

$Ca^{2+} > Mg^{2+} > K^+ > Na^+$

Cation Exchange Capacity	PERCENT CATION SATURATION (COMPUTED)				
	K %	Mg %	Ca %	H %	Na %
C.E.C. meq/100g					
11.1	1.4	18.7	38.2	41.0	0.7
10.8	2.4	19.9	46.0	31.0	0.8
13.1	1.0	22.6	37.6	38.0	0.8
12.6	3.1	12.4	49.4	34.5	0.7
12.1	3.8	14.4	43.3	38.0	0.4

# Soil Test Nutrient Levels

Provide snapshot in time

Depth of sampling

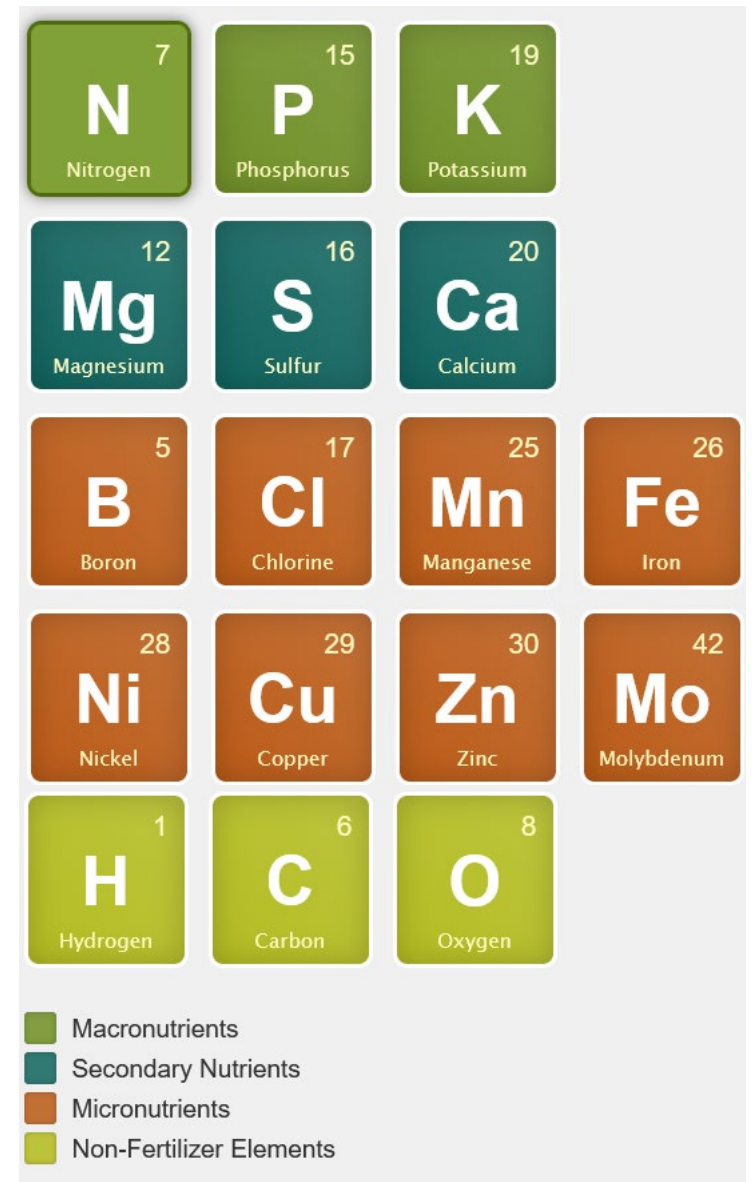
Reasons for uncertainty

When is it worth doing?

Relation to plant tissue samples



Paul's talk



# Calcium

Hidden hunger for Calcium, this is an issue in soils with low pH and low Ca saturation, or relatively high Mg saturation.

