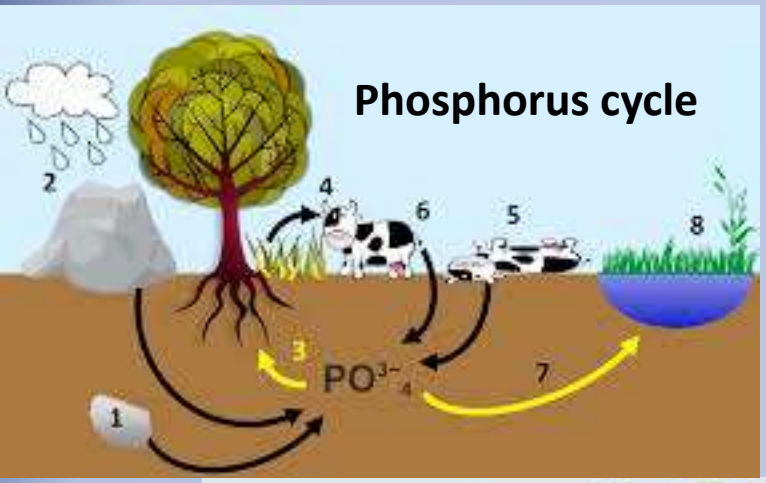
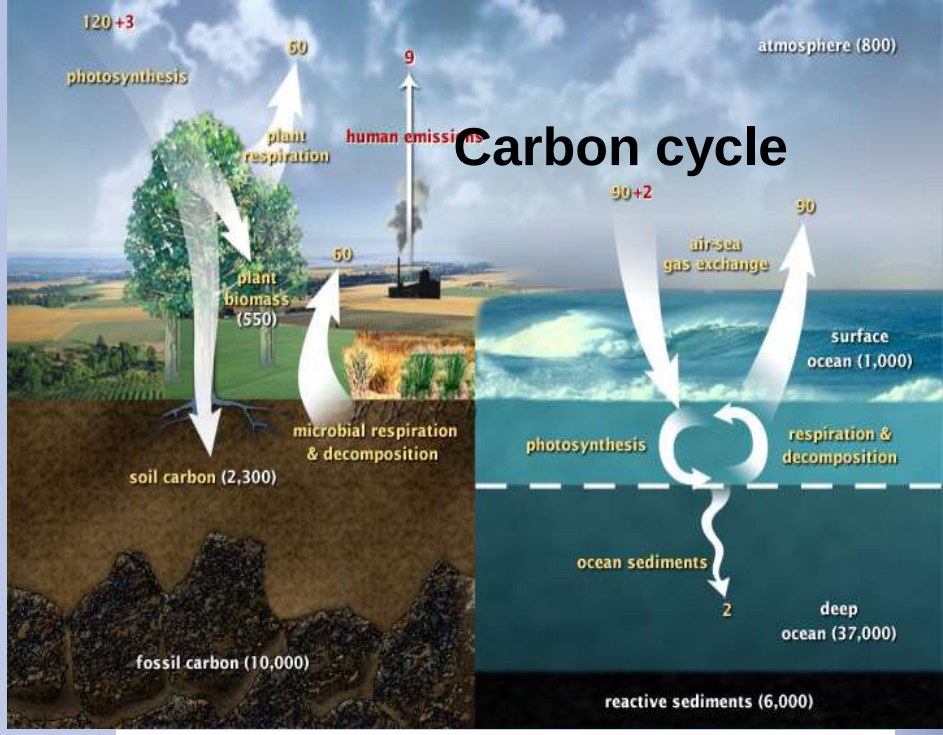
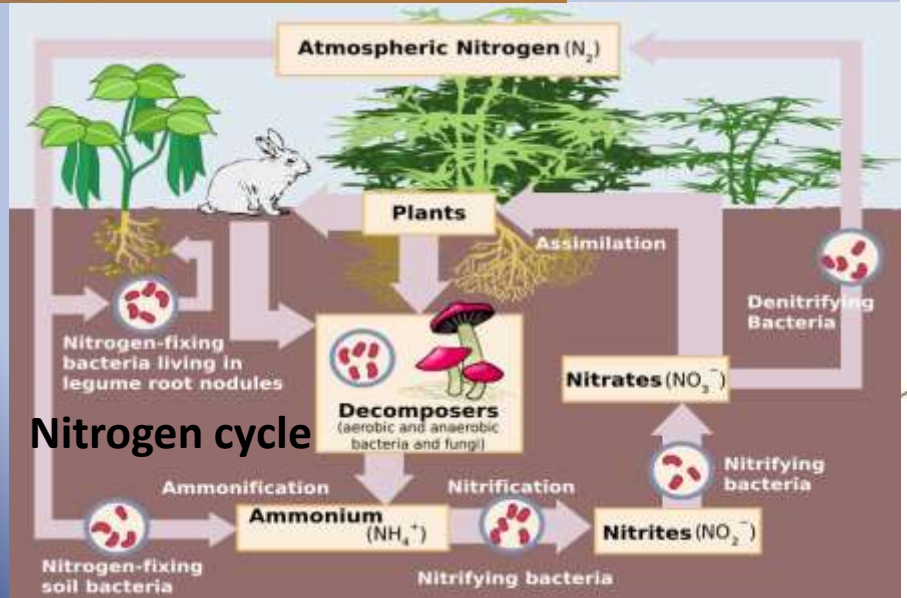
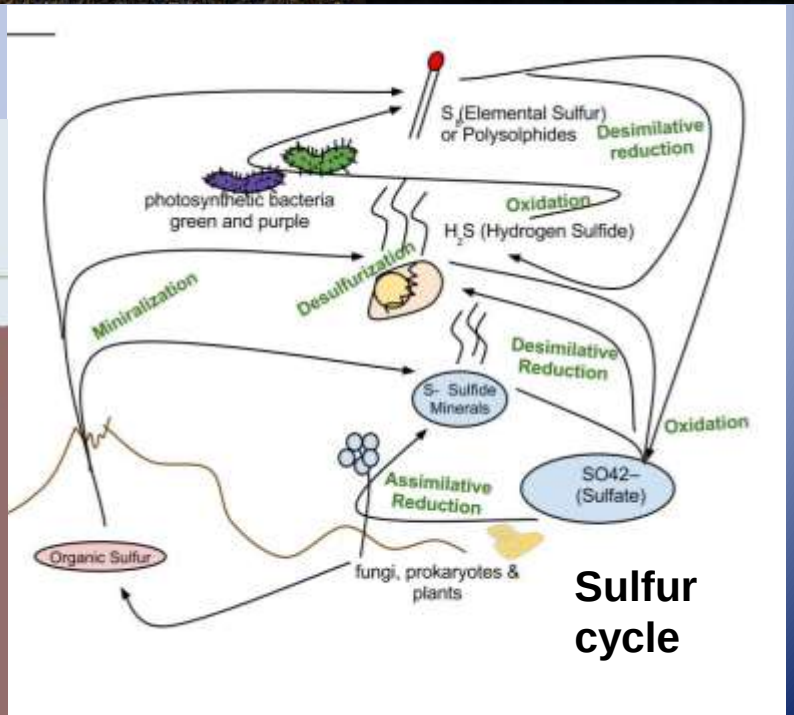
Chemistry in the Soil









Analytical Results

Sample: 'NEWVS'

Simply Soil Testing

Customer:	Roy Farrow 11918 Nevers Rd Snohomish, WA 98290	Date received: Report date: Sample reference #: Plant code:	08/15/17 08/22/17 01937 01 - Vegetable Garden
Organic Fertilizers:	Yes	Tests requested:	Basic, OrgM, B, S, Zn, Mn, Cu, Fe

RESULTS		INTERPRETATION				
Nutrient	**Level**	Low	Medium	High	V High	Result
Nitrogen (nitrate-N)	14 ppm					Low
Phosphorus (P)	147 ppm					Very High
Potassium (K)	434 ppm					Very High
Calcium (Ca)	1152 ppm					High
Magnesium (Mg)	198 ppm					High
Boron (B)	0.7 ppm					High
Sulfur (S as SO4)	5.4 ppm					Medium
Organic Matter	5.8 %					Medium

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Copper	1.2 ppm	0.3 - 0.6 ppm	Very High
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pH and Lime Requirements

Current pH = 5.28 (too acidic)

Optimal pH range: 6.0 - 7.0

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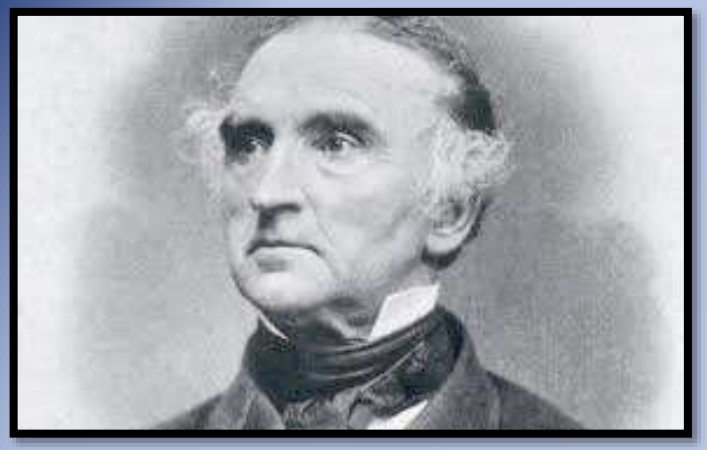
Horticulture = growing plants for Research, Conservation and Enjoyment

Agriculture = growing plants for food

Silviculture = growing trees for wood products

Floriculture = growing perennials and annuals for cut flowers



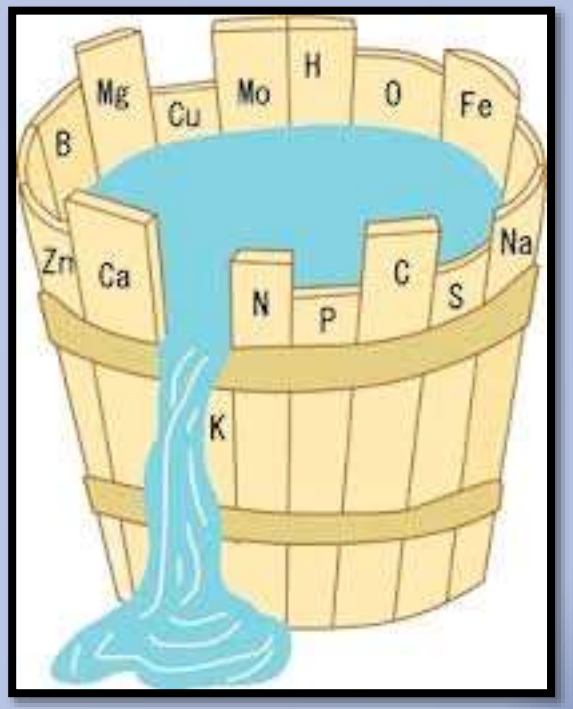
Justus Von Liebig

1803-1873

Father of Agrochemical Science

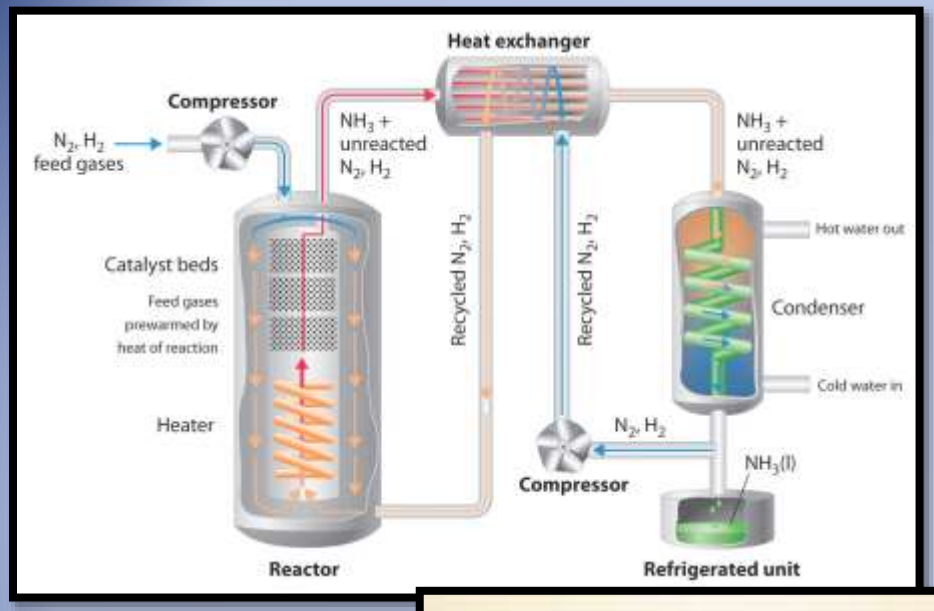
Law of the Minimum

Plant growth is limited by the least abundant nutrient



1863

Haber – Bosch Process



~1913

Nitrogen + Hydrogen $\rightleftharpoons$ Ammonia

N_2 $3H_2$ $2NH_3$

“The slow poisoning of the life of the soil by artificial manure is one of the greatest calamities which has befallen agriculture and mankind.”

Sir Albert Howard

1873-1947

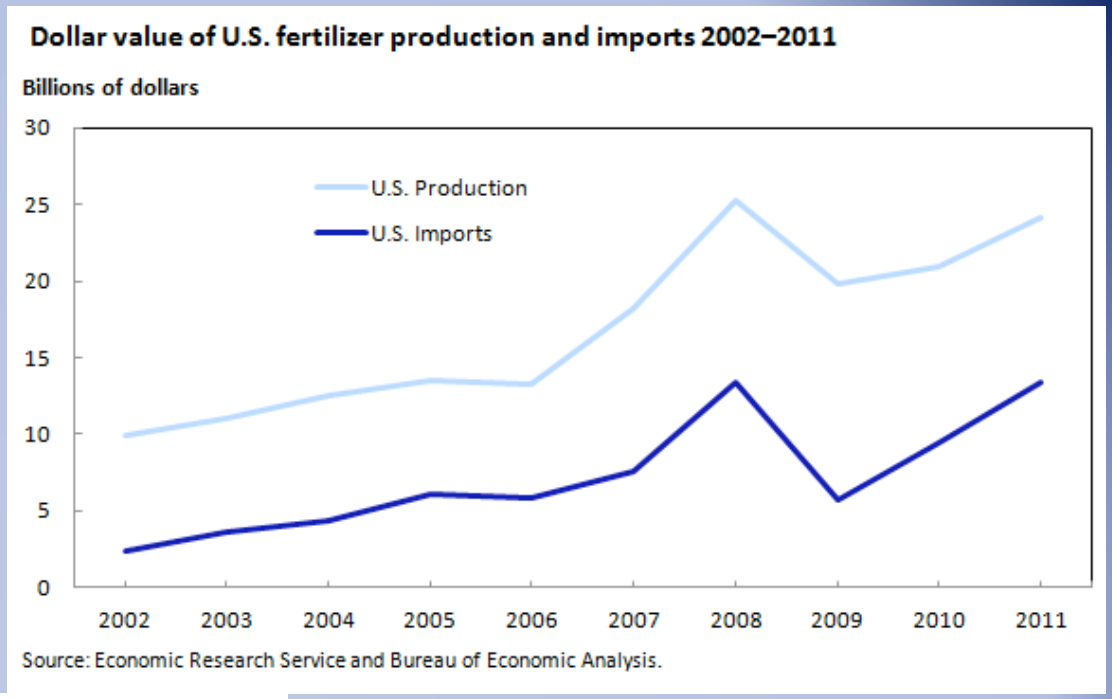
Father of Organic Gardening

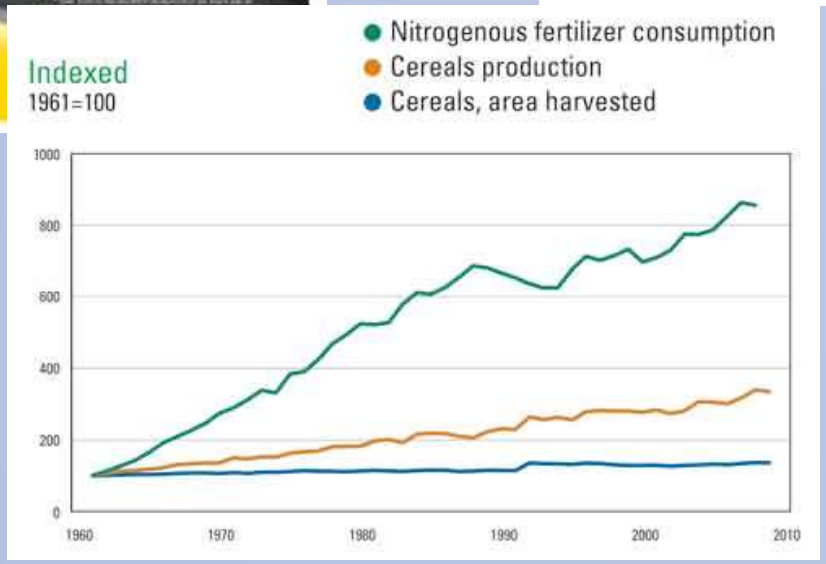
“The essence of humus manufacture is first to provide the organisms with the correct raw material and then to ensure that they have suitable working conditions.”

Sir Albert Howard's <u>Law of Return</u>

Recycle all plant and animal wastes to the soil


2X
Scotts
Turf Builder
WEED & FEED
CLEARS OUT
DANDELIONS & CLOVER
– GUARANTEED!*

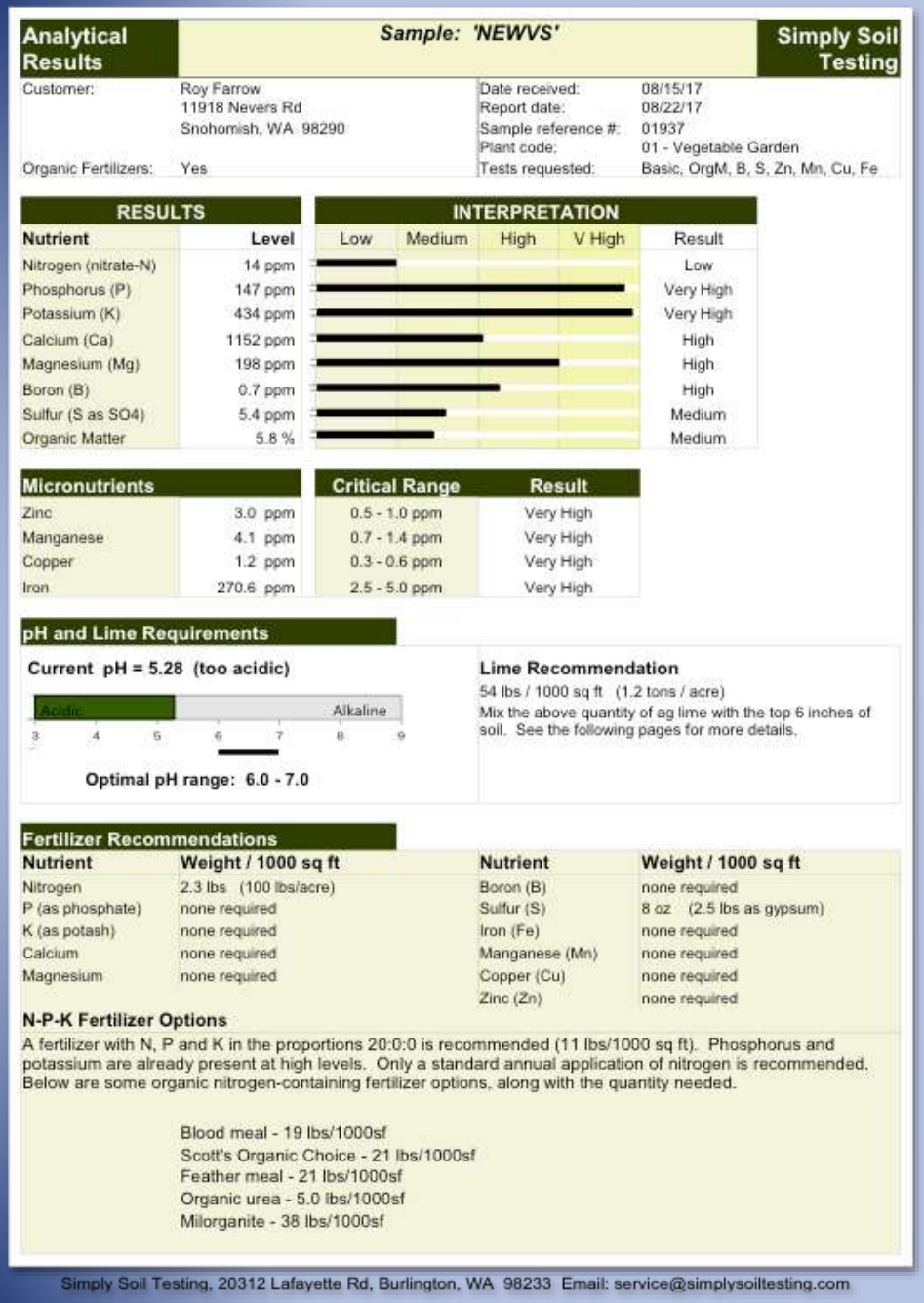

Dollar value of U.S. fertilizer production and imports 2002–2011
Billions of dollars
30
25
20
15
10
5
0
U.S. Production
U.S. Imports
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Source: Economic Research Service and Bureau of Economic Analysis.


