UF/IFAS Extension

The Journey to Sustainability Begins with Education

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UF UNIVERSITY of FLORIDA
IFAS Extension

URBAN AGRICULTURE

A Participatory Primer Course

Part 4a: Equipment and Tools

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UF/IFAS Extension Sarasota County

Outline

- **Short Review of Course Syllabus**
- **Production Equipment and Tools**
  - **Soil and water tools and tests**
  - **Field production tools**
    - **Preparation**
    - **Planting**
    - **Cultivation**
    - **Harvesting**
  - **Crop pest management tools**
  - **Hoophouses/Shadehouses**
- Post Harvest Handling & Produce Quality

Urban Agriculture Certificate Course Class Topics Sequence

- #1: Introduction and Production Systems
- #2: Business and Marketing Plans
- #3: Regulations and Direct Markets
- #4: Equipment and Tools; Post Harvest Handling
- #5: Financial Resources & Management

Today's Topic

Urban Agriculture Certificate Course Workshop Topics Sequence

- #1: Container and Hydroponic Growing
- #2: Frost Protection and IPM
- #3: Farmscaping w/ Cut Flowers
- #4: Farm Food Safety Plan
- #5 Composting and Renewable Energy Technologies

Introductory Activity (10 min.)

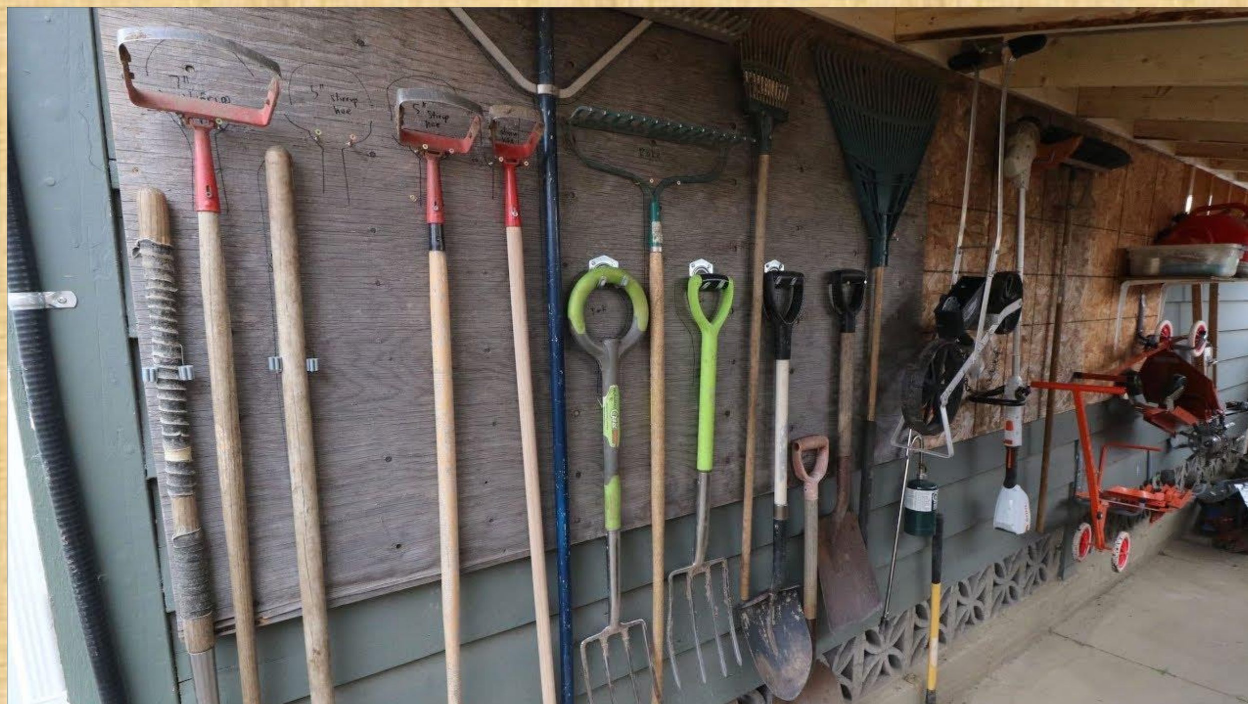
- World Café Format
  - Collaborative
  - Respectful
- Answer the following:
  - What is a tool?
  - What tools do you need for your Urban Ag plans?

- Form groups of 4 persons. Appoint 1 spokesperson to take notes and report out to the class on your group's responses, using bulleted descriptors.

Urban Agriculture Equipment/Tools Needs Factors

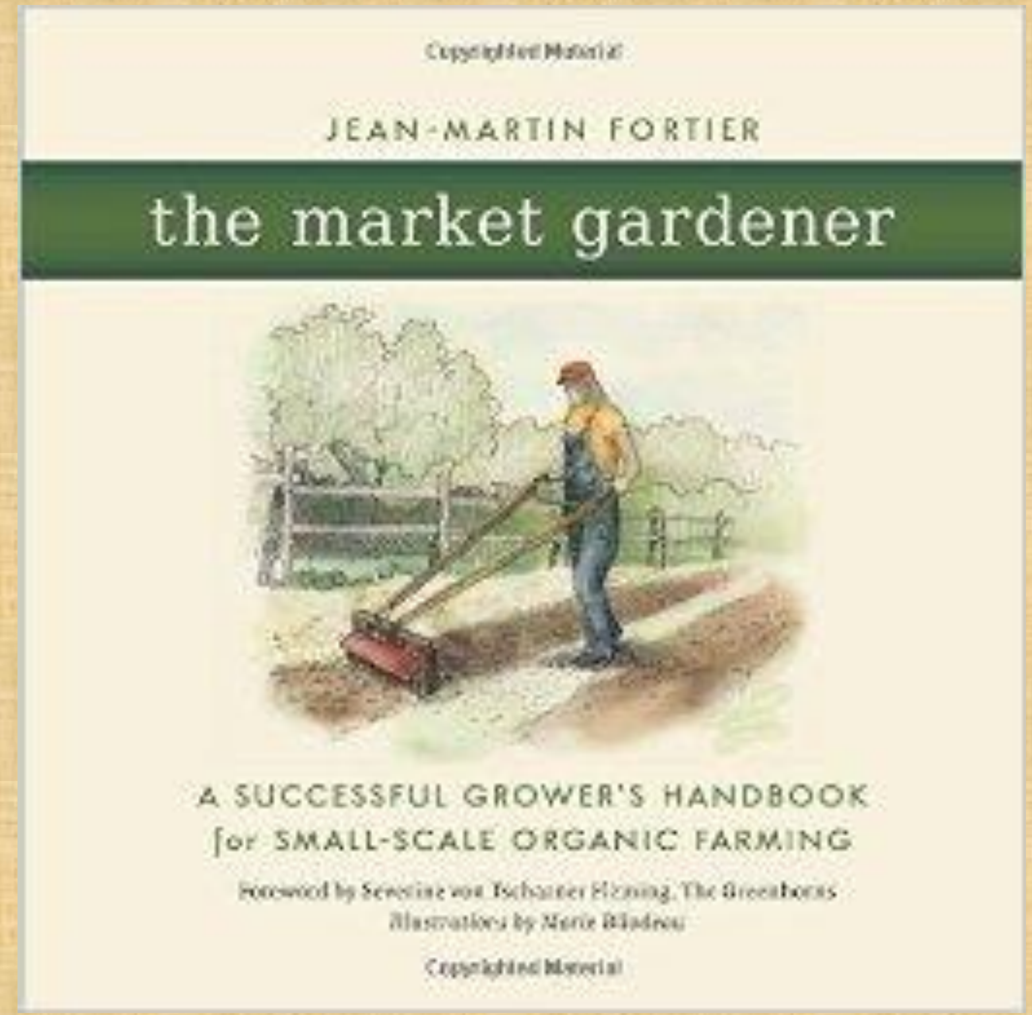
- High ‘value’ cash crops
- Done by both profit and/or non-profit groups
- Production attributes
  - Intensive production per unit area
  - High crop diversity (fruits, vegetables, flowers)
  - Field and/or protected production
  - Low volume per crop
  - More manual labor and horticultural techniques

Urban Ag Equipment/Tools Resource



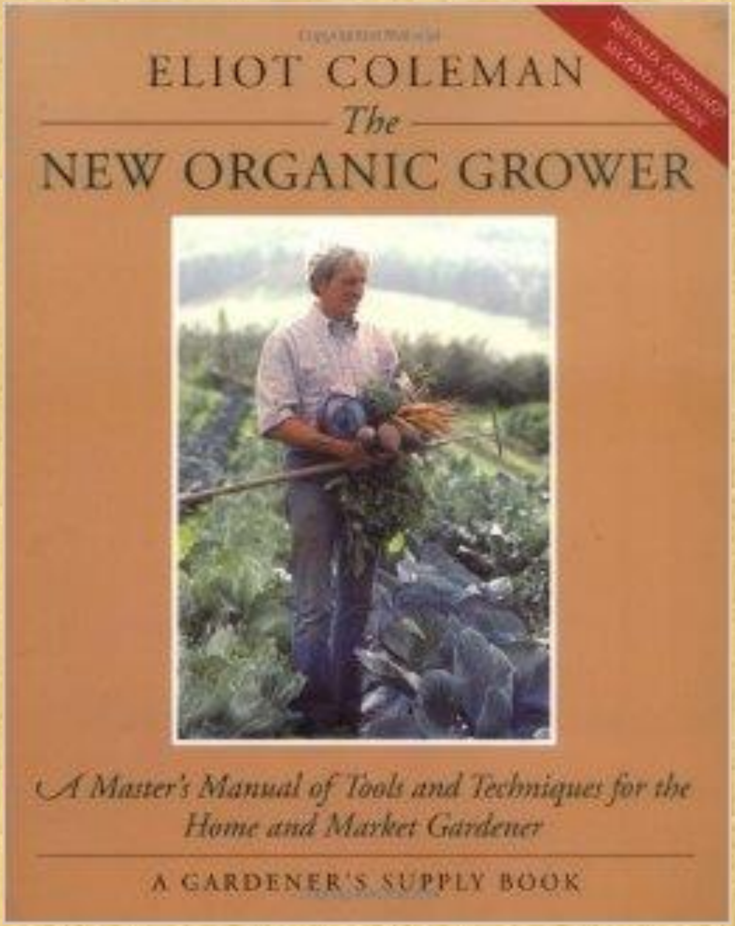
- ❖ Watch the video: “An Urban Farmers tools of the trade.” – see https://www.youtube.com/watch?v=8EcdunV2Ghg

Urban Ag Equipment/Tools Resource



Watch the videos:
http://www.themarketgardener.com/market-gardening-tools/

Urban Ag Equipment/Tools Resource



Watch the video:
https://www.youtube.com/watch?v=dsMz207FhCI&list=PLgVHK3pelUa5GsnOuP5llHhLUfURKsFEF&index=14