# Magnesium

Potential indicator of Serpentine

Excessive Mg causes soils to disperse and poor aggregate stability and slower drainage

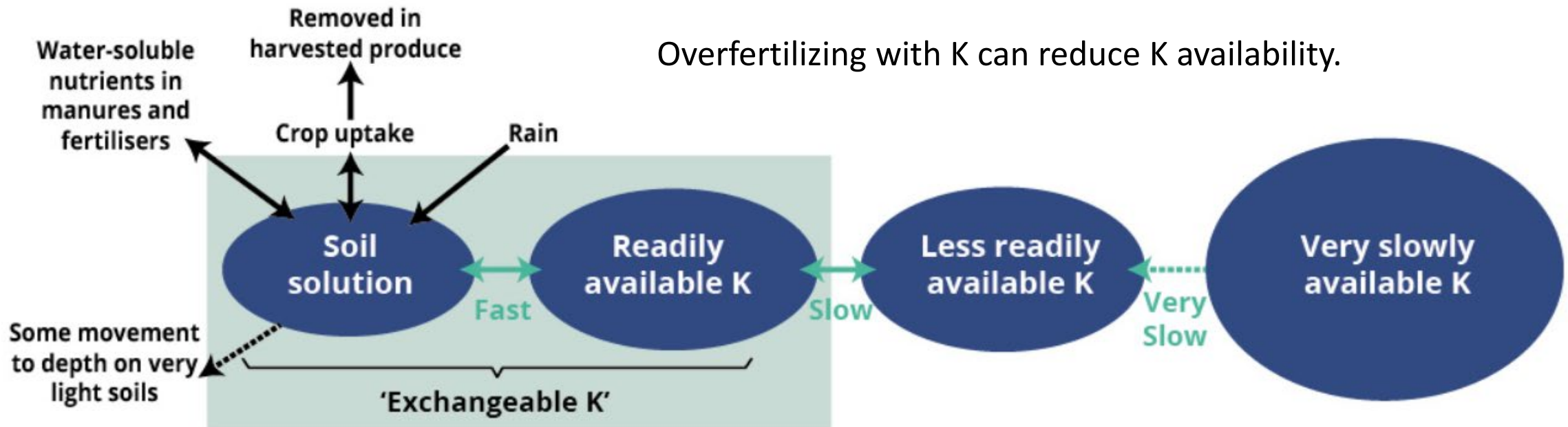
# Potassium (K<sup>+</sup>)

Soils can supply most of the K needed for crop production.

Potassium availability is closely tied to the clay, both the surface exchange sites and interlayer spaces. Subsoil typically has more clay and is important pool of K. Plants take up subsoil K and move it to the surface.

Forms are inorganic, salts. Easily leached from leaves and residues by rainfall.

Overfertilizing with K can reduce K availability.