Indexed
1961=100
Nitrogenous fertilizer consumption
Cereals production
Cereals, area harvested
1000
800
600
400
200
0
1960
1970
1980
1990
2000
2010

“Current levels of agricultural production depend on cheap oil, but this dependence needs to decline to avoid food shortages and higher prices in the future.”

“Integrating crop rotation, livestock production and zero-tillage in the Brazilian Cerrado resulted in sustainable grain and meat production on the same lands using less fertilizer and herbicides and without requiring further deforestation (in addition to less soil erosion, improved soil biological activity and nutrient recycling and lower greenhouse gas emissions)”

https://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=81



Analytical Results — *Sample: 'NEWVS'* — **Simply Soil Testing**

Customer:	Roy Farrow 11918 Nevers Rd Snohomish, WA 98290	Date received: Report date: Sample reference #: Plant code:	08/15/17 08/22/17 01937 01 - Vegetable Garden
Organic Fertilizers:	Yes	Tests requested:	Basic, OrgM, B, S, Zn, Mn, Cu, Fe

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pH and Lime Requirements

Current pH = 5.28 (too acidic)

Acidic — Alkaline

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Optimal pH range: 6.0 - 7.0

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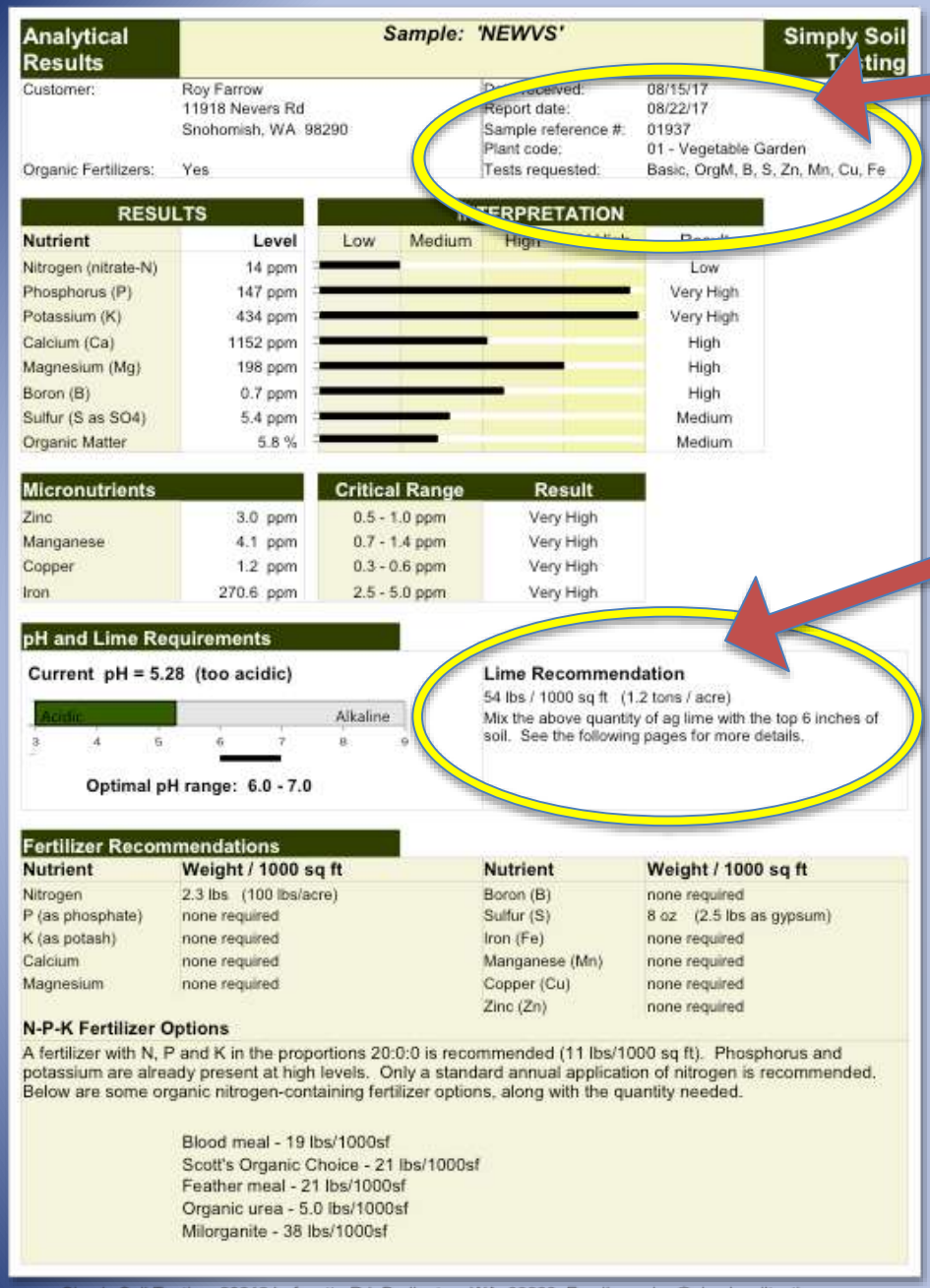
Simply Soil Testing, 20312 Lafayette Rd, Burlington, WA 98233 Email: service@simplysoiltesting.com

A starting point as well as a progress report



Analytical Results — *Sample: 'NEWVS'* — Simply Soil Testing

Customer: Roy Farrow, 11918 Nevers Rd, Snohomish, WA 98290

Organic Fertilizers: Yes

Date received: 08/15/17
Report date: 08/22/17
Sample reference #: 01937
Plant code: 01 - Vegetable Garden
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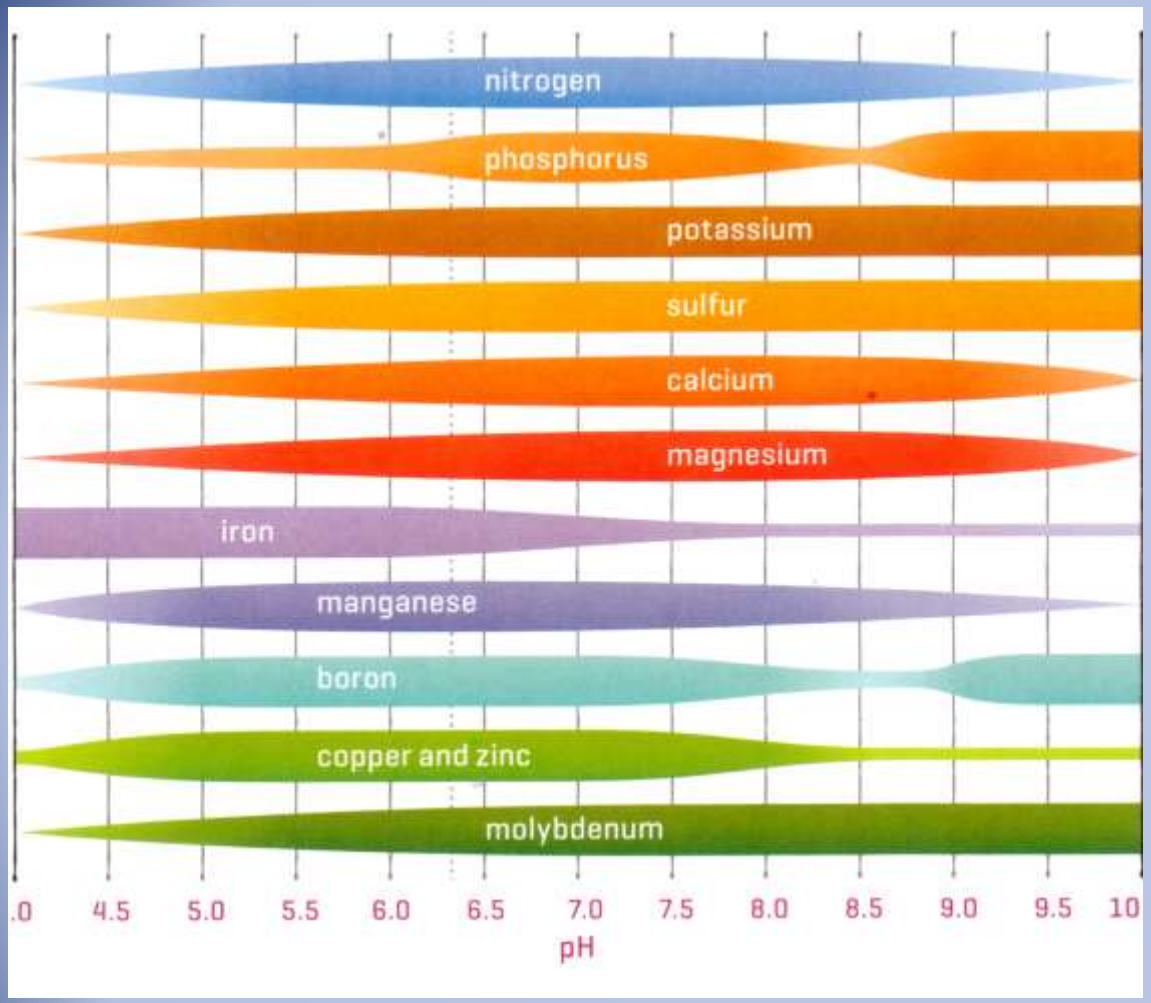
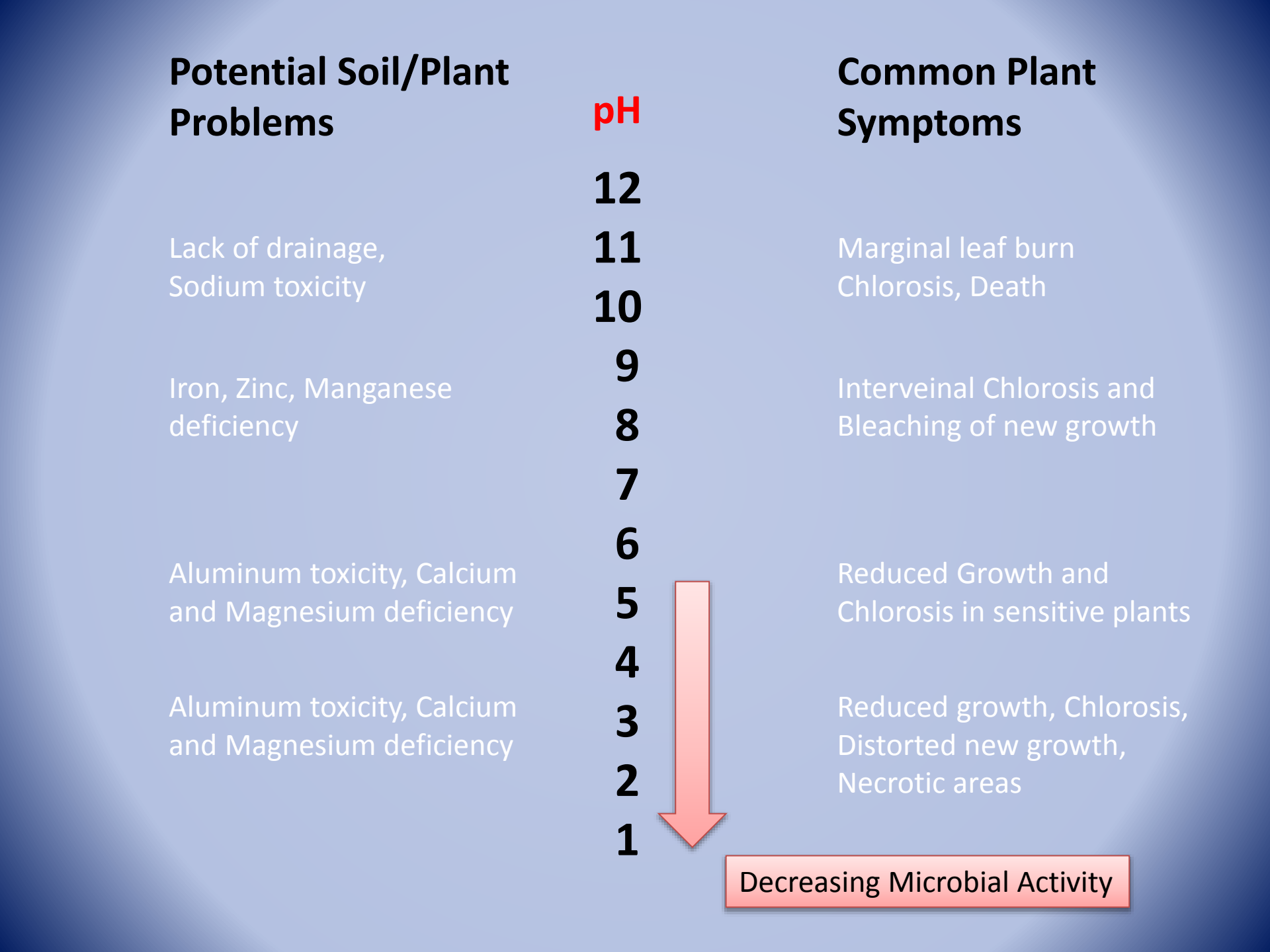
Sample ID
Requested Tests
Garden Description

Fertilizer and lime (pH) recommendations are tailored to the type of plants to be grown.



pH influences plant growth indirectly through its effects on the solubility of ions and the activity of microorganisms

Teaming With Nutrients, Jeff Lowenfels


Potential Soil/Plant Problems
pH
Common Plant Symptoms
12
11
10
9
8
7
6
5
4
3
2
1
Lack of drainage, Sodium toxicity
Marginal leaf burn Chlorosis, Death
Iron, Zinc, Manganese deficiency
Interveinal Chlorosis and Bleaching of new growth
Aluminum toxicity, Calcium and Magnesium deficiency
Reduced Growth and Chlorosis in sensitive plants
Aluminum toxicity, Calcium and Magnesium deficiency
Reduced growth, Chlorosis, Distorted new growth, Necrotic areas
Decreasing Microbial Activity

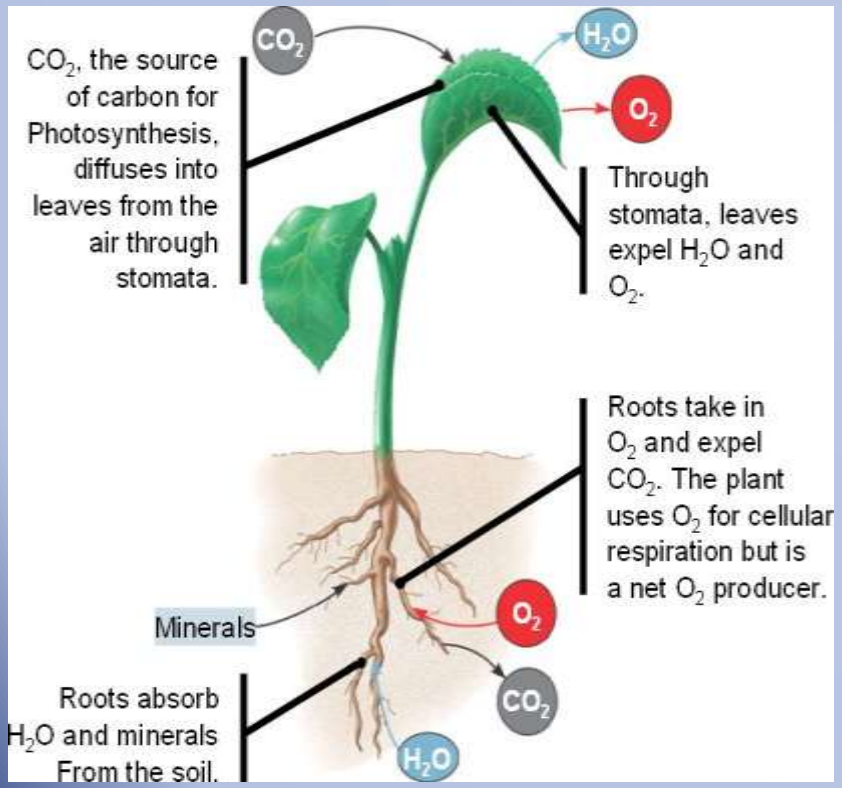
USDA pH Classification

	pH range	
Ultra acid	1.8 - 3.4	Toxic to most plants
Extremely acid	3.5 - 4.4	Restrictive to most plants
Very strong acid	4.5 - 5.0	
Strongly acid	5.1 - 5.5	Acid-tolerant plants
Moderately acid	5.6 - 6.0	
Slightly acid	6.1 - 6.5	Best nutrient availability for most plants
Neutral	6.6 - 7.3	
Slightly alkaline	7.4 - 7.8	Alkaline-tolerant plants
Moderately alkaline	7.9 - 8.4	
Strongly alkaline	8.5 - 9.0	Restrictive to most plants
Very strongly alkaline	9.1 - 11.0	Toxic to most plants

