Grapevine Nutrition:

Healthy Vines = Hardy Vines

Kevin W. Ker, PhD, P.Ag.

KCMS Applied Research and Consulting Inc. and

Cool Climate Oenology and Viticulture Institute (CCOVI)

Brock University, St. Catharines Ontario Canada

CCOVI
Brock University

KCMS

What are my objectives?

- Use proper production so it can grow grapes each year (ENVIRONMENTALLY responsible)
- Produce marketable high quality grapes each and every year (SUSTAINABILITY over time)
- Understand and use practices that enable the vineyard to be viable (ECONOMICALLY viable)

- WE must be successful for **ALL THREE** components !

CCOVI
Brock University

KCMS

Grapevine Nutrition

- What are the critical elements necessary for growth?
  - What influences nutrient availability ?
- What do I have right now?
  - What does a soil test tell me?
  - What does a tissue test tell me ?
- Avoiding luxury applications
- Vine Nutrition Top Ten

CCOVI
Brock University

KCMS

There is no “ONE SIZE FITS ALL” approach to vineyard nutrition

CCOVI
Brock University

KCMS

Factors that Influence Nutrient Availability

- Water and nutrients limit vine growth and productivity
- Frequency of precipitation to enable mineral elements to be taken up by roots
- Evaporation (temperature) and transpiration demands – more transpiration more nutrient uptake
- Mineral element balance (competition for space on soil particles and uptake by vine roots)
- Cultivar, clone, rootstock and interactions

CCOVI
Brock University

KCMS

Factors that Influence Nutrient Availability

- Nutrient elements concentrated in top 50 cm of profile
- Soil type – parent material, texture, etc
  - Soil pH
  - Organic Matter (OM) Levels
  - Vine rooting depths - roots grow in nutrient rich areas but they " do not seek out" nutrients and water!
- Different minerals at different depths
- Mineral – mobile or immobile
- Cultivar, clone, rootstock and interactions

CCOVI
Brock University

KCMS

Growth Rates and Vine Nutrient Levels

- Early season growth is based on stored nutrients in vine not from root uptake! (first 3 expanded leaves from reserves)
- Further growth requires nutrient AND water uptake
- Insufficient nutrients - growth ⬇
- Water stress reduces growth and nutrient demand ⬇
- Nutrient deficiency leads to
  - Cell division ⬇ (impact on berry /cluster size and shoot growth!)
  - Photosynthesis ⬇
  - Overall vine health ⬇
  - Fruit quality ⬇
  - Vine hardiness ⬇

CCOVI
Brock University

KCMS

Critical Elements for Vine Development

Macro Nutrients

Nitrogen, Phosphorus, Potassium, Magnesium, Calcium, Sulphur

Micro Nutrients

- Iron, Manganese, Boron, Copper, Zinc, Chlorine

CCOVI
Brock University

KCMS

Nitrogen

CCOVI
Brock University

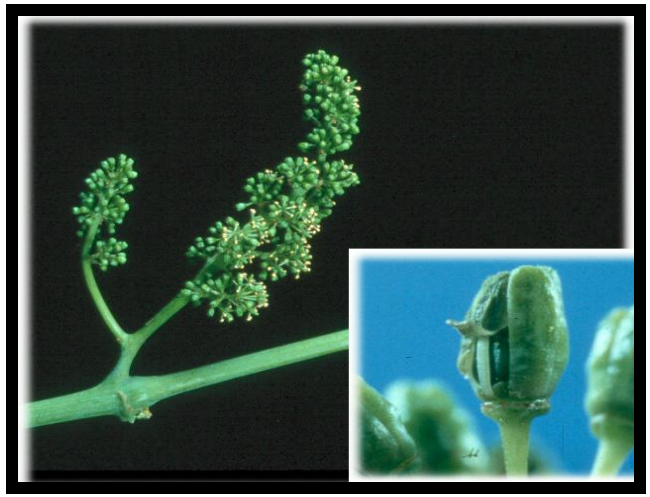
KCMS

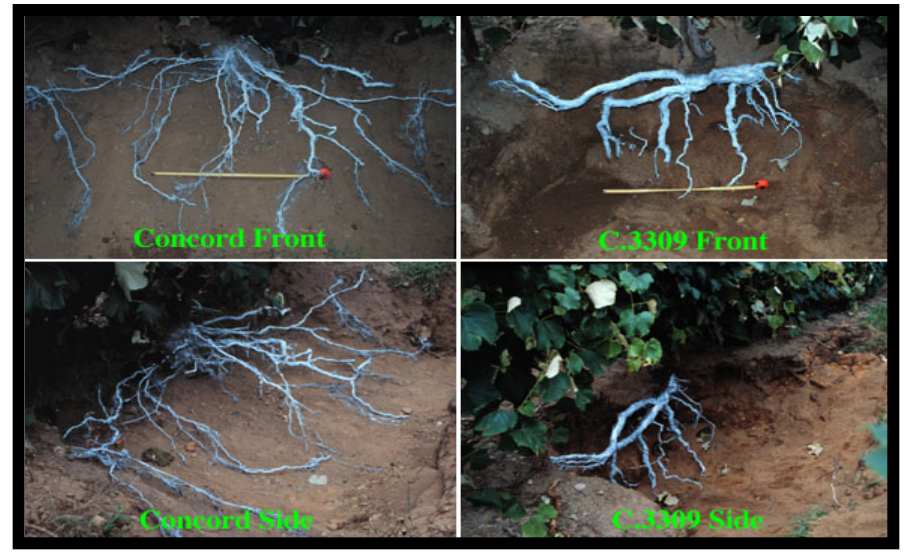
Nitrogen deficiency

- Root growth
  - Drought susceptibility
- Shoot growth ↓
- Photosynthesis ↓
  - Chlorophyll ↓ Carbohydrates ↑ Anthocyanins ↑
- Premature Leaf senescence
  - Nutrient recycling

CCOVI
Brock University

KCMS





Phosphorus

Phosphorus deficiency


P deficiency, Merlot

- Root Growth - more shallow and less at depth
  - Increase drought susceptibility
- Shoot Growth ↓
- Carbohydrates ↑
- Photosynthesis ↓
- Mg transport ↓ leads to Mg deficiency symptoms
- Premature Leaf Senescence
  - Nutrient recycling

CCOVI
Brock University

KCMS

Potassium

CCOVI
Brock University

Potassium deficiency

- Root growth – more lateral
- Shoot Growth
- Photosynthesis
- Sugar export
  - Ripening and overwintering reserves
- Xylem flow
- Premature Leaf Senescence
  - Nutrient recycling
- **Be aware of Cultivar/Clone Demand and Rootstock Interaction*

CCOVI
Brock University

KCMS

Magnesium

CCOVI
Brock University

KCMS

Magnesium deficiency

- Root growth
- Photosynthesis ⬇
  - Sugar and starch in leaves ⬆
  - Light sensitive leaves
  - Anthocyanins in leaves ⬆
- Shoot growth ⬇
- Berry development
  - Late season bunch stem necrosis
  - Shatter