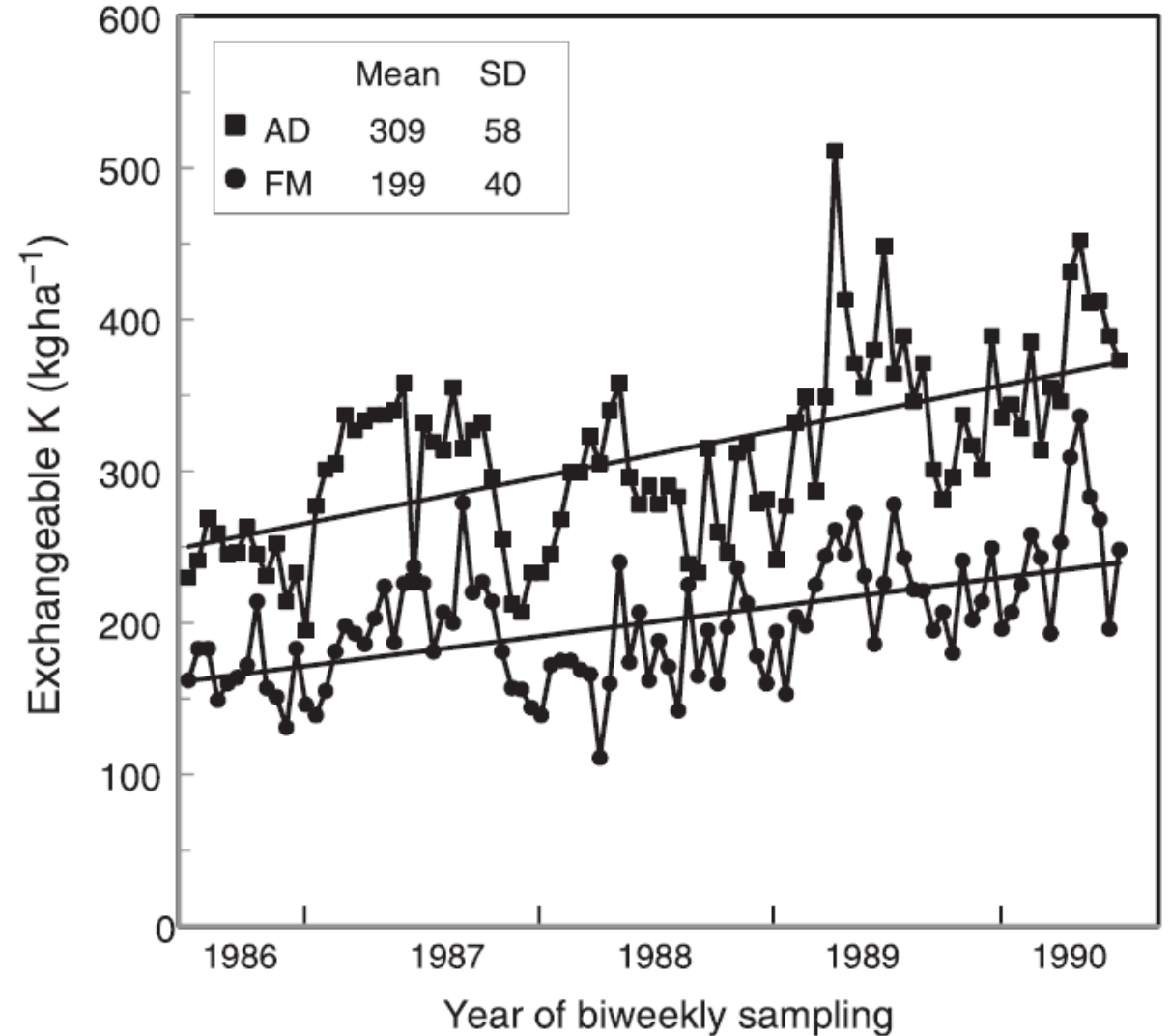
Changes in exchangeable-K, measured biweekly over 4 years

Air dry (AD) and Field Moist (FM)

Soil received no fertilizer K or P in over 20 years.

### “Potassium Paradox”

S.A. Khan *et al.*



# Soil analysis and rootstock selection

Subsoil Condition	Rootstocks	
Acidic subsoil	3309, 101-14 99R 110R	
Serpentinitic , high Mg, low K	1616C 101-14 44-53	
Alkaline subsoil	5BB 420A 5C	

# Rootstock Selection from soil test data

Serpentinitic Soil –affected soil test results showed very high Mg saturation. Soils further analyzed for Nickel after high Mg test result.

Serpentine soils form from rocks that originated in the mantle and have primarily iron and magnesium with very little calcium, potassium, sodium. They are low in phosphorus and nitrogen too. Serpentine soils can also have toxic levels of metals nickel and chromium.