Humus (compost) buffers pH towards optimal 6.3 to 6.8

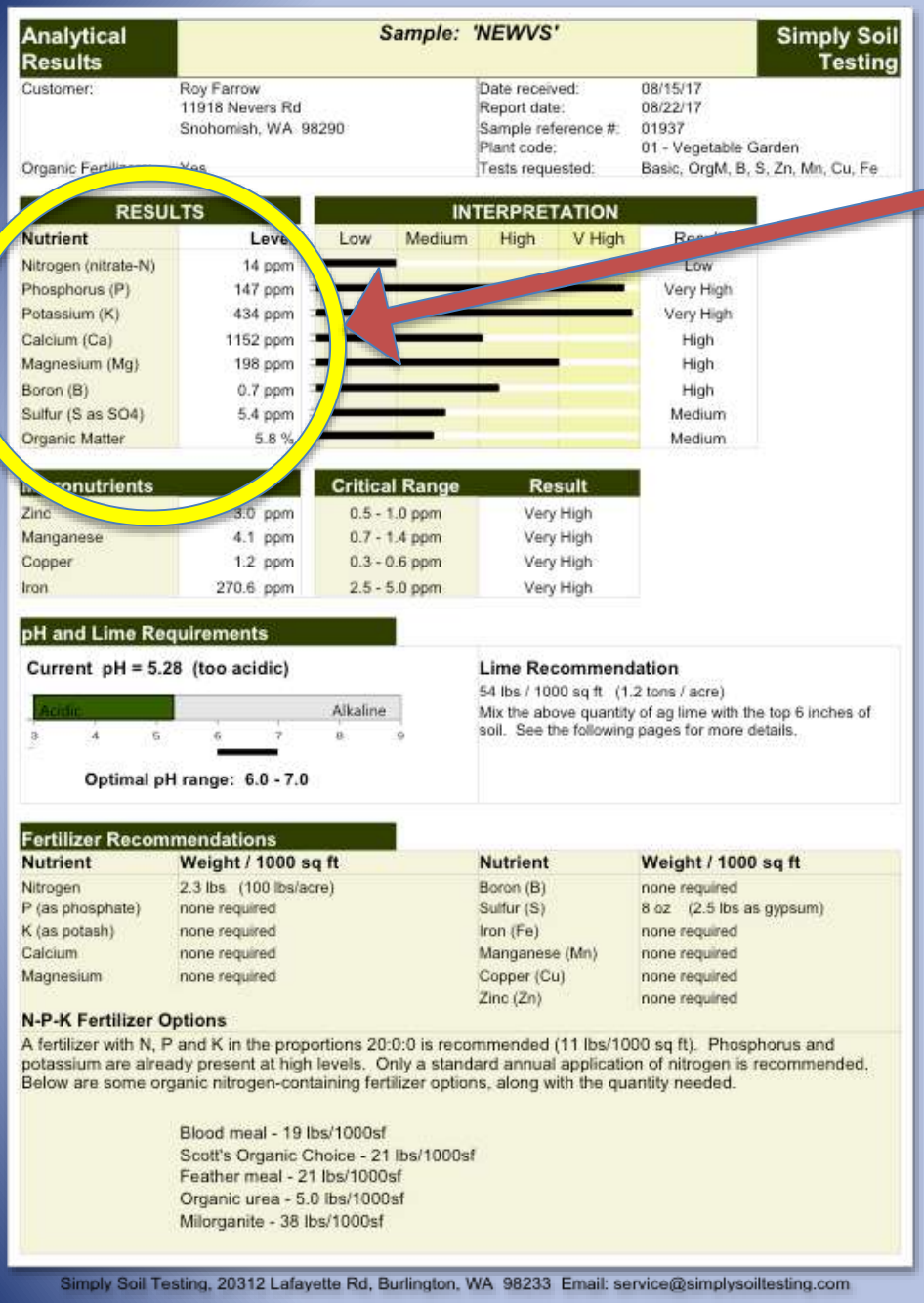
Elements Required by Plants

Base Elements	Macronutrients	Micronutrients
Oxygen (O)	Nitrogen (N)	Boron (B)
Hydrogen (H)	Phosphorus (P)	Chlorine (Cl)
Carbon (C)	Potassium (K)	Cobalt (Co)
	Calcium (Ca)	Copper (Cu)
	Magnesium (Mg)	Iron (Fe)
	Sulfur (S)	Manganese (Mn)
		Molybdenum (Mo)
		Zinc (Zn)



Plants get base elements from the air. All other nutrients come from the soil.

image: extension.missouri.edu



Analytical Results — *Sample: 'NEWVS'* — **Simply Soil Testing**

Customer:	Roy Farrow 11918 Nevers Rd Snohomish, WA 98290	Date received: Report date: Sample reference #: Plant code: Tests requested:	08/15/17 08/22/17 01937 01 - Vegetable Garden Basic, OrgM, B, S, Zn, Mn, Cu, Fe
Organic Fertil...	Yes		

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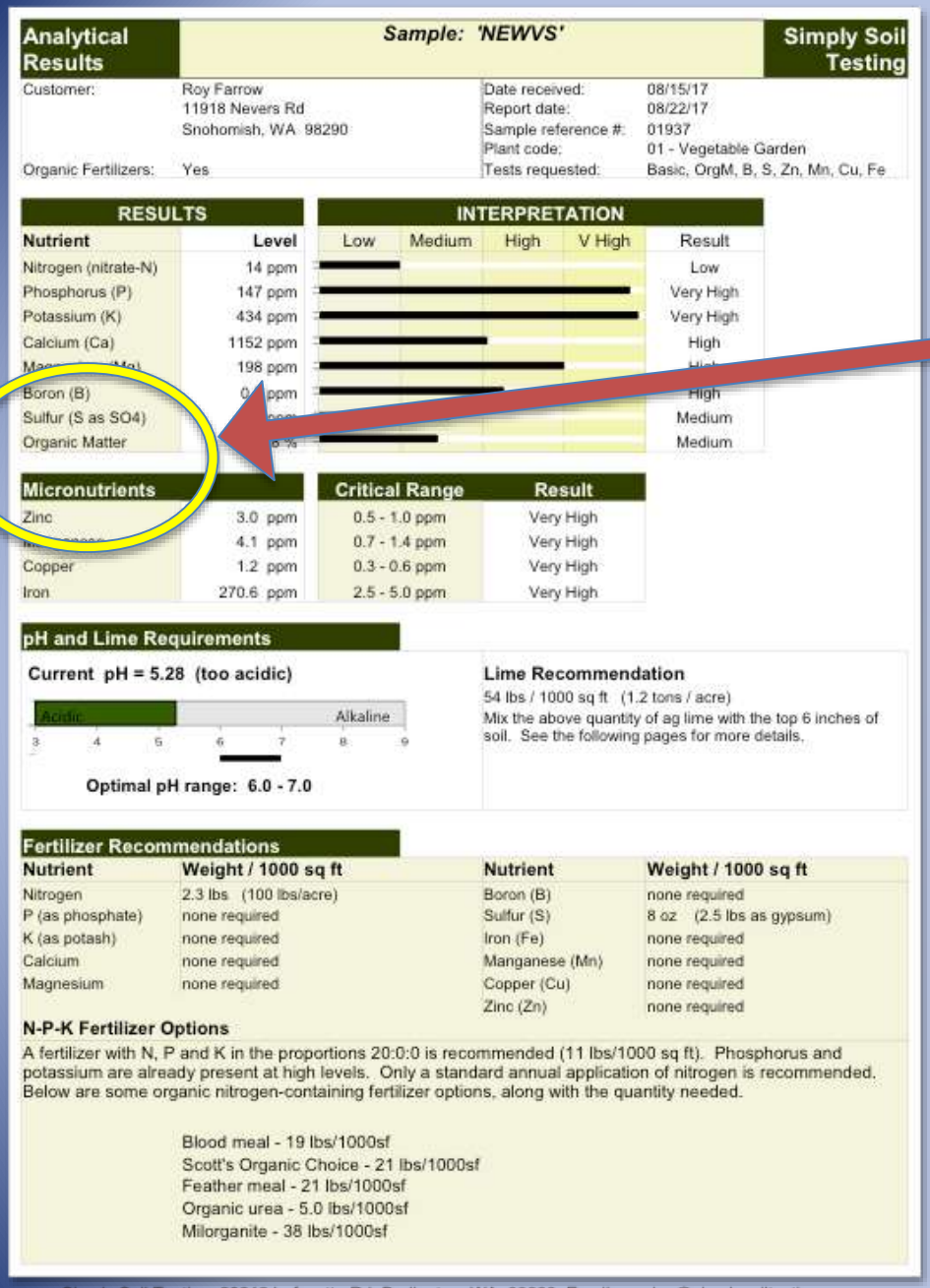
Levels of macronutrients followed by a graphical interpretation of required levels **based on the type of plant** indicated by customer.

Note: Nitrogen is sometimes excluded from basic nutrient tests due to a high degree of fluctuation.

Also, commonly, nitrogen is only measured in the form of nitrate.



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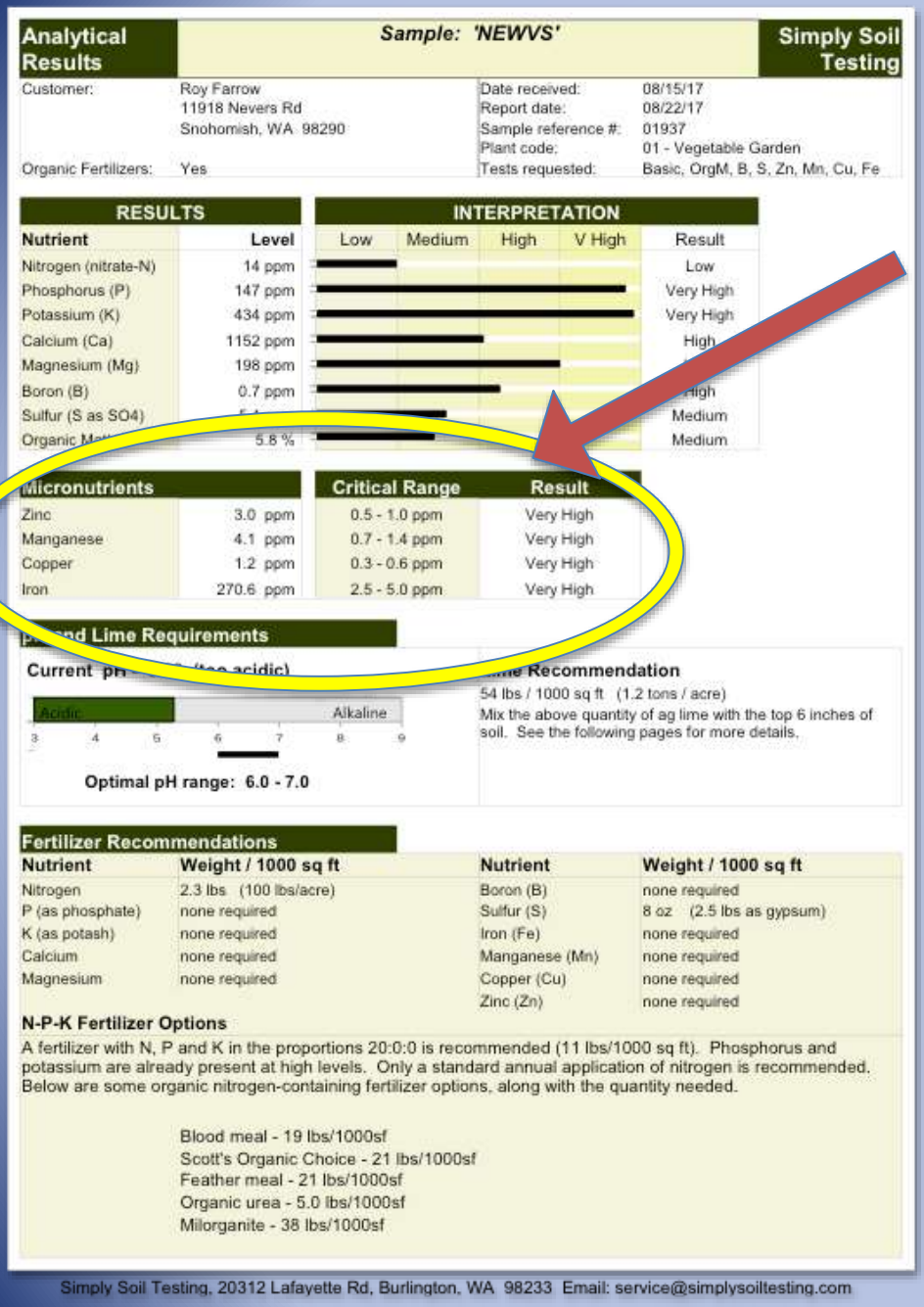
Organic matter improves soil texture, increases water and cation holding capacity and serves as a reservoir of many nutrients.

The ideal percentage of organic matter in soil is debatable and depends on the type of plant material.



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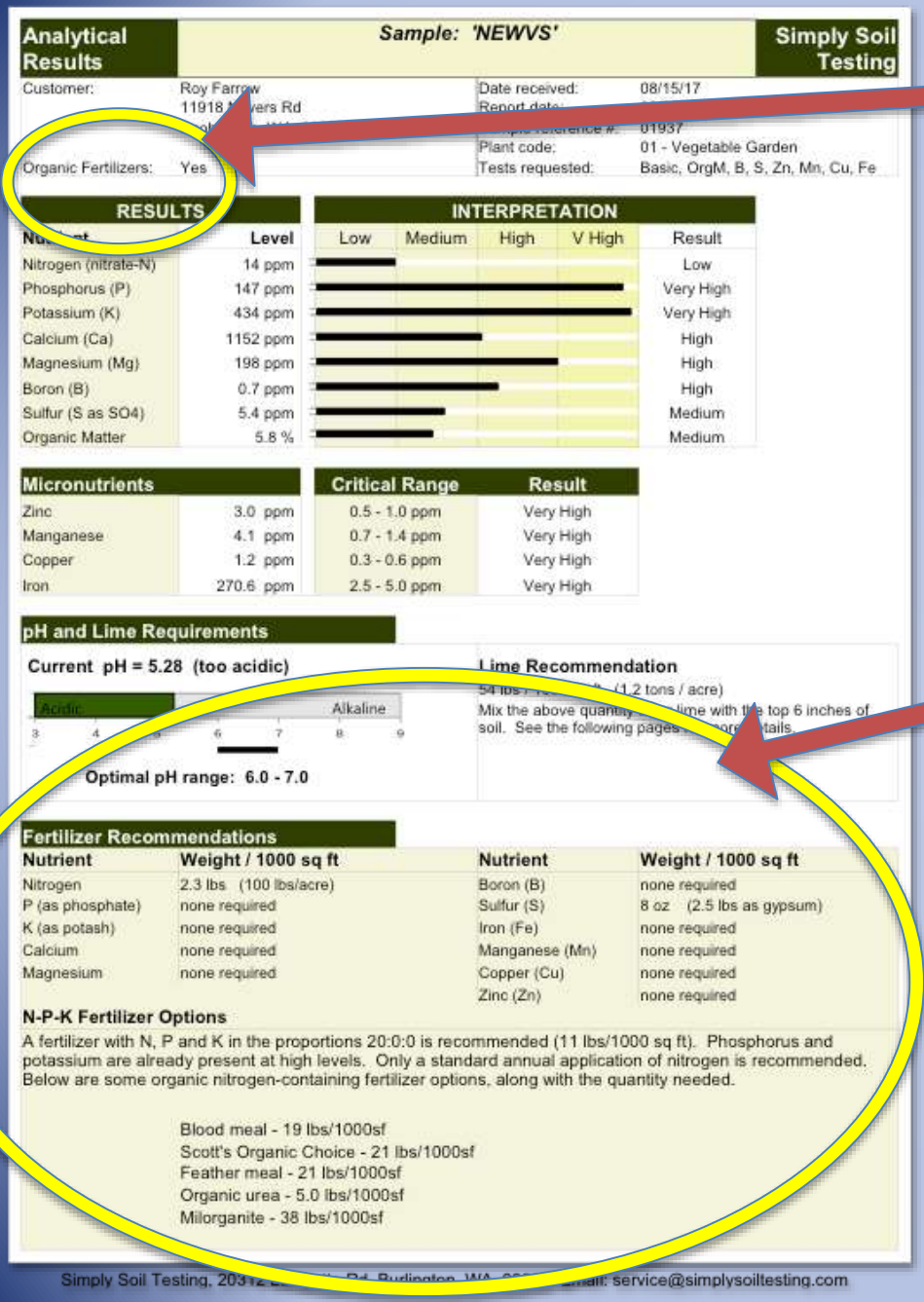
Caution:

Micronutrients are rarely deficient and the range between deficient and toxic can be very small.

Cultural conditions such as water-logged soils or extremes of pH are more often the cause of chlorosis in plants rather than a deficiency in the soil.



Analytical Results — *Sample: 'NEWVS'* — **Simply Soil Testing**

Customer: Roy Farrow
11918 [illegible]vers Rd

Organic Fertilizers: Yes

Date received: 08/15/17
Report date: [illegible]
[illegible] reference #: 01937
Plant code: 01 - Vegetable Garden
Tests requested: Basic, OrgM, B, S, Zn, Mn, Cu, Fe

RESULTS

Nutrient	Level	Low	Medium	High	V High	Result
Nitrogen (nitrate-N)	14 ppm					Low
Phosphorus (P)	147 ppm					Very High
Potassium (K)	434 ppm					Very High
Calcium (Ca)	1152 ppm					High
Magnesium (Mg)	198 ppm					High
Boron (B)	0.7 ppm					High
Sulfur (S as SO4)	5.4 ppm					Medium
Organic Matter	5.8 %					Medium

Micronutrients		Critical Range	Result
Zinc	3.0 ppm	0.5 - 1.0 ppm	Very High
Manganese	4.1 ppm	0.7 - 1.4 ppm	Very High
Copper	1.2 ppm	0.3 - 0.6 ppm	Very High
Iron	270.6 ppm	2.5 - 5.0 ppm	Very High

pH and Lime Requirements

Current pH = 5.28 (too acidic)

Acidic — Alkaline
3 4 5 6 7 8 9

Optimal pH range: 6.0 - 7.0

Lime Recommendation

54 lbs [illegible] (1.2 tons / acre)
Mix the above quantity [illegible] lime with the top 6 inches of soil. See the following pages [illegible] details.

Fertilizer Recommendations

Nutrient	Weight / 1000 sq ft	Nutrient	Weight / 1000 sq ft
Nitrogen	2.3 lbs (100 lbs/acre)	Boron (B)	none required
P (as phosphate)	none required	Sulfur (S)	8 oz (2.5 lbs as gypsum)
K (as potash)	none required	Iron (Fe)	none required
Calcium	none required	Manganese (Mn)	none required
Magnesium	none required	Copper (Cu)	none required
		Zinc (Zn)	none required

N-P-K Fertilizer Options

A fertilizer with N, P and K in the proportions 20:0:0 is recommended (11 lbs/1000 sq ft). Phosphorus and potassium are already present at high levels. Only a standard annual application of nitrogen is recommended. Below are some organic nitrogen-containing fertilizer options, along with the quantity needed.

Blood meal - 19 lbs/1000sf
Scott's Organic Choice - 21 lbs/1000sf
Feather meal - 21 lbs/1000sf
Organic urea - 5.0 lbs/1000sf
Milorganite - 38 lbs/1000sf

Simply Soil Testing, 203[illegible] [illegible] Rd, Burlington, WA [illegible] email: service@simplysoiltesting.com

This lab offers fertilizer recommendations in either organic or inorganic options.

Caution: Fertilizer recommendations need to be considered with regard to factors such as season, applications of lime, nearby water feature, etc.

2.3 lbs N
= 11 lbs NO_3^-
= 19 lbs dried blood
= 21 lbs feather meal

Test Interpretation	*Sample: 'NEWVS'*	Simply Soil Testing

Definitions

The nutrient levels in the soil are classified into four categories: low, medium, high and very high.

Low: This means that the nutrient is definitely deficient.

Medium: (also called the "Critical Range") – The nutrient may or may not be deficient depending on various factors. There is also some disagreement among scientists concerning the minimum nutrient levels required by different plants.

High / Very High: The nutrient is definitely present in sufficient quantities. If the nutrient level is "Very High", then there is probably enough of the nutrient already in the soil to last a few years.

Specific nutrient level interpretations

Phosphorus The phosphorus level in the soil is sufficient (currently 147 ppm).

Potassium The potassium level in the soil is sufficient (currently 1152 ppm).