CCOVI
Brock University

KCMS

Role of Micro Nutrients

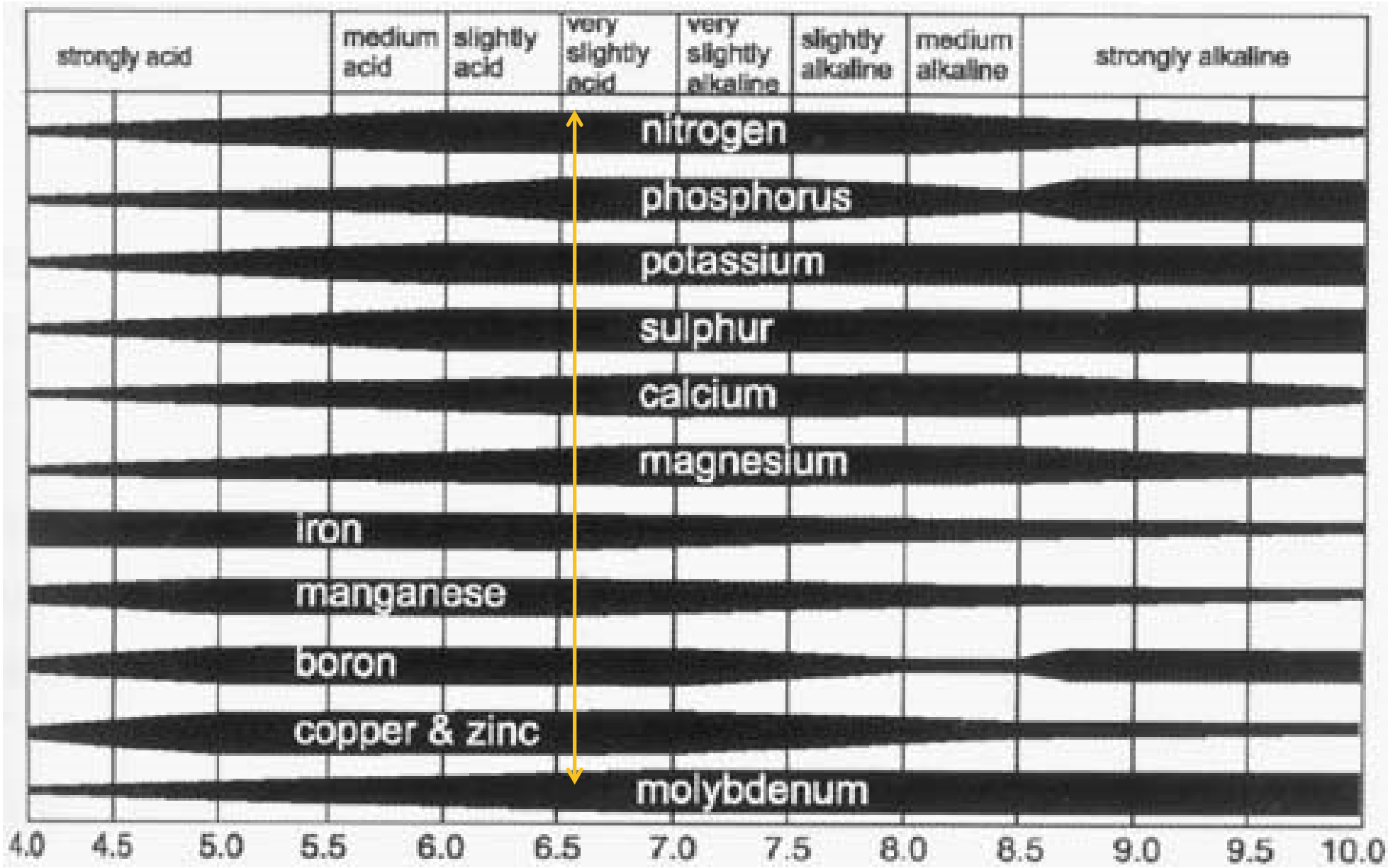
Iron	Chlorophyll, shoot growth and elongation, fruit set, shatter
Manganese	Photosynthesis, chlorophyll, enzyme activation
Boron	Pollen germination and fruit set, shoot development, root growth
Copper	Root growth, leaf formation, shoot elongation, crop load
Zinc	Plant growth and seed formation, chlorophyll, bud hardiness, stem integrity
Chlorine	Cell division, nitrogen metabolism

CCOVI
Brock University

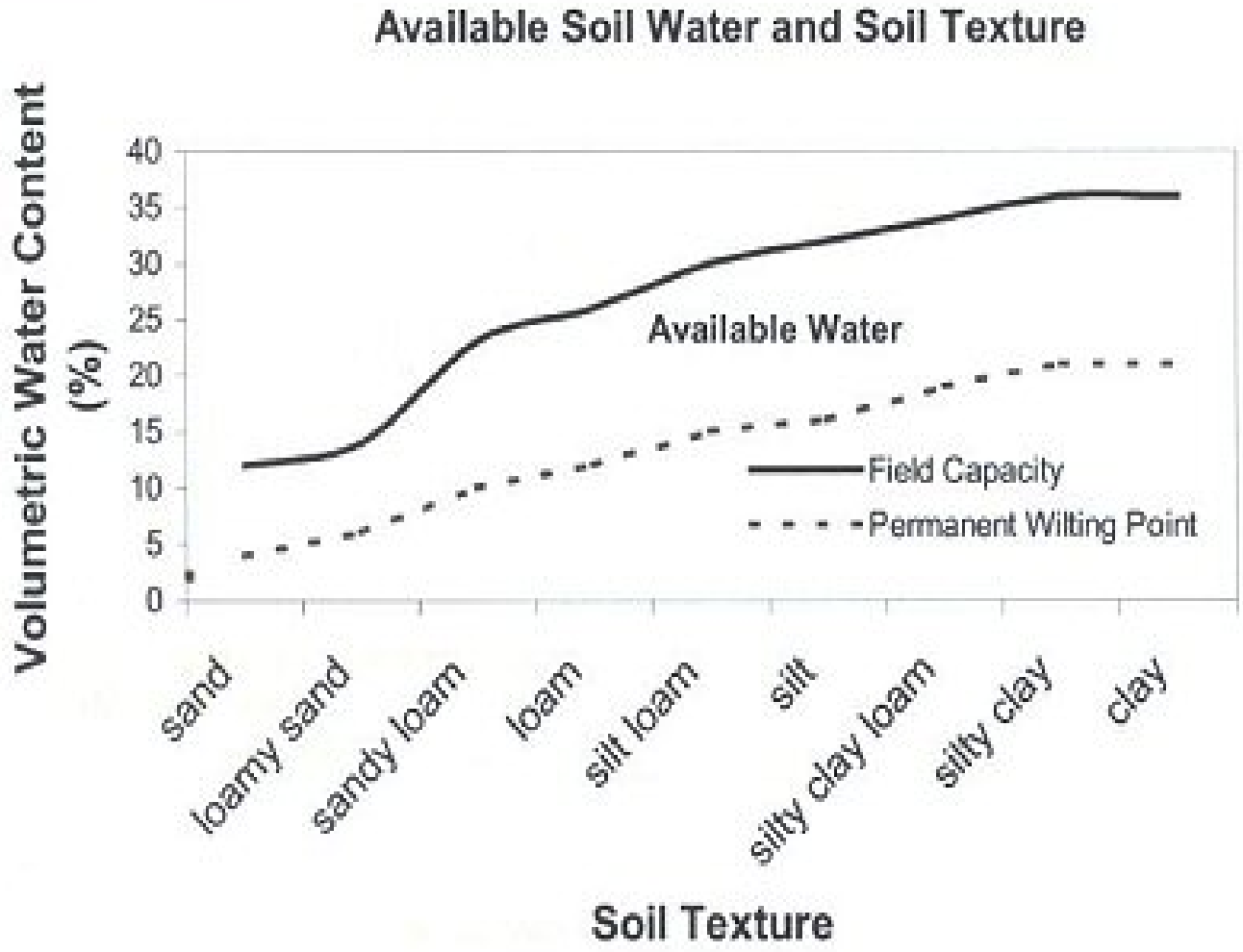
KCMS

How the nutrients move?

