ECOLOGICAL SOIL MANAGEMENT: AN INTRODUCTION TO SOIL SCIENCE

WASHINGTON STATE UNIVERSITY EXTENSION
VERSION 2020

FOUNDATIONAL SOIL PRINCIPLES NOT COVERED TODAY

Basic soil introduction

What is soil?

What is in a volume of soil?

(minerals, porosity, organic matter)

The disciplines of soil science

How we organize the study of soil science (pedology, fertility, chemistry, physics, and biology)

Soil formation, physical properties and natural history

Soil forming factors

Soil texture

Soil structure

Soil horizons

Typical WA soils

3. SOIL FUNCTION

PHOTO COURTESY: NATHAN STACEY

3. SOIL FUNCTION

- 3.1 Definitions of soil function

3. SOIL FUNCTION

Protect external environment

Mutualistic relationships

Develop healthy root systems

Suppress root diseases

Water & air infiltration

Provide water in dry spells

Supply nutrients

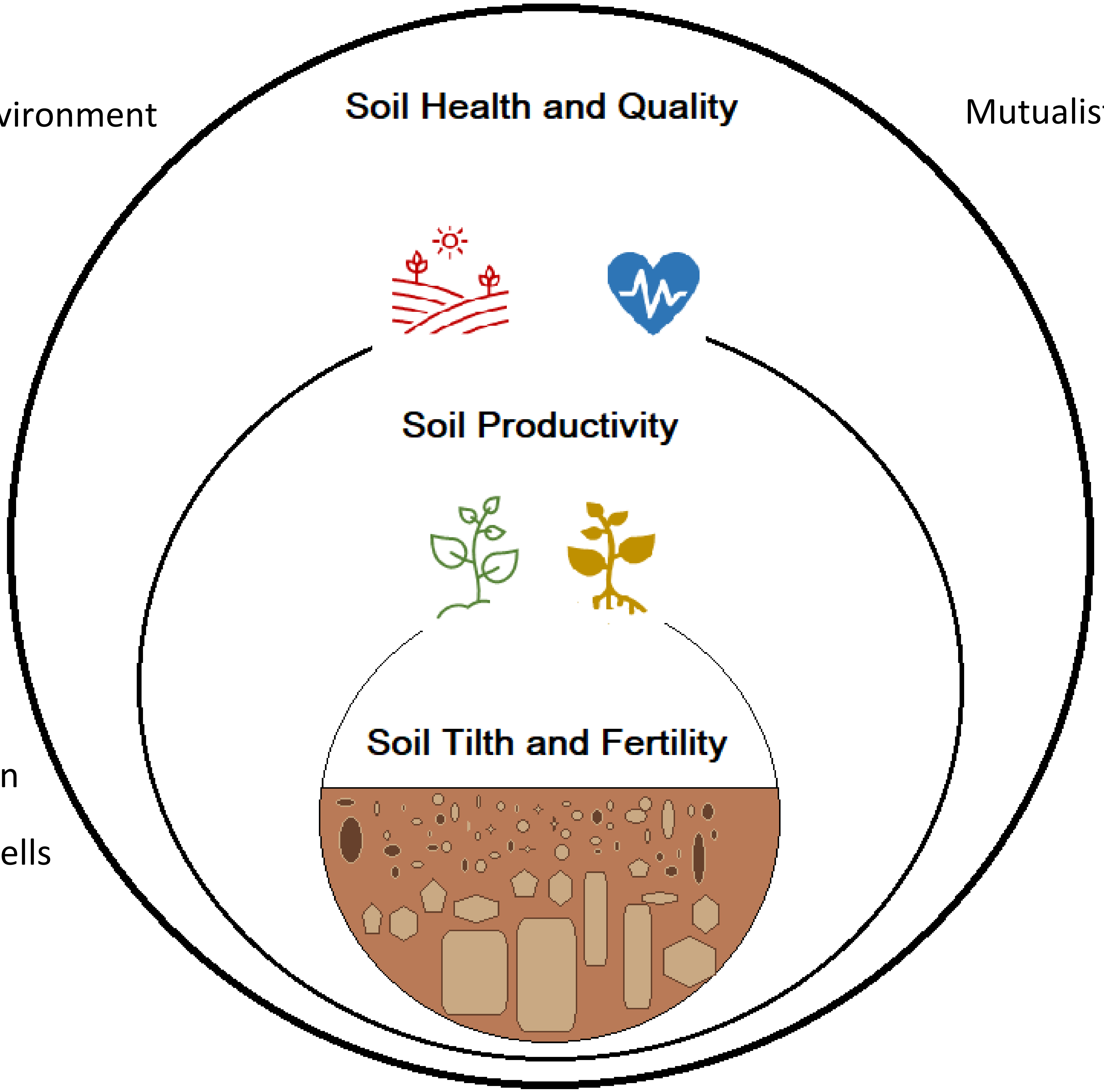


PHOTO COURTESY: NATHAN STACEY

3. SOIL FUNCTION

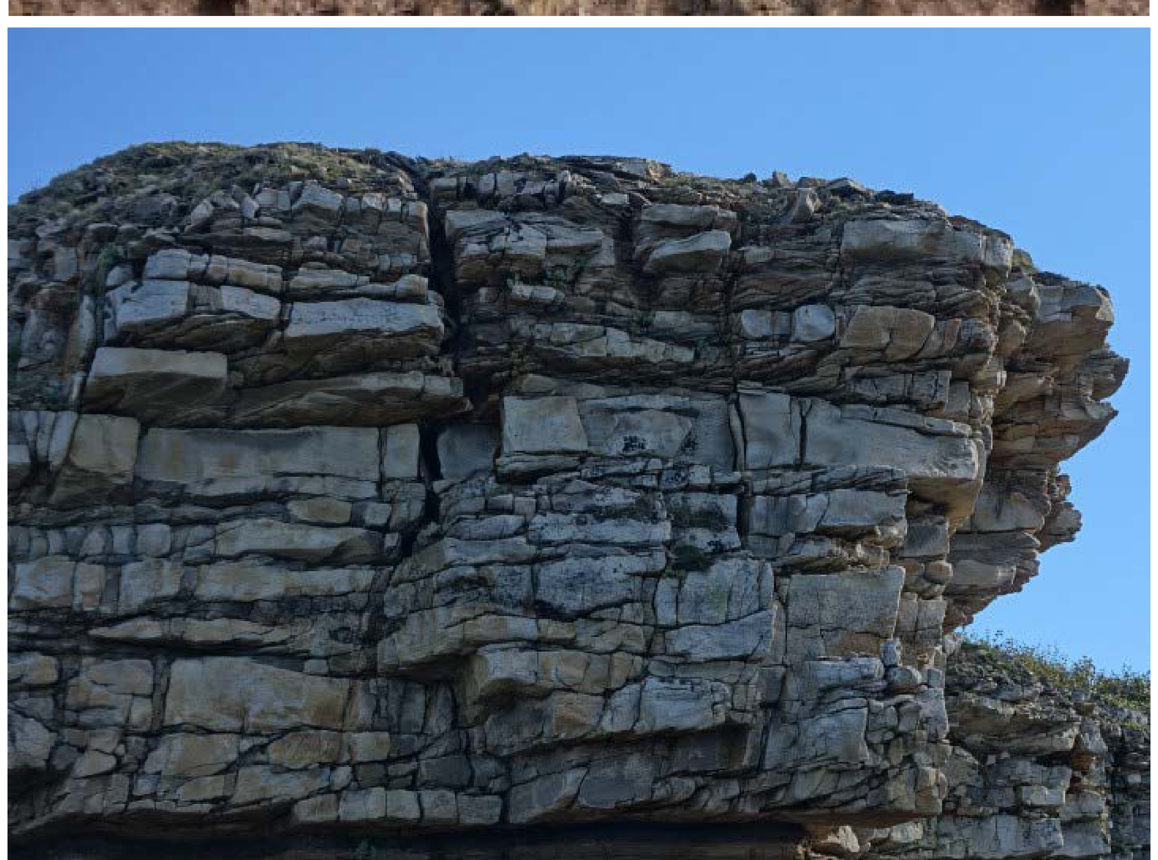
- 3.1 Definitions of soil function

What is degraded soil?