Nitrogen Nitrogen is very mobile in the soil and is readily leached out by rainwater. Nitrogen levels tend to fluctuate and test results are not necessarily indicative of total nitrogen availability. Nitrogen requirements are estimated based on specific plant requirements, the organic matter level in the soil, and other factors. Nitrogen is generally applied every year, once in the spring and sometimes again in mid season. *Please note that our nitrogen test only measures "nitrate" nitrogen, not "ammonium" nitrogen. This means that if ammonium sulfate or urea was applied recently, this added nitrogen may not be reflected in the test results.

Calcium The calcium level in the soil is sufficient (currently 1152 ppm).

Magnesium The magnesium level in the soil is sufficient (currently 198 ppm).

Boron The boron level in the soil is sufficient (currently 0.7 ppm).

Sulfur The sulfur level in the soil may be insufficient (currently 5.4 ppm). As with nitrogen, sulfur levels in soil can fluctuate rapidly which makes test interpretation difficult. Rain can leach sulfur from surface soil, and carry it to the sub-soil where it accumulates. Plants with shallow roots are more likely to be affected. Epsom salt or gypsum can be added to the soil to correct a deficiency. Spread about 4 lbs of Epsom salt or 2.5 lbs of gypsum over 1000 square feet.

Organic Matter The organic matter level in the soil is medium (5.8 %). Organic matter is beneficial for holding moisture and nutrients. Organic matter gradually releases many nutrients into the soil as it decomposes, including nitrogen.

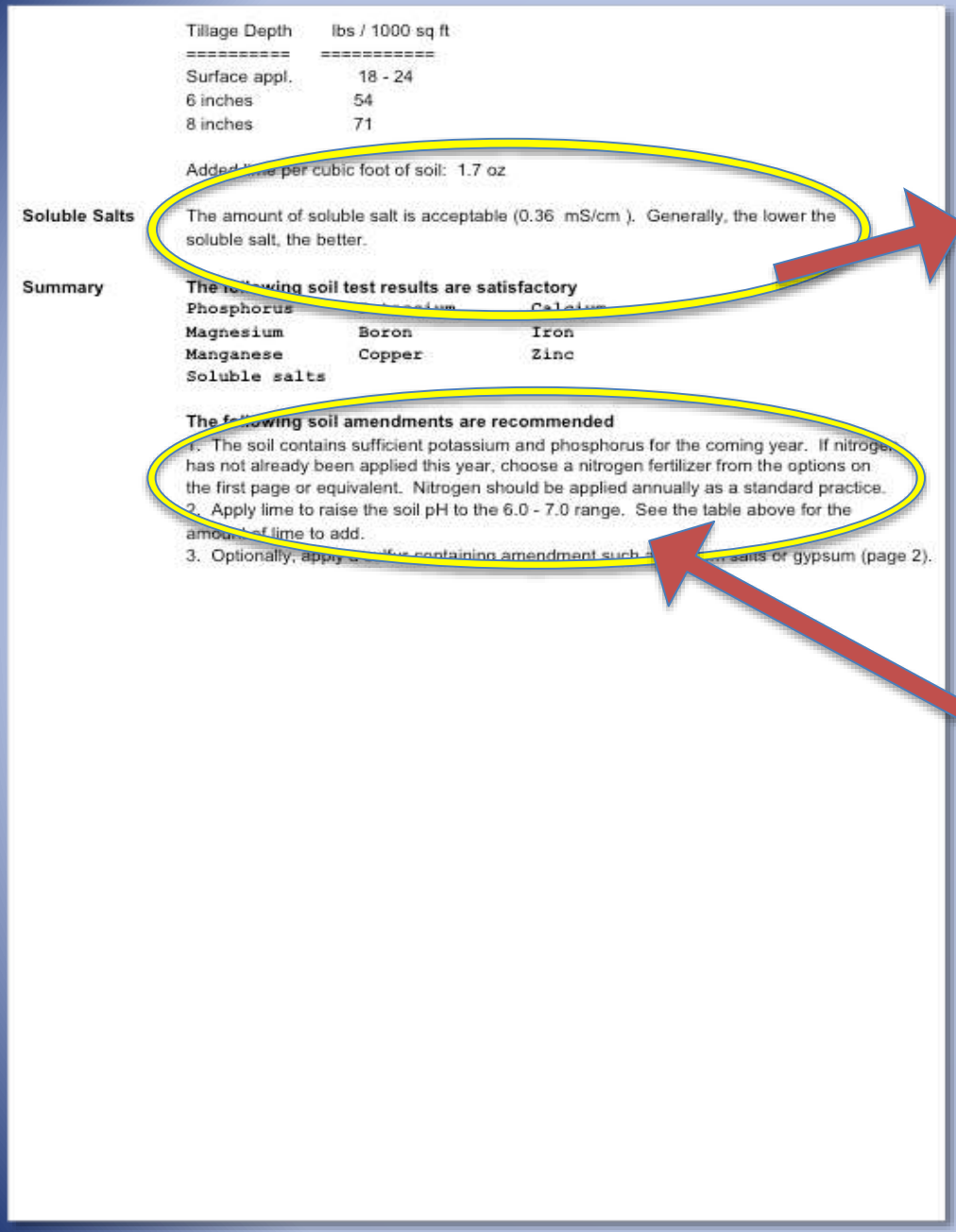
Micronutrients Sufficient: zinc (3.0 ppm), manganese (4.1 ppm), copper (1.2 ppm), iron (270.6 ppm)
Deficient: none

pH and Lime The soil is too acidic for a vegetable garden (pH = 5.28). The amount of lime required to raise the pH depends on the depth of tillage and the type of lime used. The below recommendations are based on lime with a CCE (calcium carbonate equivalent) of 100%. If using lime with a CCE of 75%, increase amounts by 33%. For surface application, such as for existing lawns or trees, do not apply more than 50 lbs / 1000 sq ft at one time.

Simply Soil Testing, 20312 Lafayette Rd, Burlington, WA 98233 Email: service@simplysoiltesting.com

"…Nitrogen levels tend to fluctuate and test results are not necessarily indicative of total nitrogen availability."

"…sulfur levels in soil can fluctuate rapidly which makes test interpretation difficult."



Tillage Depth	lbs / 1000 sq ft
Surface appl.	18 - 24
6 inches	54
8 inches	71

Added ... per cubic foot of soil: 1.7 oz

Soluble Salts

The amount of soluble salt is acceptable (0.36 mS/cm). Generally, the lower the soluble salt, the better.

Summary

The following soil test results are satisfactory

Phosphorus	...	Calcium
Magnesium	Boron	Iron
Manganese	Copper	Zinc
Soluble salts		

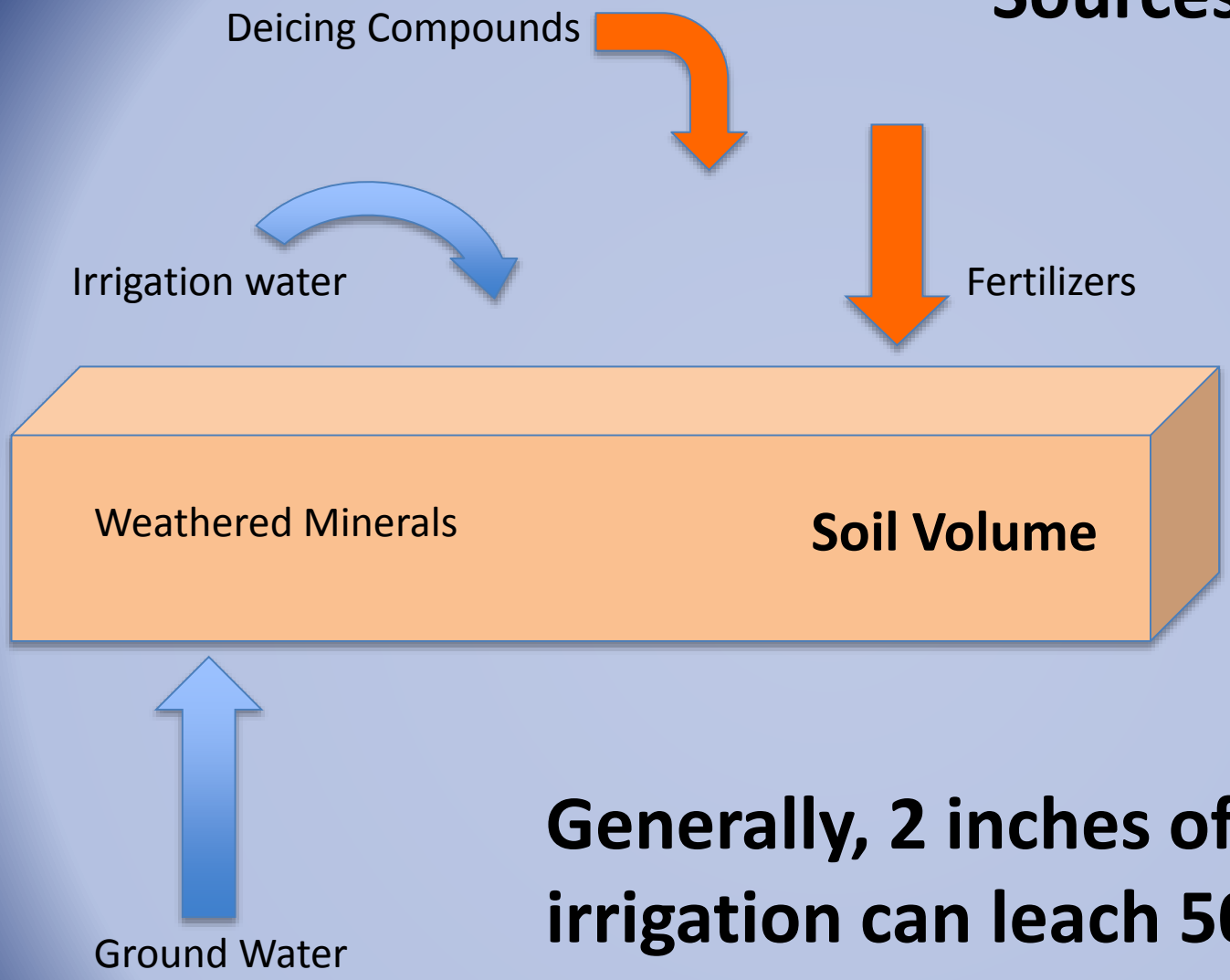
The following soil amendments are recommended

1. The soil contains sufficient potassium and phosphorus for the coming year. If nitrogen has not already been applied this year, choose a nitrogen fertilizer from the options on the first page or equivalent. Nitrogen should be applied annually as a standard practice.
2. Apply lime to raise the soil pH to the 6.0 - 7.0 range. See the table above for the amount of lime to add.
3. Optionally, apply ... containing amendment such ... salts or gypsum (page 2).

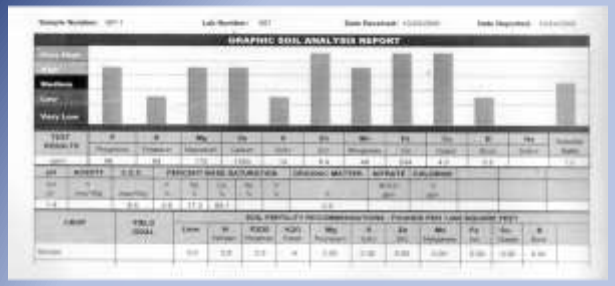
Soil soluble salt levels above 4 mS/cm is considered saline.
mS= milli Siemens an electrical conductivity measurement

"Nitrogen should be applied annually as a standard practice."

Sources of Salt



Generally, 2 inches of proper irrigation can leach 50% of salt from the top 4 inches of soil.



Common tests for your soil include:

- Nutrient Content (Fertility)
- Salt Content (Salinity)
- Cation Exchange Capacity
- Soil Texture
- pH
- Organic Matter Content

Additional tests available for soils:

- Biological Activity
- Heavy Metals
- Pesticides
- Hydrocarbons
- Irrigation Water Analysis
- Soil Particle Size
- Soilless Mix Analysis
- Water Holding Capacity
- Plant Tissue Analysis

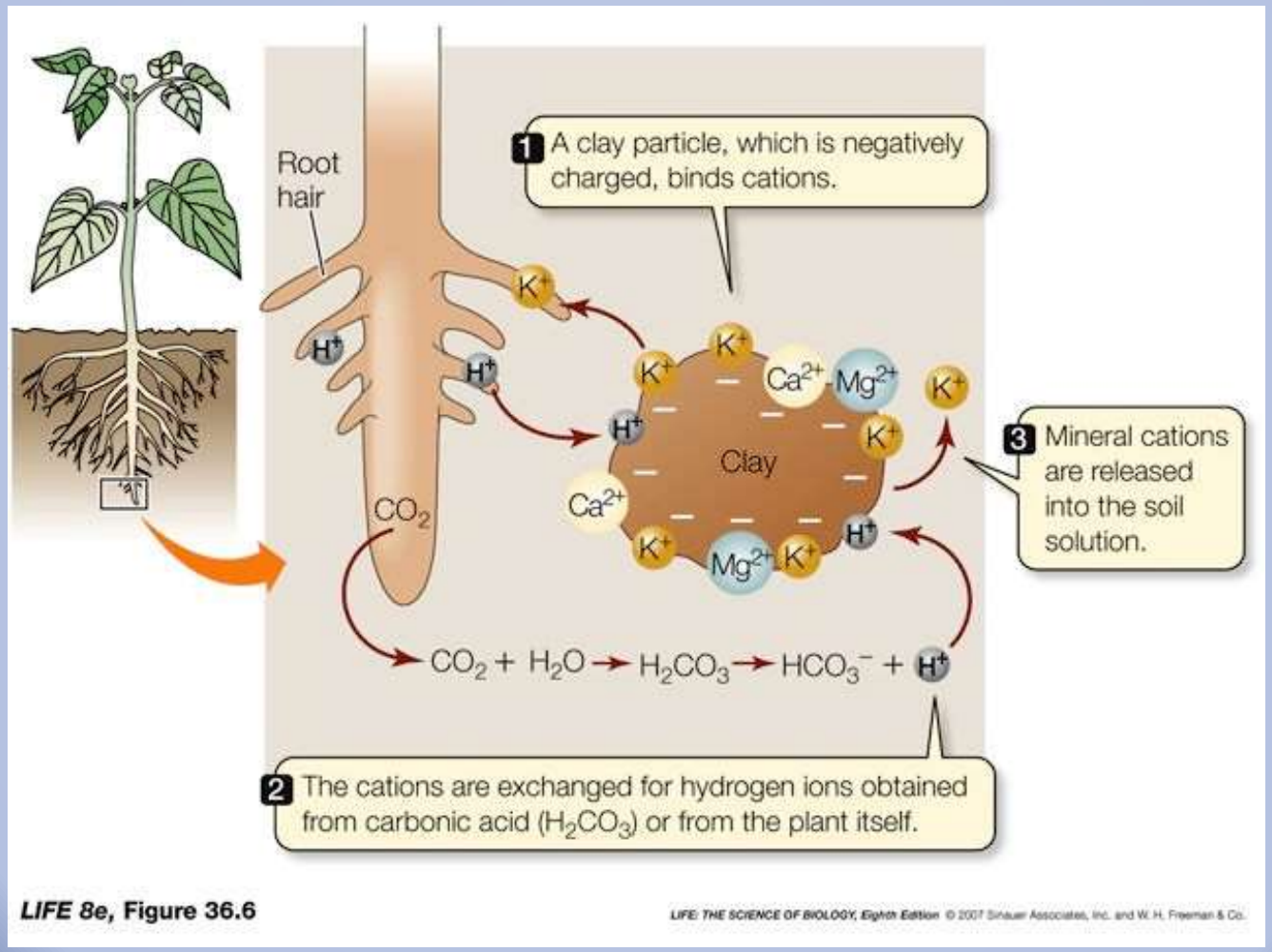
Land use and land history should guide the choice of additional tests

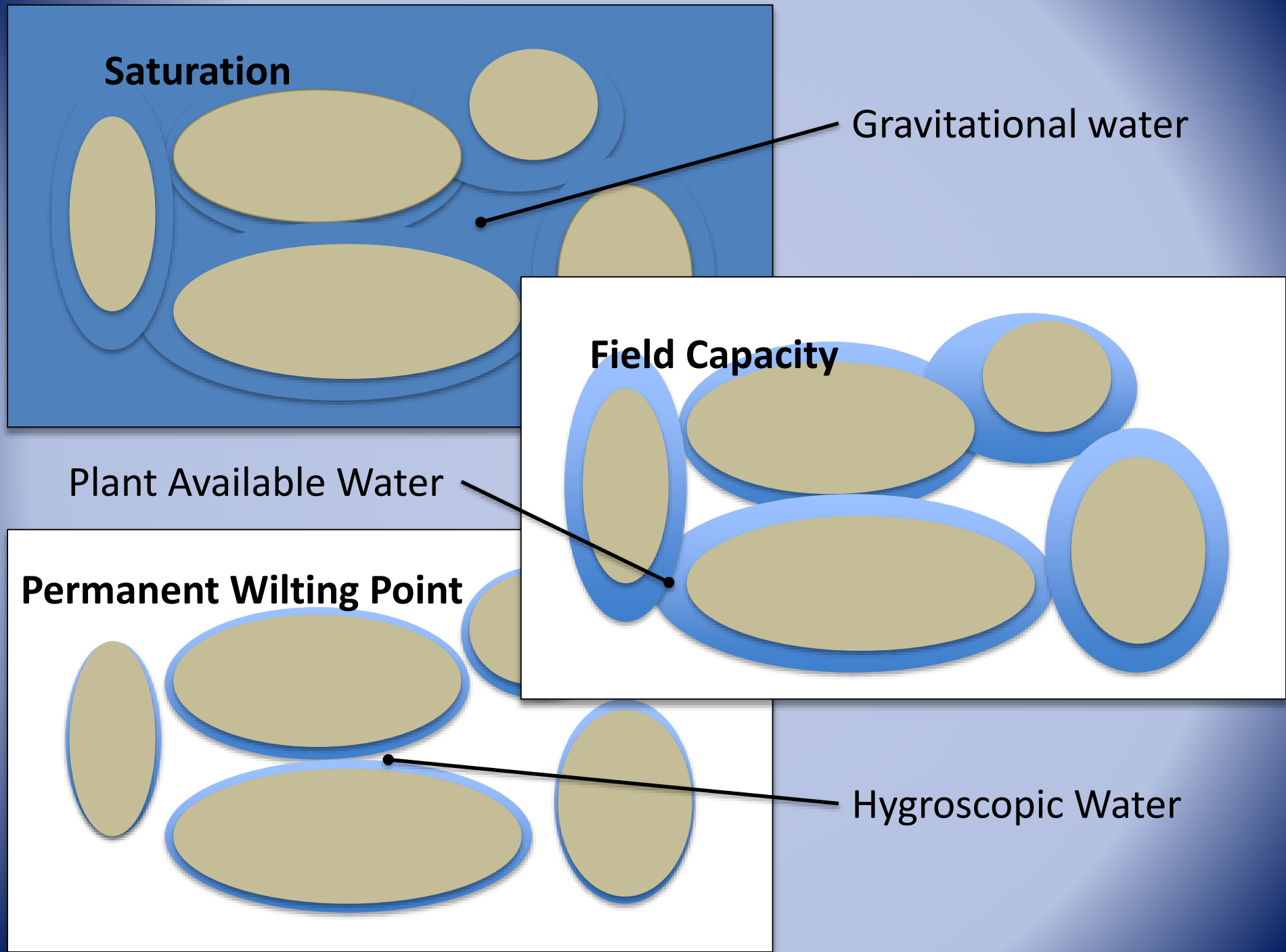
Analytical Results	*Sample: 'NEWVS'*		Simply Soil Testing
Customer:	Roy Farrow 11918 Nevers Rd Snohomish, WA 98290	Date received: Report date: Sample reference # Plant code: Tests requested:	08/15/17 08/22/17 01937 01 - Vegetable Garden Toxic Metals