- Must consider soil nutrient holding capacity – texture, CEC etc
- Impact of pH
- Soil moisture levels
- Plant growth stage and demands for mineral elements
- Mobility in the soil and in the vine



Source - http://www.fao.org/docrep/008/ae939e/ae939e03.htm



http://www.gov.mb.ca/agriculture/crops/potatoes/bda04s05.html

Macronutrients			
	Mobility in Soil	Plant Available Form	Mobility in Plant
Nitrogen	Med – High	NH_4^+, NO_3^-	High
Phosphorus	Low	$HPO4^{-2}$, $H_2PO_4^-$	High
Potassium	Low – Med	K^+	High
Calcium	Low	Ca^{+2}	Low
Magnesium	Low	Mg^{+2}	High
Sulphur	Medium	SO_4^{-2}	High

CCOVI
Brock University

KCMS

Micronutrient Mobility

	Mobility in Soil	Plant Available Form	Mobility in Plant
Boron	**High**	**$B(OH)_3$, $H_2BO_3^-$**	**Low-med**
Copper	**Low**	**Cu^{+2}**	**Med**
Iron	**Low**	**Fe^{+2}, Fe^{+3}**	**Low**
Manganese	**Low**	**Mn^{+2}**	**Low**
Molybdenum	**Low-med**	**MoO_4^{-2}**	**Low-med**
Zinc	**Low**	**Zn^{+2}, $Zn(OH)_2^0$**	**Low**
Chlorine	**High**	**Cl^-**	**High**

CCOVI
Brock University

KCMS

Why do people use fertilizers?

Habit

Good Salesman

Laboratory Recommendation

CCOVI
Brock University

KCMS

How should I decide what nutrients are *REALLY* needed ?

Need to think like Sherlock Holmes and Dr. Watson

- Observe the patient in the field (vine)
- Understand the patient's lifestyle (crop load, pruning, training, environment, etc)
- Check the patients diet (soil)
- Physically check over the patient (tissue)

CCOVI
Brock University

KCMS

Soil and Tissue Sampling

- Establish base levels of nutrients
- Diagnose problem areas
- Monitor nutrient levels
- Assist in establishing fertilizer and lime requirements

CCOVI
Brock University

KCMS

Why do people take soil and tissue samples?

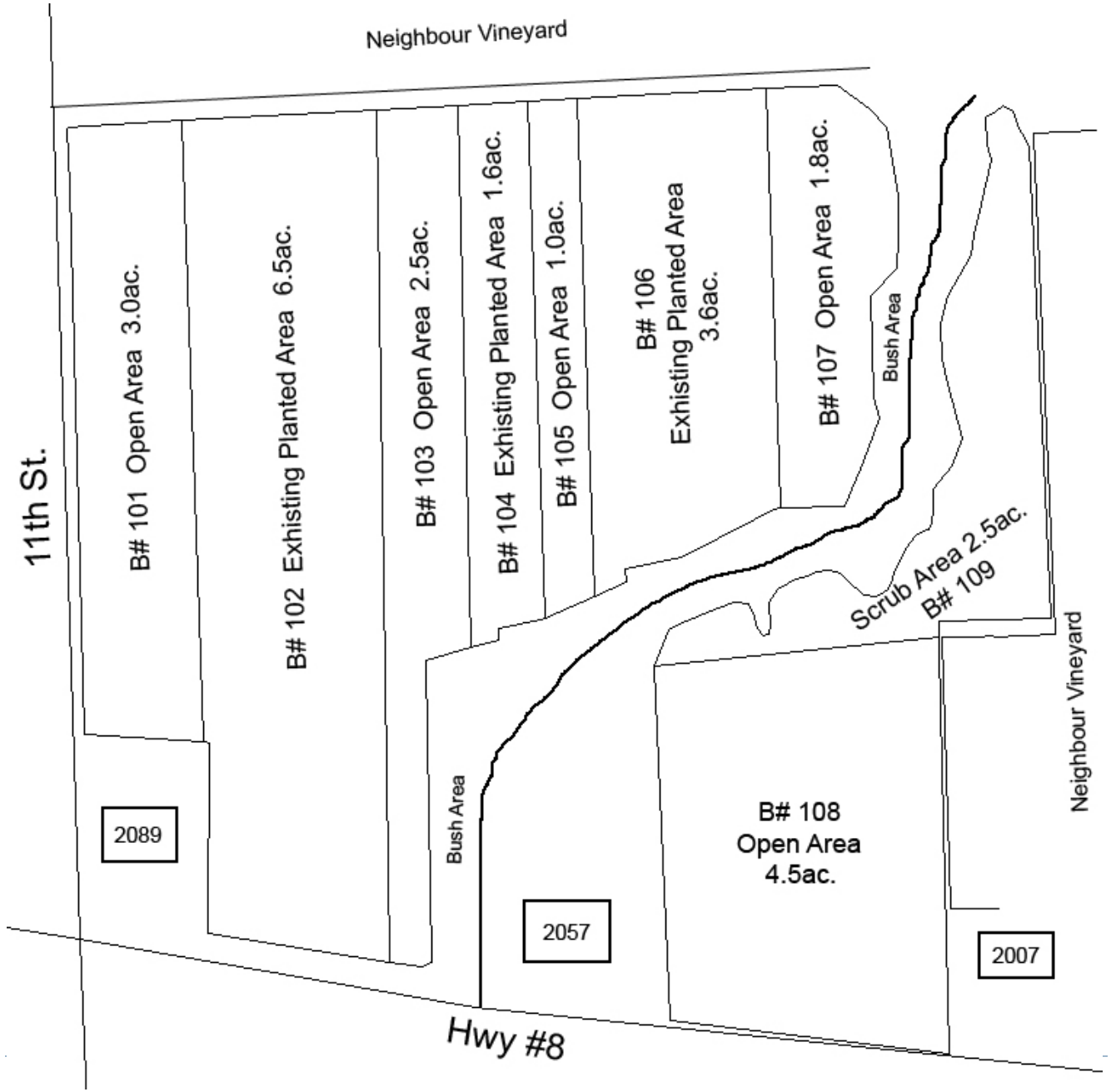
- Observations of poor vine growth or fruit quality
- Poor yields
- Want higher yields than what they are currently getting
- Correct issues before they become a problem (prevention versus treatment!)
- Understand need to develop personal and site specific vineyard data