3. SOIL FUNCTION

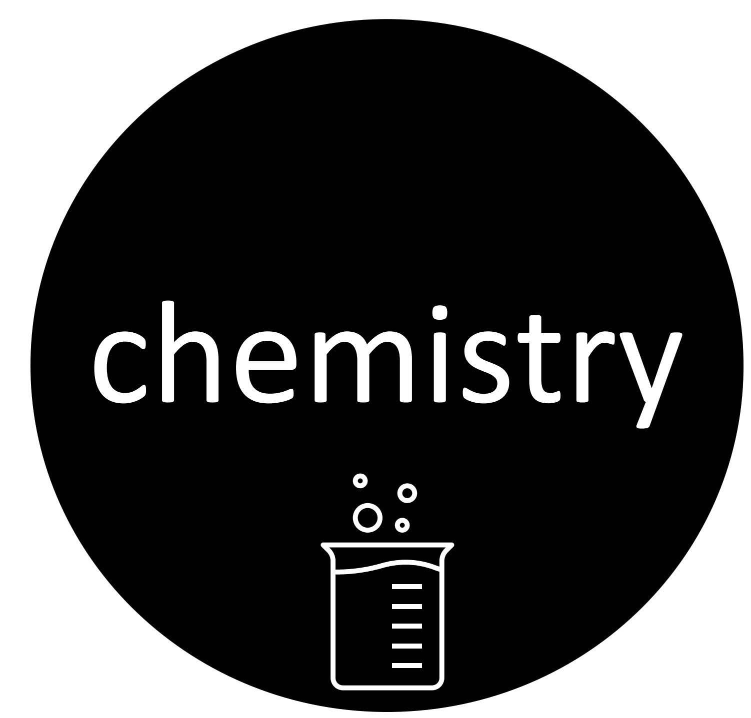
- 3.1 Definitions of soil function

- 3.2 **Inherent** & Dynamic properties

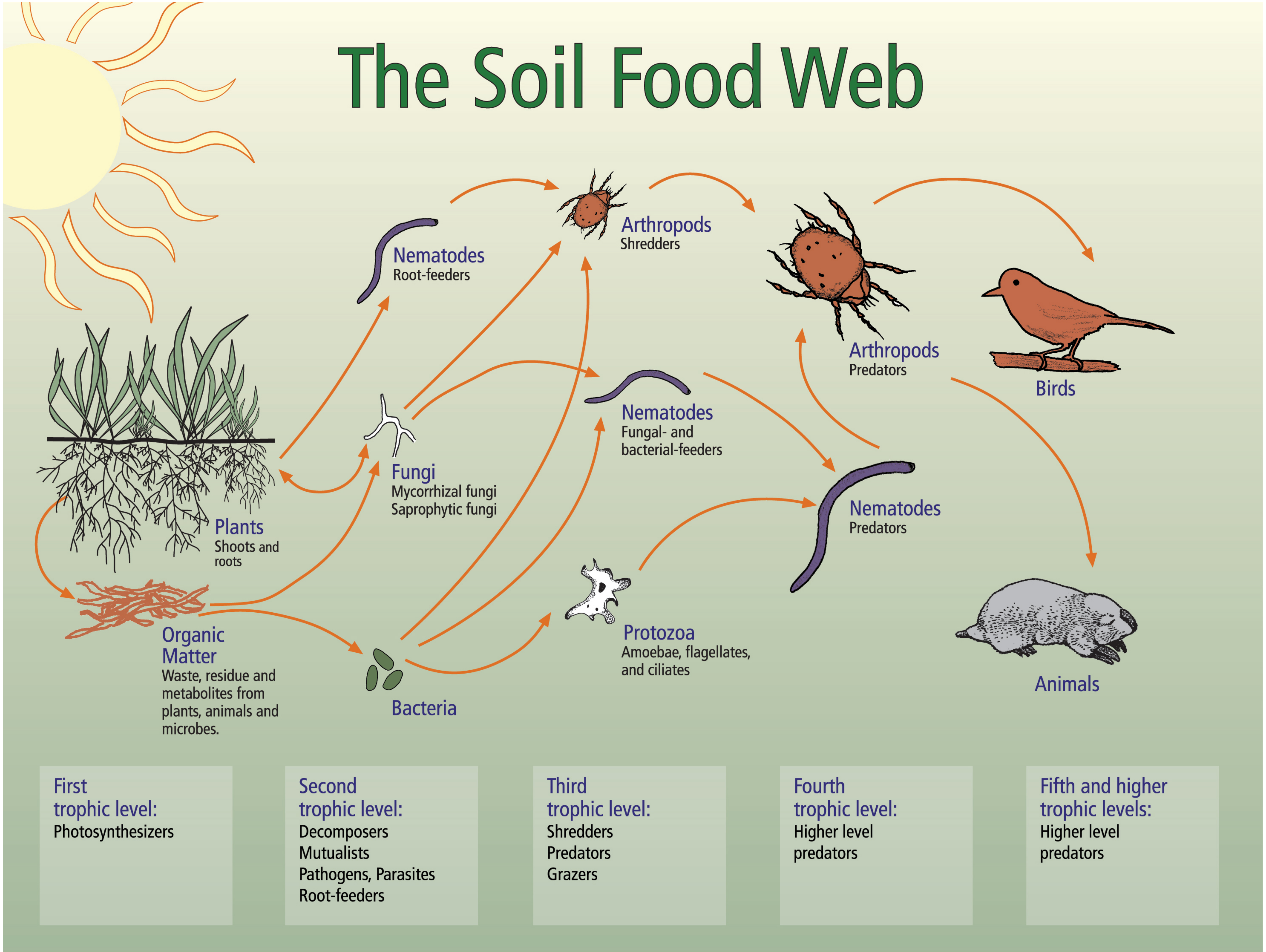


3. SOIL FUNCTION

- 3.2 Inherent & **Dynamic** properties



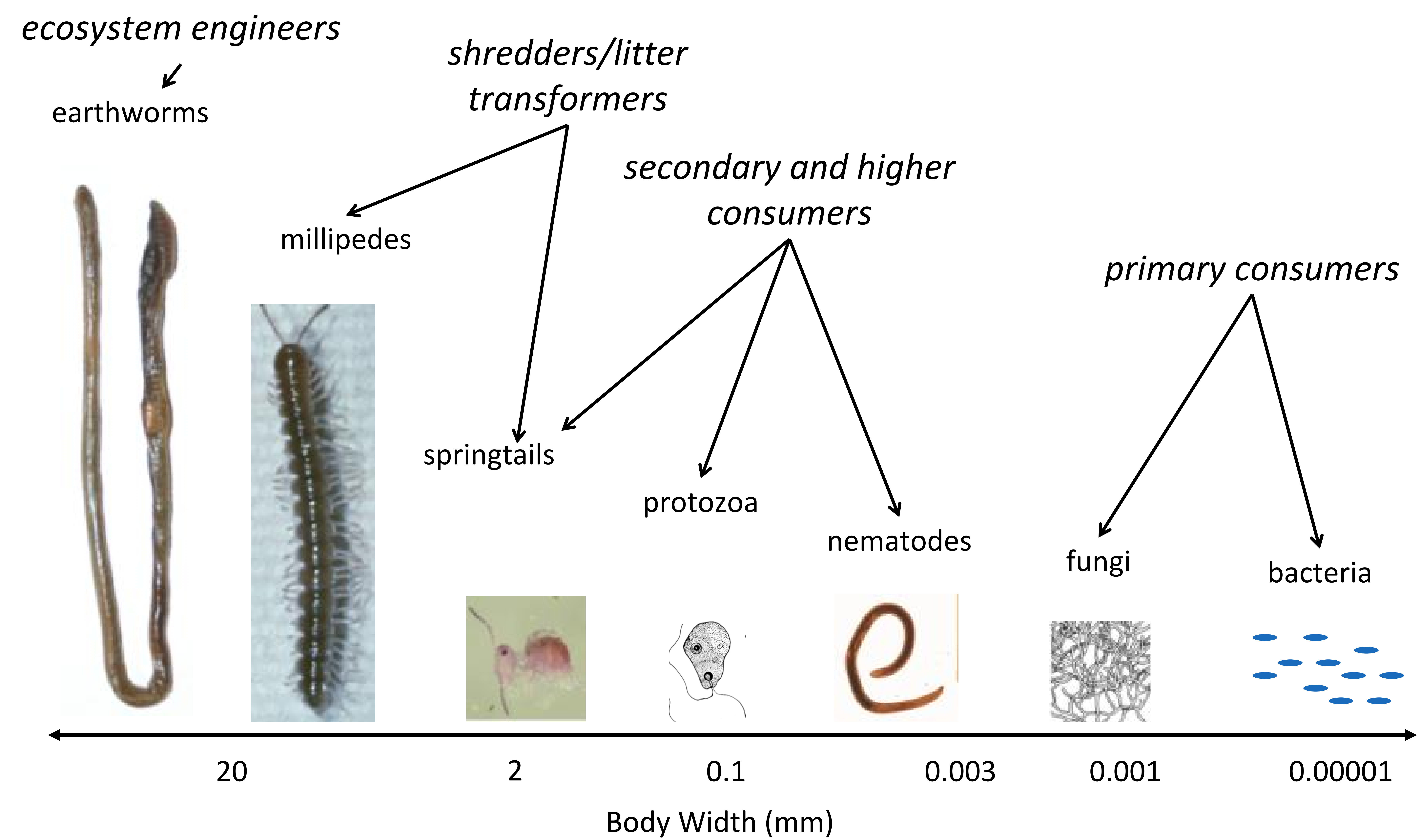
3.3 Soil biological communities



3.3 Soil biological communities

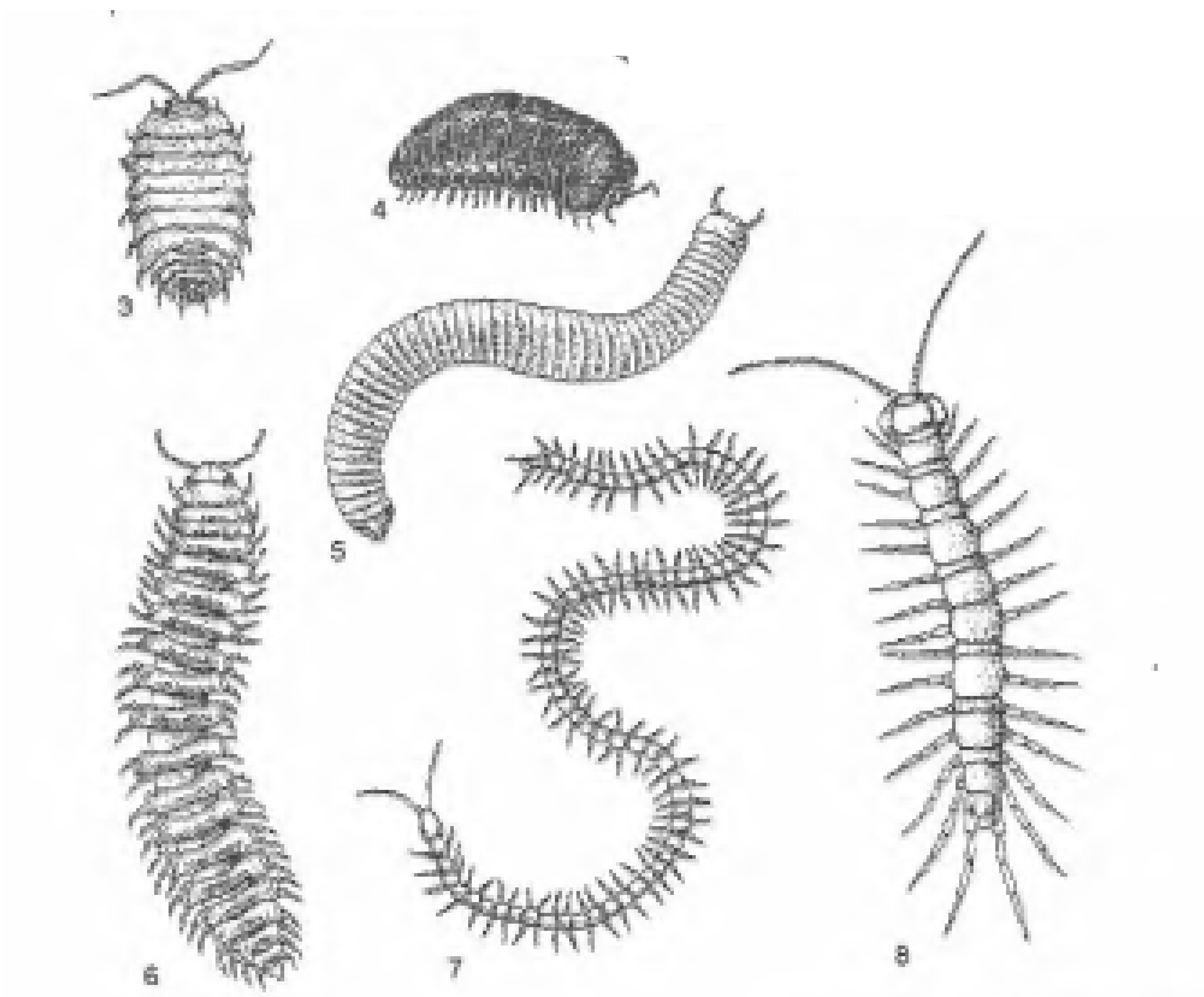
GROUPS OR GUILDS OF SOIL ORGANISMS AND THEIR RELATIVE SIZES

Functions of soil organisms go beyond who eats whom



3.3 Soil biological communities

LITTER TRANSFORMERS SPEED DECOMPOSITION THROUGH AN “EXTERNAL RUMEN.”



Wolters and Ekshmitt, 1997

3.3 Soil biological communities

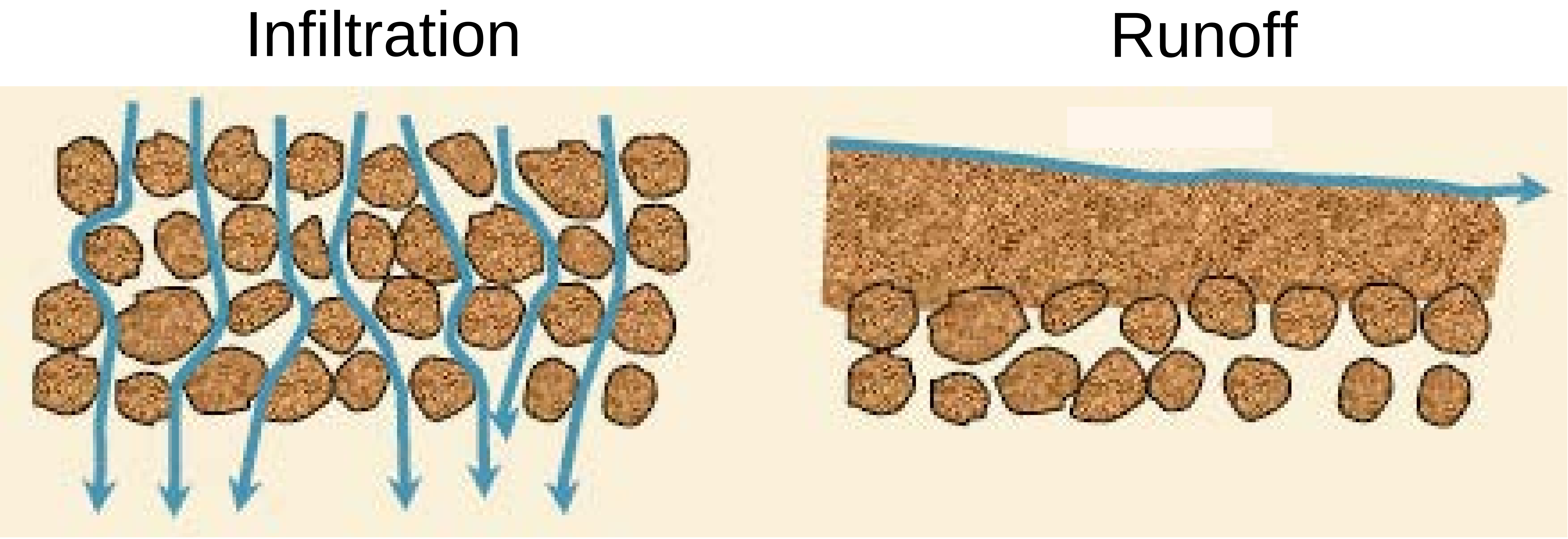
EARTHWORMS ARE "ECOSYSTEM ENGINEERS"; CHANGING THEIR ENVIRONMENT TO SUIT THEIR PHYSIOLOGY.

3.3 Soil biological communities

EARTHWORMS DEAL WITH WASTE SIMILARLY TO FRESHWATER ORGANISMS

3.3 Soil biological communities

INCREASED AGGREGATION ALLOWS WATER TO INFILTRATE EASILY DURING A DOWN POUR AND DRAIN AFTERWARD TO LET AIR IN.



Magdoff & Van Es, 2009

4. SOIL FERTILITY AND NUTRIENTS

4. SOIL FERTILITY AND NUTRIENTS

- 4.1 Soil nutrients and availability

Macronutrients		Micronutrients	
Carbon (C)	45.00%	Chlorine (Cl)	0.01 %
Oxygen (O)	45.00%	Iron (Fe)	0.01%
Hydrogen (H)	6.00%	Manganese (Mn)	0.005%
Nitrogen (N)	1.50%	Boron (B)	0.002%
Potassium (K)	1.00%	Zinc (Zn)	0.002%
Calcium (Ca)	0.50%	Copper (Cu)	0.0006%
Phosphorus (P)	0.20%	Molybdenum (Mo)	0.00001%
Magnesium (Mg)	0.20%	Nickel (Ni)	0.000001%
Sulphur (S)	0.20%		

Percentages by plant dry weight

4. SOIL FERTILITY AND NUTRIENTS

- 4.1 Soil nutrient and availability

Cations (+)

Ammonium
NH_4^+

Potassium
K^+

Anions (-)