Heavy Metals Analysis

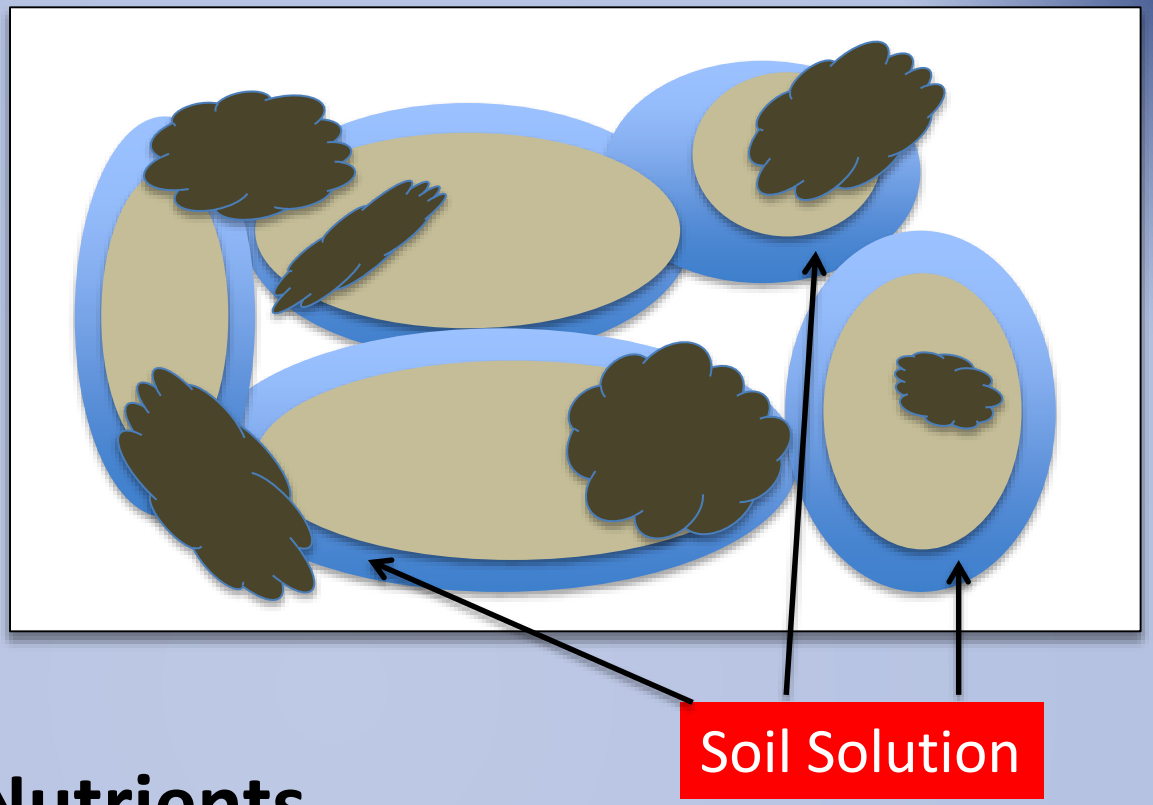
	Measured level in soil sample	Typical levels in soil	Safe Levels	Result
Lead (Pb)	12 ppm	3 - 50 ppm	< 400 ppm	Safe
Cadmium (Cd)	0.4 ppm	0.2 - 1.5 ppm	< 10 ppm	Safe
Arsenic (As)	0.4 ppm	0.1 - 10 ppm	< 50 ppm	Safe

Soil chemistry and how it relates to soil structure, texture and biology



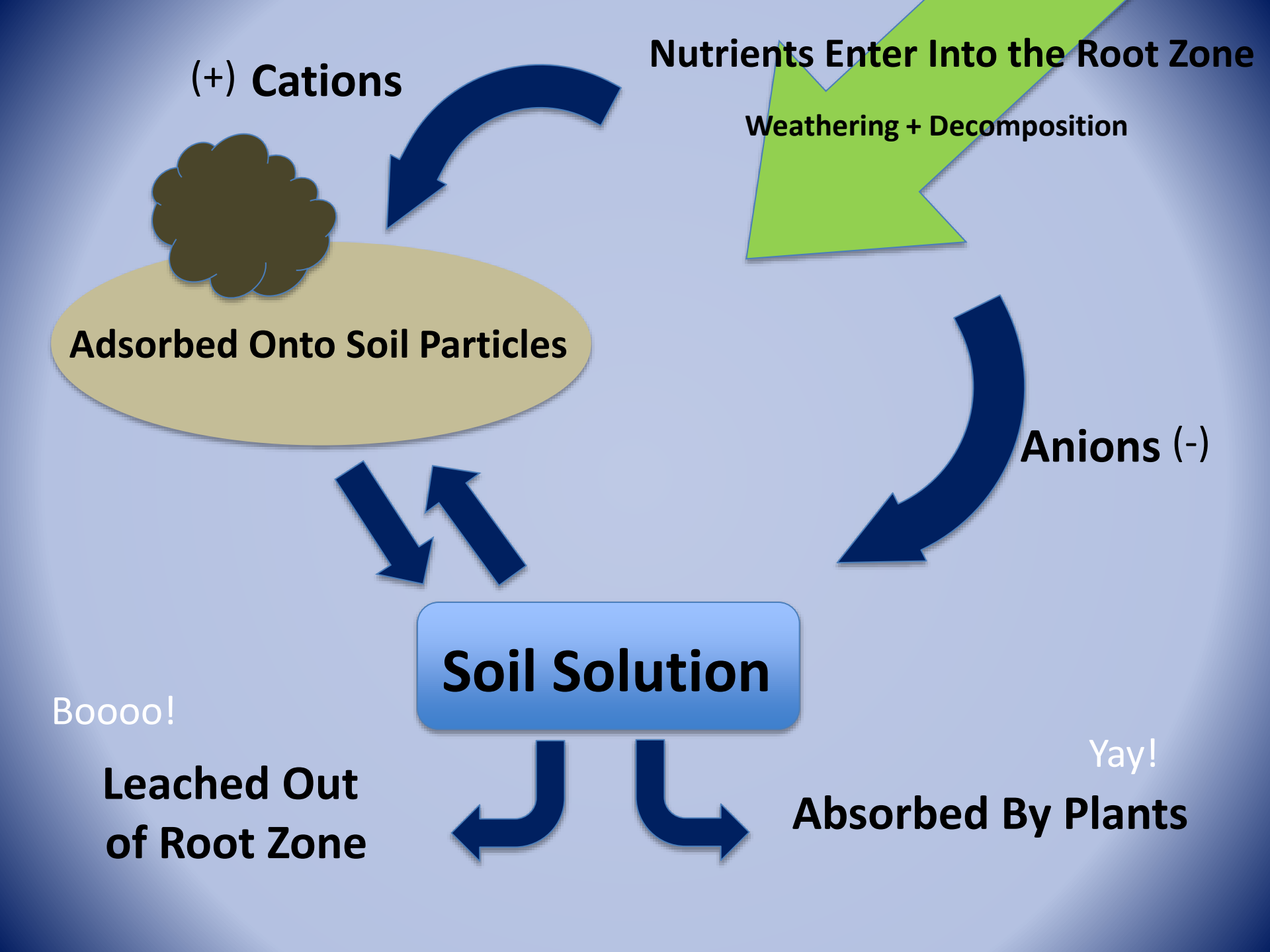

Saturation
Gravitational water
Field Capacity
Plant Available Water
Permanent Wilting Point
Hygroscopic Water

Micropores and Macropores at Field Capacity



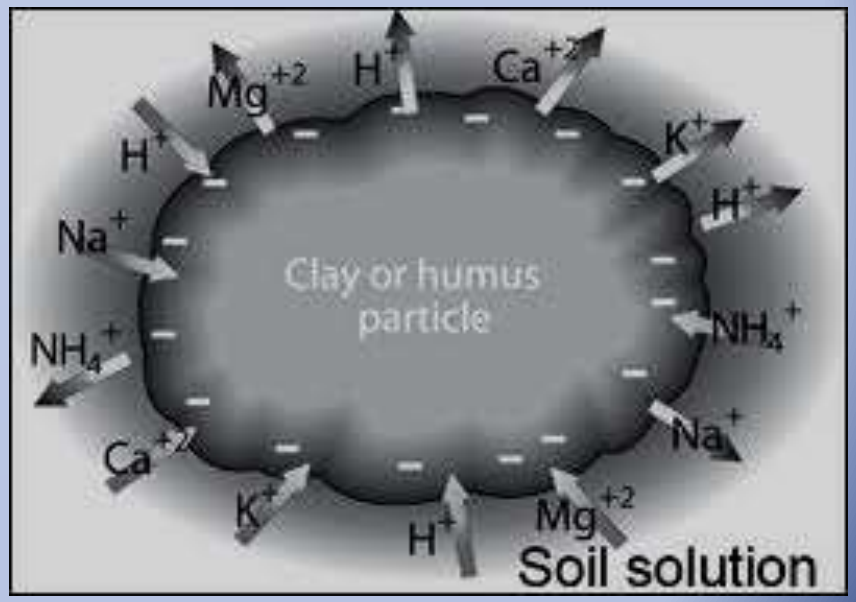
Four States of Nutrients

1. Parent minerals ($CaCO_3$, $CaSO_4$, Mica, Granite, etc.) [rocks]
2. Parent organics (sugars, proteins, lignins, etc.) [all things dead]
3. Dissolved ions in solution
4. Exchangeable ions adsorbed onto particle surfaces


Nutrients Enter Into the Root Zone
Weathering + Decomposition
(+) Cations
Adsorbed Onto Soil Particles
Anions (-)
Soil Solution
Boooo!
Leached Out of Root Zone
Yay!
Absorbed By Plants

Cation Exchange Capacity (CEC, meq/110 g)

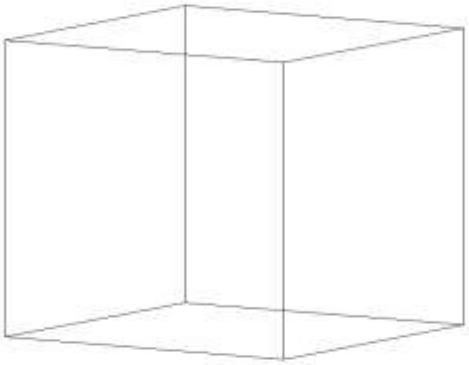
The Cation Exchange Capacity is a measure of how many negatively charged sites are available in a particular soil.



The soil particle is like a bus. The seats are the negative charges. All the seats must always be full with positively charged particles. Hydrogen (H^+) and Ammonium (NH_4^+) "exchange" seats if the Ammonium ion wants to sit down.

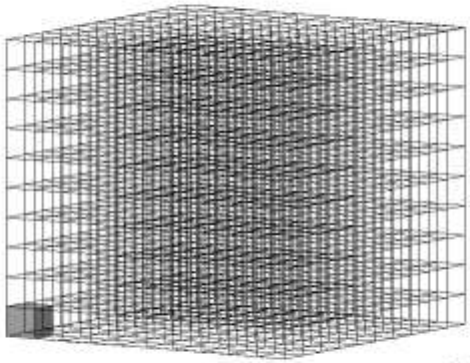
Sand

1 Particle Fine **Sand** .2mm
0.24mm^2 Surface Area



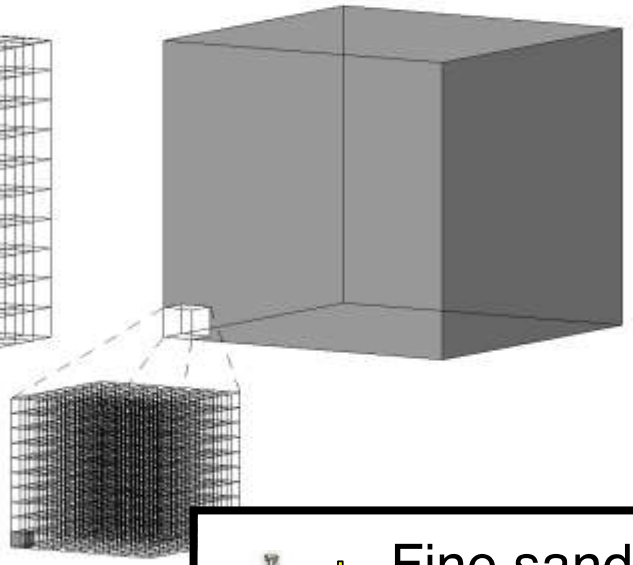
Silt

1,000 Particles **Silt** .02mm
2.4 mm^2 Surface Area



Clay

1,000,000 Particles **Clay** .002 mm
24 mm^2 Surface Area



Cation Exchange Capacity by soil type

Sand	**Less than 5** meq/100g
Silt	**5 -10** meq/100g
Clay	**10 - 50 ish** meq/100g
Compost / humus	**up to 400** meq/100g

High organic matter content

High CEC value

LABORATORIES

68-9225 I FAX (503) 598-7702

REPORT NUMBER: 17-234-132 CLIENT NO: 4793

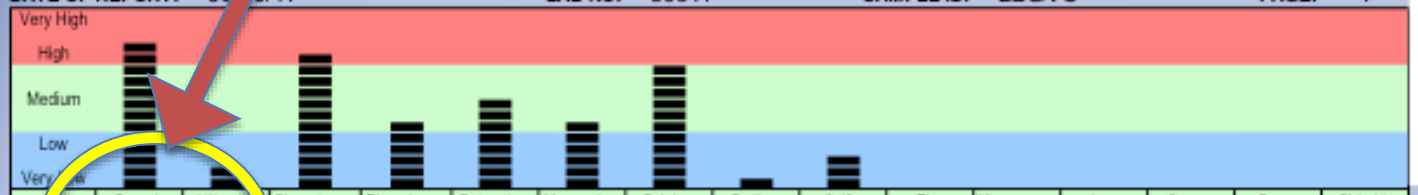
SEND TO: KING CO SERVATION DISTRICT
1107 SW GRADY WAY STE 130
RENTON, WA 98057

GROWER: WASHINGTON PARK ARBORETUM

SUBMITTED BY: ROY FARROW

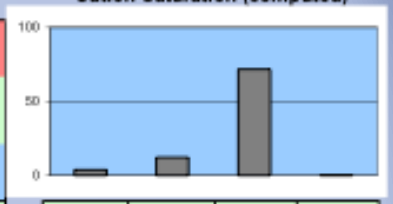
Graphical Soil Analysis Report

DATE OF REPORT: 08 0/17 LAB NO: 59917 SAMPLE ID: LBGVC PAGE: 1



Analyte	Organic Matter %	Nitrogen NO_3-N ppm	Phosphorus Weak Bray ppm	Phosphorus $NaHCO_3$-P ppm	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Chloride Cl ppm
Results	7.3	6	36	27	165	164	1 0	8	6						

Percent Cation Saturation (computed)



Potassium K %	Magnesium Mg %	Calcium Ca %	Sodium Na %
3.8	12.2	71.7	0.3

ACIDIC BASIC

LOW AVERAGE HIGH

ECe dS/m

INCREASING SALINITY

11.1 CEC meq/100g

Ex. Lime

6.2 pH

INCREASING NEED FOR LIME

Buffer pH: 6.7

Soil Fertility Guidel es

CROP: TREES SHRUBS RATE: lb/1000 sq ft NOTES:

Dolomite 100 score	Lime 100 score	Gypsum	Elemental Sulfur	Nitrogen N	Phosphate P_2O_5	Potash K_2O	Magnesium Mg	Sulfur SO_4-S	Zinc Zn	Mang se Mn	Iron Fe	Copper Cu	Boron B	
50				0.8		3.0		0.6						

COMMENTS

INCORPORATE 3.0 to 6.0 cubic yards/1,000 sq ft (one to two-inch layer) o nitrified/composted organic amendment where organic matter levels are rated as LOW ("L") t
MULCHING the surface to a depth of 2-4 inches will discourage in problem soils, and conserve moisture. However, monitor nitroge
MAINTENANCE: Split the above amount over the year at a time ac requirements. Choose a source that best fits this combination.
ACIDIFICATION of high pH soils should improve soil environment. Compare different sources of acidifying materials, but be aware that sulfate-sulfur (as shown on report) has NO acidifying power.

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Rogell Rogers, CCA, PCA
A & L WESTERN LABORATORIES, INC

Low organic matter content

. LABORATORIES
) 968-9225 I FAX (503) 598-7702

REPORT NUMBER: 17-234-132 CLIENT NO: 4793

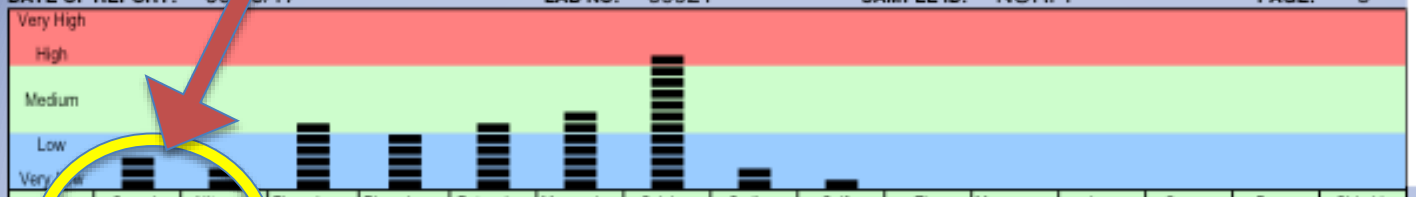
SEND TO: KING CO SERVATION DISTRICT
1107 SW GRADY WAY STE 130
RENT N, WA 98057

GROWER: WASHINGTON PARK ARBORETUM

SUBMITTED BY: ROY FARROW

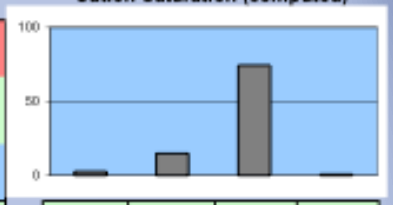
Graphical Soil Analysis Report

DATE OF REPORT: 08 0/17 LAB NO: 59921 SAMPLE ID: NORPI PAGE: 5



Analyte	Organic Matter %	Nitrogen NO_3-N ppm	Phosphorus Weak Bray ppm	Phosphorus $NaHCO_3$-P ppm	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Chloride Cl ppm
Results	1.0	3	20	14	55	98	[illegible]	7	1						

Percent Cation Saturation (computed)



Potassium K %	Magnesium Mg %	Calcium Ca %	Sodium Na %
2.6	14.7	74.6	0.6

ACIDIC BASIC

LOW AVERAGE HIGH

ECe dS/m

INCREASING SALINITY

5.5 CEC meq/100g

Ex. Lime

6.5 pH

INCREASING NEED FOR LIME

Buffer pH: 7.4

Soil Fertility Guidelines

CROP: CONIFERS RATE: lb/1000 sq ft NOTES:

Dolomite 100 score	Lime 100 score	Gypsum	Elemental Sulfur	Nitrogen N	Phosphate P_2O_5	Potash K_2O	Magnesium Mg	Sulfur SO_4-S	Zinc Zn	Manganese Mn	Iron Fe	Copper Cu	Boron B	
			10	1.7	1.0	5.0								

COMMENTS

Low CEC value

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Cation Exchange Capacity (CEC)

CEC is measured in milliequivalents per 100 grams of soil (meq/100g)