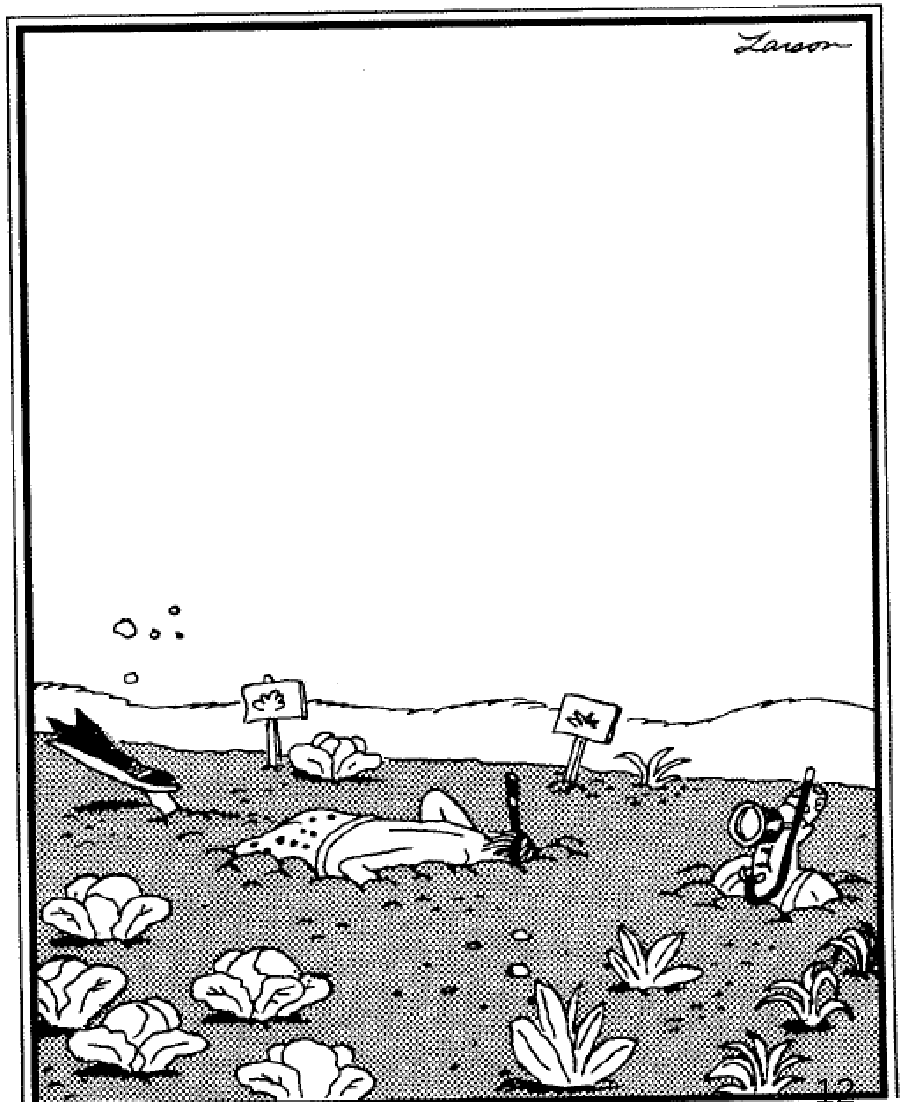
Urban Ag Equipment/Tools Resource

USDA NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service

Watch the short video “NRCS: Urban Farming” – see https://www.youtube.com/watch?v=l0OaU4RnIB4

Urban Ag Equipment and Tools Intro

- “The right tool for the right job will save your time, money, and you . . . Anonymous
- One machine can do the work of fifty ordinary men. No machine can do the work of one extraordinary man . . . Elbert Hubbard
- Law of the workshop: Any tool, when dropped, will roll to the least accessible corner. . . Anonymous



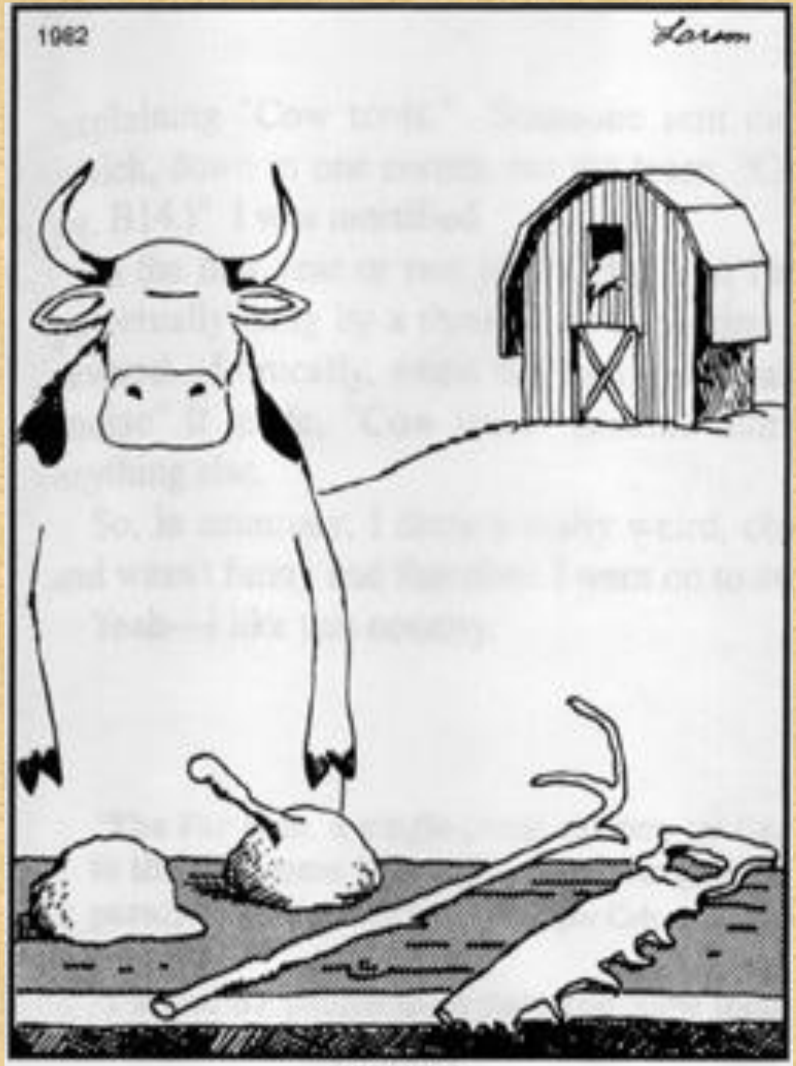
“No gophers, Stuart ... but there’s an old garden rake of yours down here.”

What is a Tool?

- Something (as an instrument or apparatus) used in performing an operation or necessary in the practice of a vocation or profession

  http://www.merriam-webster.com/

- Holistic management has an expanded definition of tools!



Cow tools

http://agonist.org/jimbo92107/20080321/cow_tools_revisiting_a_comic_masterpiece

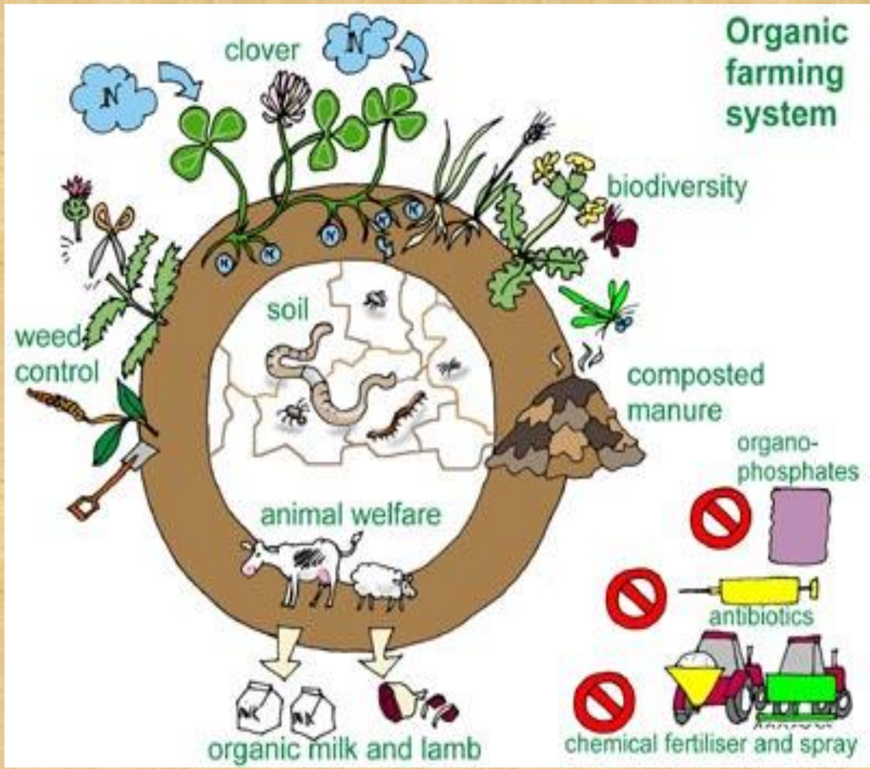
"Building a Sustainable Business" and Holistic Management Concepts

- How do you achieve the holistic goal from your business plan of your selected production systems?
  - Appropriate use & planning of <u>tools</u>
    - Financial
    - Land
    - Biological
  - Monitoring of decisions and actions w/ <u>tools</u>

https://www.misa.umn.edu/publications/buildingasustainablebusiness

“Holistic Management”
- Review -

- ❖Work with ecological cycles as “tools”
  - Water hydrology
  - Nutrient recycling
  - Biodiversity
  - Energy flow



Example biological tools

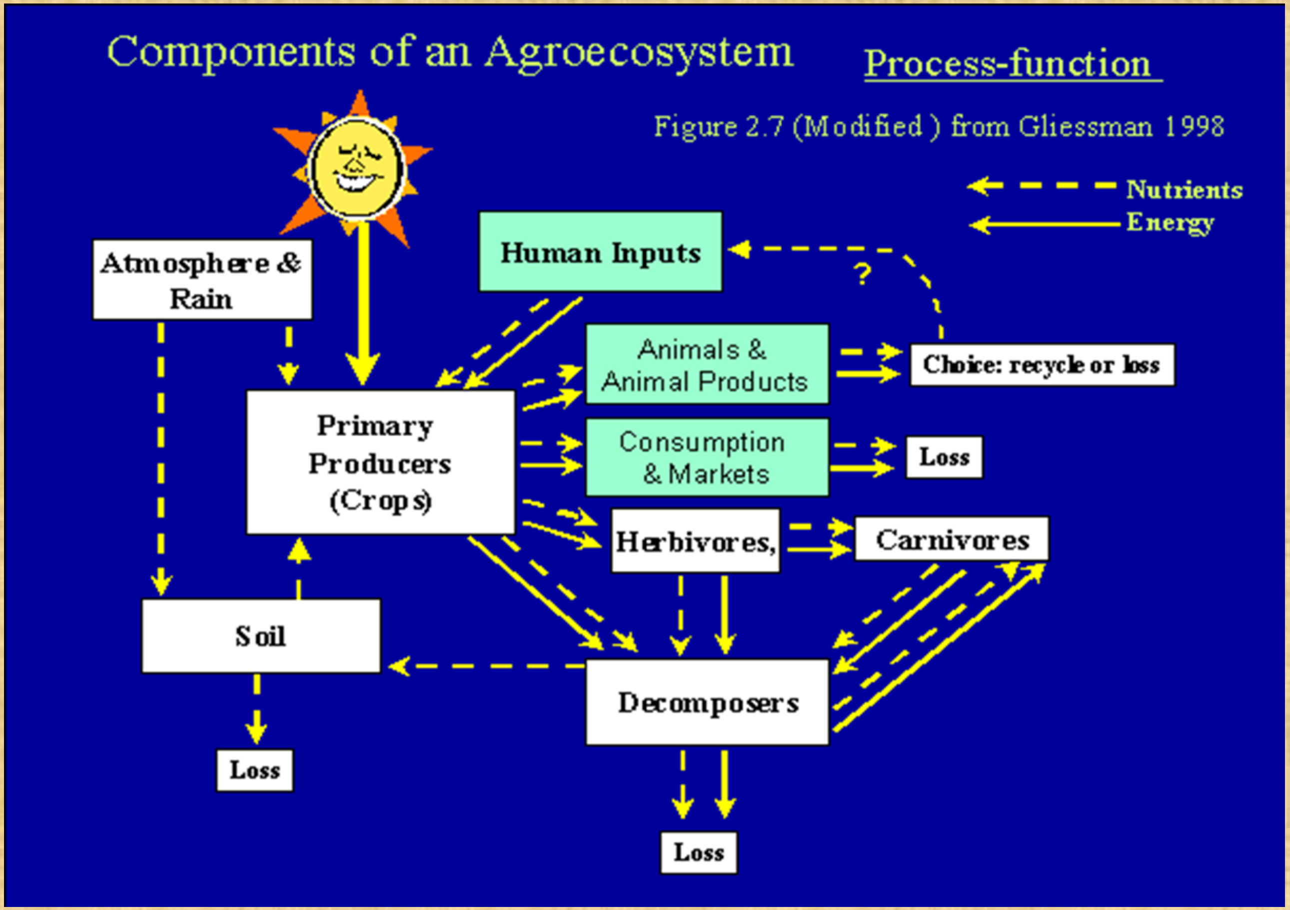
- ❖Use “biological tools” to replace technological tools

Urban Agroecology Review

- Agroecology provides concepts for the design of Urban Ag that achieves:
  - Improved overall biological efficiency & production
  - Biodiversity preservation
  - Maintenance of productivity and self-regulating capacity/resiliency

- Ecosystem concept from ecology science is the unifying concept of agroecology
  - the idea that farms are “agroecosystems” with subsystems (e.g., soil) & should mimic the functioning of local ecosystems with tight nutrient cycling, complex structure, and enhanced biodiversity conservation.