Nitrate
NO_3^-

Phosphorus
$H_2PO_4^-$

4. SOIL FERTILITY AND NUTRIENTS

- 4.1 Soil nutrient and availability

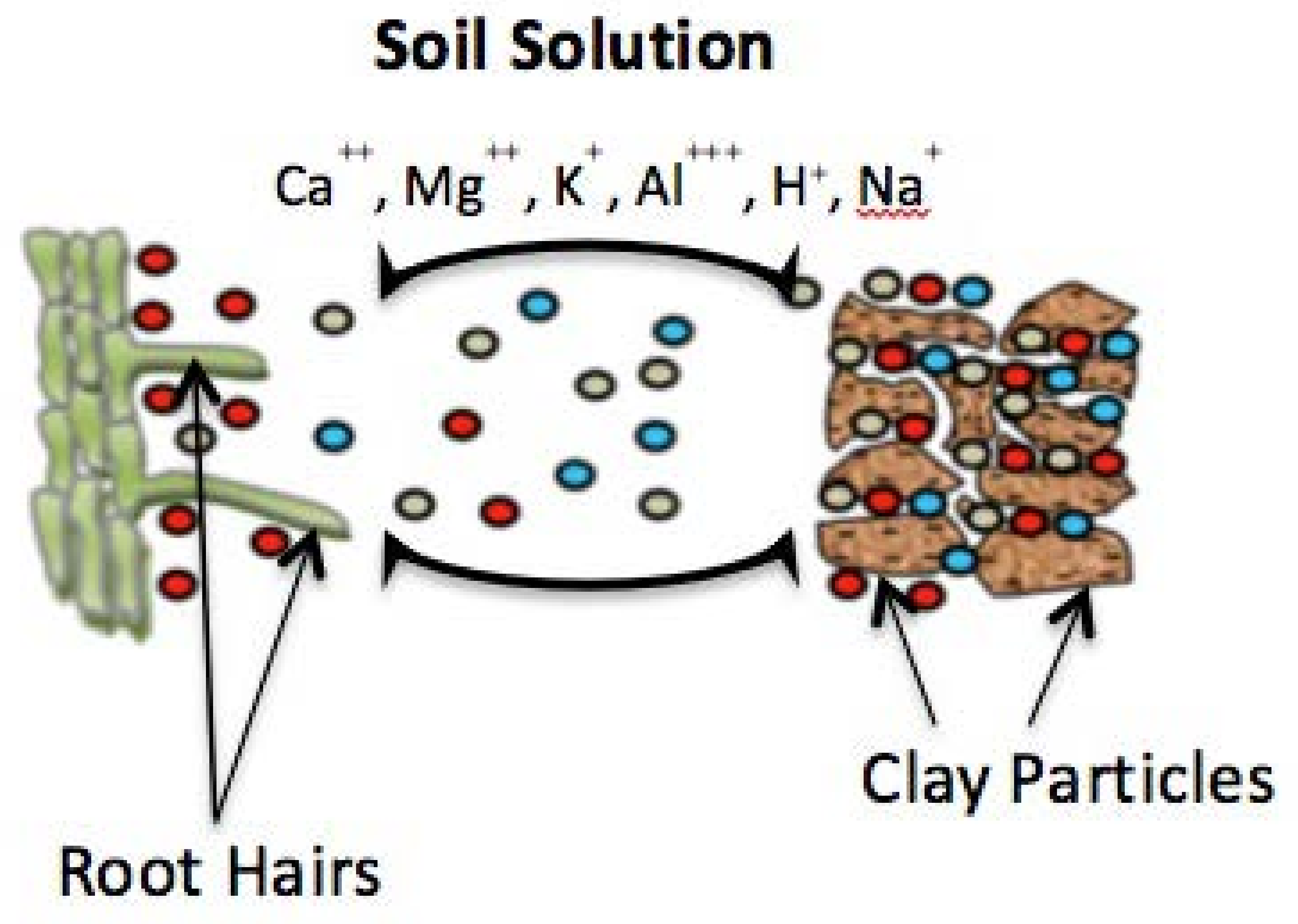


ILLUSTRATION COURTESY: UNIVERSITY OF GEORGIA EXTENSION

4. SOIL FERTILITY AND NUTRIENTS

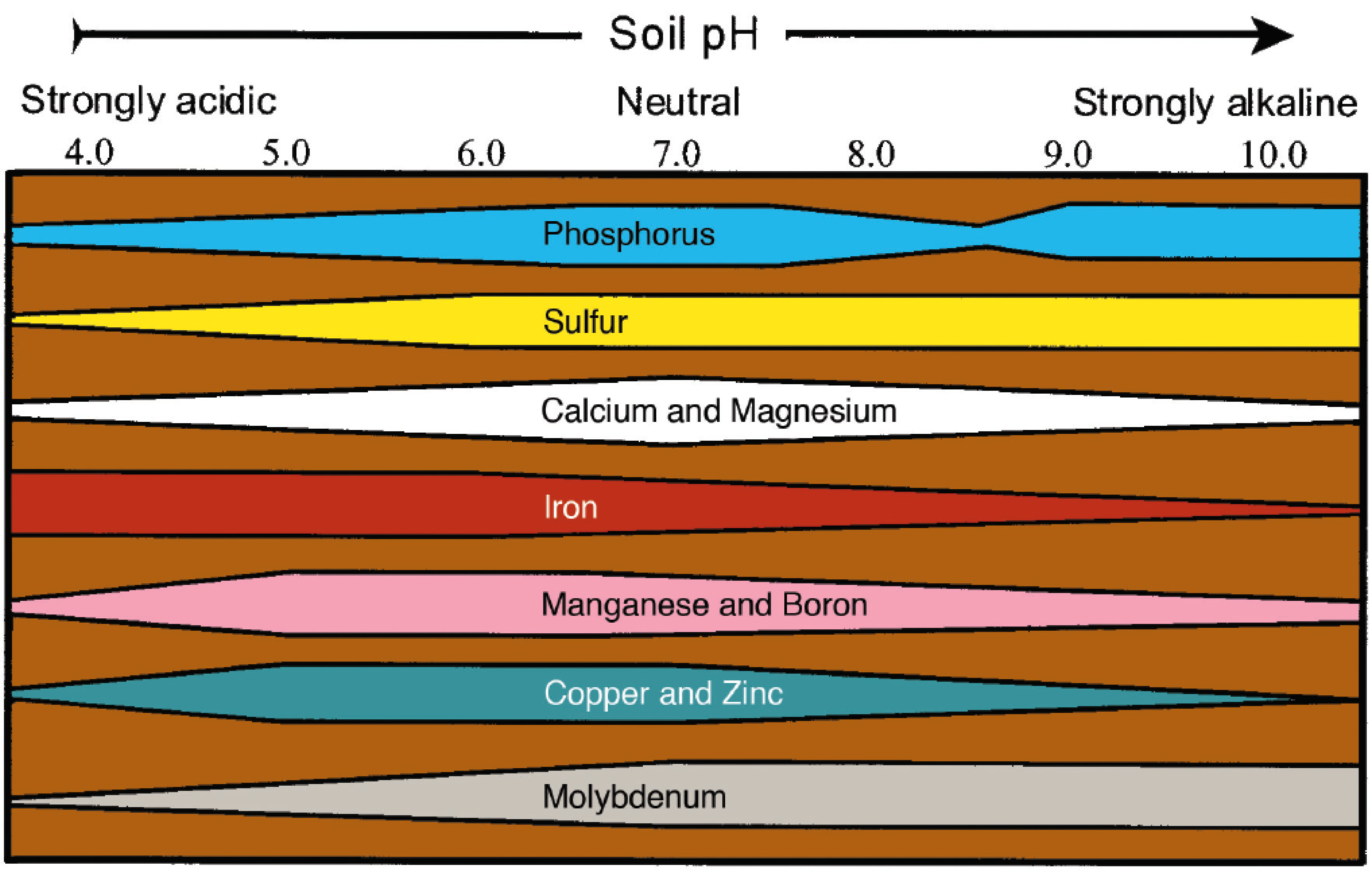
- 4.1 Soil nutrients and availability

pH

Measure of how acid or alkaline a substance is (related to H conc.)

6.0 to 7.5 ideal for most crops.

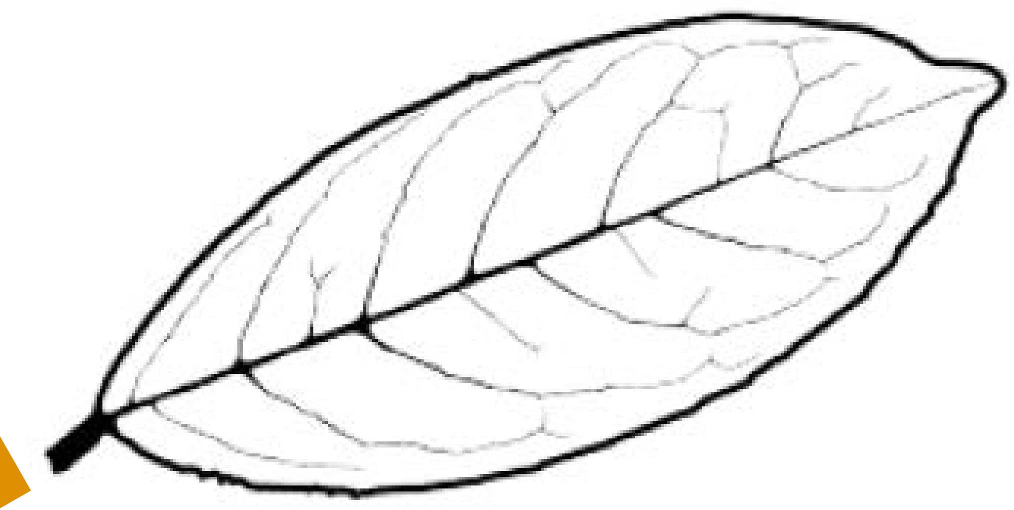
Blueberries 4.5 to 5.5



4. SOIL FERTILITY AND NUTRIENTS

- 4.1 Soil nutrients and availability

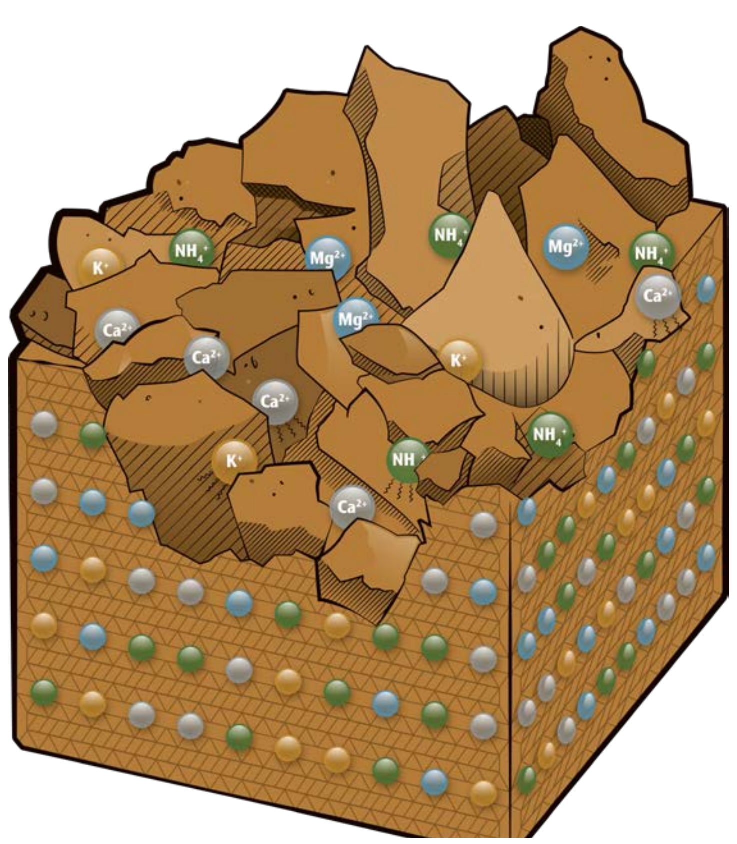
Rocks and minerals
(parent material)



Organic Matter
(litter, amendments, root exudates, protected, etc.)

PO_4^-
K^+
Ca^{2+}
SO_4^{2-}
Fe^{2-}
Mg^{2+}
NO_3^-
NH_4^+

Nutrients in solution



Surface adsorbed
(organo-mineral complexes)

Surface adsorbed
(soluble organic molecules)

- 4.1 Soil nutrient and availability

Chemical weathering

Very slowly available

Rocks and minerals
(parent material)

K^+ Ca^{2+}

PO_4^- Mg^{2+} Fe^{2-}

Elements
unavailable

Weathering
physical and chemical

Elements available
“nutrients”

Minerals

e.g.: Hornblende ((Ca,Na)2(Mg,Fe,Al)$_5$(Al,Si)$_8$O$_{22}$(OH)$_2$)
Potassium Feldspar (KAlSi$_3$O$_8$)

4. SOIL FERTILITY AND NUTRIENTS

- 4.1 Soil nutrient and availability

Mineralizable

slowly available

PO_4^{-}

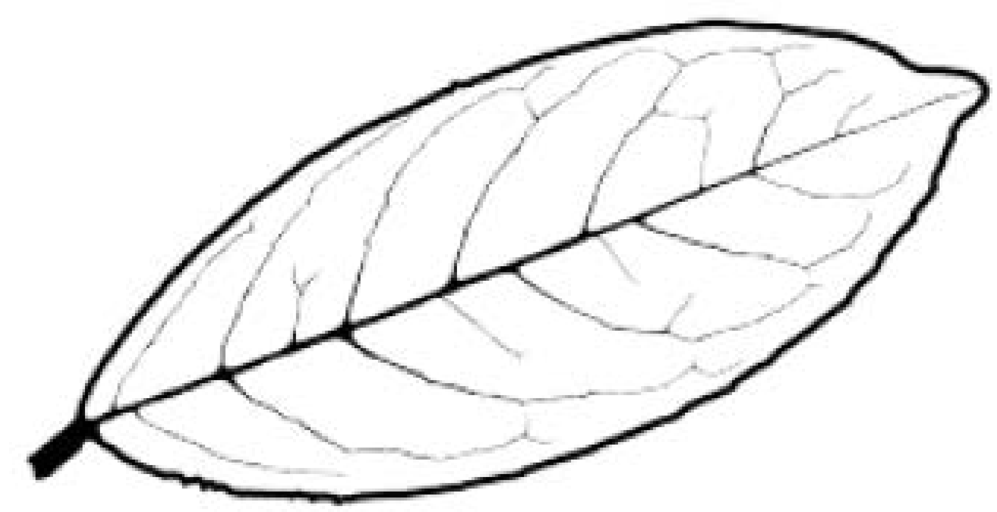
K^{+} Ca^{2+}

SO_4^{2-} Fe^{2-}

Mg^{2+}

NO_3^{-} NH_4^{+}

Nutrients in solution



Organic Matter
(litter, amendments, root exudates, protected, etc.)