CCOVI
Brock University

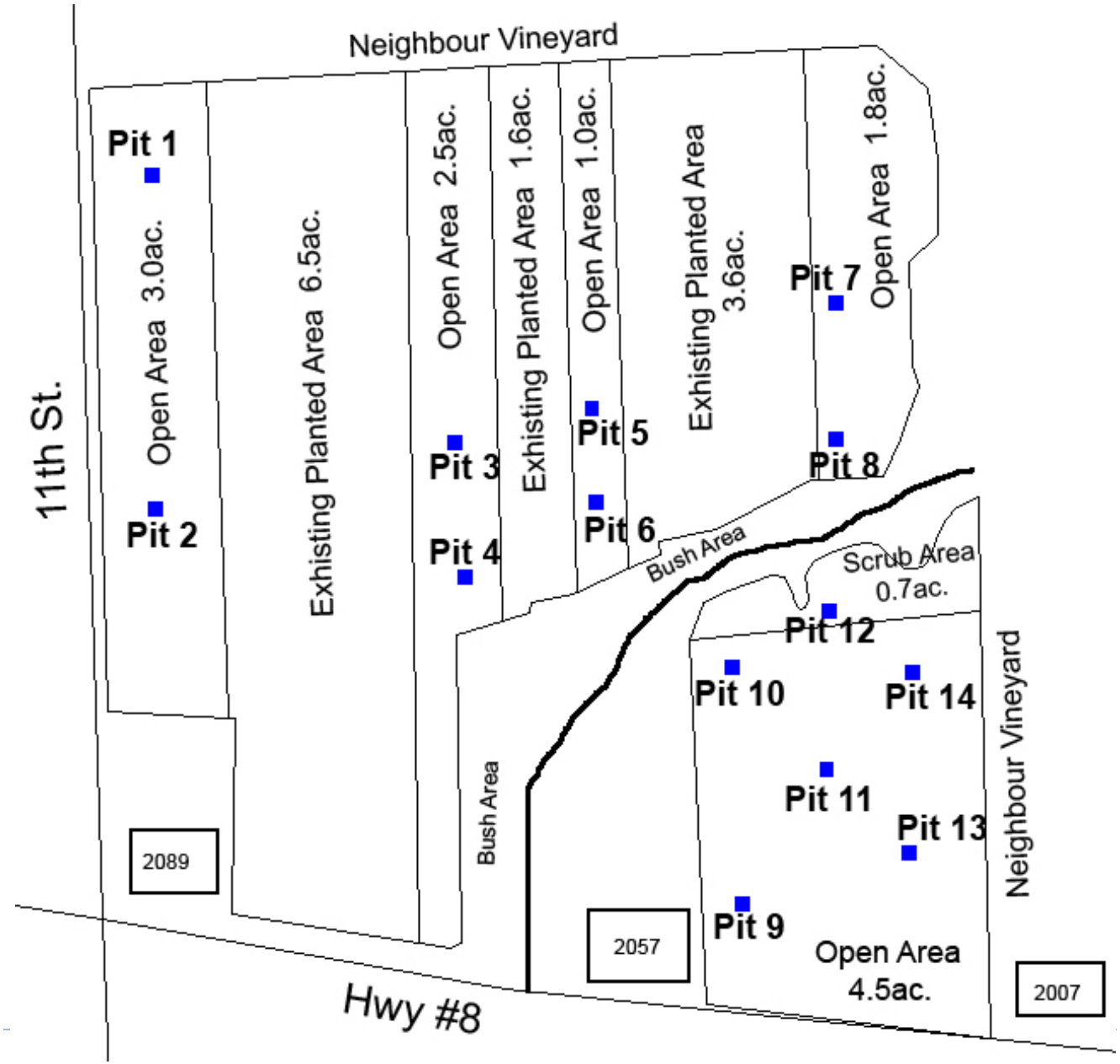
KCMS

- What do I have available ? (Soil)
- What is the vine taking up ? (Tissue)
- What do I change? (Fertilization)

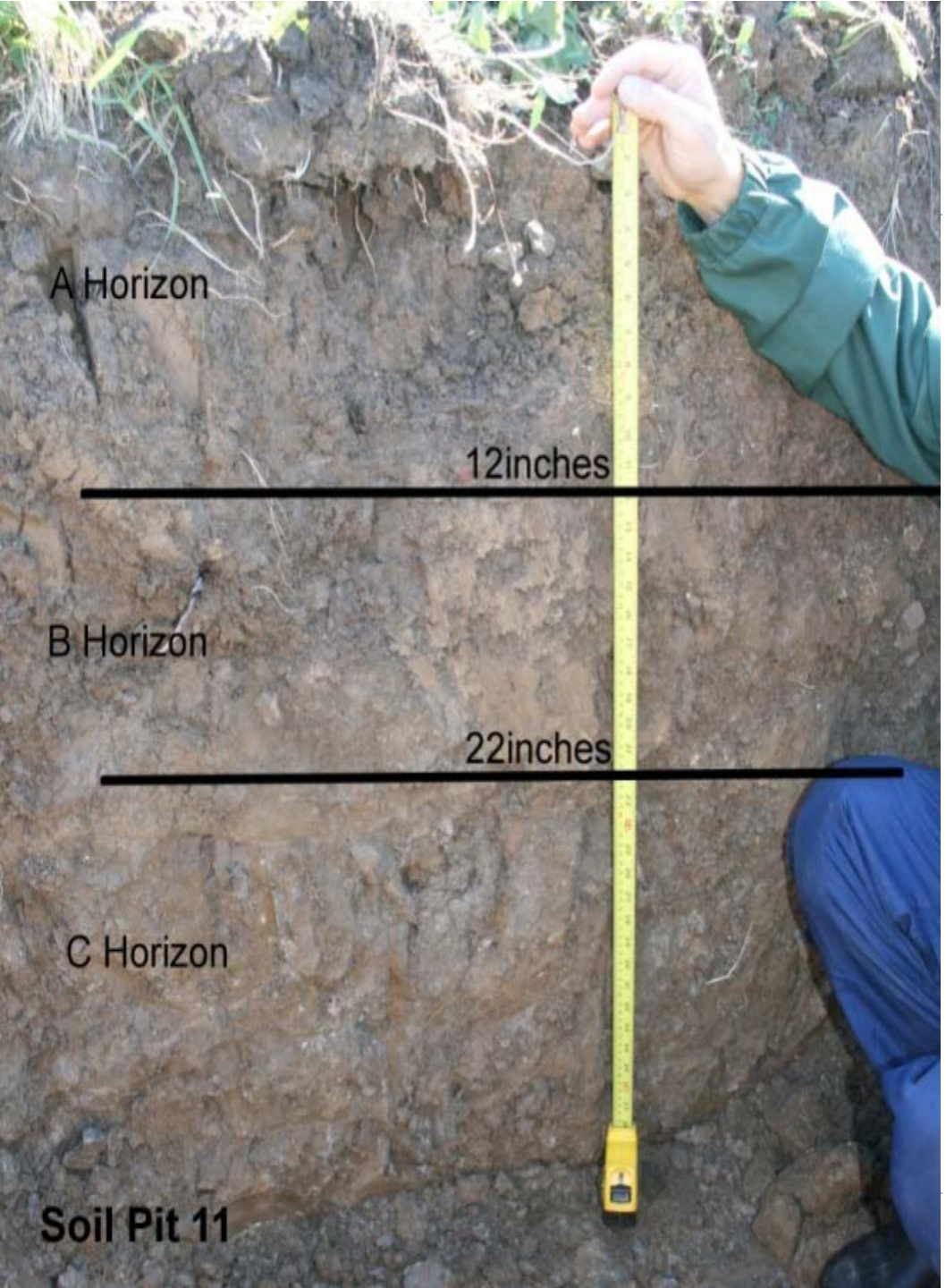
Source - http://cit.cati.csufresno.edu/images/photos/cit4.jpg



Start with a Good Map



Dig Some Pits



- Clover mix and barnyard grasses mainly present in this area

A Horizon

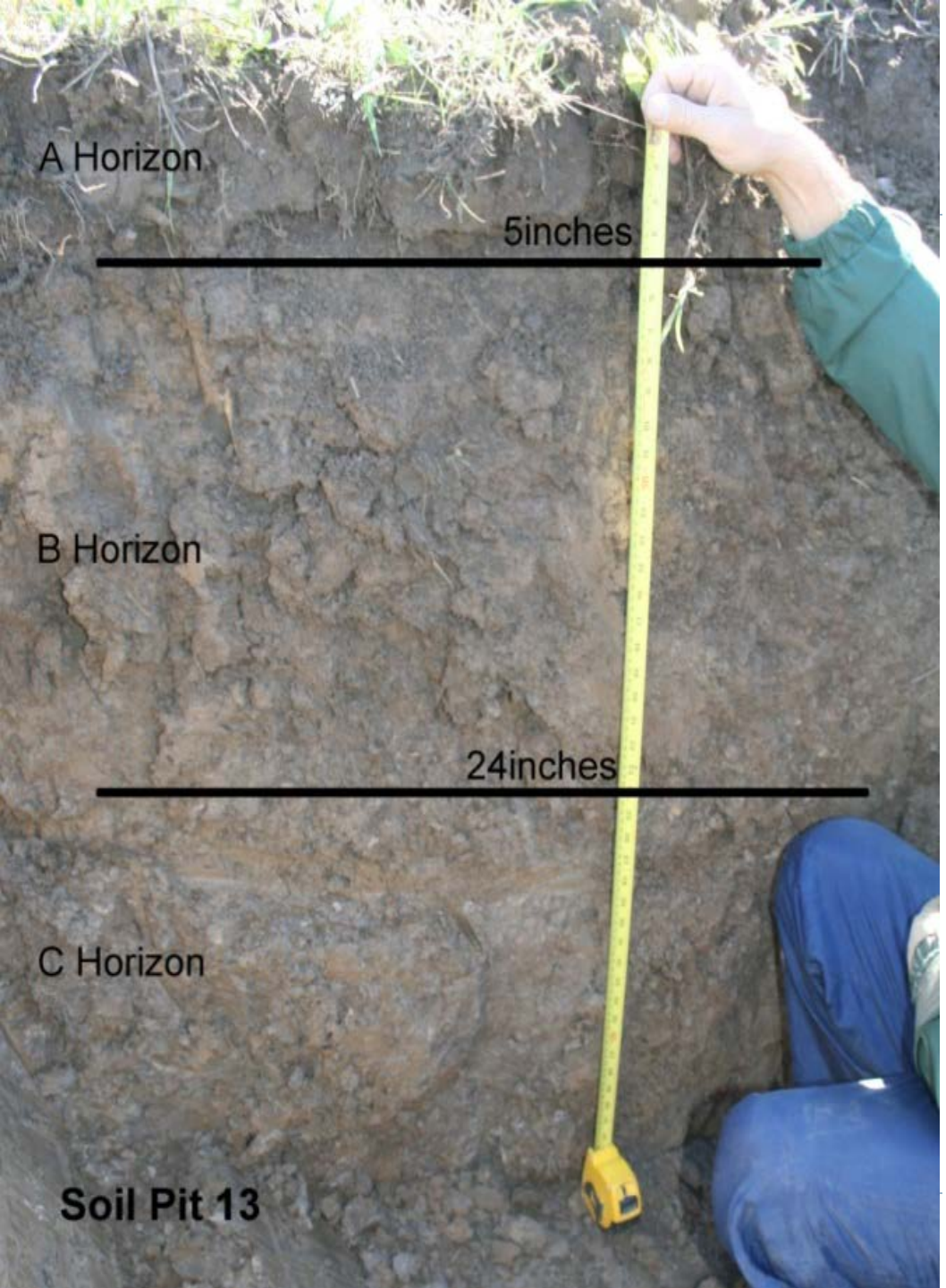
- 0-12 inches
- Highly fractured and good soil tilth
- Quite friable and appears to be in good condition
- Earthworm activity noted