Serpentine rock from Josephine Co. OR

# Serpentine Area of Southern Oregon

## CORNUTT [Soil Data Explorer](#)

19,644 acres

## BROCKMAN [Soil Data Explorer](#)

8,555 acres

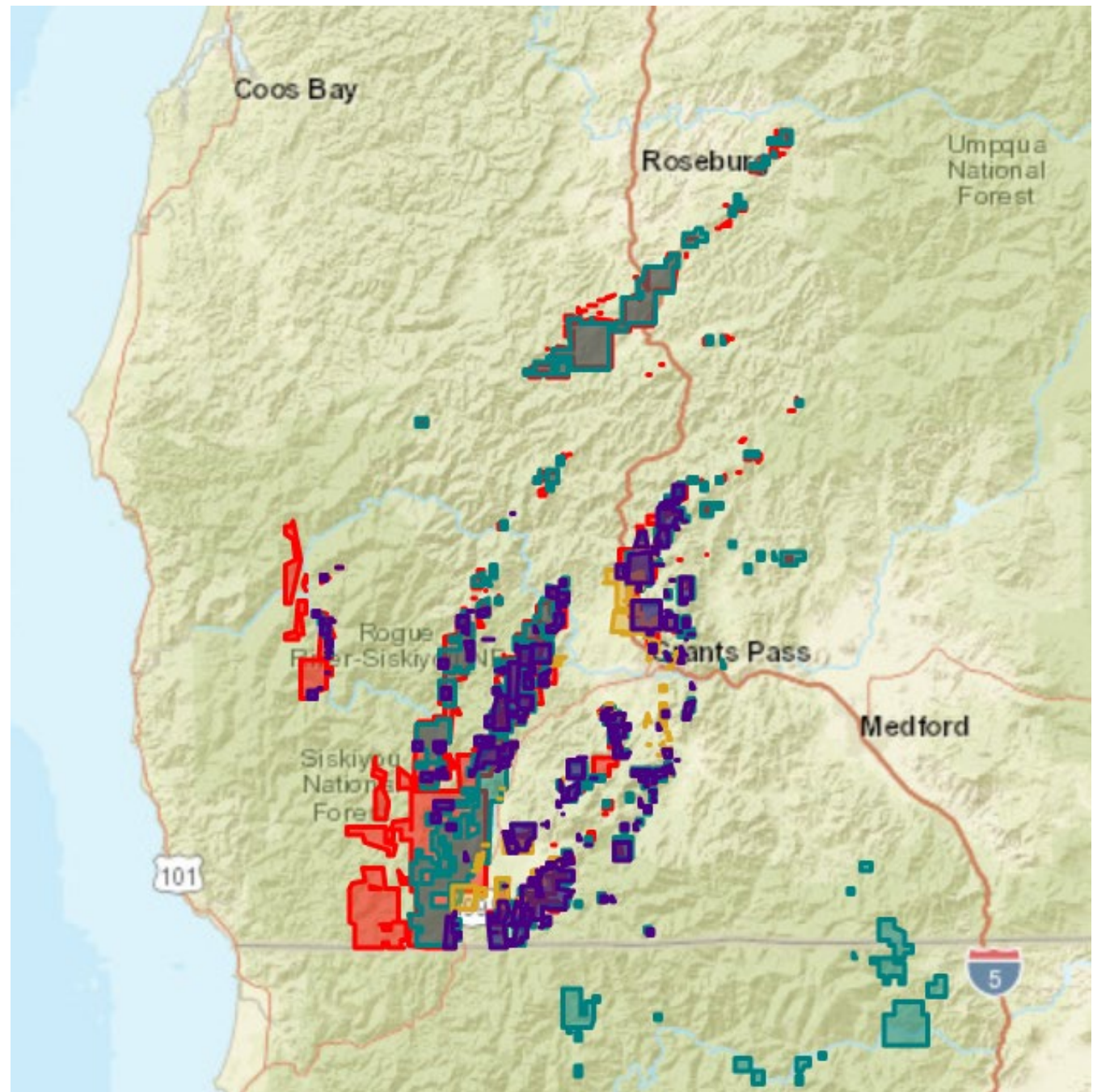
## DUBAKELLA [Soil Data Explorer](#)

124,915 acres

6 pedons sampled for lab analysis

## PEARSOLL [Soil Data Explorer](#)

57,538 acres



# Rootstock Selection

## Example: Alkaline subsoils

Alkaline soils induce iron deficiency chlorosis



*Rootstocks with genetics from Vitis berlandieri* a grape adapted to grow in alkaline soils in its native Hill Country of Texas are useful in vineyards with alkaline subsoils such as chalky soils in French vineyards.



Alkaline subsoil near Fredericksburg TX

# Boron

- Element essential to grape production
- Naturally deficient in many of our soils
- Danger in overapplying
- Look for about 2 pounds per acre
- Apply regularly as needed

# Nitrogen

- Overapplying inorganic N fertilizer burns up SOM
- Soil Microbes use extra N to consume more Soil C
- Offsite impacts of overapplying N.
- Nitrogen fixed by legumes

# Conclusions

Soil analysis is a useful tool for:

- Preplant or dormant season when no vines or no leaves are on vines
- Site evaluation and Soil classification
- Identifying subsoil properties like acidity, alkalinity and chemical imbalances
- Can be helpful in rootstock selection
- Monitoring key soil properties over time to evaluate management over time

Soil analysis is less useful for predicting the nutrient needs of the grape vine and foliar nutrient analysis is better suited to that purpose.

Thank you!