ILLUSTRATION COURTESY: SOIL FERTILITY IN ORGANIC SYSTEMS: A GUIDE FOR GARDENERS AND SMALL ACREAGE FARMERS

4. SOIL FERTILITY AND NUTRIENTS

Nutrient pool

- 4.1 Soil nutrient and availability

Quickly available

PO_4^-

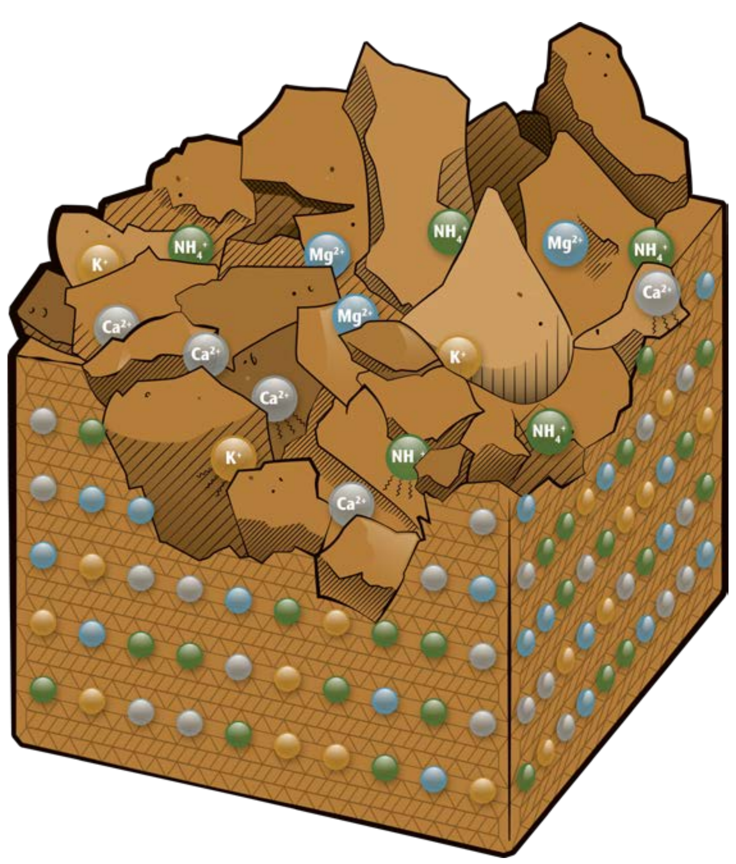
K^+ Ca^{2+}

SO_4^{2-} Fe^{2-}

Mg^{2+}

NO_3^- NH_4^+

<u>Nutrients in solution</u>



<u>Surface adsorbed</u>
(organo-mineral complexes)

<u>Surface adsorbed</u>
(soluble organic molecules)

4. SOIL FERTILITY AND NUTRIENTS

- 4.1 Soil nutrient and availability

TYPICAL CEC VALUES FOR DIFFERENT SOIL TEXTURES

Soil Type	CEC meq/100g
Sands (light colored)	3 to 5
Sands (dark colored)	10 to 20
Loams	10 to 15
Silt Loams	15 to 25
Clay and clay loams	20 to 50
Organic soils	50 to 100

4. SOIL FERTILITY AND NUTRIENTS

- 4.2 Nitrogen cycle and organic matter

PO_4^-

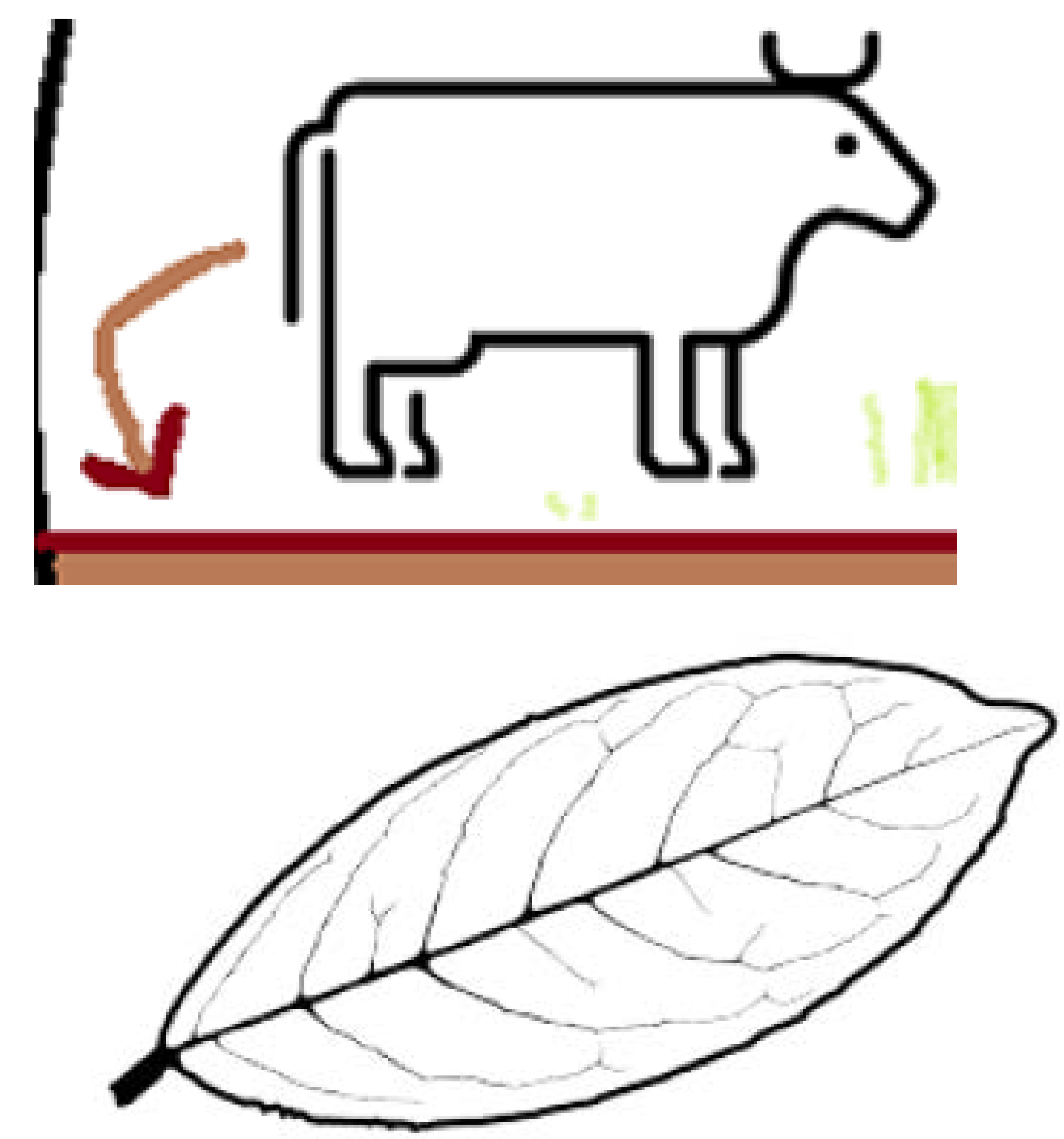
K^+ Ca^{2+}

Fe^{2-}

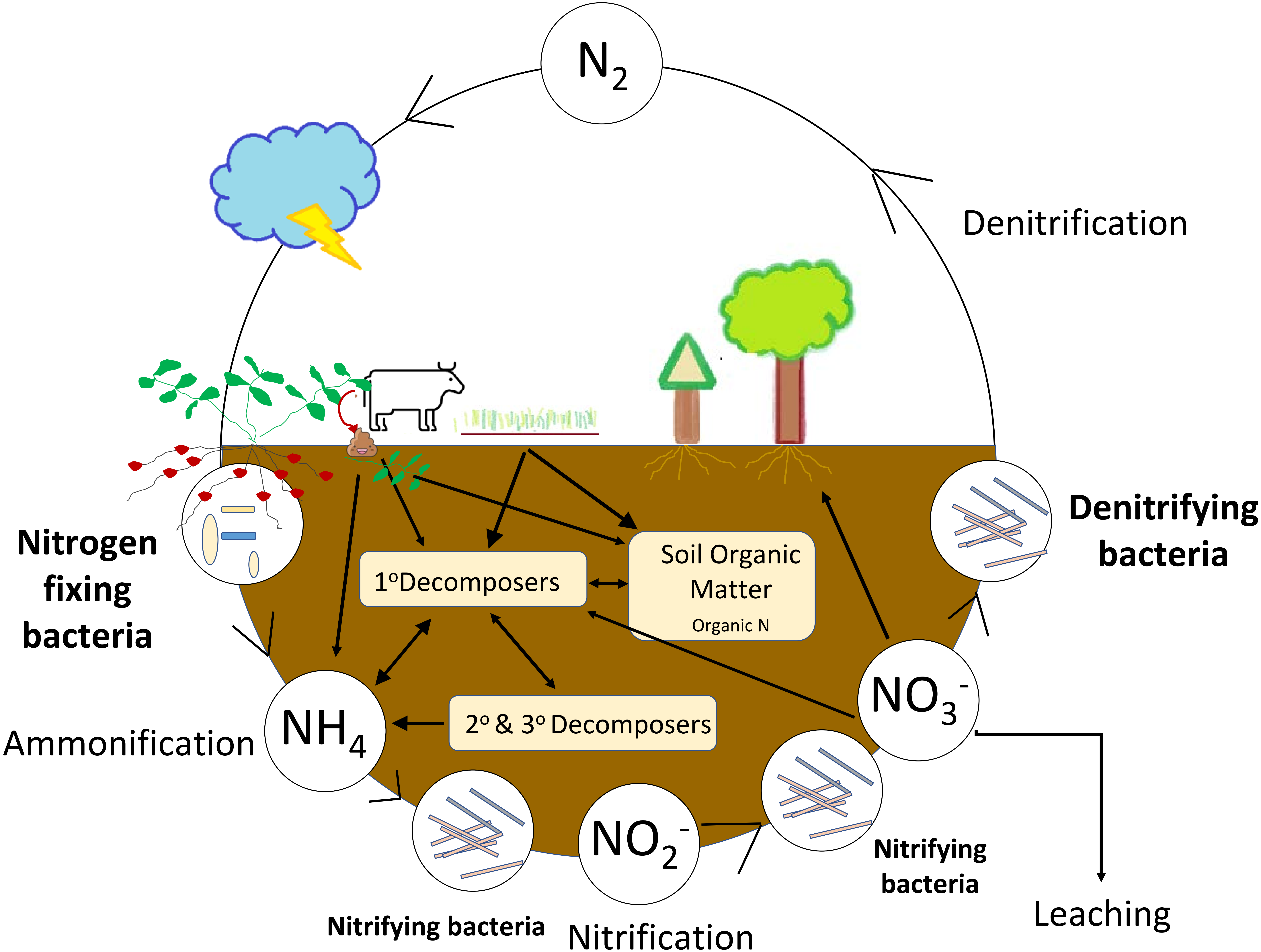
SO_4^{2-}

Mg^{2+}

NO_3^- NH_4^+



Organic Matter
(litter, amendments, root exudates, protected, etc.)


N2
Denitrification
Denitrifying bacteria
Nitrogen fixing bacteria
1°Decomposers
Soil Organic Matter
Organic N
NH4
Ammonification
2° & 3° Decomposers
NO3-
Leaching
NO2-
Nitrifying bacteria
Nitrification
Nitrifying bacteria

5. SOIL MANAGEMENT

PHOTO COURTESY: NATHAN STACEY

5. SOIL MANAGEMENT

What can/are we trying to manage?

5. SOIL MANAGEMENT

What can/are we trying to manage?

5. SOIL MANAGEMENT

- 5.1 Strategies for soil management

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Don’t allow bare soil

1. Cover crops
2. Ground covers
3. Mulch

5. SOIL MANAGEMENT

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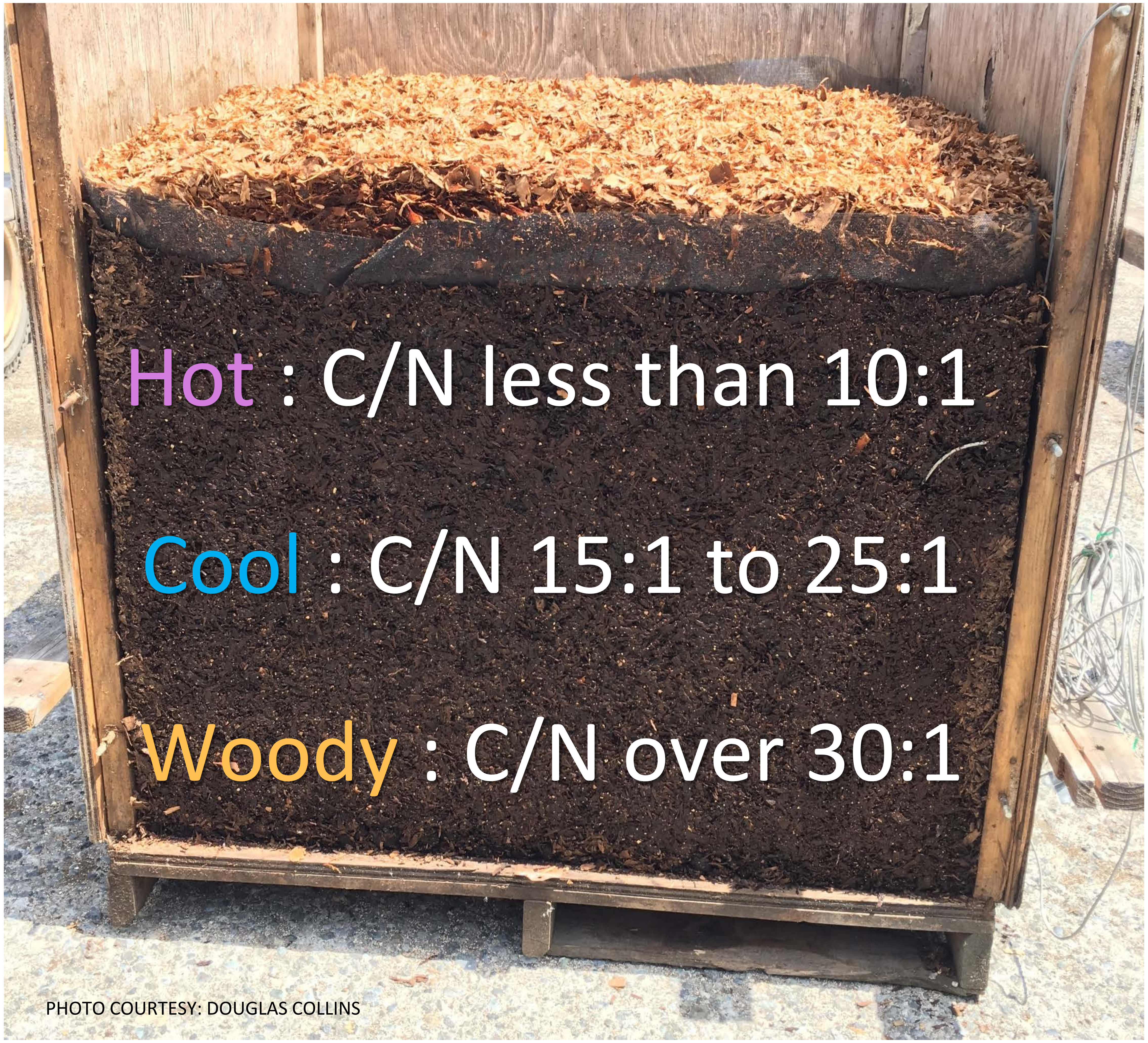