B Horizon

- 12-22 inches
- Some roots and earthworm activity found at depth
- Appears loose with some minor silt packing
- Orange coloured (iron) streaks throughout this layer

C Horizon

- 22+ inches
- Good structure however slightly packed
- Some roots are present in this horizon
- Mainly clay with a higher degree of gravel mix than the other pits



- Clover mix and barnyard grasses mainly present in this area

A Horizon

- 0-5 inches
- Some mixing has occurred with the B horizon
- Appears to break apart easily when digging
- Iron streaking is present and slightly more wet that other areas
- Earthworm and root presence noted

B Horizon

- 5-24 inches
- Some roots and earthworm activity found at depth
- Appears loose with some minor silt packing

C Horizon

- 24+ inches
- No signs of any roots
- Very hard packed clay with poor natural drainage

What a Soil Analyses provides

- General composition of the soil
- Soil pH at time of sampling
- Assist in planning fertilization program for the future

CCOVI
Brock University

KCMS

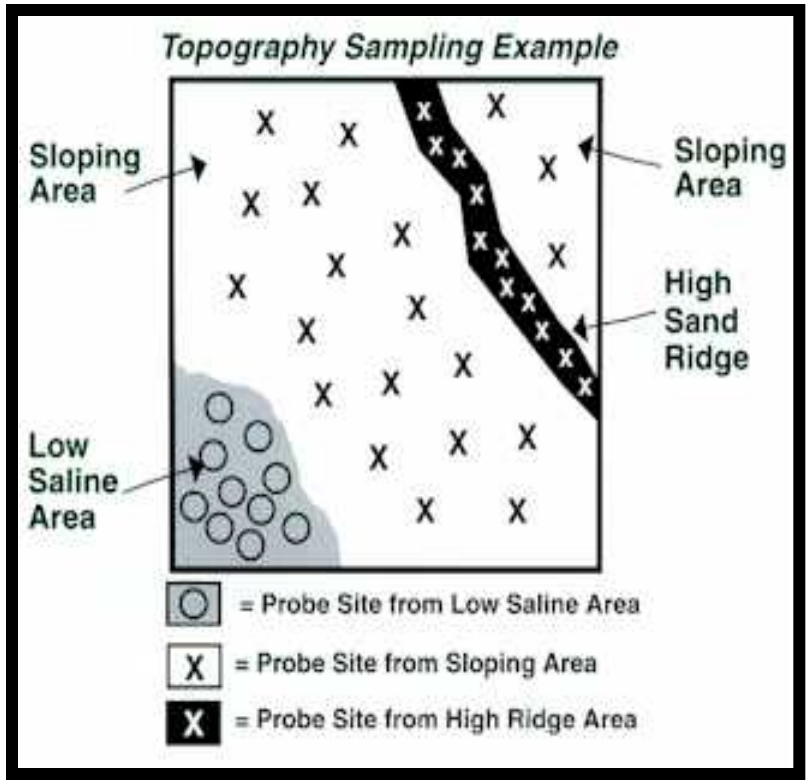
Soil sampling location