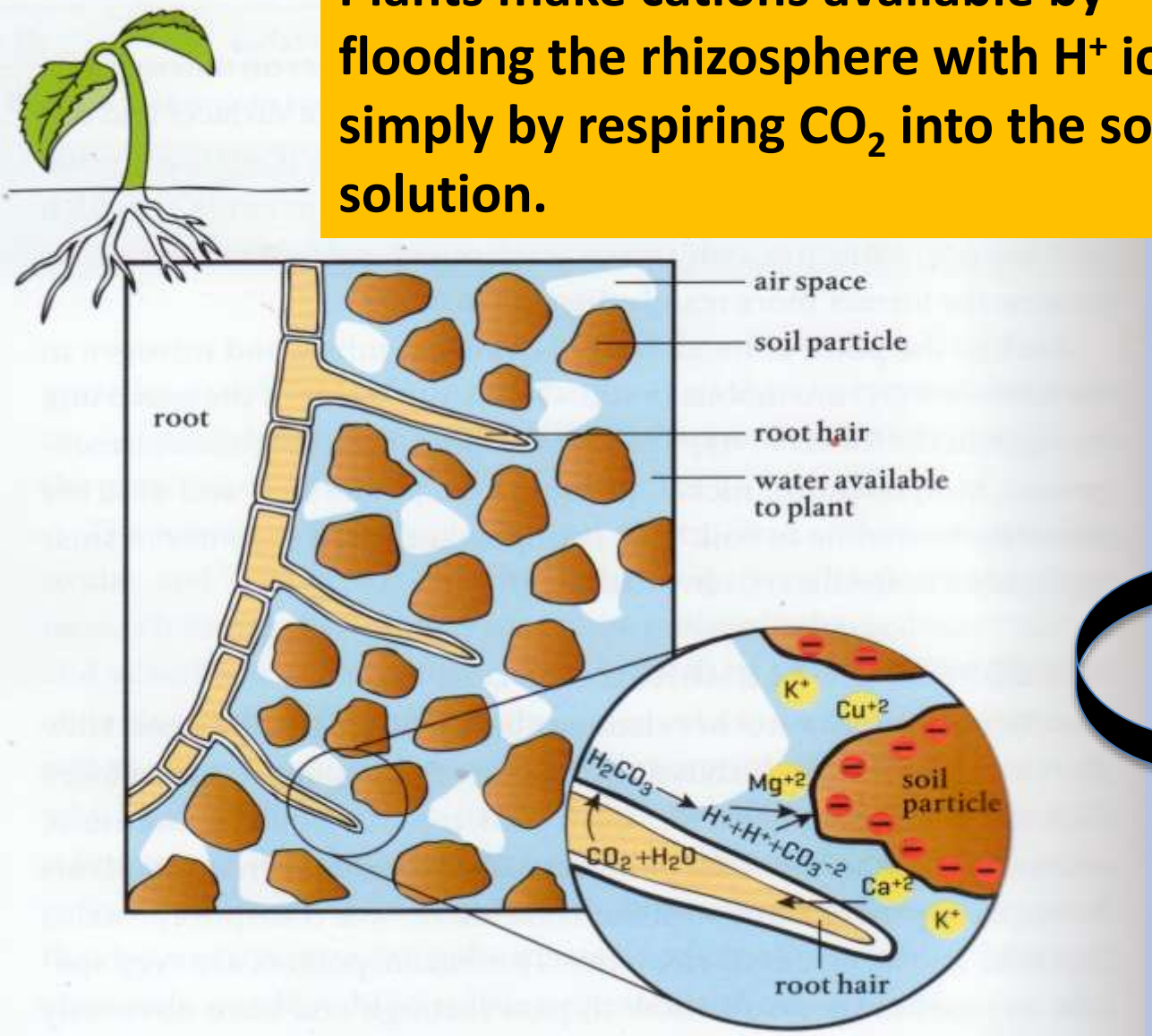
1 meq/100g

= 1 cmol/kg

= 6×10^{21} negative charges for positive ions to adsorb to in 1 kg of soil

6,000,000,000,000,000,000,000

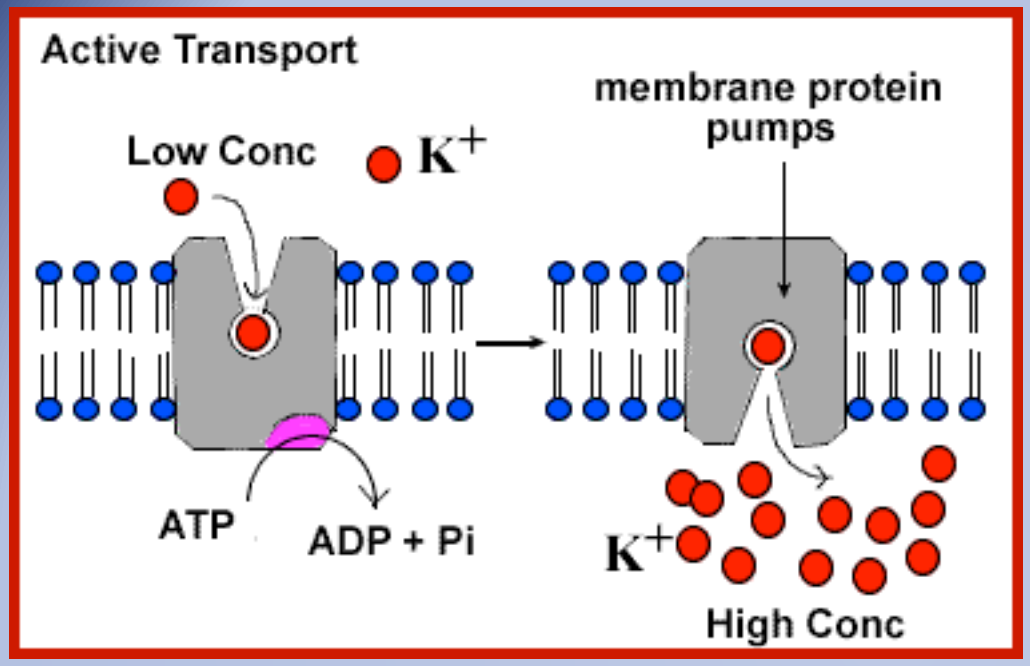
Plants make cations available by flooding the rhizosphere with H^+ ions simply by respiring CO_2 into the soil solution.



$CO_2 + H_2O$

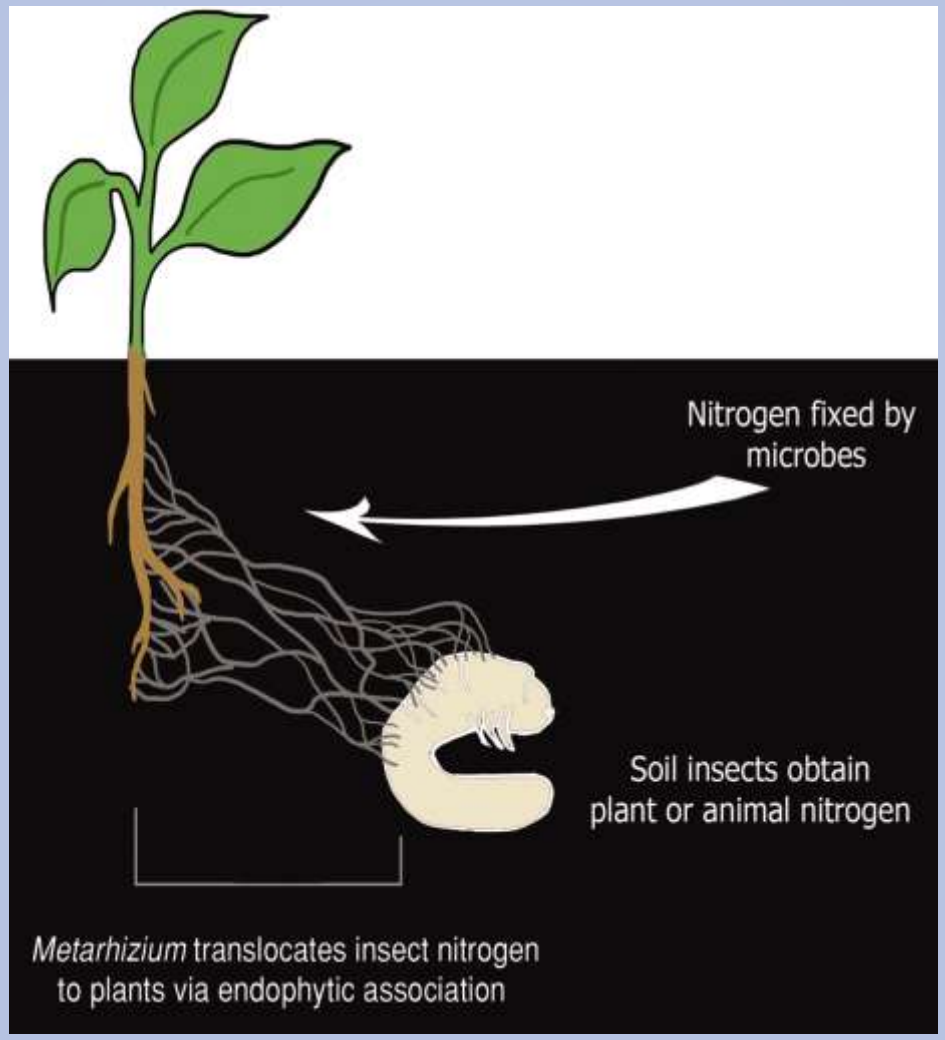
H_2CO_3

$H^+ + HCO_3^-$


Active Transport
membrane protein pumps
Low Conc
K+
ATP
ADP + Pi
K+
High Conc

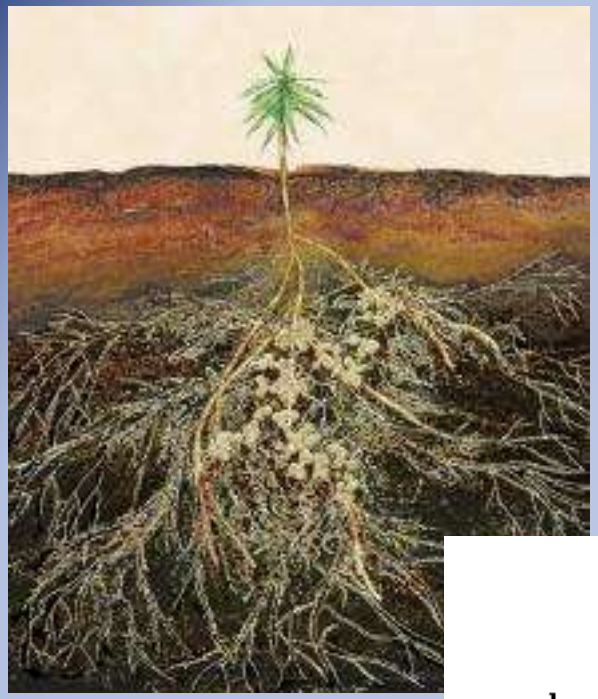
The previous example is how a plant acquires nutrients without the aid of soil microbiology.

Transfer of insect-derived nitrogen to plants through an association with endophytic, insect-parasitic Metarhizium.

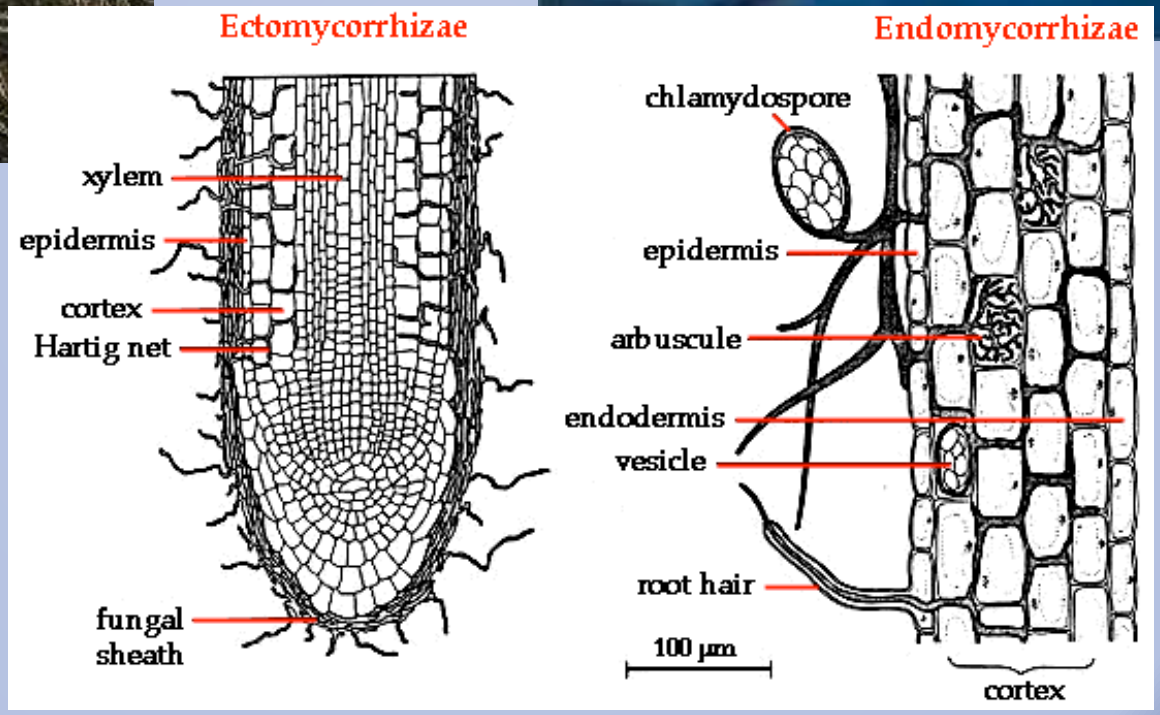


S. W. Behie et al. Science 2012;336:1576-1577

Published by AAAS




Mycorrhizae
Root


Ectomycorrhizae
xylem
epidermis
cortex
Hartig net
fungal sheath
Endomycorrhizae
chlamydospore
epidermis
arbuscule
endodermis
vesicle
root hair
100 µm
cortex

Benefits of Mycorrhizae

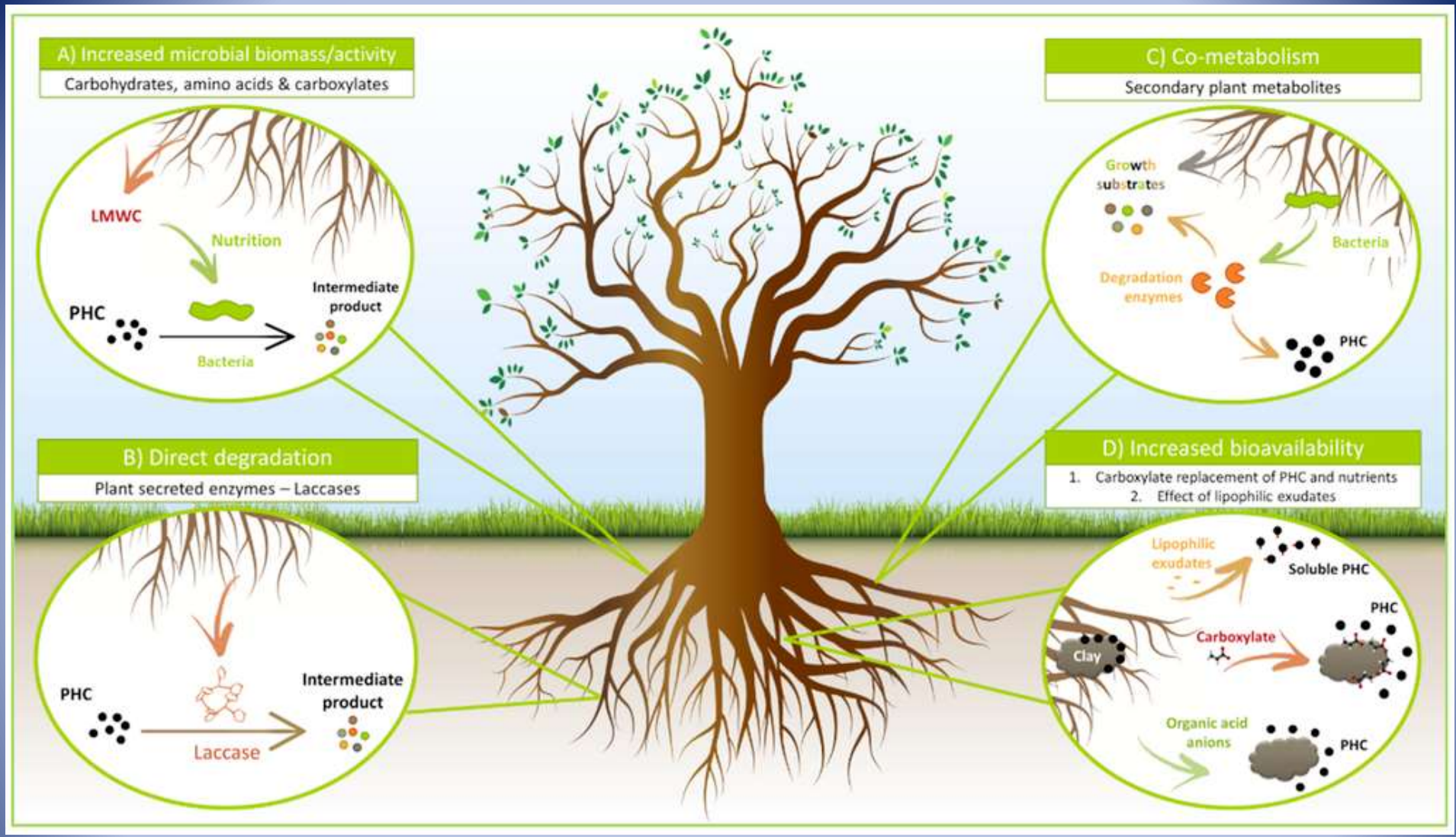
- Stimulates photosynthesis
- Facilitates uptake of immobile elements such as Phosphorus, Nitrogen, Zinc, Copper, Cobalt, Molybdenum, Calcium, Magnesium and Iron
- Offers tolerance against a range of soil stresses like heavy metal toxicity, salinity, drought, and high soil temperatures
- Offers higher resistance to soil and root-borne pathogens
- Helps in soil stabilization

Translation: More productive and healthier plants using less fertilizer and pesticides.