5. SOIL MANAGEMENT

- 5.1 Strategies for soil management

C:N LESS THAN 10:1 *HOT*

Fish and feather meals	Easy to over-apply
Poultry/ Fresh rabbit manure	Leads to excess nutrient levels
Seed meals	Potential to harm crop
	Degrade water quality

5. SOIL MANAGEMENT

- 5.1 Strategies for soil management

C:N FROM 15:1 TO 25:1 *COOL*

Composted: yard debris, most manures, biosolids

Fresh materials: yard debris, coffee grounds, dairy manure solids

Slow-release nitrogen

Use as soil amendment

Releases additional nutrients in subsequent seasons

5. SOIL MANAGEMENT

- 5.1 Strategies for soil management

C:N OVER 30:1 ***WOODY***

Straw

Sawdust

Paper waste

Horse bedding

Leaves

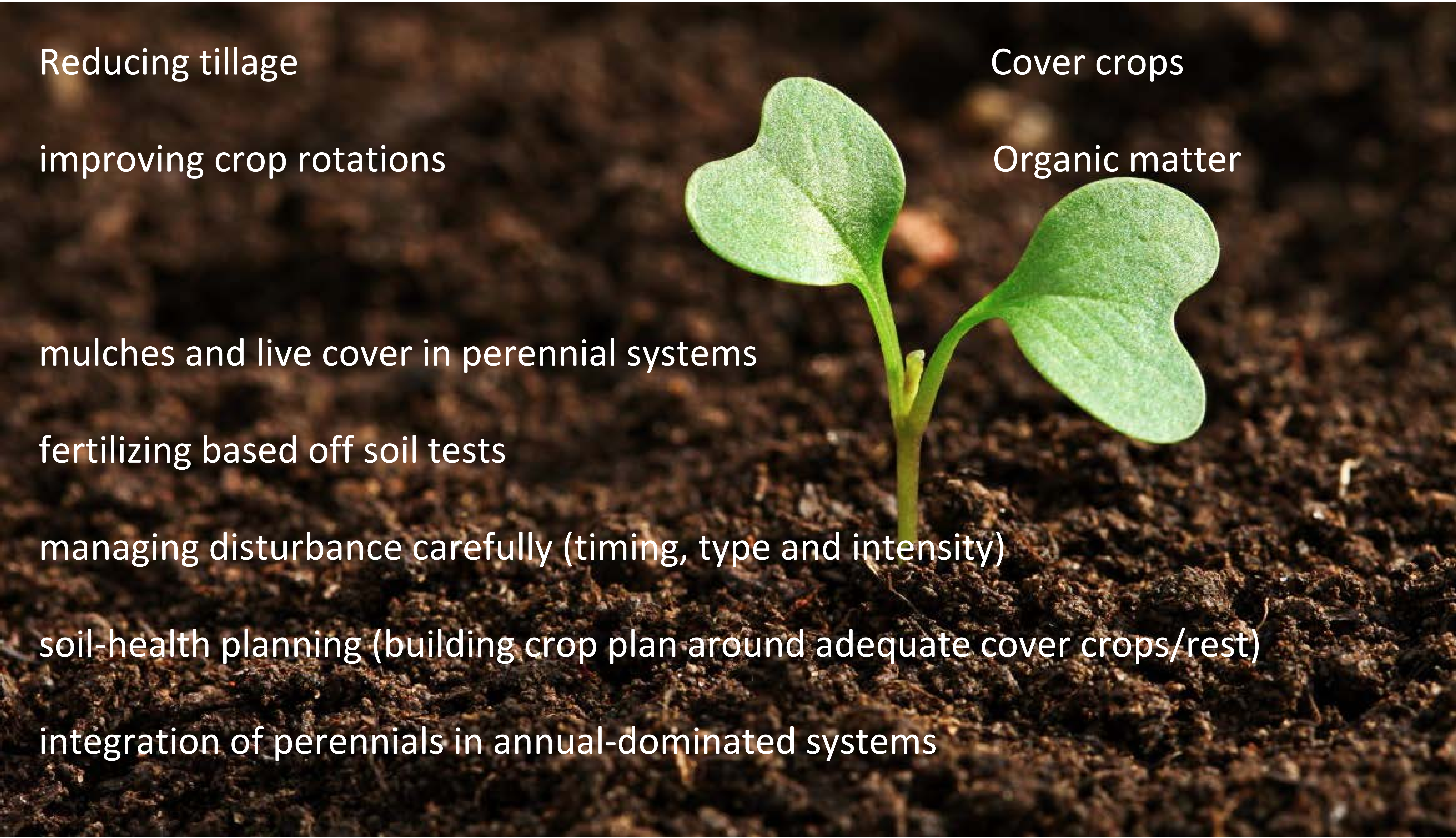
Nitrogen immobilization

Use as mulch

Carbon resource in compost

5. SOIL MANAGEMENT

What tools can we use?



Reducing tillage

Cover crops

improving crop rotations

Organic matter

mulches and live cover in perennial systems

fertilizing based off soil tests

managing disturbance carefully (timing, type and intensity)

soil-health planning (building crop plan around adequate cover crops/rest)

integration of perennials in annual-dominated systems

6. SOIL TESTING

6. SOIL TESTING

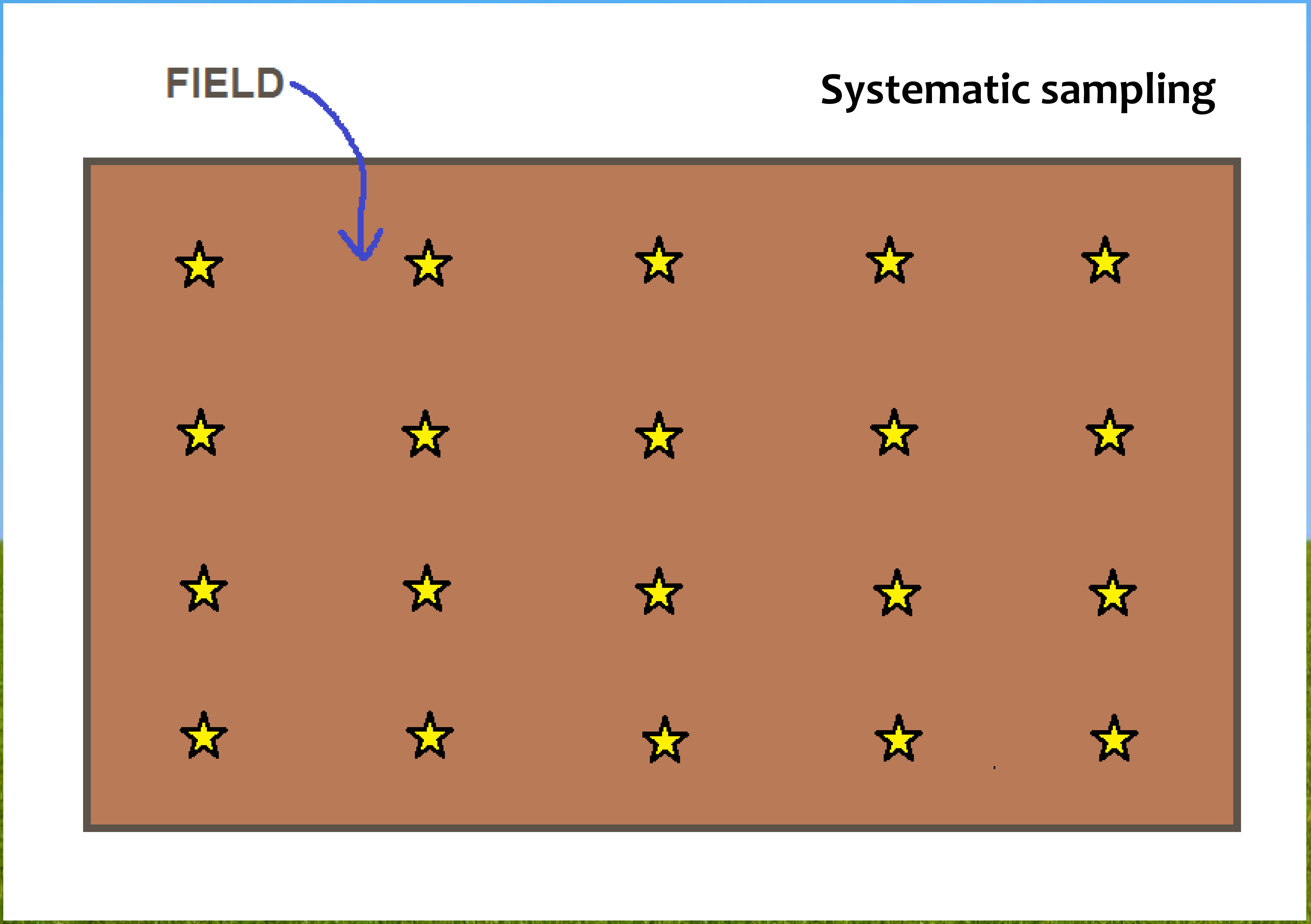
- 6.1 Taking a soil fertility test

WHY DO WE SAMPLE SOIL?

Soil is NOT homogeneous.

6. SOIL TESTING

- 6.1 Taking a soil fertility test



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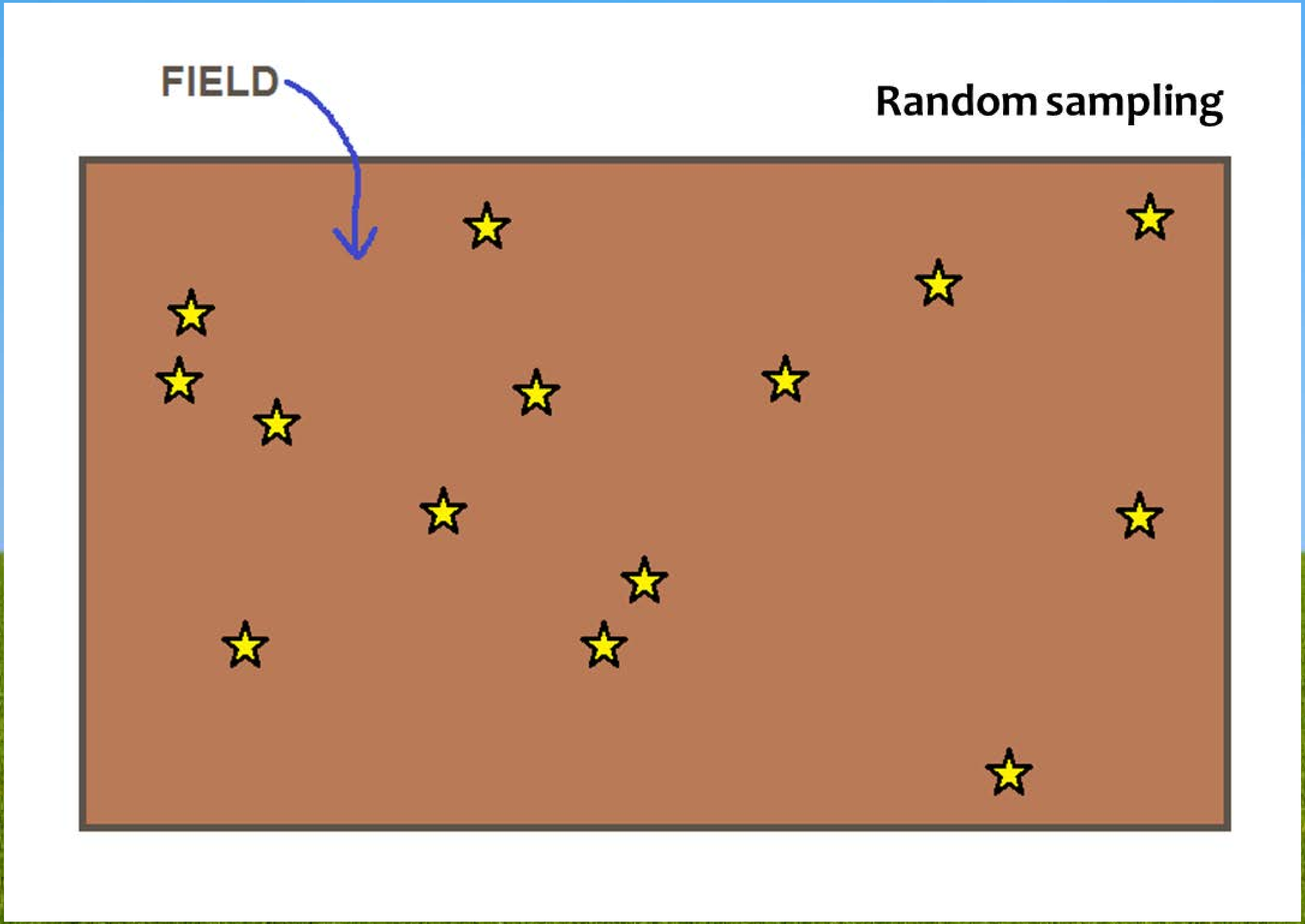
- 6.1 Taking a soil fertility test