Agroecosystem “<u>Tools</u>”



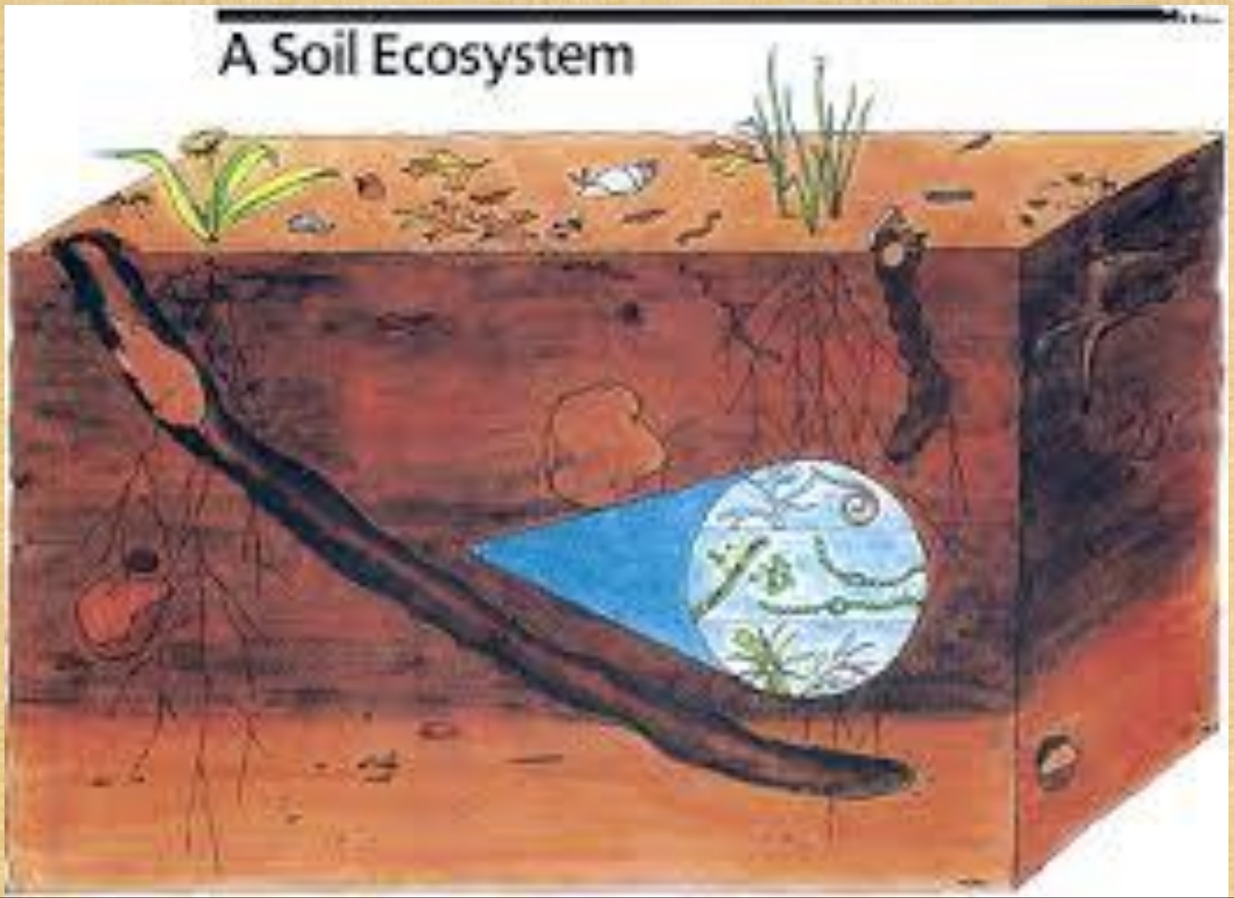
- ✓ Assess <u>tools </u>available with integration of all “subsystems” of the agroecosystem of your urban farm
- ✓ Identify <u>tools</u> to serve as indicators for monitoring all subsystems, as well

Assessment of Urban Soils

- Impacts of the urban environment on soils:
  - physical soil properties are strongly influenced by compaction that occurs during the transformation of native and agricultural lands into urban environments
  - urban heat island effect, modifications of local cloud cover and precipitation, & alterations to hydrologic regimes by urban infrastructure can strongly affect soil microclimates, the availability of water, & activity of soil organisms.
- The net effect of these urban effects on the physical, chemical, and biological properties of soils is an alteration of the fundamental nature of the belowground component of urban ecosystems.
- Urban soils with drastic changes and degradation require strong manipulations and interventions.

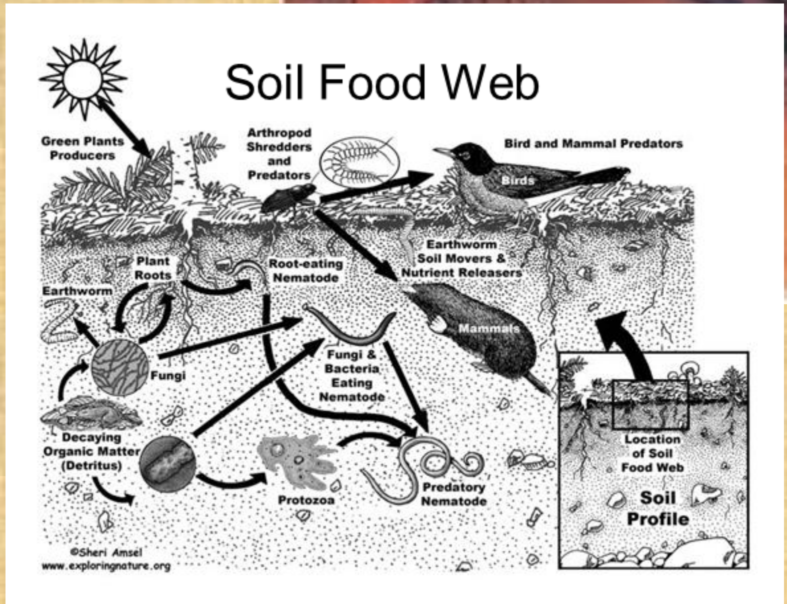
http://www.u.arizona.edu/~mzucker/Pavao-Zuckerman%202008%20Restoration%20Ecology.pdf

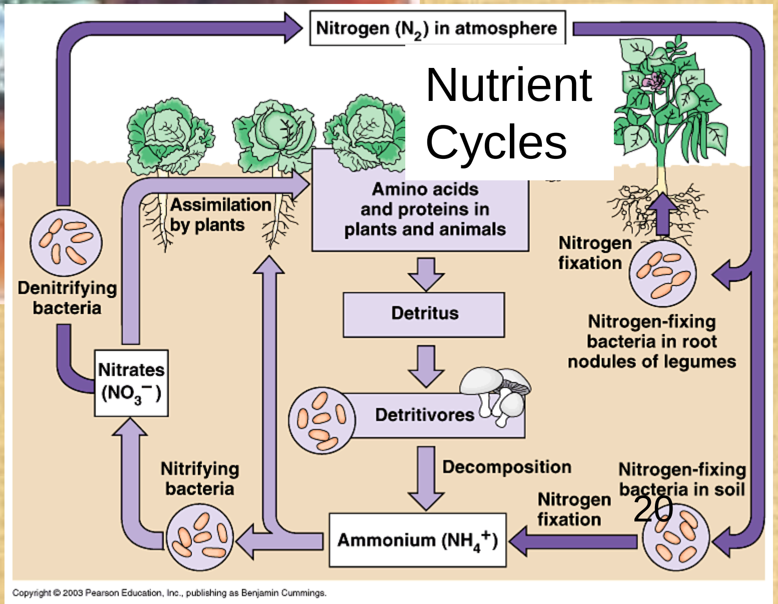
Soil Ecosystem Restoration for "Tools" of Crop Production



Watch the short video "Regenerate Life in Your Soil | healthy soil" – see https://www.youtube.com/watch?v=XOgnB0KoCaQ

‘Tools’ of the Soil Ecosystem





Management Goal: Increase Soil Ecosystem 'Emergent' Properties

Examples

- Soil fertility and tilth
- Nutrient cycling
- Soil life
- Organic matter (OM)
- Soil 'quality' and 'health'

Watch the short video "Emergent Properties – see https://www.youtube.com/watch?v=R-auQOP1sCM

Gliessman, S., 1999. Agroecology: Ecological Processes in Sustainable Agriculture

Basic Strategies or “Tools” for Sustainalble Soil Management

- Soil care (composting, cover crops, soil testing, etc.)
- Crop rotations
- Variety selection and cultural practices
- Encourage natural predators
- Managing water
- Prevent compaction

http://www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition

Soil and Water Tests “Tools”

- Soil and water tests were developed to assist in fertility management of vegetable, fruit and agronomic crops.

How to Sample Your Lawn or Garden

Obtain a small amount of soil from 10-15 different spots over the area you wish to test (a minimum of one-half pint). When you sample a lawn, take the soil from the upper 2-4 inches. When sampling a vegetable garden or landscape plants, take soil from the upper six inches. If soil is wet, spread soil on clean paper or other suitable material to air dry.

Figure 1a. Use a soil probe to speed soil sampling, or...

SAMPLES WILL NOT BE PROCESSED WITHOUT PAYMENT.
Please enclose payment and this sheet in the same package as sample(s).
Do not send cash through the mail.

Figure 1b. Use a hand trowel, shovel or other garden tool. Trim out soil of uniform thickness to the recommended depth.

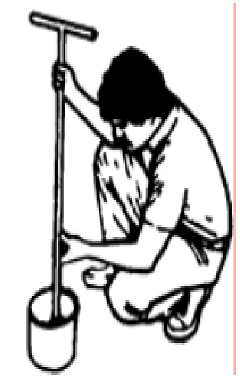


Figure 2. Place 10 to 15 soil cores into a plastic bucket; mix, dry, and transfer to a bag.

http://soilslab.ifas.ufl.edu/ESTL%20Tests.asp

Soil and Water Tests

- **UF/IFAS Extension Soil Testing Laboratory (including water, manure, soilless media & plant tissue)**

see - http://soilslab.ifas.ufl.edu/ESTL%20Tests.asp

Analysis Code	Analysis Name	Determinations Made	Analysis Cost
1	Standard Soil Fertility Test	pH, lime requirement, P, K, Ca, and Mg	$7.00
2*	Soil pH and Lime Requirement	pH and lime requirement	$3.00
3	Soil Micronutrients	Cu, Mn, Zn, and pH	$5.00
4	Organic Matter	percent organic matter	$10.00
5	Electrical Conductivity ("soluble salts")	conductivity in 1:2 soil:water	$2.00
13	Bahia Standard Soil Fertility Test	pH, lime requirement, K, Ca, Mg, and P Value	$7.00
B1	Bahia P Test	pH, lime requirement, P, K, Ca, and Mg (Soil) P test (Tissue)	$15.00

* Included in Standard Soil Fertility Test. Do not request both codes 1 and 2 for the same soil sample.