Functions of Root Exudates

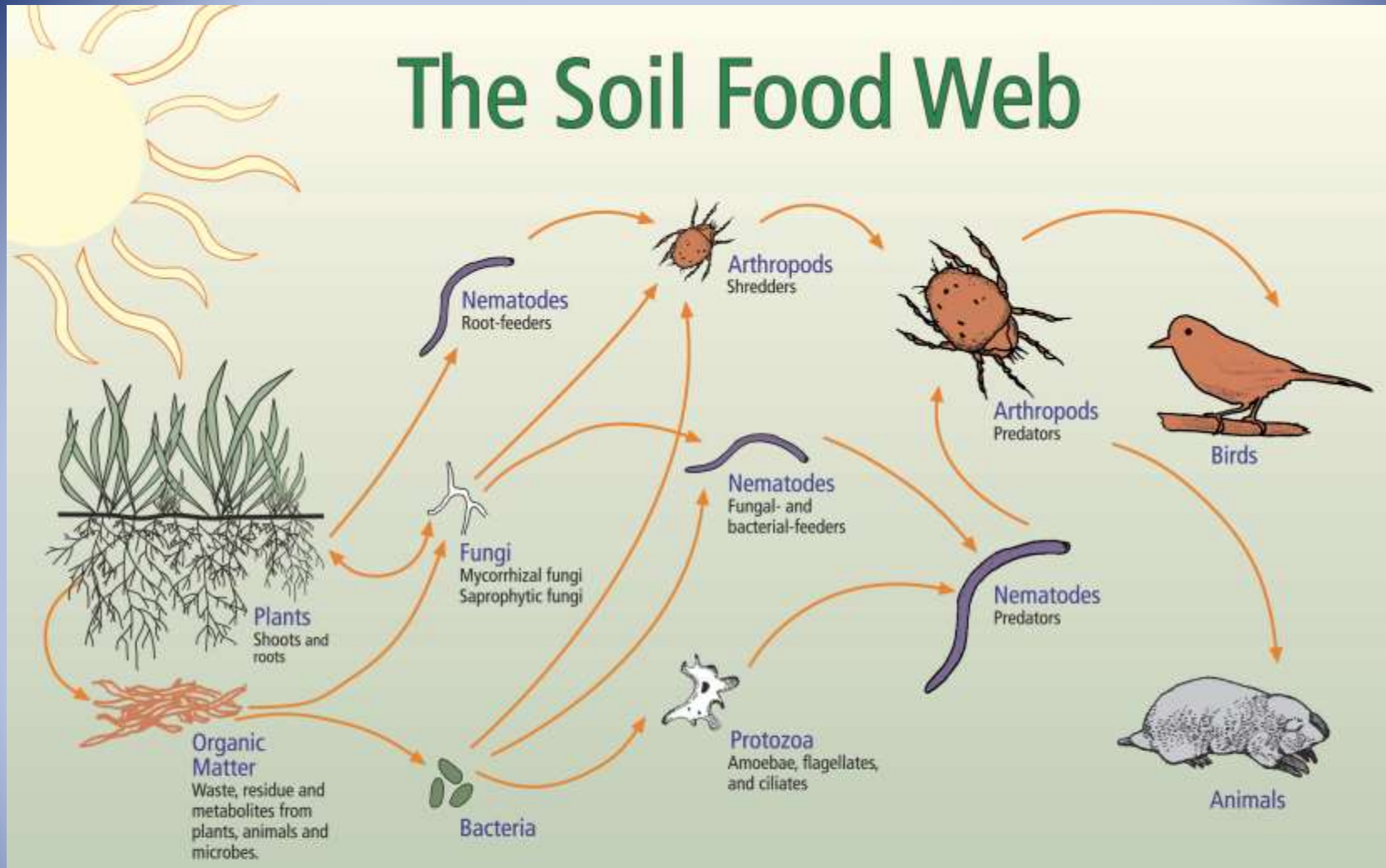
sugars, proteins, enzymes, catalysts, amino acids, microbial stimulants and repellants

1. Regulation of soil microbial community
2. Encourage beneficial symbiosis
3. Change physical and chemical properties of soil
4. Inhibit growth of competing plants
5. 5%-21% (40%) of all photosynthetically fixed carbon transferred to the rhizosphere through exudates



Bioremediation of Petroleum Polluted Soils

The Soil Food Web



First trophic level:
Photosynthesizers

Second trophic level:
Decomposers
Mutualists
Pathogens, Parasites
Root-feeders

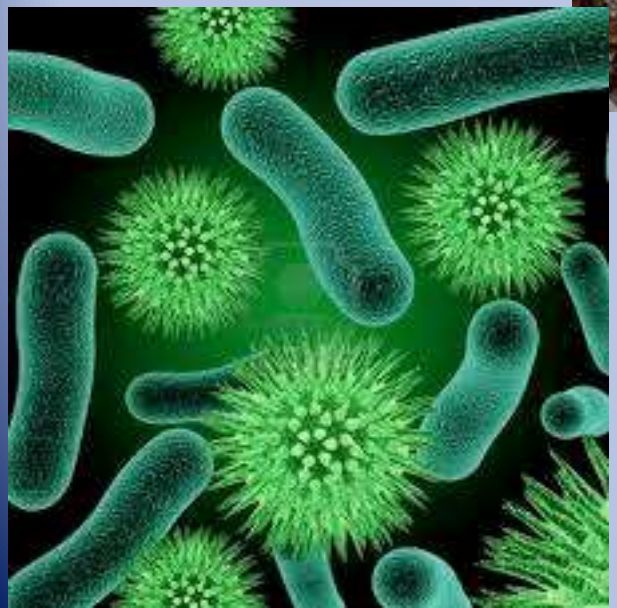
Third trophic level:
Shredders
Predators
Grazers

Fourth trophic level:
Higher level predators

Fifth and higher trophic levels:
Higher level predators

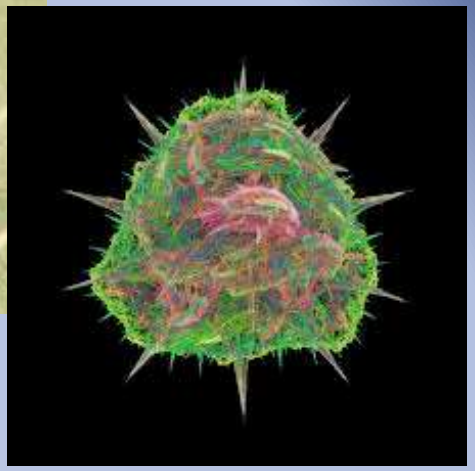
Second Trophic Level:

Decomposers, Pathogens, Parasites, Mutualists, Root Feeders



Third Trophic Level:

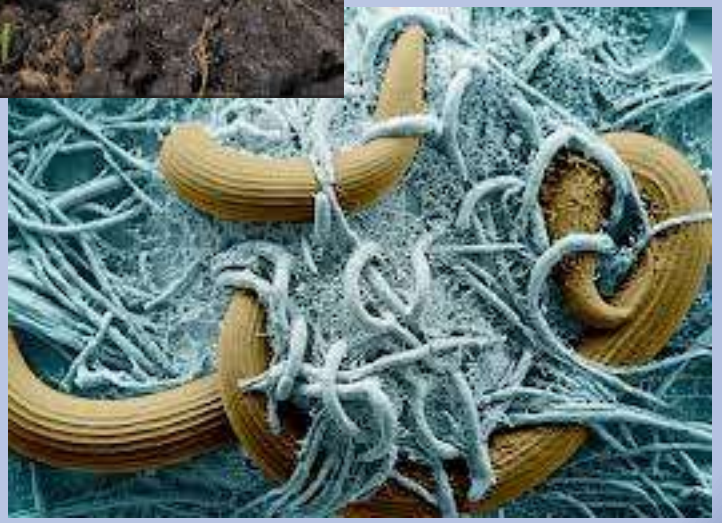
Shredders, Predators, Grazers

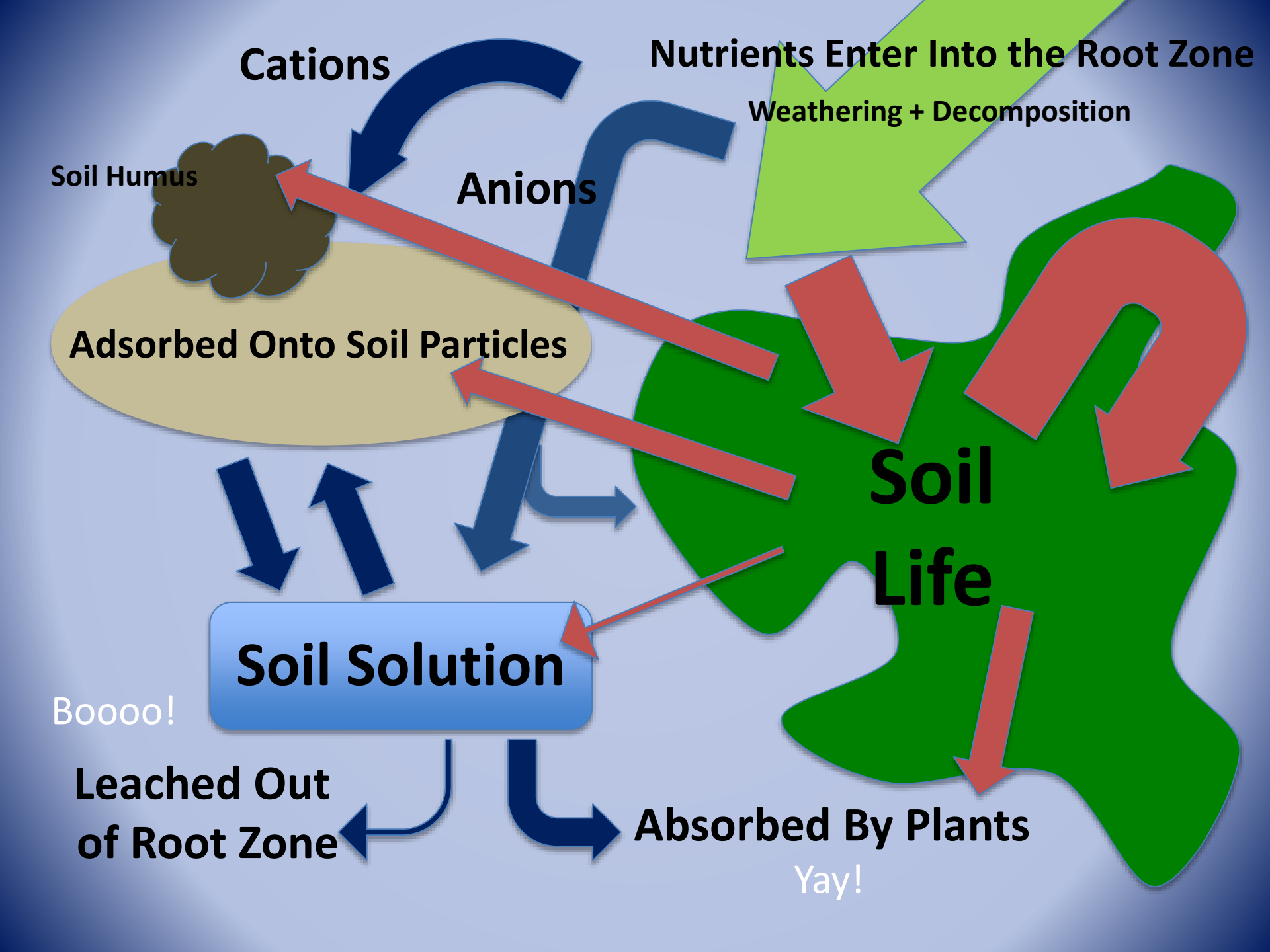


"These organisms do the work that a pack of dogs would do if given free rein in a room filled with bones, shoes, and fuzzy balls."
-David Montgomery, The Hidden Half of Nature

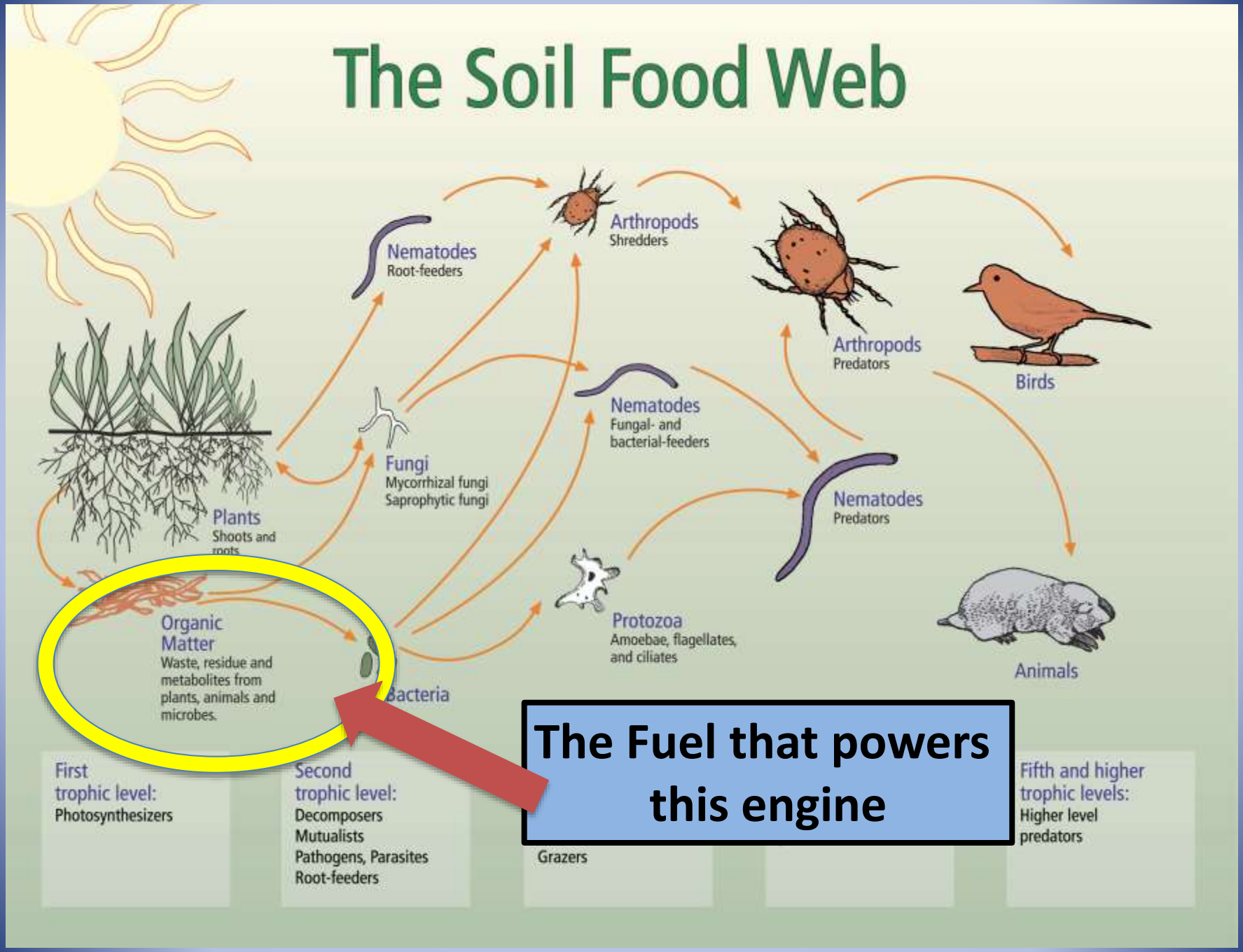
Fourth, Fifth Trophic Levels:

Predators

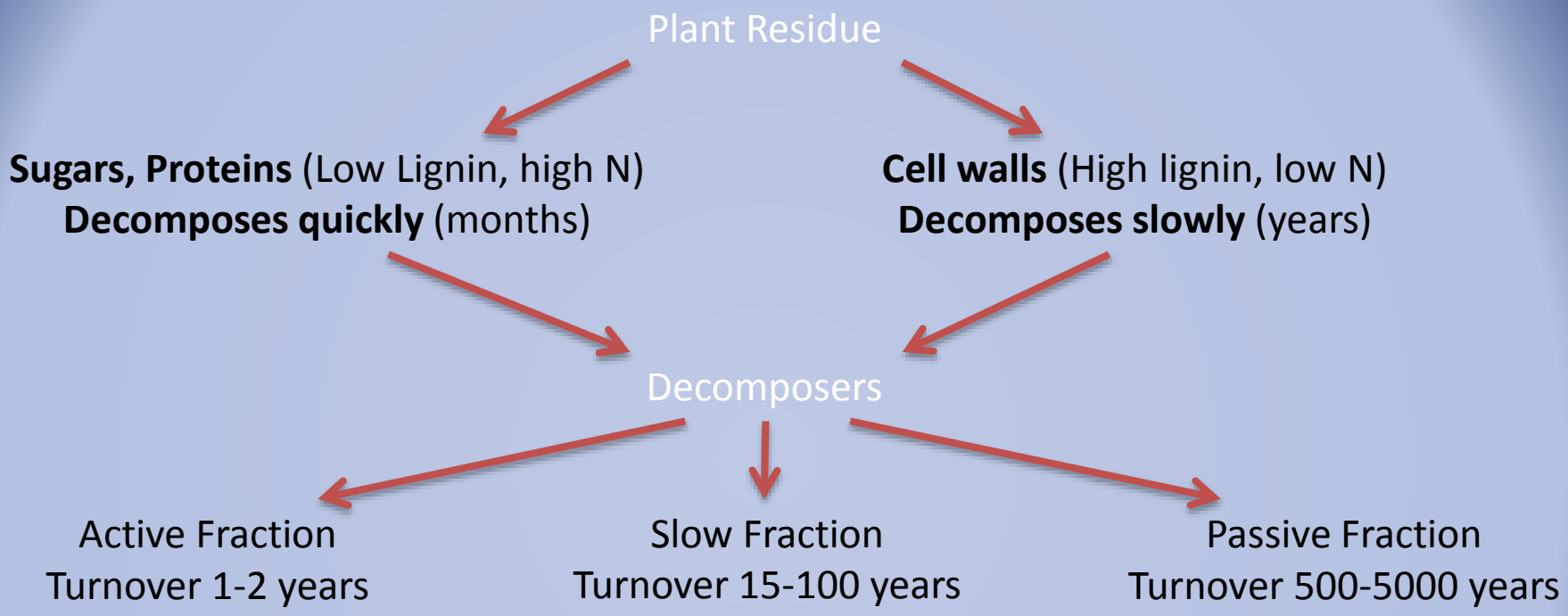



Cations
Nutrients Enter Into the Root Zone
Weathering + Decomposition
Soil Humus
Anions
Adsorbed Onto Soil Particles
Soil Life
Soil Solution
Boooo!
Leached Out of Root Zone
Absorbed By Plants
Yay!

The Soil Food Web



What Happens to Organic Soil Ammendments?



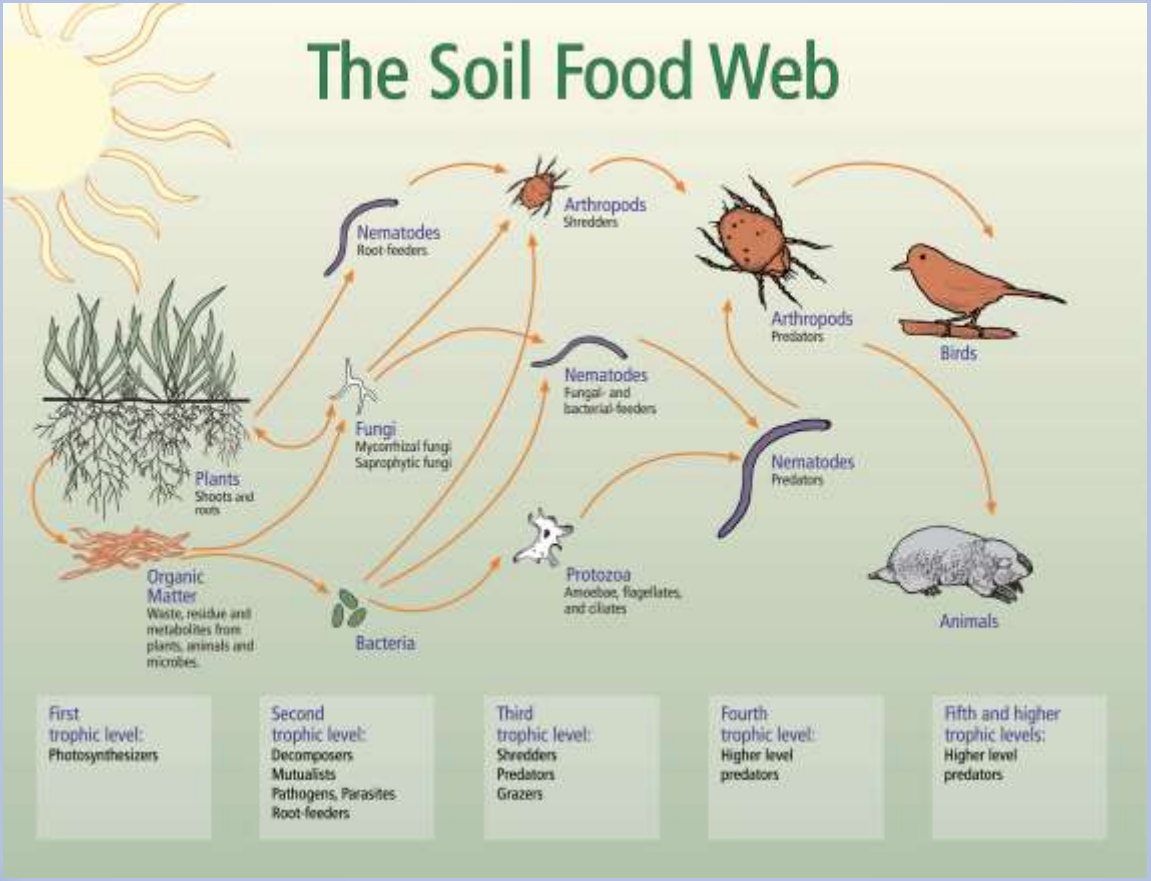
Soil structural stability, food for microorganisms and mineralization of nutrients

Food for some microorganisms, mineralization of some nutrients

Cation exchange capacity, water holding capacity

“The essence of humus manufacture is first to provide the organisms with the correct raw material and then to ensure that they have suitable working conditions.”