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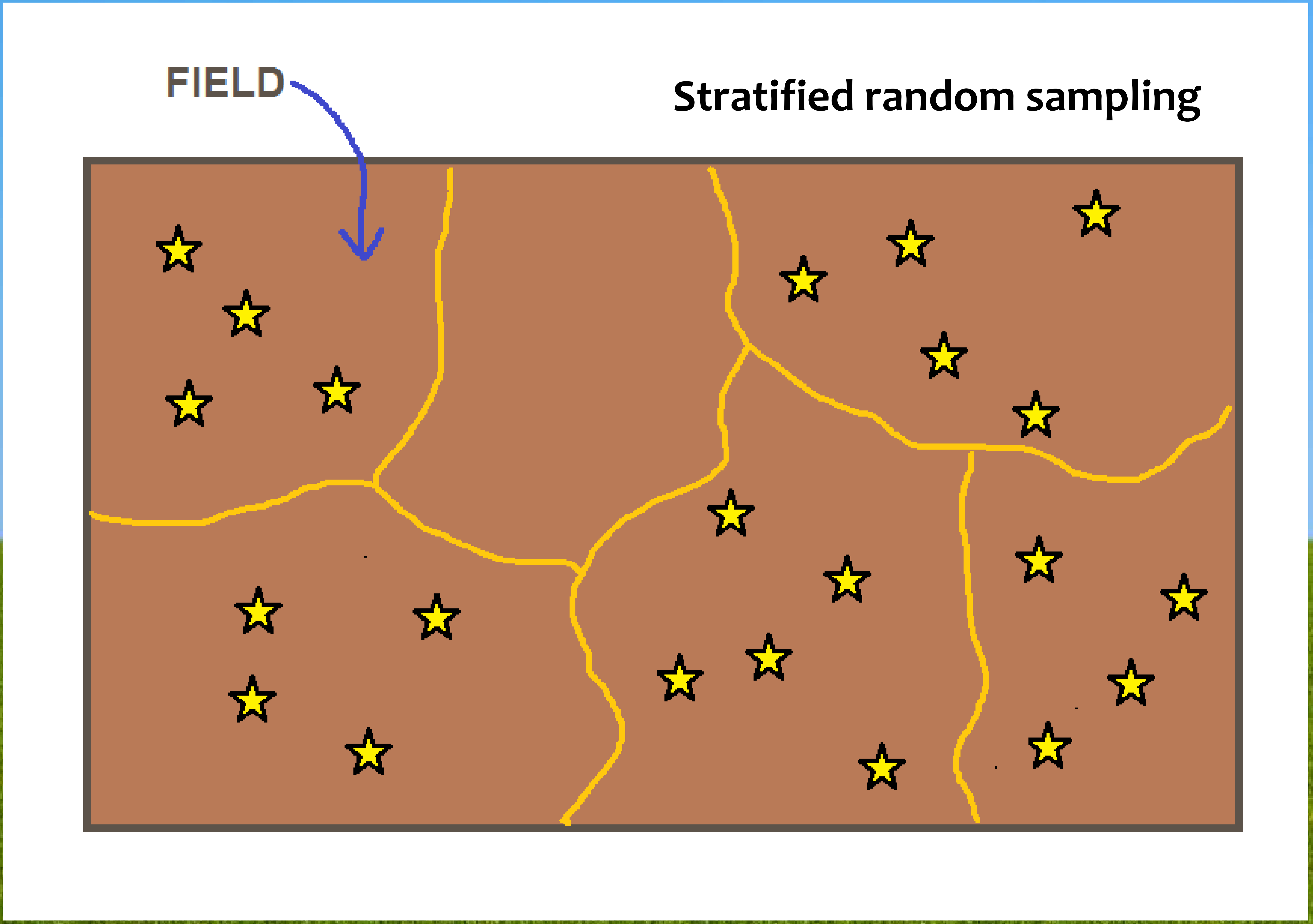
- 6.1 Taking a soil fertility test



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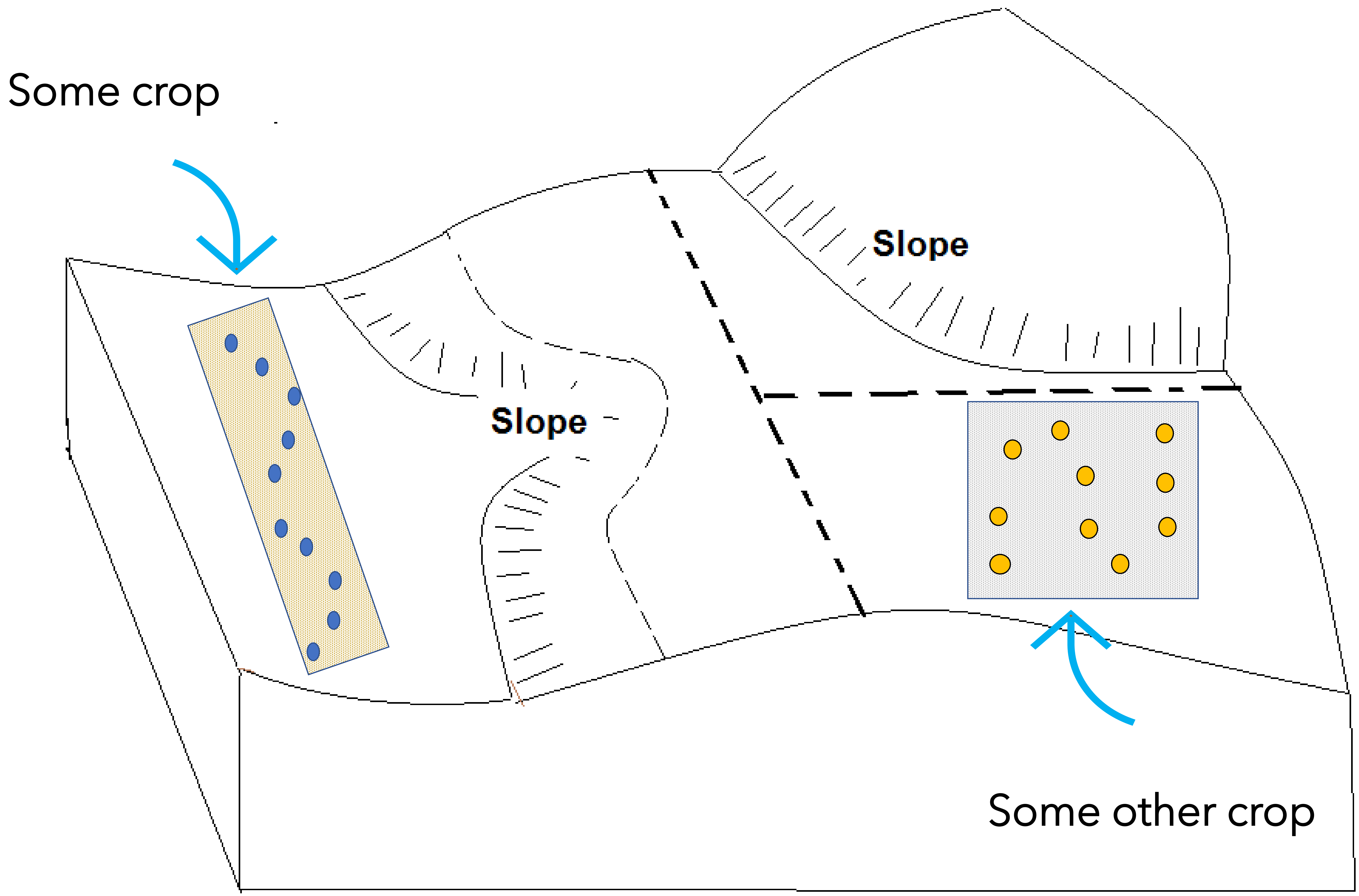
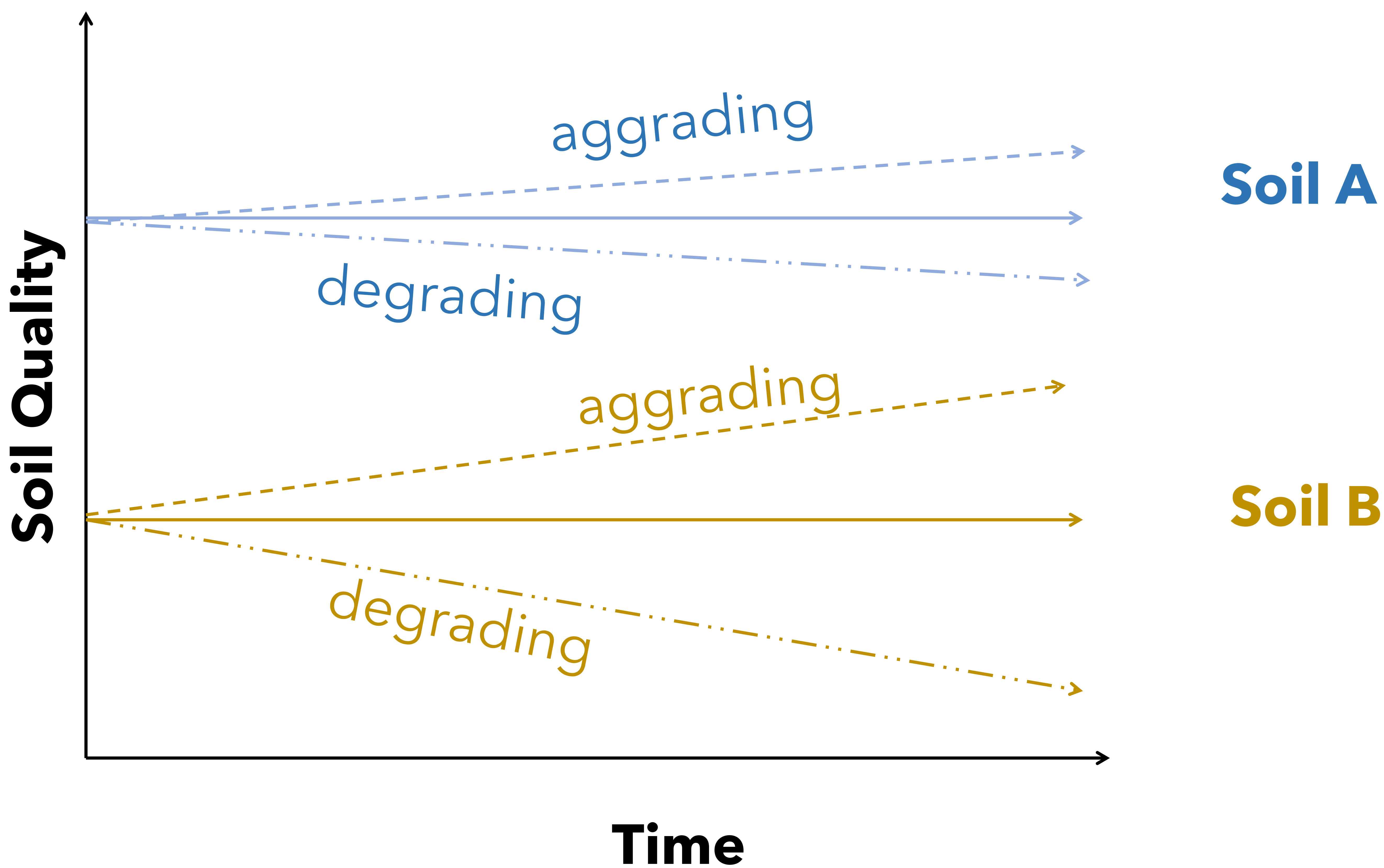


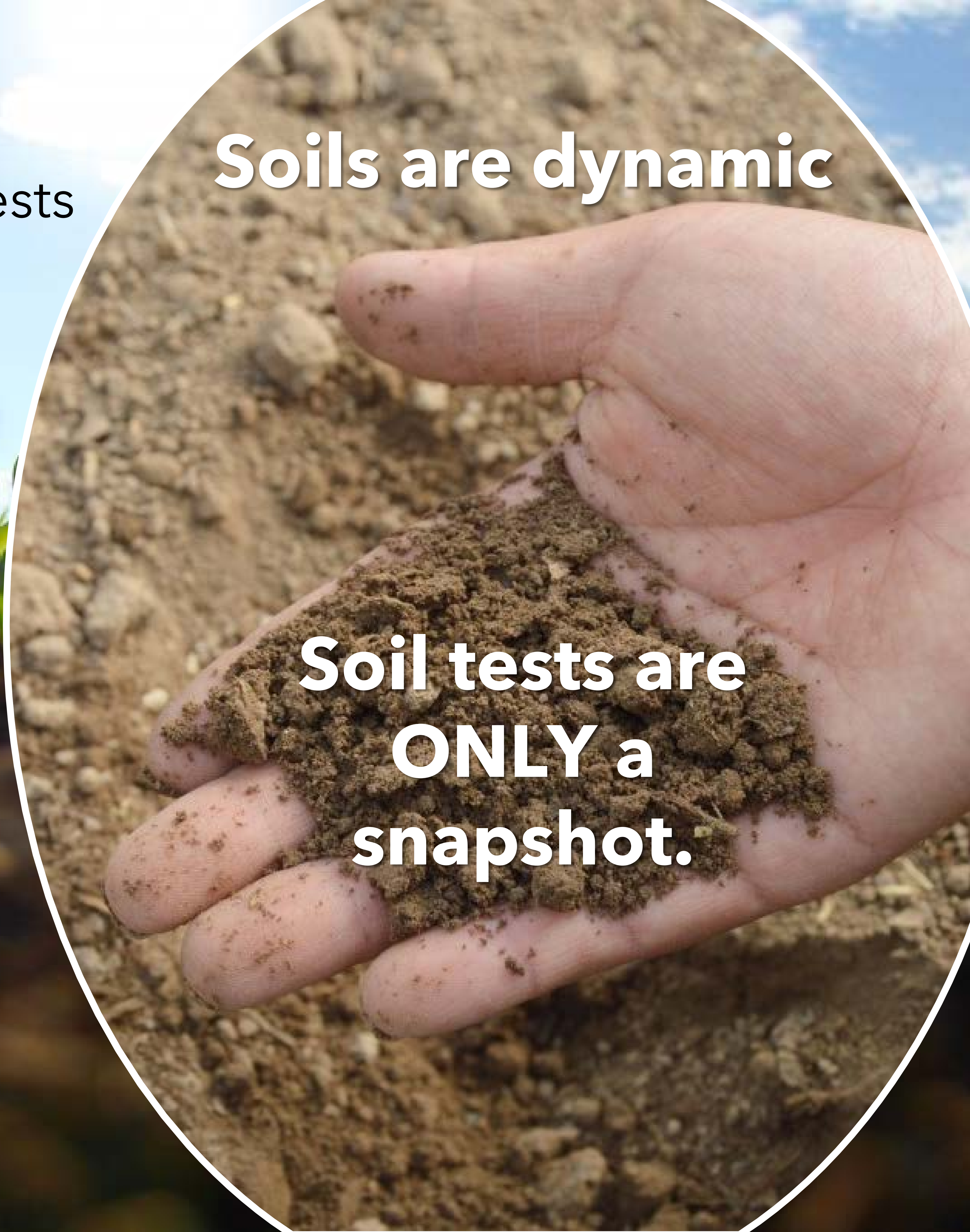
6. SOIL TESTING

- 6.1 Taking a soil fertility test



6. SOIL TESTING

- 6.2 Interpreting soil tests



6. SOIL TESTING

- 6.2 Interpreting soil tests

- **USE Chemical extractant**

- **Measure nutrients that are expected to be plant available.**

6. SOIL TESTING

- 6.2 Interpreting soil tests

University Extension
University of Missouri
Columbia

Soil Test Report
For Lawns and Gardens
------------------**MU Laboratories**-------------