Soil and Water Tests "Tools"

❖ **Water tests require precise procedures for sampling too**

Taking a Representative Water Sample

Tools

1. A clean plastic bottle holding about 1 pint to collect the water sample. Do not use shampoo or detergent bottles because it is difficult to remove all residues. Glass bottles are not recommended.
2. A corrugated shipping box. These boxes (also used to mail soil samples) are available for free at your local county UF/IFAS Extension office.
3. Packing material. Use this material to pack the sample to avoid damage or leakage during shipment to the UF/IFAS Extension Soil Testing Laboratory.
4. This form. Use additional copies if you plan on sending more than 5 water samples.

Sampling

1. Allow the water source to run from the intended collection point for several minutes.

   For household samples, allow the water to flow for several minutes to ensure the water sample is directly from the well. Water standing in the house plumbing for some time is not a representative sample.

   For irrigation and microirrigation samples, sampling as close to the water source as possible will ensure that the sample represents the water source. If you are filtering the water, you may wish to sample the water both before and after filtration to assess the effect of the filtering operation. Filtration will only affect the physical characteristics (suspended solids) of the water.
2. Rinse the sample container and its lid several times in the flowing water. Do not use soap or detergent during this rinsing step.
3. Fill the container completely with the flowing water. Leave as little air as possible in the container. Tightly seal the lid immediately after filling the container to ensure against leakage.
4. Label the container and pack it carefully in the prelabeled shipping box.
5. Include in the shipping box:
   - ☐ Your labeled water sample(s)
   - ☐ This Water Test Form with all the requested information on page 1 completed
   - ☐ A check or money order payable to: **University of Florida**. Checks written to any ot name will NOT be honored and will be returned, causing a delay in processing the samples.

http://edis.ifas.ufl.edu/pdffiles/SS/SS18400.pdf

Soil and Water Tests

- UF/IFAS Extension Soil Testing Laboratory (including water, manure, soilless media & plant tissue)

UF/IFAS Analytical Services Laboratories
Extension Soil Testing Laboratory

2390 Mowry Road/PO Box 110740/Wallace Building 631
Gainesville, FL 32611-0740
Email: soilslab@ifas.ufl.edu Website: http://soilslab.ifas.ufl.edu

WATER TEST FORM

Note: This lab only tests samples from Florida.

Direct any questions about this test or the interpretation of the results to your county UF/IFAS Extension agent.

NOTE: These tests will not determine if the water is suitable for human consumption. Bacteriological tests may be available from the county health department or select commercial laboratories.

Lab Use Only	Sample ID	County	Crops to be grown	Water Source Information					Water Use Information				Cost	
				Well	If well, specify location and depth			Surface ditch or pond	General Household Use	Irrigation			Irrigation and micro-irrigation	House-hold
				Check	Range	Town-ship	Sec-tion	Check		Household Overhead or seep	Overhead or seep	Micro-irrigation		
													$10	$9
													$10	$9
													$10	$9

http://edis.ifas.ufl.edu/pdffiles/SS/SS18400.pdf

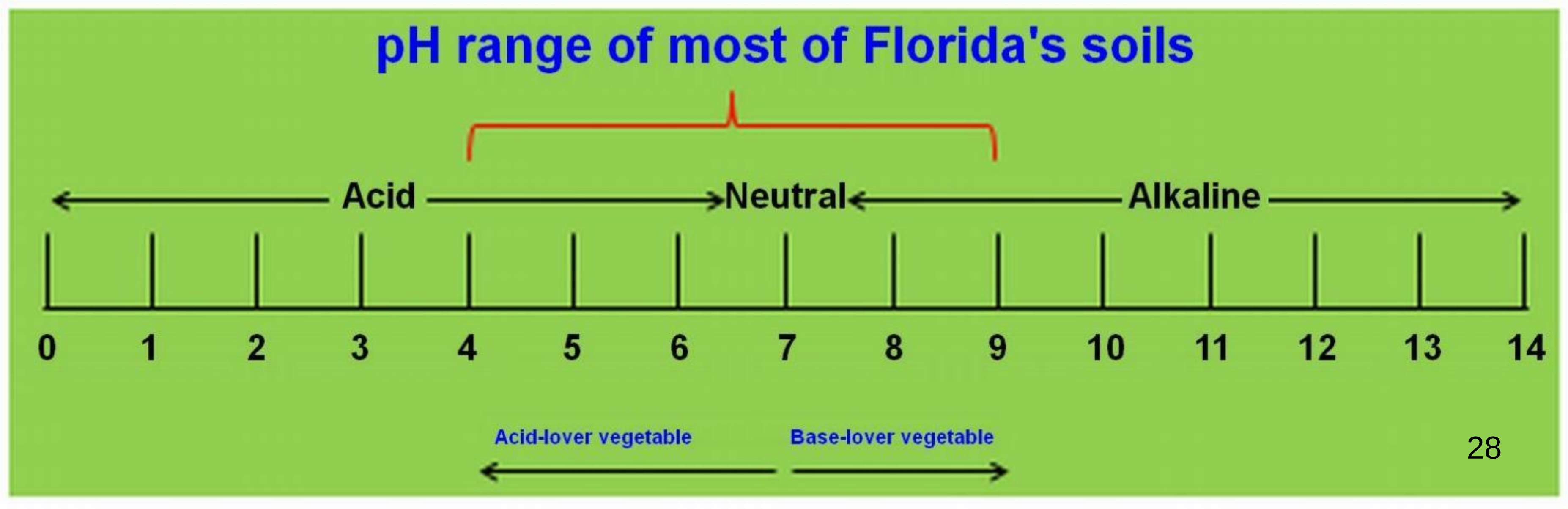
Soil and Water Tests

❖ Soil Contaminants and Soil Testing

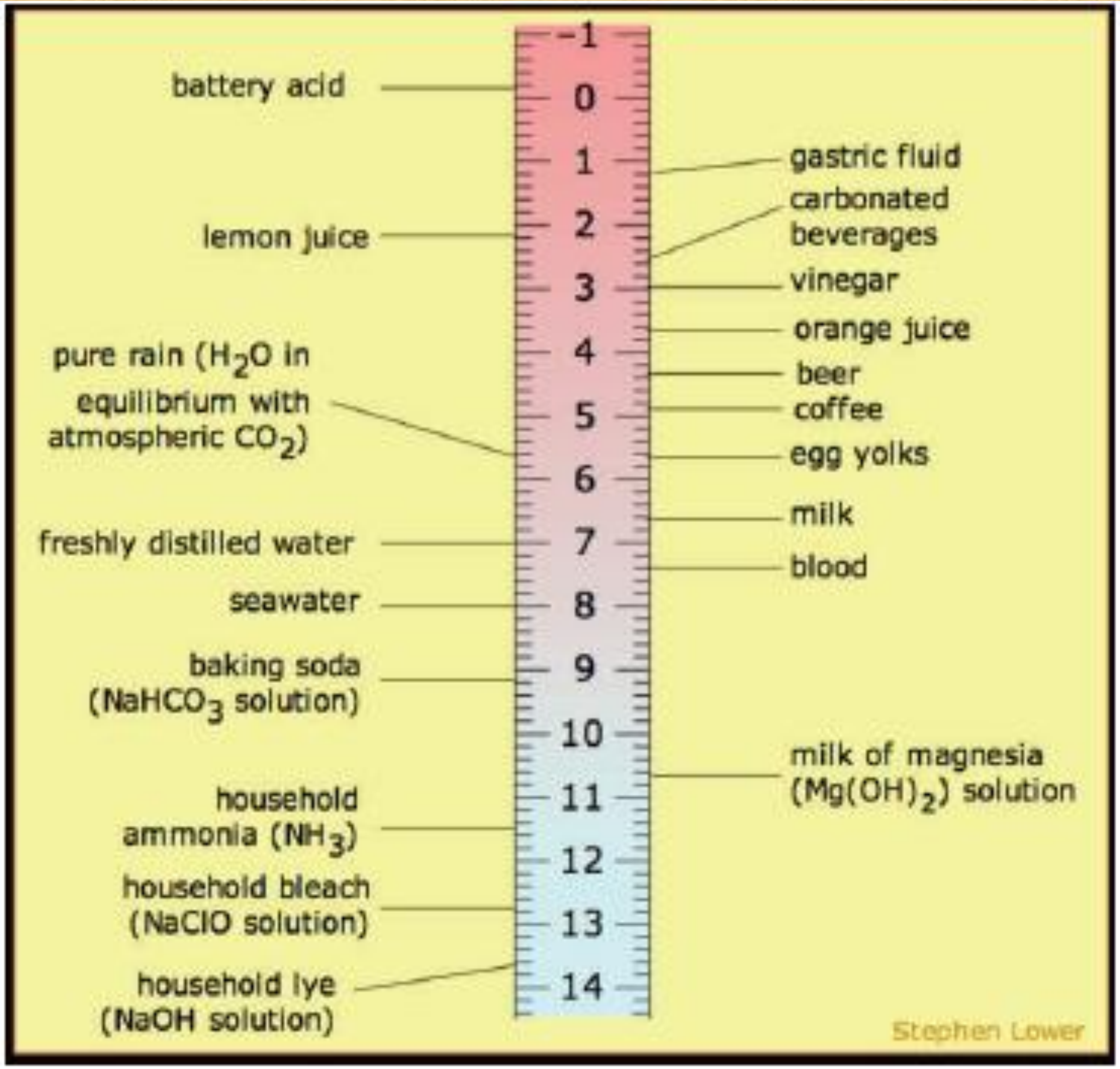
❖ For resources on testing urban soils for contaminants see http://ucanr.edu/sites/UrbanAg/Production/Soils/Soil_Contaminants_and_Soil_Testing/

Soil pH Basics

- The measure of acidity or alkalinity of the soil
- Determines the concentration of available plant nutrients and toxicities in the soil solution
- Typically pH 6.5 is recommended