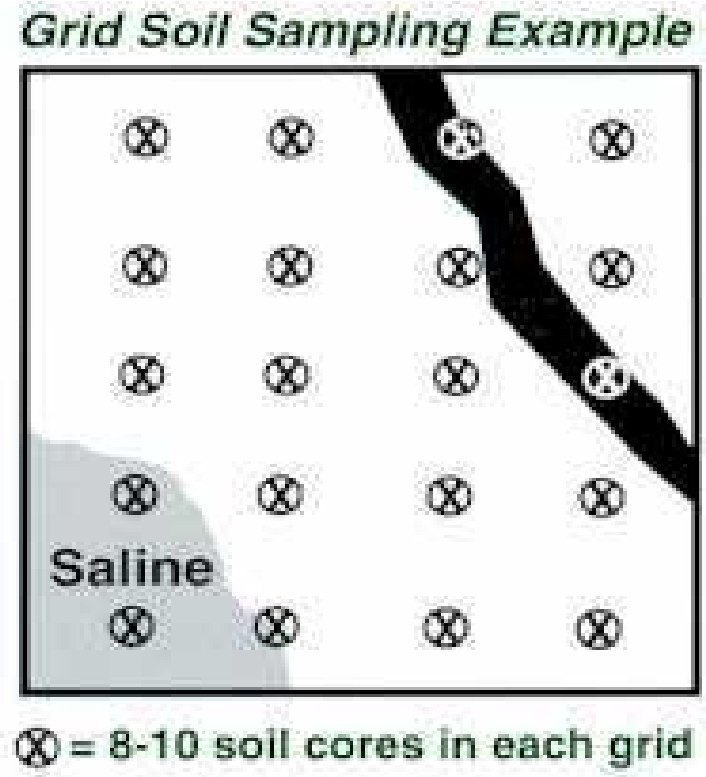
- Sampling zone

CCOVI
Brock University

KCMS

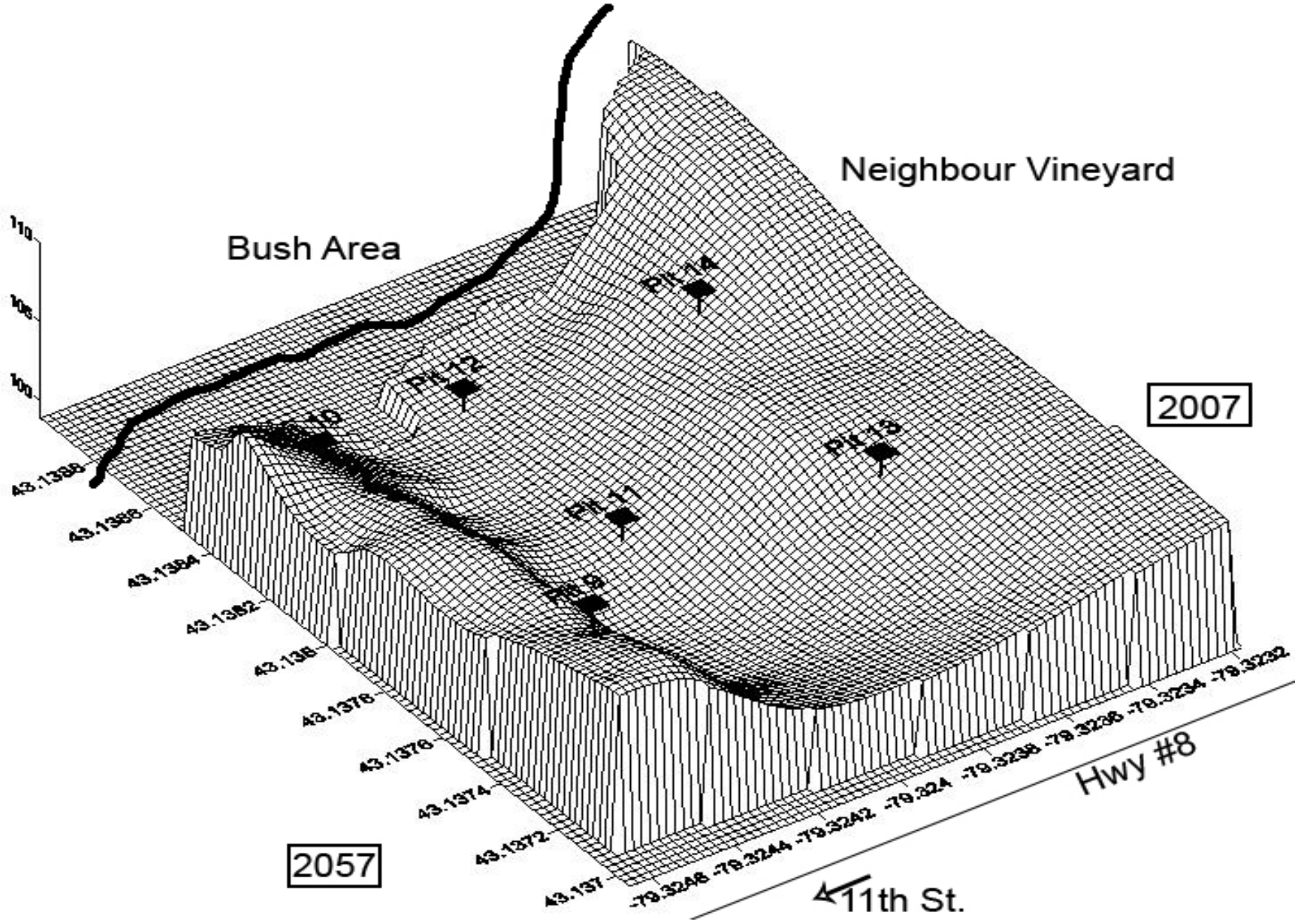
Location in Vineyard





CCOVI
Brock University

KCMS


Neighbour Vineyard
Bush Area
2007
2057
Hwy #8
11th St.
Pt-14
Pt-12
Pt-13
Pt-11
Pt-10
Pt-9
110
105
100
43.1388
43.1386
43.1384
43.1382
43.138
43.1378
43.1376
43.1374
43.1372
43.137
-79.3248
-79.3244
-79.3242
-79.324
-79.3238
-79.3236
-79.3234
-79.3232

What a Tissue Analyses provides

- General concentration in tissue
- Results will be variable with tissue selected and time of season selected
- Nitrogen content will fluctuate over season
- Plant stresses not taken into consideration – e.g. drought, excessive crop level, recent pruning, shading
- Does NOT tell you what is available in the soil

CCOVI
Brock University

KCMS

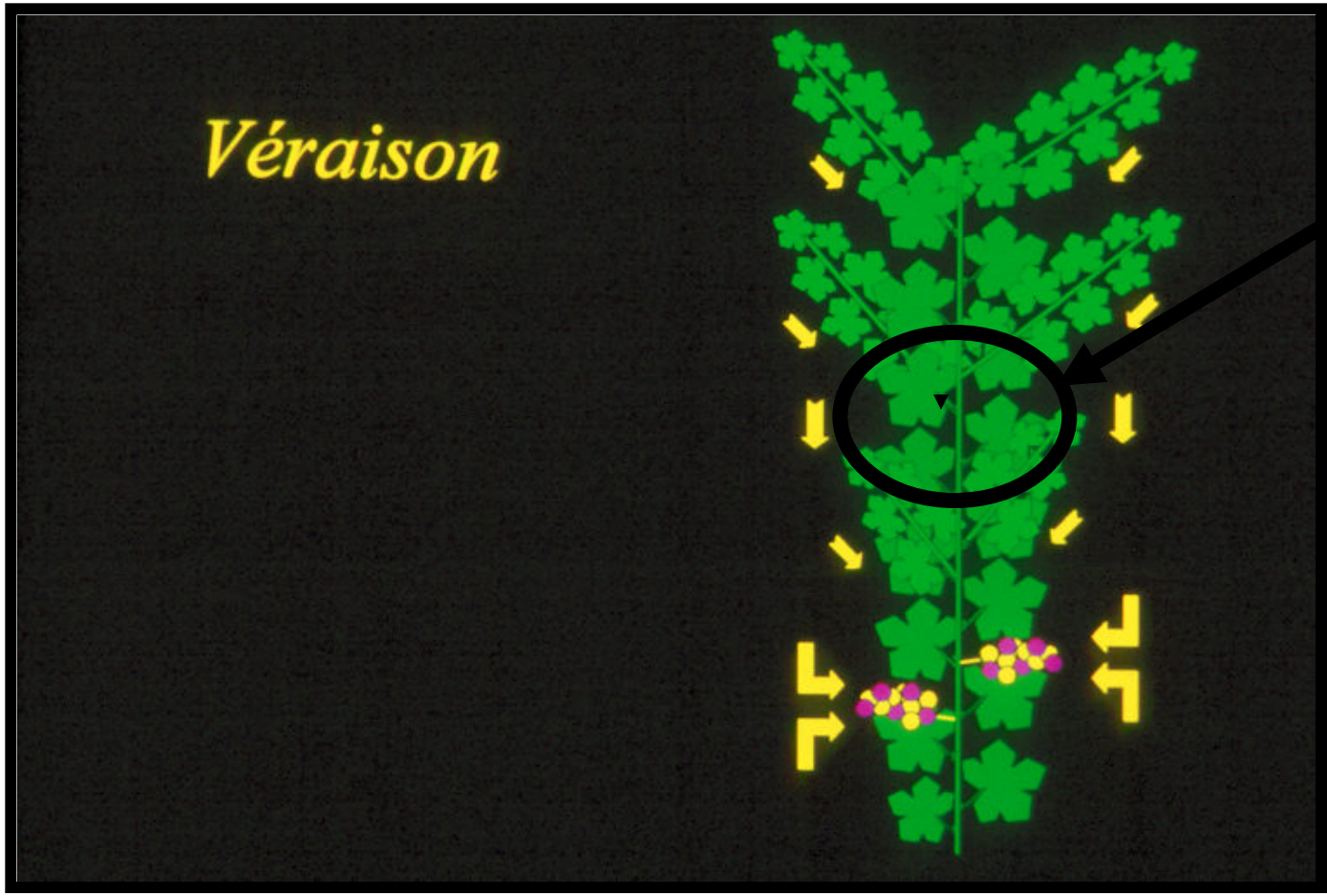
Sample Tissue Just Before Bloom

- Leaf opposite primary fruit cluster

CCOVI
Brock University

KCMS

Veraison Tissue Sampling



- Petiole sampling area

CCOVI
Brock University

KCMS

Getting Laboratory Results

- Be very aware !