23 Mumford Hall
Columbia, MO 65211
(573) 882-0623

or

P.O. Box 160
Portageville, MO
(573) 379-5431

Serial No.	County	Regi
H46109H-1	Boone	
Submitted	Processed	
3/2/2016	3/29/2007	

http://www.soiltest.psu.missouri.edu/

Sample ID: Home garden 1

Lab No: C06088
8

This report is for:
Lawn Garden
1000 Univ. Ave
Columbia, MO 65201

Last Limed: unknown

SOIL TEST RESULTS			RATING					
			Very low	Low	Medium	High	Very high	Exce
pHs	5.5		**********************					
Phosphorus (P)	7	lbs/a	***					
Potassium (K)	191	lbs/a	******************					
Calcium (Ca)	5253	lbs/a	***********************************					
Magnesium (Mg)	495	lbs/a	********************************					
Organic Matter:	2.6 %		**Neutr. Acidity:**	2.0 meq/100 g		**CEC:**	16.0 meq/100g	

Fertilizer & Limestone Recommendations (lbs/1000 sq ft)

Crop	Nitrogen(N)	Phosphorus(P_2O_5)	Potash (K_2O)	Zinc(Zn)	Sulfur(S)	LIM
1 vegetables	0.5	4.0	0.5			100
2 blueberries	1.0	4.0	1.0		50	0

6. SOIL TESTING

- 6.2 Interpreting soil tests

Test	Method	Results	SOIL TEST RATINGS: Very Low	Low	Medium	Optimum	Very High
Soil pH	1:1	6.0					
Buffer pH	SMP	6.77					
Phosphorus (P)	M3	18 ppm					
Potassium (K)	M3	96 ppm					
Calcium (Ca)	M3	1441 ppm					
Magnesium (Mg)	M3	143 ppm					
Sulfur (S)							
Boron (B)							
Copper (Cu)							
Iron (Fe)							
Manganese (Mn)							
Zinc (Zn)							
Sodium (Na)							
Soluble Salts							
Organic Matter	LOI	10.6 % ENR 150					
Nitrate Nitrogen							

Calculated Cation Exchange Capacity

10.2 meq/100g

%Saturation

	%sat	meq
K	2.4	0.2
Ca	70.6	7.2
Mg	11.7	1.2
H	15.7	1.6

K/Mg Ratio: 0.21

Ca/Mg Ratio: 6.03

6. SOIL TESTING

- 6.2 Interpreting soil tests

soiltest
farm consultants, inc.
2925 Driggs Dr., Moses Lake, Wa 98837 - www.soiltestlab.com
Office: (509)765-1622 - Fax:(509)765-0314 - (800)764-1622

PAP-Accredited NAPT 2020

Soil & Plant Program 2020 NAPT Participating Laboratory

SOILTEST FARM CONSULTANTS - 1
2925 DRIGGS DR

Moses Lake , WA 98837

Laboratory #: S20-07508

Date Received:	5/13/2020
Grower:	NATHAN STACEY
Sampled By:	
Field:	WSU BIOAG PROJ 2019 101
Customer Account #:	
Customer Sample ID:	

Soil Test Results

Cation Exchange	CEC	meq/100g	19.7

pH 1:1		7.1	
E.C. 1:1	m.mhos/cm		
Est Sat Paste E.C.	m.mhos/cm		
Effervescence			
			Lbs/Acre
Ammonium - N	mg/kg	1.6	6
Organic Matter W.B.	%	ENR:	

Depth inches	Nitrate-N mg/kg	Nitrate-N lbs/acre	Sulfate-S mg/kg	Moisture Inches
0 - 12	1.9	8		
Totals	**1.9**	**8**		

Sum of Tested N: 14 lbs/acre N

Other Tests:

6. SOIL TESTING

- 6.2 Interpreting soil tests

Soil tests indicate how much of a nutrient is likely to be available to plants

6. SOIL TESTING

- 6.2 Interpreting soil tests

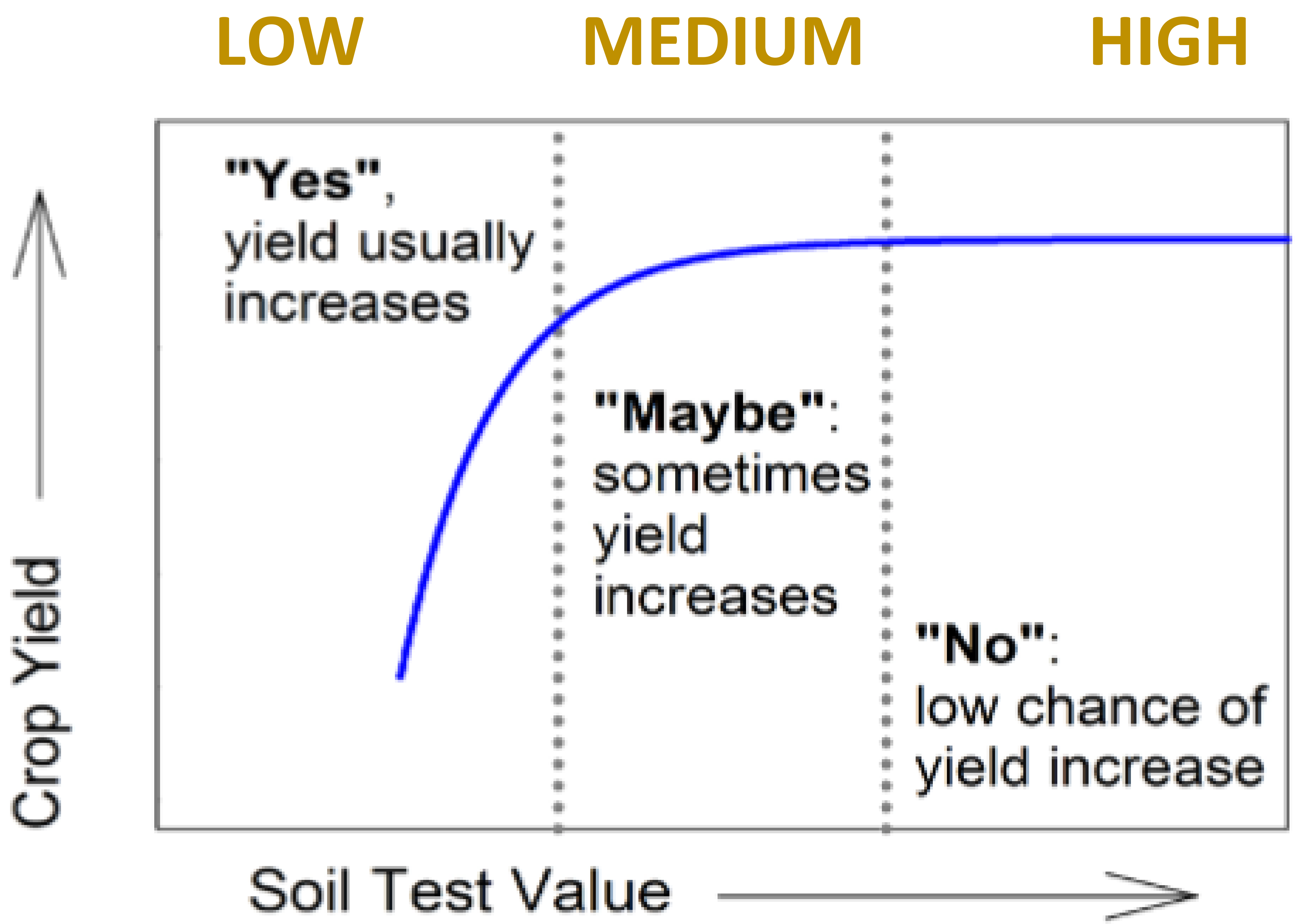


ILLUSTRATION ADAPTED FROM: SOIL TEST INTERPRETATION GUIDE, OREGON STATE UNIVERSITY EXTENSION

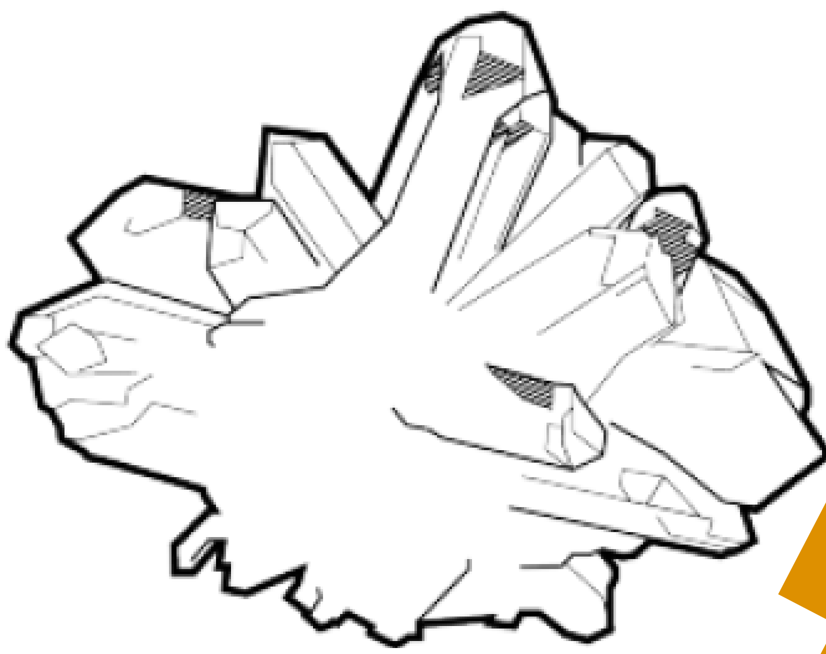
6. SOIL TESTING

- 6.2 Interpreting soil tests

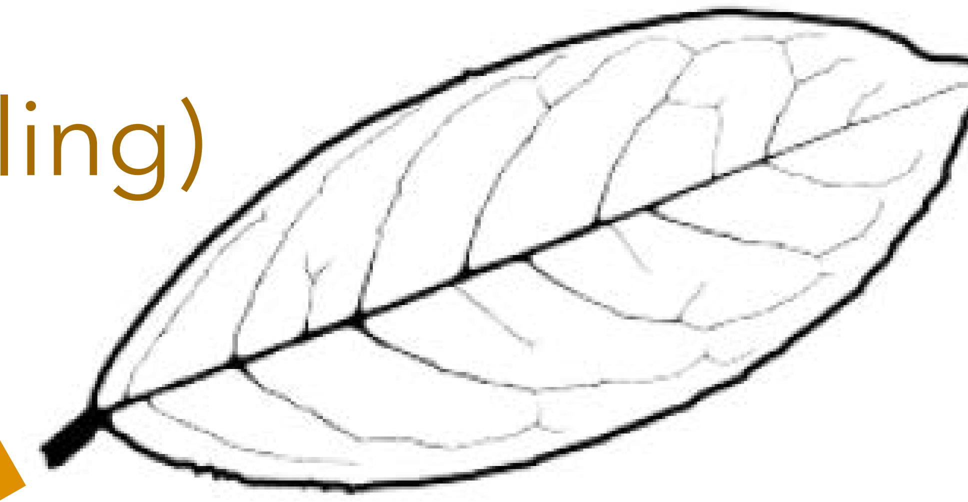
Plant Nutrient	Common Extractants
NO_3^-	KCl, $CaCl_2$
NH4+	KCL
$H_2PO_4^-/HPO_4^{-2}$	NH_4F/HCL (Bray-P)
	$NH_4F/CH_3COOH/HNO_3$(Melich-P)
	$NaHCO_3$ (Olsen-P)
K^+	NH_aOAc
SO_4^{-2}	$Ca(H_2PO_4)_{2,}CaCl_2$
Zn^{+2},Fe^{+3},Mn^{+2},Cu^{+2}	DTPA,EDTA
H_3BO_3	Hot Water
Cl-	Water

- 6.2 Interpreting soil tests

Different pools of nutrients (cycling)



Rocks and minerals
(parent material)



Organic Matter
(litter, amendments, root exudates, protected, etc.)