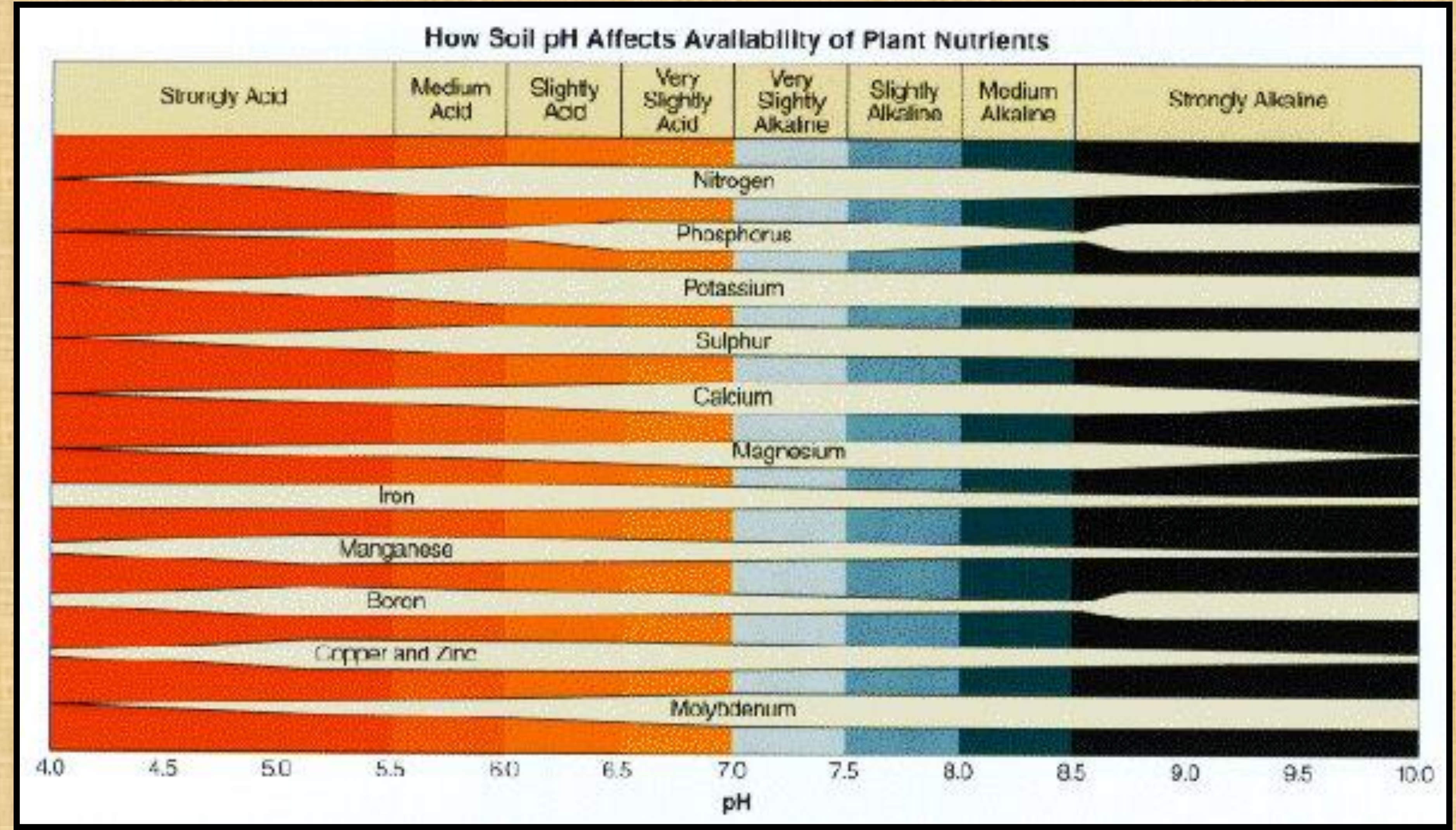


pH Range Examples



The pH scale and the acidity and alkalinity of reference materials. (Credit: Steven Lower)

Soil pH and Nutrients Basics



Horizontal bars with increasing width demonstrate pH range for greater nutrient availability

Soil pH & Food Crops Tolerance Examples

Vegetables & Herbs	Preferred pH Range
Artichoke	6.5 - 7.5
Asparagus	**6.0 - 8.0**
Basil	5.5 - 6.5
Bean	**6.0 - 7.5**
Beetroot	6.0 - 7.5
Broccoli	**6.0 - 7.0**
Brussels	6.0 - 7.5
Cabbage	**6.0 - 7.5**
Calabrese	6.5 - 7.5
Carrot	**5.5 - 7.0**
Cauliflower	5.5 - 7.5
Celery	**6.0 - 7.0**
Chicory	5.0 - 6.5
Chinese Cabbage	**6.0 - 7.5**
Chives	6.0 - 7.0

http://homeharvest.com/vegeherbphpreference.htm

Soil pH Management Basics

- To raise soil pH (make more alkaline): apply lime (calcium carbonate) or dolomite (magnesium carbonate) - carbonate compounds
- To lower soil pH (acidify): apply elemental sulfur compounds
- To add calcium or magnesium without changing soil pH: use sulfate compounds (ex.: gypsum = calcium sulfate)

Soil pH and Liming Basics

- There's lots of misunderstanding about the use of agriculture lime
- We lime a soil to avoid Iron (Fe) and Aluminum (Al) toxicity at high soil levels !
- Low pH factors
  - Fe and Al are active at low pH ranges
  - Proper soil tests methods of 'reserve pH' levels are critically important for correct interpretation to correctly measure Fe and Al levels.
  - UF/IFAS Soil Lab uses the Adams/Evans Buffer and water pH with a calibration curve to recommend liming rates!

http://edis.ifas.ufl.edu/hs1207

Soil Test Results Example

UF UNIVERSITY of FLORIDA IFAS

UF/IFAS Analytical Services Laboratories

Extension Soil Testing Laboratory

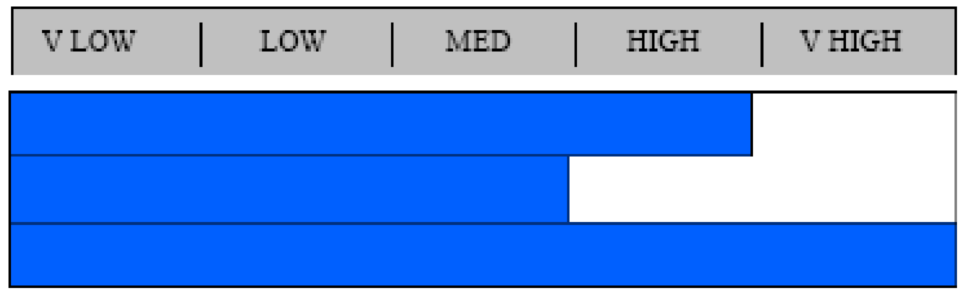
Wallace Building 631 PO Box 110740 Gainesville, FL 32611-0740

Email: soilslab@mail.ifas.ufl.edu Web: soilslab.ifas.ufl.edu Phone #:352-392-1950

SOIL TEST RESULTS AND THEIR INTERPRETATIONS

Target pH:	6.0
pH (1:2 Sample:Water)	7.5
A-E Buffer Value:	N/A

MEHLICH-1 EXTRACTABLE



PHOSPHORUS	(ppm P)	58
POTASSIUM	(ppm K)	59
MAGNESIUM	(ppm Mg)	> 218
CALCIUM	(ppm Ca)	> 2648

LIME AND FERTILIZER RECOMMENDATIONS

Crop:	Woody orn/trees in the landscape	
Lime:	0.0	lbs per 1000 sq. ft (1 Ton = 2000 Lbs)
Nitrogen:	2.30	lbs per 1000 sq. ft.
Phosphorus: (P_2O_5)	0	lbs per 1000 sq. ft.
Potassium: (K_2O)	0.70	lbs per 1000 sq. ft.
Magnesium: (Mg)	0	lbs per acre

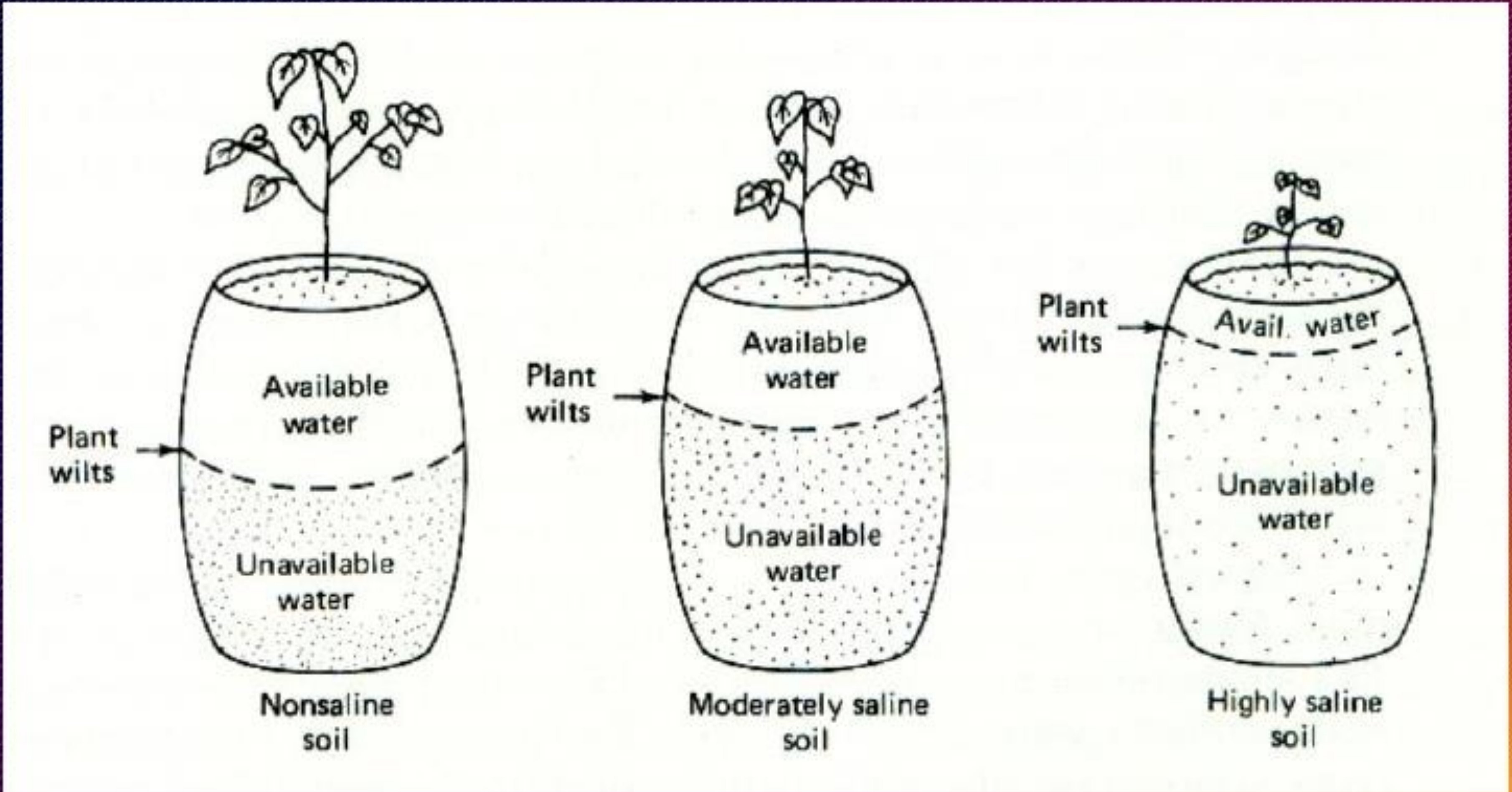
Soil & Water Total Salts Tests Basics

- ❖ Used to monitor salts in soil and water (i.e., composites of positive and negative ions) which can damage organisms at high levels.
- ❖ Contributed to by soil mineral components, organic matter components, fertilizers, pollutants, and from salt water.
- ❖ Salts are especially an issue in areas where salt water flooding occurs or where irrigation water is from a salt-intruded source (salty well; brackish canal; etc.).

Understanding Water Salts Tests

- Two most important measures for determining irrigation water quality are:
  - Total amount of dissolved salts (TDS)
  - Amount of sodium (Na) compared to calcium (Ca)
  - Or both
- Liming potential
  - Amounts of carbonates
- Salinity level comparisons
  - fresh water < 1500 mg/L TDS
  - brackish water <1500 to 5000 mg/L TDS
  - saline water > 5000 mg/L TDS

Salinity and Plant Water Availability



Water Quality Ratings Basics

- Water Hardness (Ca + Mg salts only)

0-60 ppm	Soft
61-120 ppm	Moderately hard
121-180 ppm	Hard
> 180 ppm	Very hard

VS

Salinity Assessment

Irrigation water Quality	EC mmho/cm or dS/m	TDS ppm
Excellent	< 0.25	< 175
Good	0.25 – 0.75	175 – 525
Permissible	0.75 – 2.00	525 – 1400
Doubtful	2.00 – 3.00	1400 – 2100
Unsuitable	> 3.00	> 2100

Don’t Confuse Different Water Quality Ratings !