- Tissue results will vary
  - with the age of the vines
  - cultivars
  - time of the year sampled
  - plant part sampled
  - representativeness of the sample for the area
  - vine ***stress*** – water, heat, crop load, competition, injury from pests
  - pesticide use – some have trace elements or active (e.g.. Cu and S)

CCOVI
Brock University

KCMS

		TISSUE		TISSUE	
HOME		2012		2011	
MERLOT		ABC-3		ABC-3	
	pH	******		******	
	O M	******		******	
	N	0.65	L	0.70	A
	Ca	1.98	A	1.91	A
	P	0.25	A	0.23	A
	K	4.61	H	4.94	H
	Mg	0.68	A	0.50	A
	Zn	99.37	A	66.23	A
	Mn	59.80	A	113.68	A
	Cu	5.54	A	8.25	A
	Fe	34.41	A	54.56	A
	B	42.94	A	49.14	A

		TISSUE		TISSUE	
HOME		2012		2011	
CHARD		ABC-4		ABC-4	
	pH	******		******	
	O M	******		******	
	N	0.83	A	0.70	A
	Ca	2.22	A	1.98	A
	P	0.15	A	0.19	A
	K	2.91	H	2.81	H
	Mg	0.69	A	0.55	A
	Zn	84.83	A	62.32	A
	Mn	61.90	A	92.74	A
	Cu	4.21	A	4.55	A
	Fe	24.43	A	31.67	A
	B	36.09	A	42.08	A

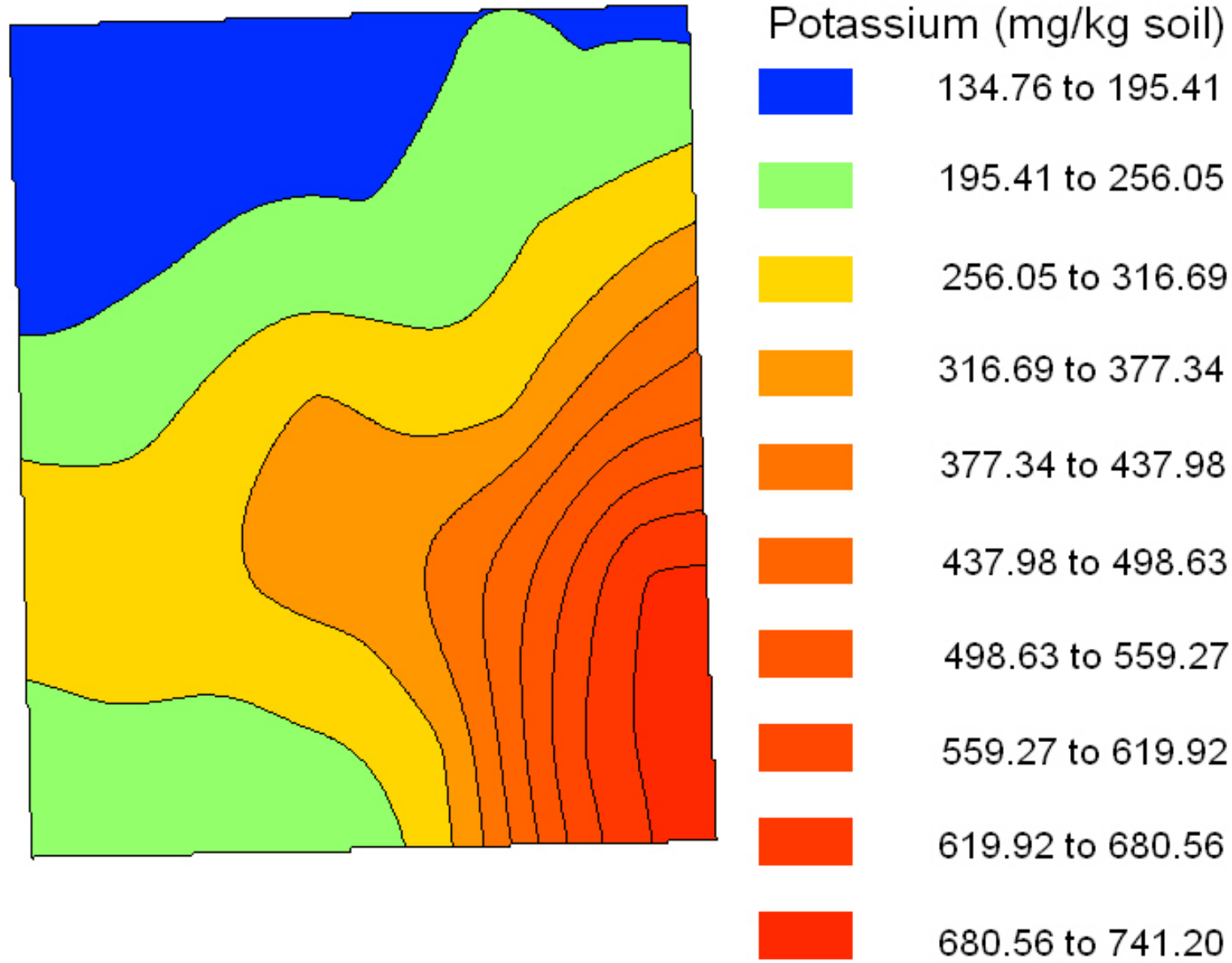
		TISSUE 2012		SOIL 2011		TISSUE 2010	
		10284606		2932907		9527206	
		KLM - 7		**KLM-6**		**KLM- 6**	
	pH	********		7.01	**A**	********	
	O M	********		2.4	**A**	********	
Cab. Sauv	**N**	0.6	**L**	********		0.7	**A**
South end	**Ca**	2.0	**A**	71.2	**A**	1.7	**A**
	P	0.2	**A**	38.5	**A**	0.2	**A**
	K	**3.5**	**A**	**3.1**	**L**	**4.3**	**H**
	Mg	0.6	**A**	14.5	**A**	0.5	**A**
	Zn	**63**	**A**	**2.9**	**H**	**43.8**	**A**
	Mn	61	**A**	17.5	**A**	76.0	**A**
	Cu	4	**A**	6.5	**A**	8.7	**A**
	Fe	20	**A**	27.5	**A**	45.5	**A**
	B	**33**	**A**	**0.71**	**H**	**42.1**	**A**

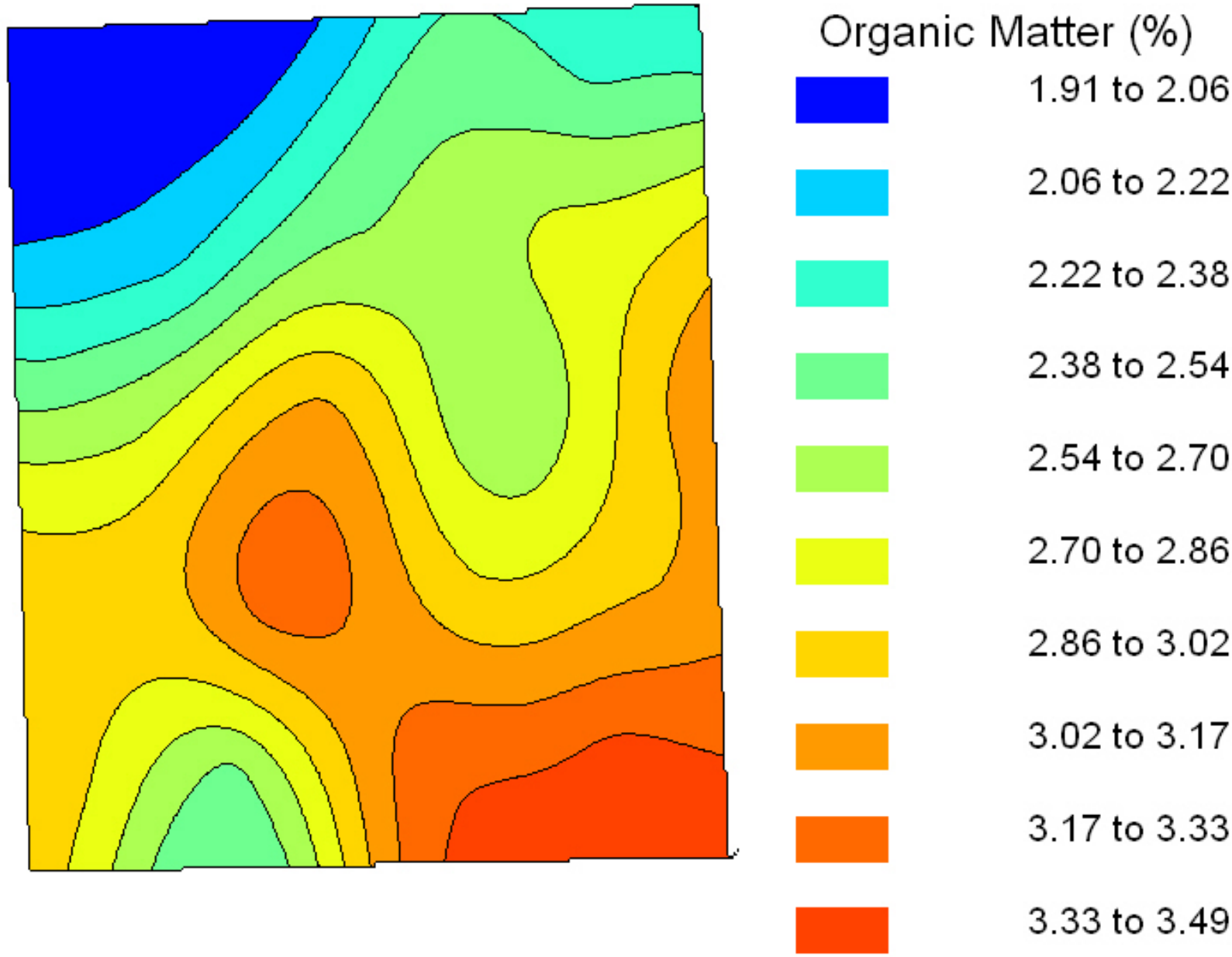
		TISSUE 2012		TISSUE 2012			
		10284607		10284606			
		KLM -8		**KLM -7**			
	pH	********		********			
	O M	********		********			
Cab. Sauv	**N**	0.7	**L**	0.6	**L**	Cab. Sauv	
North end	**Ca**	1.7	**A**	2.0	**A**	South end	
	P	0.3	**A**	0.2	**A**		
	K	**2.2**	**A**	**3.5**	**H**		
	Mg	0.8	**A**	0.6	**A**		
	Zn	42	**A**	63	**A**		
	Mn	61	**A**	61	**A**		
	Cu	2.3	**A**	4	**A**		
	Fe	23	**A**	20	**A**		
	B	35	**A**	33	**A**		