PO_4^-

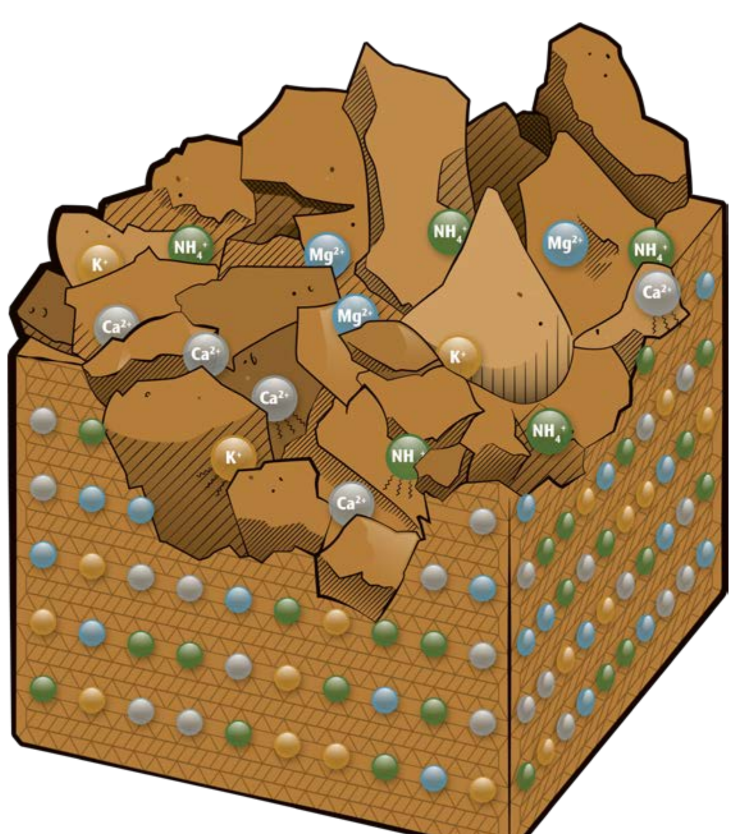
K^+ Ca^{2+}

SO_4^{2-} Fe^{2-}

Mg^{2+}

NO_3^- NH_4^+

Nutrients in solution



Surface adsorbed
(organo-mineral complexes)

Surface adsorbed
(soluble organic molecules)

6. SOIL TESTING

- 6.2 Interpreting soil tests

7

N

14.007

NO_3^--N in surface foot (ppm)	
Low	**<10**
Medium	**10-20**
High	**20-30**
Excessive	**>30**

6. SOIL TESTING

- 6.2 Interpreting soil tests

15

P

30.974

	Bray 1	Olsen	lbs. per acre (P_2O_5)
Low	<20	<10	0-300
Medium	20-40	10-25	0-200
High	40-100	25-50	0-30
Excessive	>100	>50	0

6. SOIL TESTING

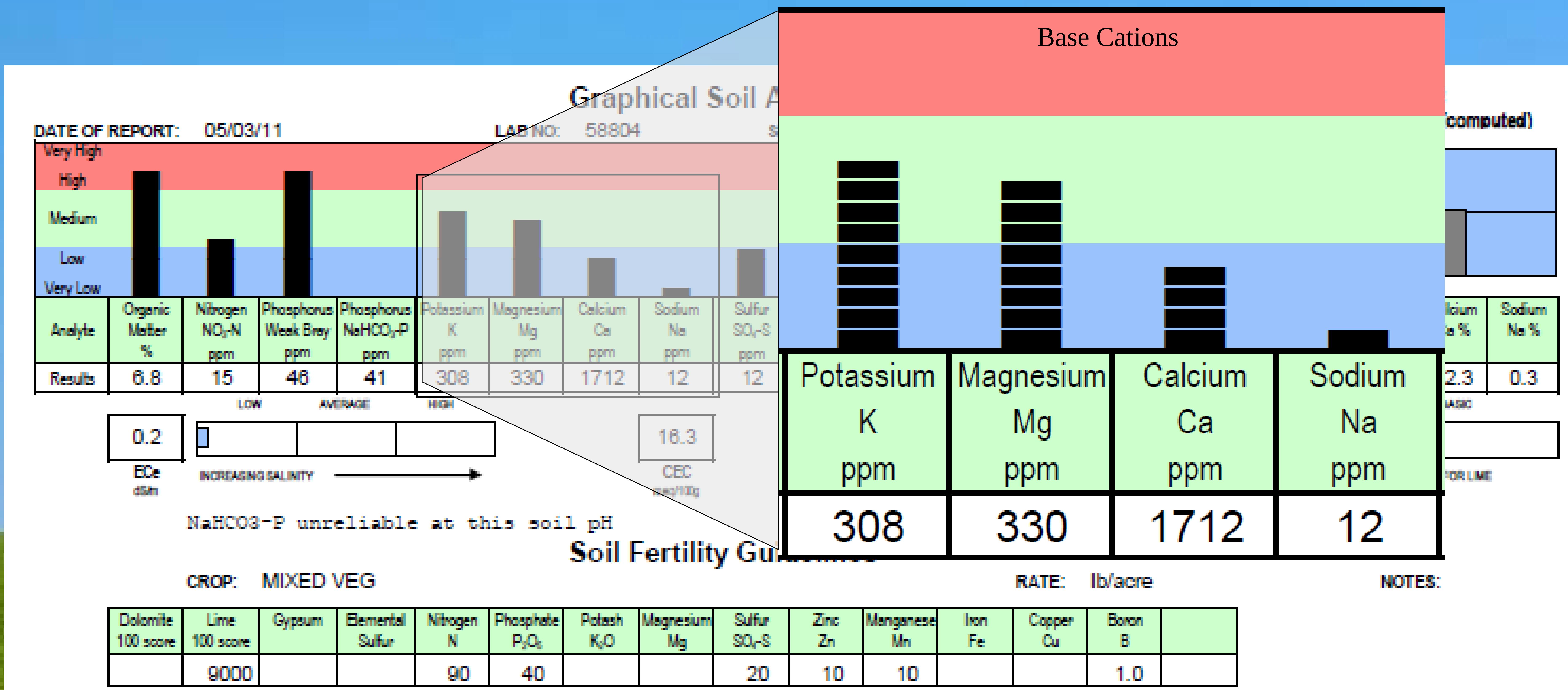
- 6.2 Interpreting soil tests

19
K
39.098

	Soil test K	lbs. per acre (K_2O)
Low	<150 ppm	100-300
Medium	150-250 ppm	60-250
High	250-800 ppm	0
Excessive	>800 ppm	0

6. SOIL TESTING

- 6.2 Interpreting soil tests



6. SOIL TESTING

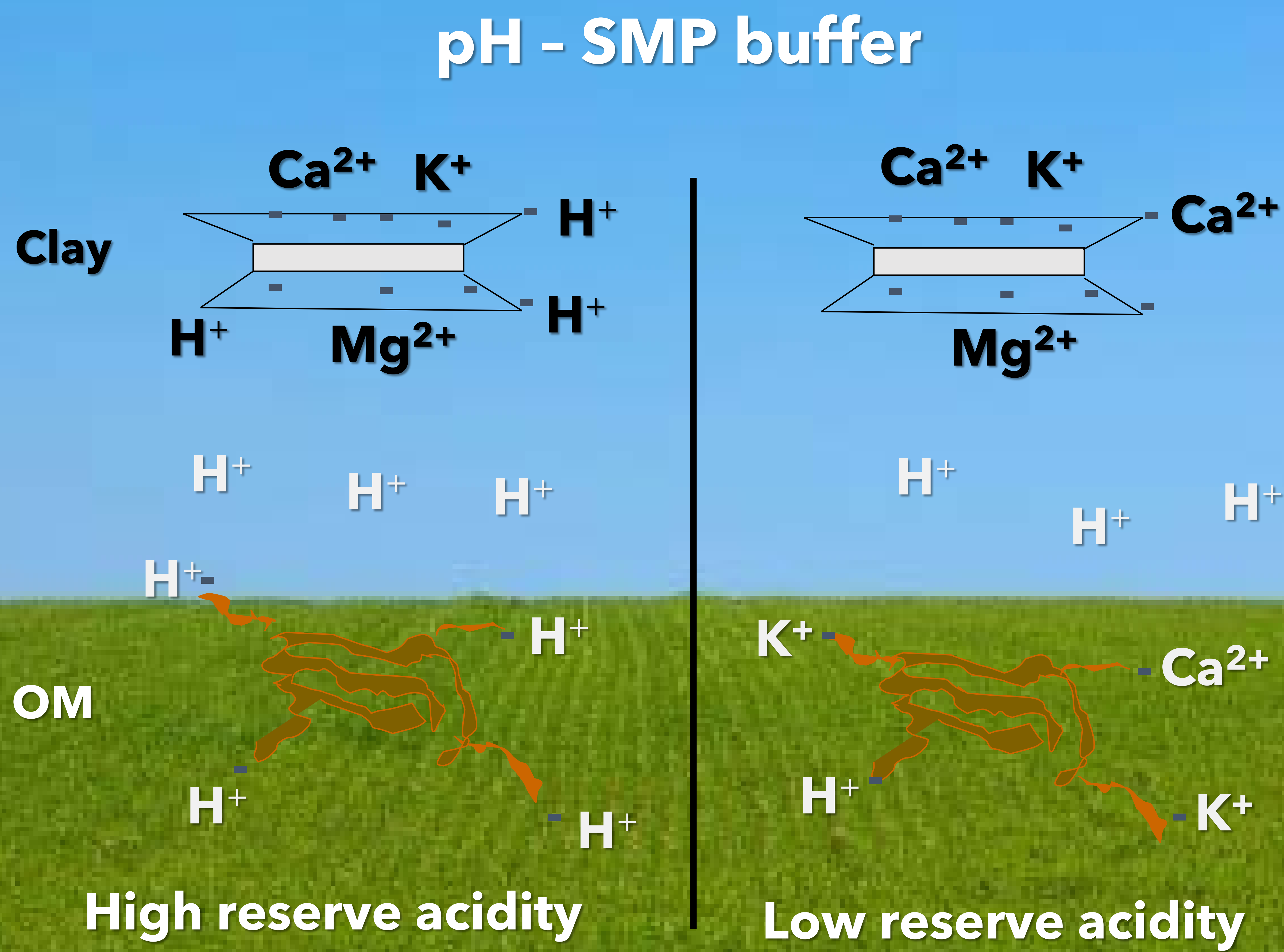
- 6.2 Interpreting soil tests

pH – the master chemical control

	pH
Strongly acidic	<5.1
Moderately acidic	5.2-6.0
Slightly acidic	6.1-6.5
Neutral	6.6-7.3
Moderately alkaline	7.4-8.4
Strongly alkaline	>8.5

6. SOIL TESTING

- 6.2 Interpreting soil tests



6. SOIL TESTING

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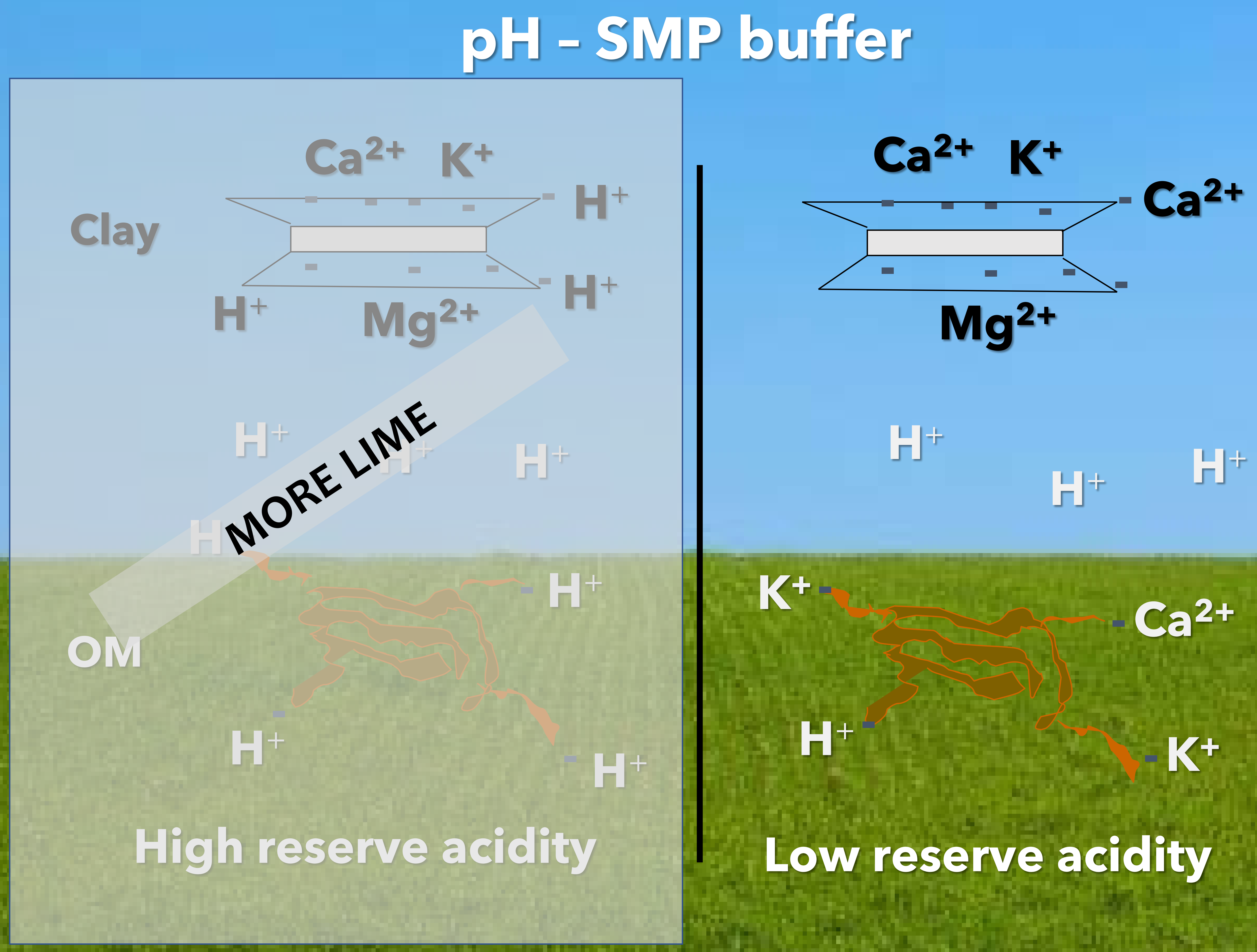

6. SOIL TESTING

- 6.2 Interpreting soil tests

Cation Exchange Capacity (CEC)