Salinity & Crop Tolerance Examples

ppm

980	2100	4200	7000
Sensitive	**Moderately sensitive**	**Moderately tolerant**	**Tolerant**
almond	alfalfa	red beet	sugarbeet
apple	broccoli	safflower	cotton
avocado	cabbage	olive	date palm
bean	tomato	soybean	bermuda-grass
carrot	lettuce	wheat	
grapefruit	corn	ryegrass	
orange	cucumber	wheatgrass	
lemon	grape	wildrye	
okra	peanut		
onion	potato		
strawberry	radish		
peach	rice		
plum	sugarcane		

(adopted from Jensen, 1980)

Water Quality Tests Basics

❖ Water Tests by UF/IFAS Soil Test Lab for Irrigation Problems (including micro-irrigation)

(http://soilslab.ifas.ufl.edu/ESTL%20Pages/ESTLAnalysis.htm)

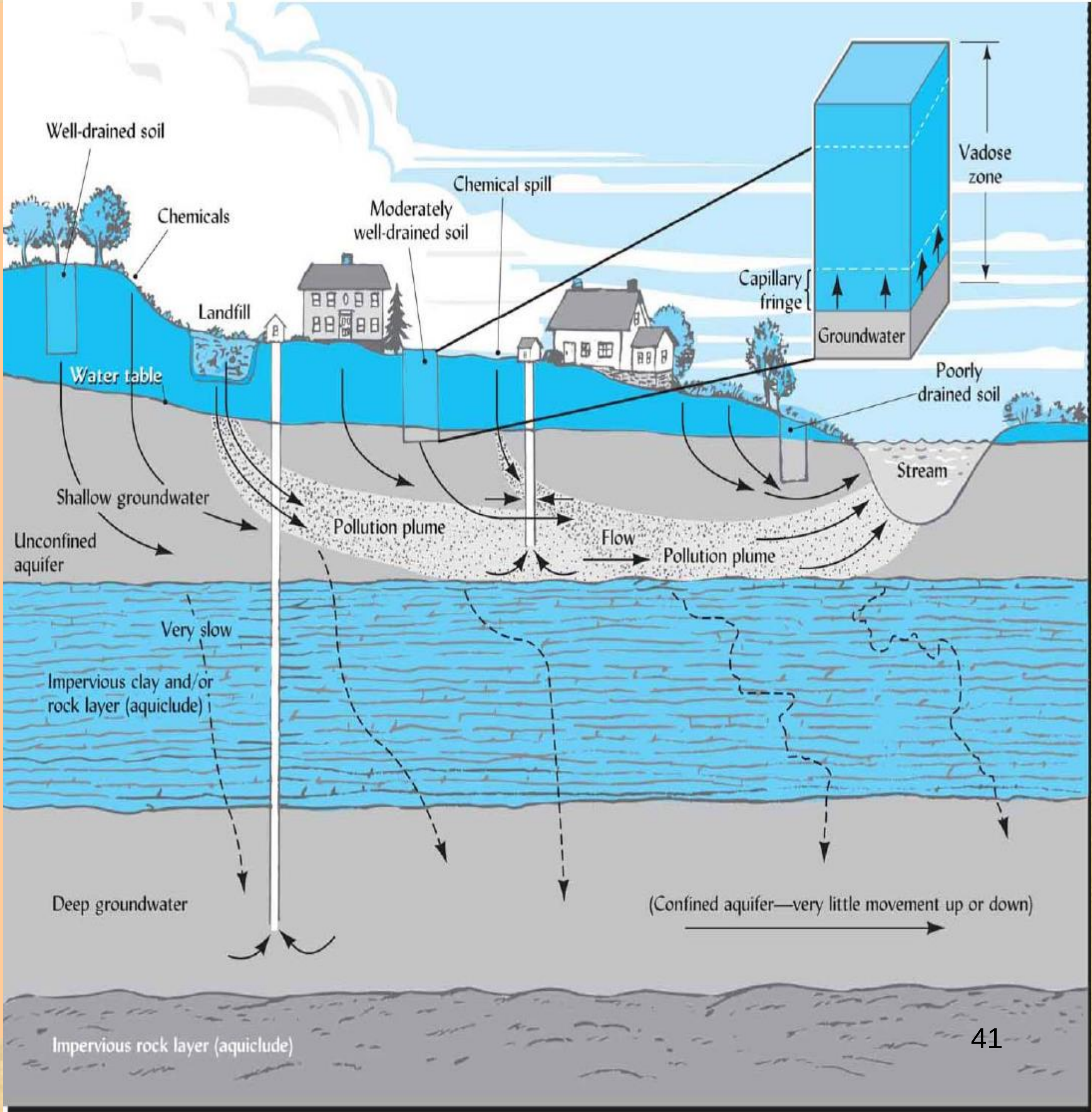
- **Ca, Mg, & Total carbonates**
- **liming**
- **hardness**
- **Fe & Mn**
- **foliage stains**
- **staining, taste**
- **Na & Cl**

- **electrical conductivity**
- **plant damage from salt content**
- **pH**
- **corrosion potential/plugging**
- **corrosion**
- **suspended solids**
- **plugging problems**

Well Water Quality:

What's In Your Water ?

Hidden Sources of Pollution



Taking a Representative Water Sample

Tools

1. A clean plastic bottle holding about 1 pint in which to collect the water sample. Do not use shampoo or detergent bottles since it is difficult to remove all residues. **Glass Bottles Are Not Recommended.**

2. A corrugated shipping box. These boxes (also used to mail soil samples) are available free of charge at your local county Cooperative Extension Service office.

3. Some packing material with which to pack the sample to avoid damage or leakage during shipment to the Extension Soil Testing Laboratory.

4. This form. Use additional copies if you plan on sending more than 5 water samples.

Sampling

1. Allow the water source to run from the intended collection point for several minutes.

   For household samples, allow the water to flow for several minutes to ensure the water sample is directly from the well. Water that has been standing in the house plumbing for some time is not a representative sample.

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2. Rinse the sample container and its lid several times in the flowing water. Do not use soap or detergent during this rinsing step.

3. Fill the container completely with the flowing water. Leave as little air as possible in the container. Tightly seal the lid immediately after filling the container to ensure against leakage.

4. Label the container and pack it carefully in the prelabeled shipping box.

5. Include in the shipping box:

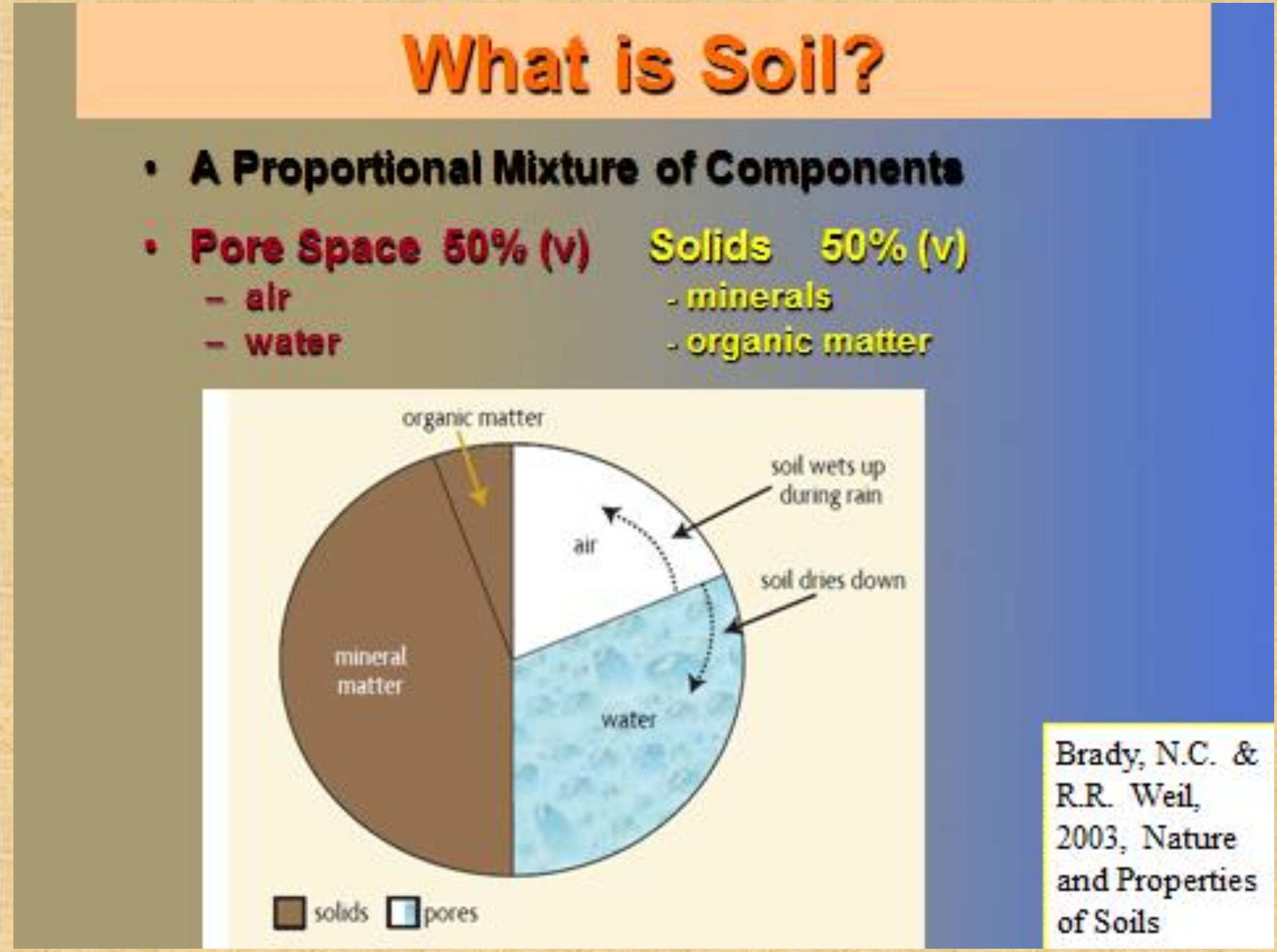
   - Your labeled water sample(s)
   - This Water Test Information Sheet with all the requested information on page 1 of the form completed

Water Quality Tests Sampling Procedure

Alternative Soil Tests

- ❖ Alternative Soil Testing Laboratory Database - see http://attra.ncat.org/attra-pub/soil-lab.html
- ❖ What additional information do they provide?
  - organic matter
  - soil life
  - tilth
  - soil health
- ❖ And why would you consider them?
  - assessment of soil restoration needs
  - monitoring of soil restoration strategies