Sir Albert Howard



Soil Testing Resources

Washington State University
http://puyallup.wsu.edu/soilmgmt/Soils.html

King Conservation District
http://www.kingcd.org/pro_far_soi.htm
King County Conservation District offers free basic soil testing

Grow Smart Grow Safe
http://www.growsmartgrowsafe.org/SoilAmend.aspx

Teaming With Nutrients
Jeff Lowenfels

Soil Life Resources

Teaming with Microbes

Jeff Lowenfels and Wayne Lewis

Life in the Soil

James B. Nardi

The Hidden Half of Nature

David Montgomery and Anne Bikle

Building Soil

Elizabeth Murphy

University of Washington Botanic Gardens

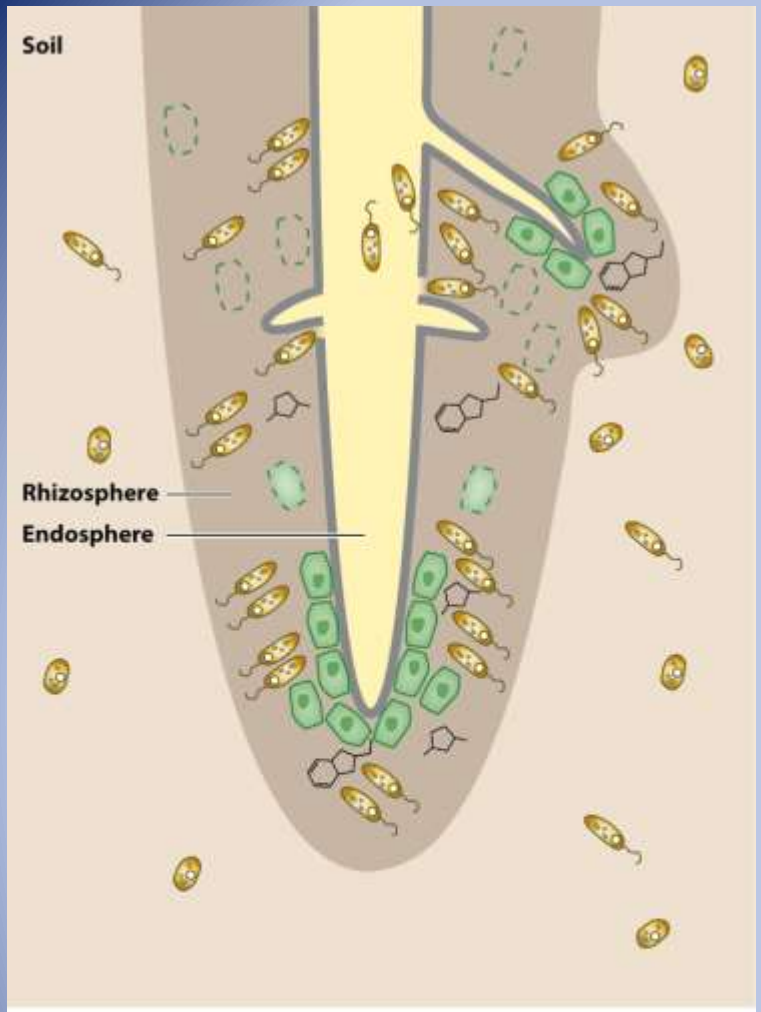
Elisabeth C. Miller Library

http://depts.washington.edu/hortlib/index.shtml

Try the Gardening Answers Knowledgebase, a searchable database of Plant Answer Line question/answer sets and recommended websites.

Call the Plant Answer Line at 206-897-5268 (**206-UW-PLANT**)
or email **hortlib@uw.edu**.

Plant Answer Line



Bacteria
Living root cap border cell
Decaying root cap border cells
Organic compounds released by rhizodeposition

Bulgarelli D, et al. 2013.
Annu. Rev. Plant Biol. 64:807–38

Annual Reviews

Beware of Bio-accumulation!

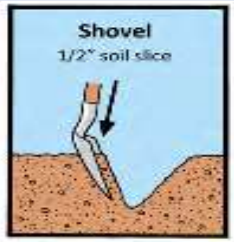
Source	Heavy Metal									
	As	Cd	Co*	Cr	Cu*	Hg	Mn*	Ni	Pb	Zn*
Natural										
Mineral parent material		X		X	X			X	X	X
Volcanic gasses		X		X	X	X	X	X		X
Precipitation		X			X				X	X
Marine aerosols	X	X			X		X	X		
Forest Fires	X	X			X	X		X	X	X
Anthropogenic										
Fossil fuel combustion	X	X	X		X			X	X	X
Industrial and domestic chimneys					X			X	X	X
Automobiles		X		X		X		X	X	X
Mining and smelting		X	X		X		X	X	X	X
Fertilizers		X		X	X		X	X		X
Pesticides	X				X	X				
Liming materials					X		X			X
Organic manures		X		X	X		X	X	X	X
Sewage Sludge		X		X	X		X	X	X	X

Elements of Plants

Element		Percentage by weight	Relative number of atoms
Nitrogen	N	1.5	1,000,000
Potassium	K	1.0	250,000
Calcium	Ca	0.5	125,000
Magnesium	Mg	0.2	80,000
Phosphorus	P	0.2	60,000
Sulfur	S	0.1	30,000
Chlorine	Cl	0.01	3,000
Boron	B	0.0067	2,000
Iron	Fe	0.0067	2,000
Manganese	Mn	0.003	1,000
Zinc	Zn	0.001	300
Copper	Cu	0.0003	100
Molybdenum	Mo	0.000003	1
Cobalt	Co	<0.000001	<1

www.waternut.org

How to Take a Sample



Take thin slices of soil approximately 1/2 inch. It is easiest to take a slice if you first remove a v-shaped hole, as shown above.

Avoid sampling when soils are saturated (after heavy rain) or within a few weeks after applying lime, fertilizer, compost or aged manure. You will need:

- A shovel, hand trowel or a soil probe
- A clean plastic container, such as a bucket
- Sampling bags (Ziploc-style bags will work)

1. Designate sample areas by what is growing there. For example, if you have a garden of mixed vegetables, that could be one sample area. If you have a pasture and a garden, take separate samples of each. If an area has varied characteristics, such as topography, soil moisture, soil type (sandy, clay, muck), or one area grows poorly, designate separate sample areas for each characteristic.
2. For each sample, take 10 to15 sub-samples across the whole sample area. Be sure to get even coverage of the entire area. Take randomly located but evenly distributed sub-samples. A zig-zag pattern works for larger sample areas. Make thin slices of soils with a shovel or trowel; to a sampling depth between three and twelve inches of soil, depending on the crop and time of year. (See the table below for instructions.) Place the sub-samples in your clean container/bucket.
3. Thoroughly mix the 15 sub-samples and scoop out **TWO to THREE CUPS** of the soil and place into a bag.
4. Label the bag with your
   - Name
   - Five letters and/or numbers that will help you remember where the sample came from (such as PSTR1, GRDN1).

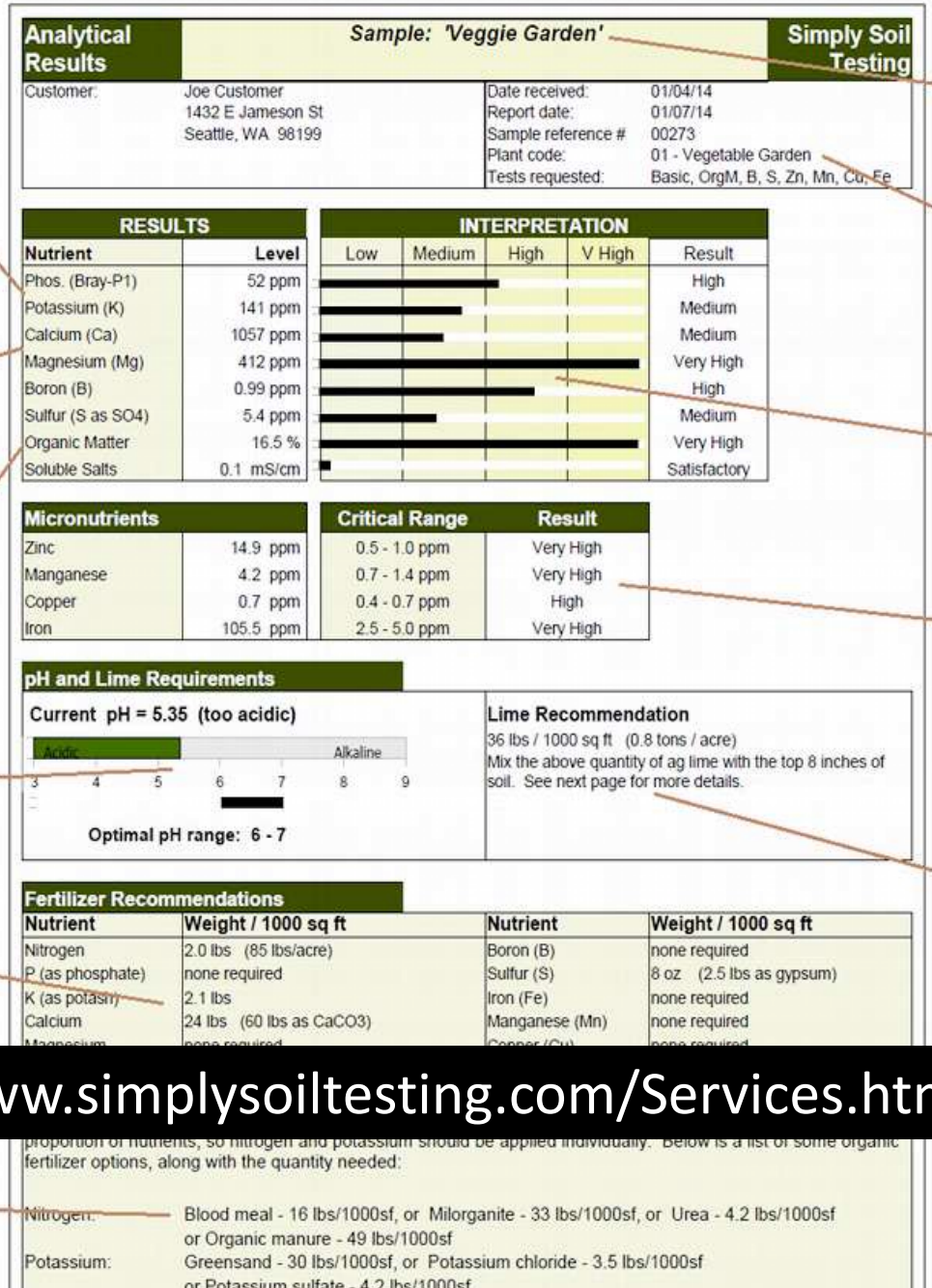
5. If you are taking more than one sample, repeat steps 2-5 for each area.
6. Mail or deliver the samples immediately. Soil nutrient levels continue to change even after a sample is taken, due to microbiological activity. It is critical, therefore, that this activity be stopped as soon as possible after sampling (within 12 hours).

   If you are not mailing the samples that day, put the sealed samples in a refrigerator. If samples are over-saturated, put soil on a newspaper and air dry overnight in a cool location. The soil should have moisture similar to damp sponge.
7. Fill out the Soil Sample Information Sheet and mail or deliver samples to:
   King Conservation District
   Attn: Soil Sampling
   1107 SW Grady Way, Suite 130
   Renton, WA 98057

Results are generally available within three weeks and will be e-mailed to you, or sent via postal mail.

Guidelines for Sampling Depth

	Type of Crop	Sampling Depth
For samples taken in September and October	All samples	12"
For samples taken any other time of year	Established lawn & pasture	4"
	New lawn & pasture	6"
	Gardens	6"
	Trees & shrubs	8"
	Commercial crops	8"



Analytical Results — *Sample: 'Veggie Garden'* — **Simply Soil Testing**

Customer:	Joe Customer 1432 E Jameson St Seattle, WA 98199	Date received: Report date: Sample reference # Plant code: Tests requested:	01/04/14 01/07/14 00273 01 - Vegetable Garden Basic, OrgM, B, S, Zn, Mn, Cu, Fe

RESULTS

Nutrient	Level
Phos. (Bray-P1)	52 ppm
Potassium (K)	141 ppm
Calcium (Ca)	1057 ppm
Magnesium (Mg)	412 ppm
Boron (B)	0.99 ppm
Sulfur (S as SO4)	5.4 ppm
Organic Matter	16.5 %
Soluble Salts	0.1 mS/cm

INTERPRETATION

Low	Medium	High	V High	Result
				High
				Medium
				Medium
				Very High
				High
				Medium
				Very High
				Satisfactory

Micronutrients		Critical Range	Result
Zinc	14.9 ppm	0.5 - 1.0 ppm	Very High
Manganese	4.2 ppm	0.7 - 1.4 ppm	Very High
Copper	0.7 ppm	0.4 - 0.7 ppm	High
Iron	105.5 ppm	2.5 - 5.0 ppm	Very High

pH and Lime Requirements

Current pH = 5.35 (too acidic)

Acidic — Alkaline

3 4 5 6 7 8 9

Optimal pH range: 6 - 7

Lime Recommendation

36 lbs / 1000 sq ft (0.8 tons / acre)

Mix the above quantity of ag lime with the top 8 inches of soil. See next page for more details.

Fertilizer Recommendations

Nutrient	Weight / 1000 sq ft	Nutrient	Weight / 1000 sq ft
Nitrogen	2.0 lbs (85 lbs/acre)	Boron (B)	none required
P (as phosphate)	none required	Sulfur (S)	8 oz (2.5 lbs as gypsum)
K (as potash)	2.1 lbs	Iron (Fe)	none required
Calcium	24 lbs (60 lbs as CaCO3)	Manganese (Mn)	none required
Magnesium	none required	Copper (Cu)	none required

proportion of nutrients, so nitrogen and potassium should be applied individually. Below is a list of some organic fertilizer options, along with the quantity needed:

Nitrogen:	Blood meal - 16 lbs/1000sf, or Milorganite - 33 lbs/1000sf, or Urea - 4.2 lbs/1000sf or Organic manure - 49 lbs/1000sf
Potassium:	Greensand - 30 lbs/1000sf, or Potassium chloride - 3.5 lbs/1000sf or Potassium sulfate - 4.2 lbs/1000sf

The report shows the levels of macro-nutrients, phosphorus and potassium (in ppm). Nitrogen levels are not customarily tested.

The secondary nutrients, calcium, magnesium and sulfur are often deficient in NW soils, and are not included in conventional fertilizer blends.

Organic matter improves the texture of garden soil and serves as a reservoir for many nutrients.

This graph shows the current soil pH and whether it is within the optimal range for your garden, orchard or lawn.

This section shows which nutrients are deficient and how much of each nutrient is needed to achieve recommended levels.

Recommended addition rates of various conventional or organic fertilizers (your choice) in pounds per 1000 sq ft.

Customer's description of the location where the soil sample was taken.

The plant or crop that the customer has indicated will be planted. The fertilizer and lime recommendations are tailored to the selected plants.

The bar graphs show, at a glance, whether the soil nutrient levels are adequate.

The micro-nutrients are less often deficient. Deficiencies are usually only observed in particular geographical regions.

If the soil pH is below what is recommended for your plants, this section will show the recommended amount of lime to add.

http://www.simplysoiltesting.com/Services.html#report

Justus Von Liebig's Law of the Minimum:

A plant's yield is limited by the most limited nutrient.

Sir Albert Howard's Law of Return:

Plant and animal wastes should be returned to the soil to maintain nutrient and humus levels.

Analytical Results

Sample: 'NEWVS'

Simply Soil Testing

Customer:	Roy Farrow 11918 Nevers Rd Snohomish, WA 98290	Date received: Report date: Sample reference #: Plant code:	08/15/17 08/22/17 01937 01 - Vegetable Garden
Organic Fertilizers:	Yes	Tests requested:	Basic, OrgM, B, S, Zn, Mn, Cu, Fe

RESULTS / INTERPRETATION

Nutrient	Level	Low	Medium	High	V High	Result
Nitrogen (nitrate-N)	14 ppm					Low
Phosphorus (P)	147 ppm					Very High
Potassium (K)	434 ppm					Very High
Calcium (Ca)	1152 ppm					High
Magnesium (Mg)	198 ppm					High
Boron (B)	0.7 ppm					High
Sulfur (S as SO4)	5.4 ppm					Medium
Organic Matter	5.8 %					Medium

Micronutrients		Critical Range	Result
Zinc	3.0 ppm	0.5 - 1.0 ppm	Very High
Manganese	4.1 ppm	0.7 - 1.4 ppm	Very High
Copper	1.2 ppm	0.3 - 0.6 ppm	Very High
Iron	270.6 ppm	2.5 - 5.0 ppm	Very High

pH and Lime Requirements

Current pH = 5.28 (too acidic)

Optimal pH range: 6.0 - 7.0

Lime Recommendation

54 lbs / 1000 sq ft (1.2 tons / acre)

Mix the above quantity of ag lime with the top 6 inches of soil. See the following pages for more details.

Fertilizer Recommendations

Nutrient	Weight / 1000 sq ft	Nutrient	Weight / 1000 sq ft
Nitrogen	2.3 lbs (100 lbs/acre)	Boron (B)	none required
P (as phosphate)	none required	Sulfur (S)	8 oz (2.5 lbs as gypsum)
K (as potash)	none required	Iron (Fe)	none required
Calcium	none required	Manganese (Mn)	none required
Magnesium	none required	Copper (Cu)	none required
		Zinc (Zn)	none required

N-P-K Fertilizer Options

A fertilizer with N, P and K in the proportions 20:0:0 is recommended (11 lbs/1000 sq ft). Phosphorus and potassium are already present at high levels. Only a standard annual application of nitrogen is recommended. Below are some organic nitrogen-containing fertilizer options, along with the quantity needed.

Blood meal - 19 lbs/1000sf
Scott's Organic Choice - 21 lbs/1000sf
Feather meal - 21 lbs/1000sf
Organic urea - 5.0 lbs/1000sf
Milorganite - 38 lbs/1000sf

Simply Soil Testing, 20312 Lafayette Rd, Burlington, WA 98233 Email: service@simplysoiltesting.com