Getting Laboratory Results

- Be very aware of the generalizations used by labs!

- Soil Results will vary
  - with topography
  - cultivation practices
  - time of the year sampled
  - prior application of OM or fertilizers
  - representativeness of the sample for the area
  - pesticide use – some have trace elements or active (e.g.. Cu and S)


Potassium (mg/kg soil)
134.76 to 195.41
195.41 to 256.05
256.05 to 316.69
316.69 to 377.34
377.34 to 437.98
437.98 to 498.63
498.63 to 559.27
559.27 to 619.92
619.92 to 680.56
680.56 to 741.20


Organic Matter (%)
1.91 to 2.06
2.06 to 2.22
2.22 to 2.38
2.38 to 2.54
2.54 to 2.70
2.70 to 2.86
2.86 to 3.02
3.02 to 3.17
3.17 to 3.33
3.33 to 3.49

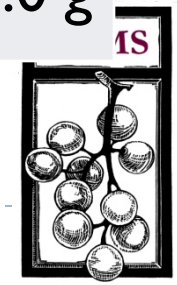
Now I have some numbers so…….?

- General assumption that 50% of nutrients taken up by the vine are assimilated in roots/leaves/shoots or lost

- Crop removal in fruit is estimated at:

	N	P	K	Ca	Mg	Mn	Fe	Zn	Cu	B
Lb/t	4.5	1.5	6.75	0.5	0.4	.005	.01	.02	.002	.005
Kg/t	2.25	0.8	3.5	0.25	0.20	7 g	15 g	30 g	2.5 g	6.0 g

CCOVI
Brock University



Now I have some numbers so…….?

- Must remember that results must be interpreted using local data and experience

CCOVI
Brock University

KCMS

Minor Element Tissue Test Values

Element (ppm)	Ontario (Cline)	NE USA	Australia	Oregon
Boron	20-60	25-50	30-100	25-50
Iron	15-100	30-100	NA	31-100
Manganese	20-200	100-1500	25-200	61-650
Copper	NA	5-15	10-300	6-20
Zinc	15-100	30-60	35-60	41-100
Aluminum	NA	NA	NA	NA

CCOVI
Brock University

KCMS

Major Element Tissue Test Values

Element	Ontario (Cline)	NE USA	Australia	Oregon
Nitrogen	0.7-1.3 %	0.8-1.2 %	2.2-4.0 %	0.6-1.5 %
Phosphorus	.15- .40 %	.14- .30 %	.15- .30 %	.16- .25 %
Potassium	0.8 – 2.5%	1.2- 2.0 %	.8 –1.6 %	0.5-1.5%
Calcium	1.0-3.0 %	1.2-2.0%	1.8-3.2 %	2.0-4.0%
Magnesium	0.5-1.5 %	.35- .75 %	0.3-0.6 %	0.2-0.4 %

CCOVI
Brock University

KCMS

Major Element Soil Test Values

Element	**Ontario**	**NE USA**	**Australia**	**Oregon**
pH	6.5 – 7.2	6.0 – 7.0	6.0 – 7.5	6.5 – 7.4
Organic Matter	2.0 – 3.5%	3 – 5 %	2 –3 %	2.5 %
Nitrogen	NA	NA	NA	NA
Phosphorus	20 ppm	20-50 ppm	30-80 ppm	20-100 ppm
Potassium	120 –150	75 – 100	100 -250	150
Calcium	1000- 5000	500-2000	1000 –2500	1000-2500
Magnesium	100 -250	100- 250	NA	60 - 180

Minor Element Soil Test Values

Element	**Ontario**	**NE USA**	**Australia**	**Oregon**
Zinc	1 ppm	2 ppm	0.8 –2 ppm	1 ppm
Manganese	NA	20 ppm	4 ppm	1.5 ppm
Copper	NA	0.5 ppm	0.3 ppm	0.6 ppm
Iron	NA	20 ppm	20 ppm	NA
Boron	0.5 ppm	0.3-2.0 ppm	0.5 ppm	0.5 ppm

Now I have some numbers so……..?

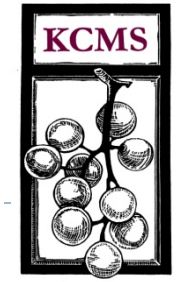
- Must remember that the elements all work in concert with one another – No single element performs alone!

CCOVI
Brock University

KCMS

Questions ?

CCOVI
Brock University



Nutrition 101- Top Ten

1. Make a good site map for you and others to follow
2. Collect data over time for YOUR site – no two locations are the same
3. Compare your results with ONSITE observations of vine performance

CCOVI
Brock University

KCMS

Nutrition 101- Top Ten

4. Sample from GOOD and POOR areas on same site to develop your own target values for results
5. Be consistent - create a 5 year plan of sampling - same time of year and general locations
6. Before applying any fertilizers be sure it to meet a REAL need **not a guess** of need

CCOVI
Brock University

KCMS

Nutrition 101- Top Ten

7. Nutrient applications are not cheap and costs skyrocket if you blend in micronutrients (are they really needed?)
8. Foliar fertilizers good when symptoms visible but a luxury expense when not needed
9. All purpose foliar products often have you paying for what is not needed

CCOVI
Brock University

KCMS

Nutrition 101- Top Ten

10. Walk your vineyard regularly –

Using your own experience and knowledge along with your senses (sight, touch, taste, smell) can tell you a lot more than paper results!

CCOVI
Brock University

KCMS

Additional Information Sources

- Wine Grape Production Guide for Eastern North America (2008) – T.K. Wolf , Editor
- Oregon Viticulture (2003) – E.W. Hellman, Editor
- Grapevine Nutrition into Practice (2005) CCRV Australia
- Mineral Nutrition of Higher Plants 2Nd Ed. (2003). - H. Marschner
- The Science of Grapevines: Anatomy and Physiology (2010). -M. Keller WSU

CCOVI
Brock University

KCMS

Thanks for your time!