Soils and Crop Nutrition Basics

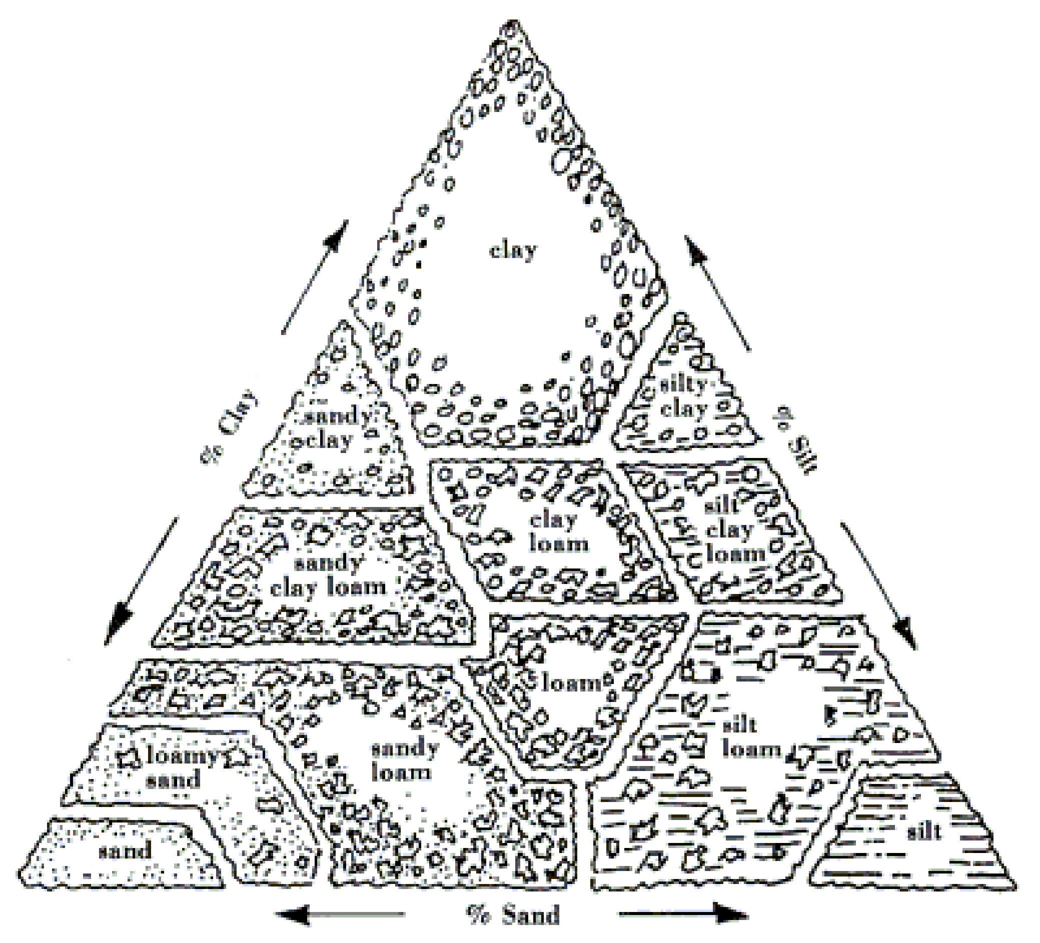


Soils and Crop Nutrition Basics

- Triangle used to Determine Soil Texture Class
- Depends on %

of sand, silt & clay

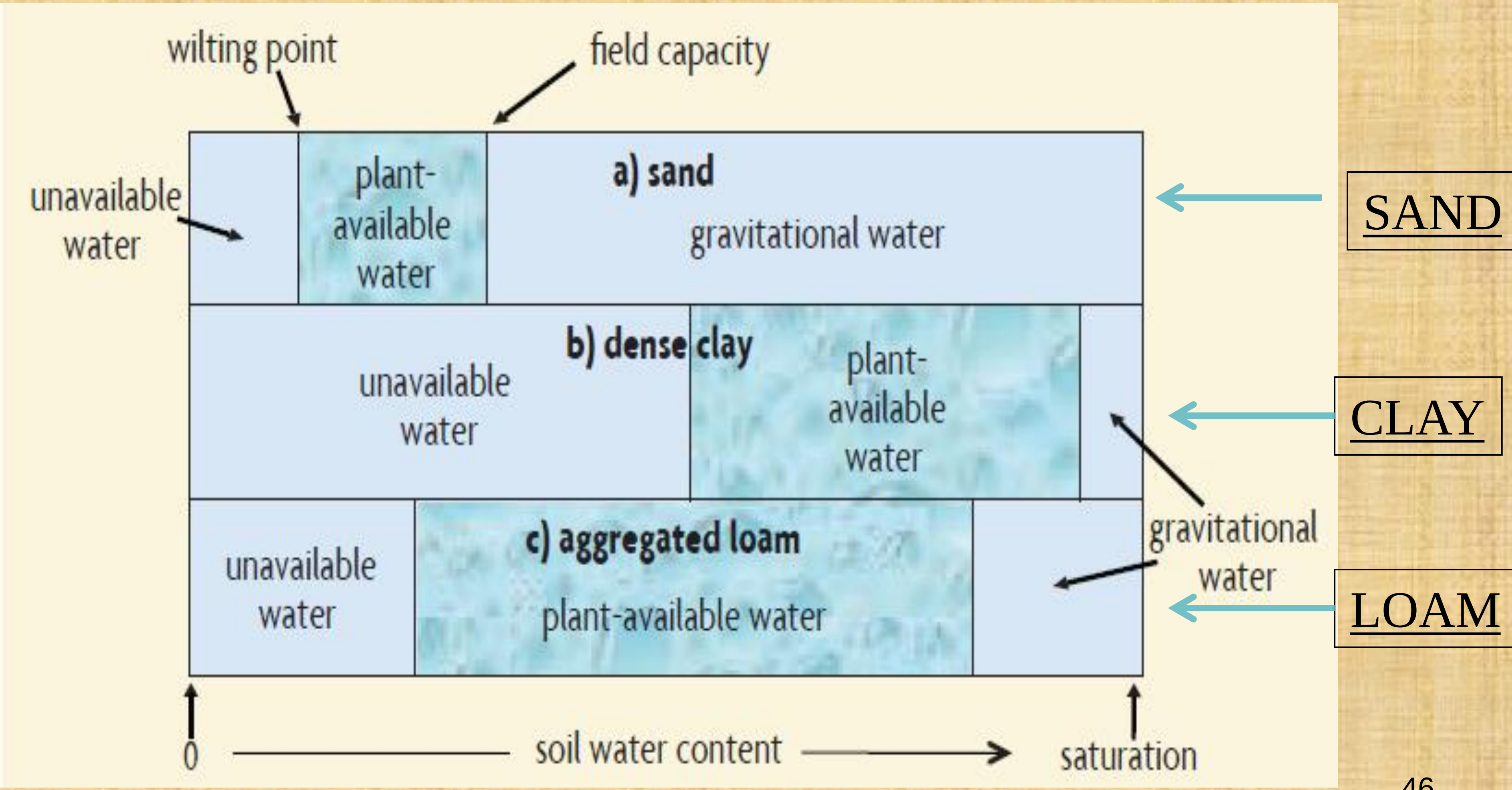
- For example,
  - Loamy soils: mixture of all 3 components
  - Sandy loam: mostly silt w/ sand
  - Loamy sand: mostly sand w/ silt



FL soils are typically in different sand texture classes!

Soil Texture Property Basics

Water Holding Capacity (WHC)

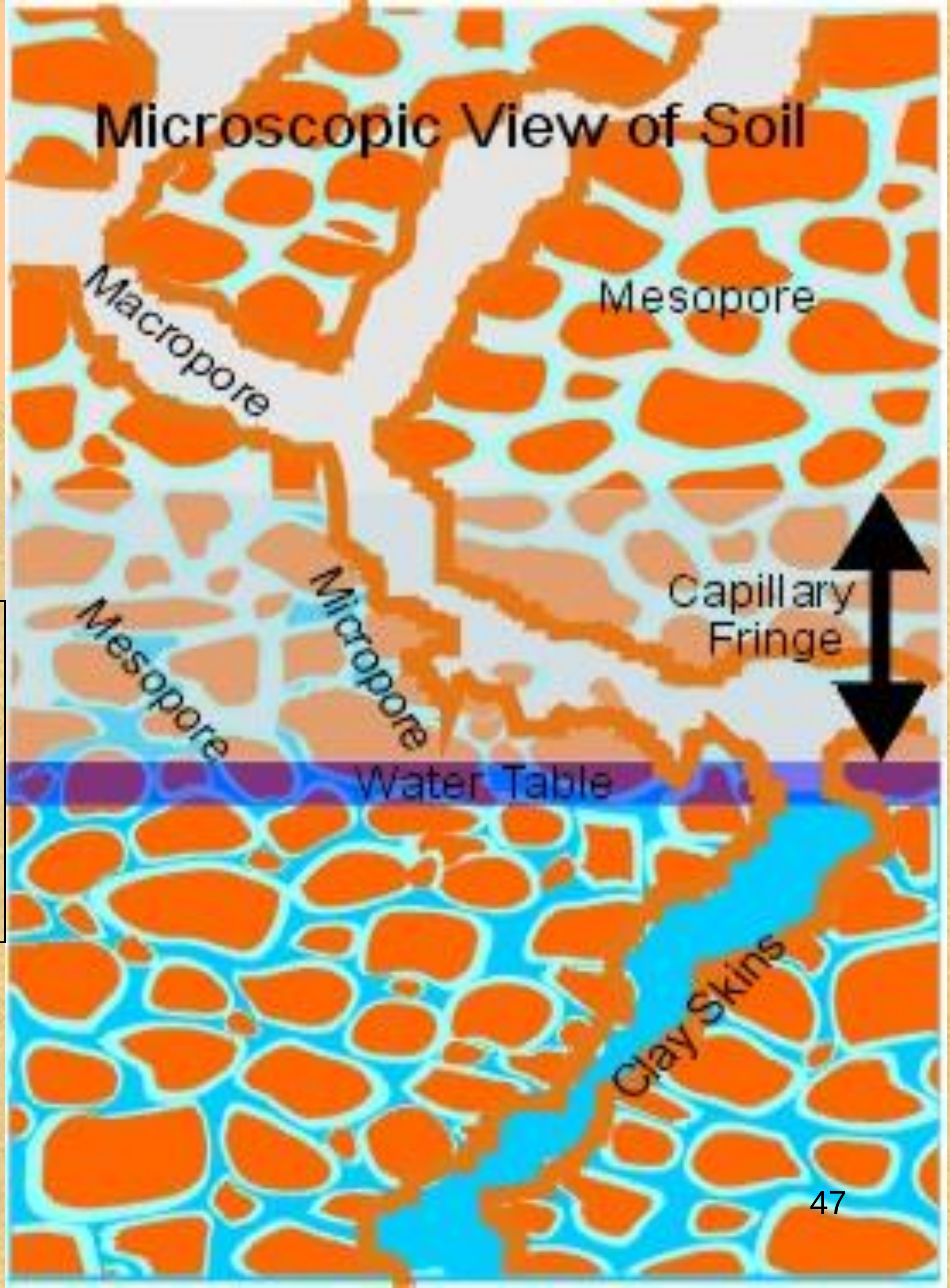


Soil Texture Property Basics

Soil Pore Sizes

Pore size by soil texture:

- Sand – macropore
- Loam – mesopore
- Clay - micropore



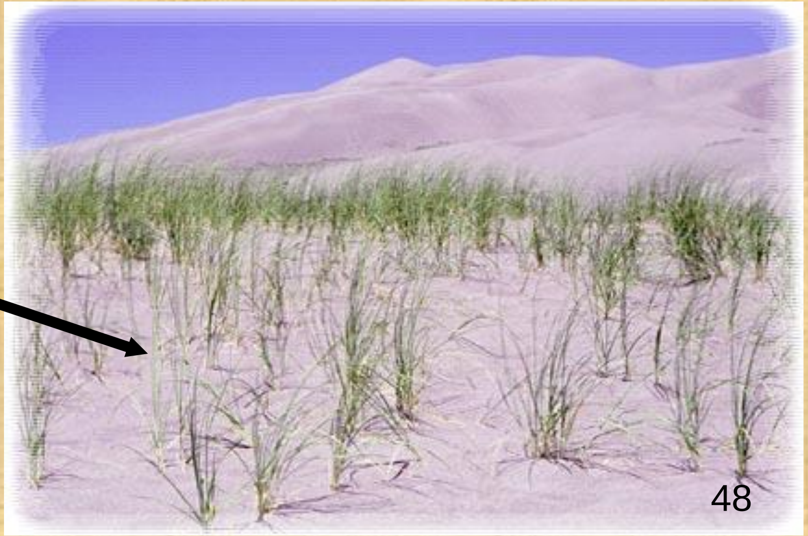
[www.homepage.montana.edu/~ueswl/307%2008A.**ppt**](www.homepage.montana.edu/~ueswl/307%2008A.ppt)

Soil Texture Property Basics

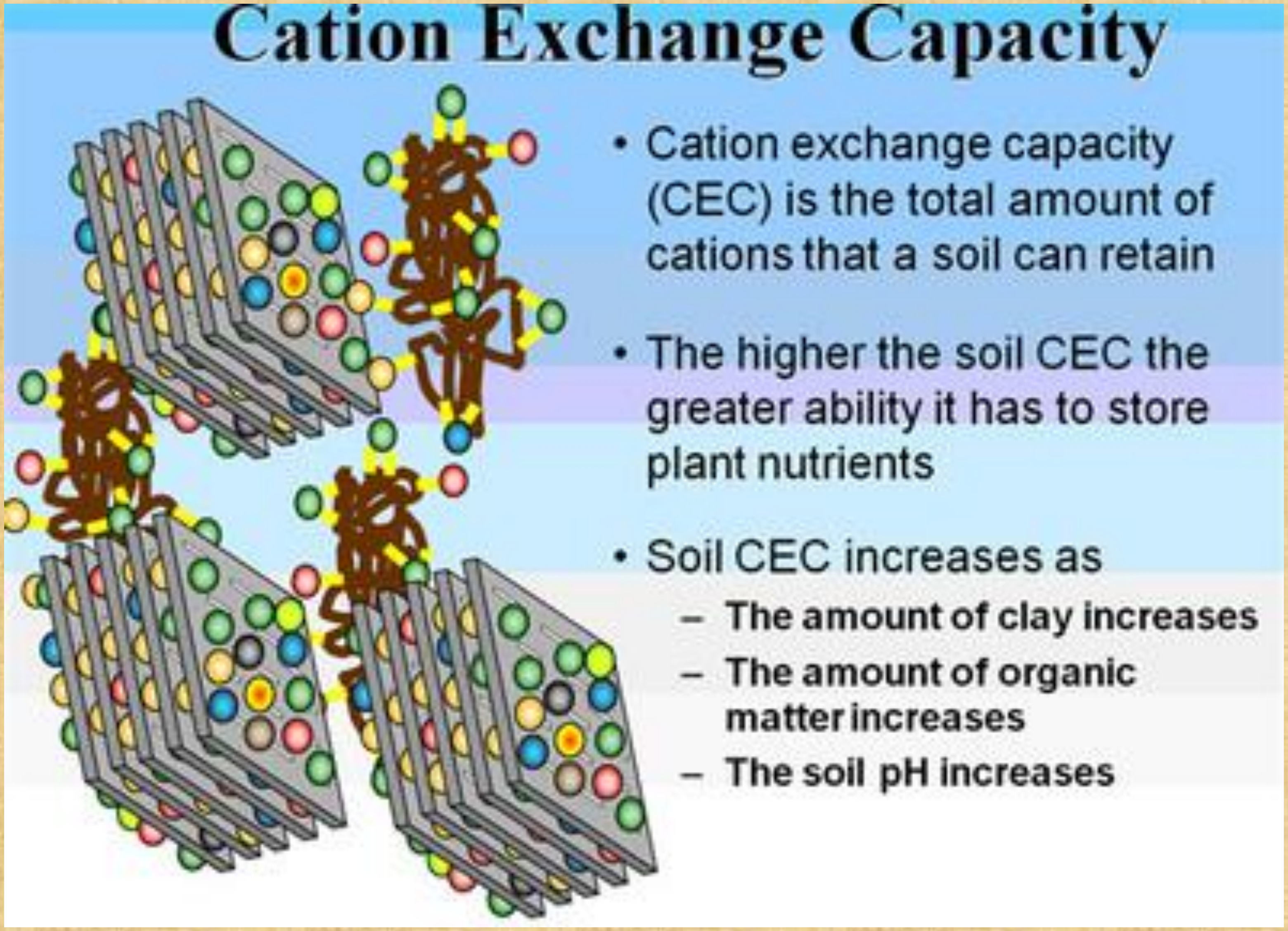
<u>Cation Exchange Capacity (CEC)</u>

- A high CEC value (>25) is a good indicator that a soil has a high clay and/or organic matter content and can hold a lot of nutrients.

- Soil with a low CEC value (<5) is a good indication that a soil is sandy with little or no organic matter that cannot hold many nutrients. <u>Typical of FL sandy soils</u>



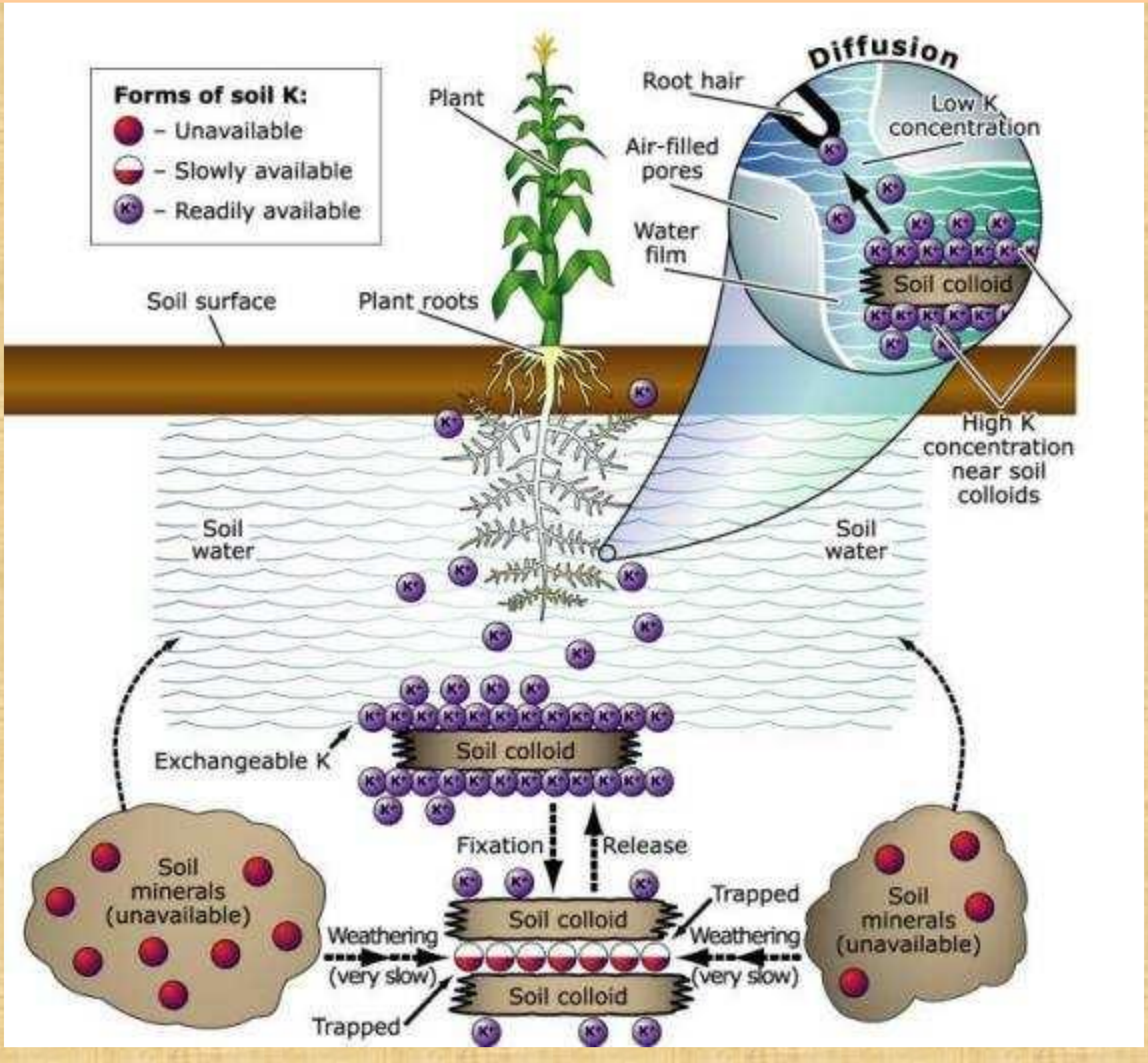
What Is Cation Exchange Capacity?



Management of Soil Texture, Pore Space, WHC, and CEC

- Negative Impacts
  - – compaction
  - – mixing of soil profile strata
  - – excessive soil salt concentrations
- Positive Impacts
  - – soil organic matter additions & conservation
  - – plant root growth

Soil and Crop Nutrition Basics



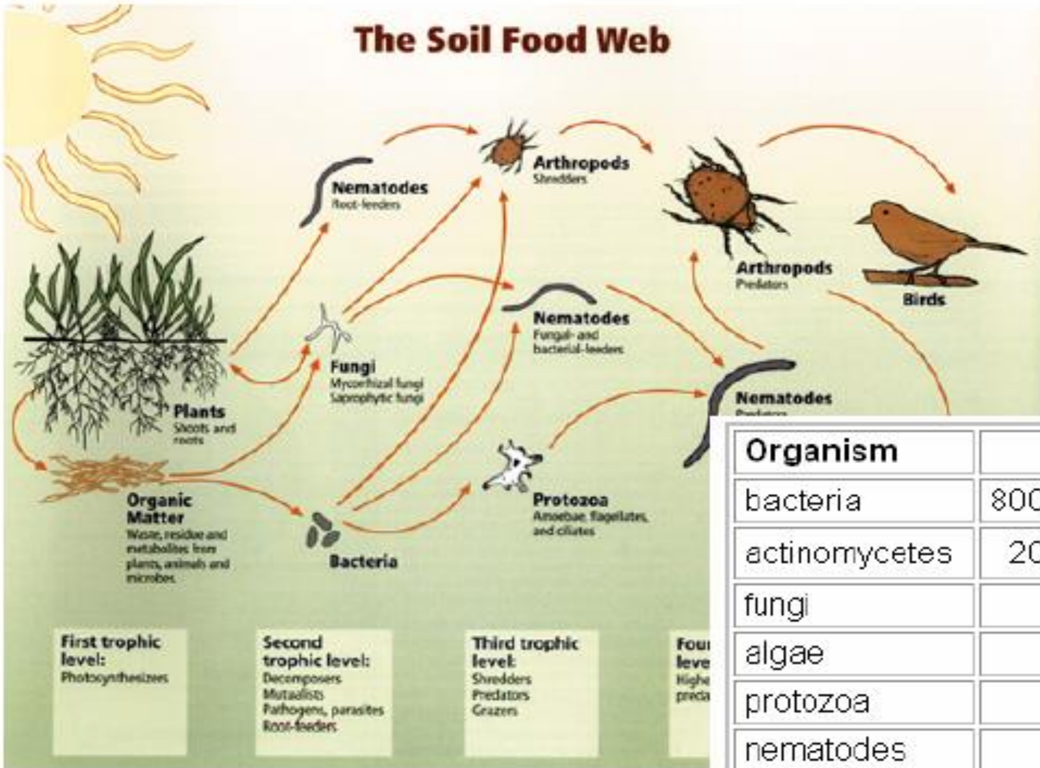
Chemical Processes of Crop Nutrition:

Potassium (K) & Cation Exchange Capacity Example

Soil and Crop Nutrition Basics

Soil Biological Activity As a ‘Tool’ for Crop Nutrition

Soil is Alive



Importance of Soil Biology
- diversity
- nutrient cycling
- pest/pathogen suppression
- symbioses

Organism	Number/acre	Lbs./acre
bacteria	800,000,000,000,000,000	2600
actinomycetes	20,000,000,000,000,000	1300
fungi	200,000,000,000,000	2600
algae	4,000,000,000	90
protozoa	2,000,000,000,000	90
nematodes	80,000,000	45
earthworms	40,000	445
insects & other arthropods	8,160,000	830

Source: Thompson and Troeh, 1978

Watch these videos:

https://www.youtube.com/watch?v=Qas9tPQKd8w

https://www.youtube.com/watch?v=4wO5WwOaPKE

Soil and Crop Nutrition Basics

Biological Processes of Plant Nutrition: Rhizosphere

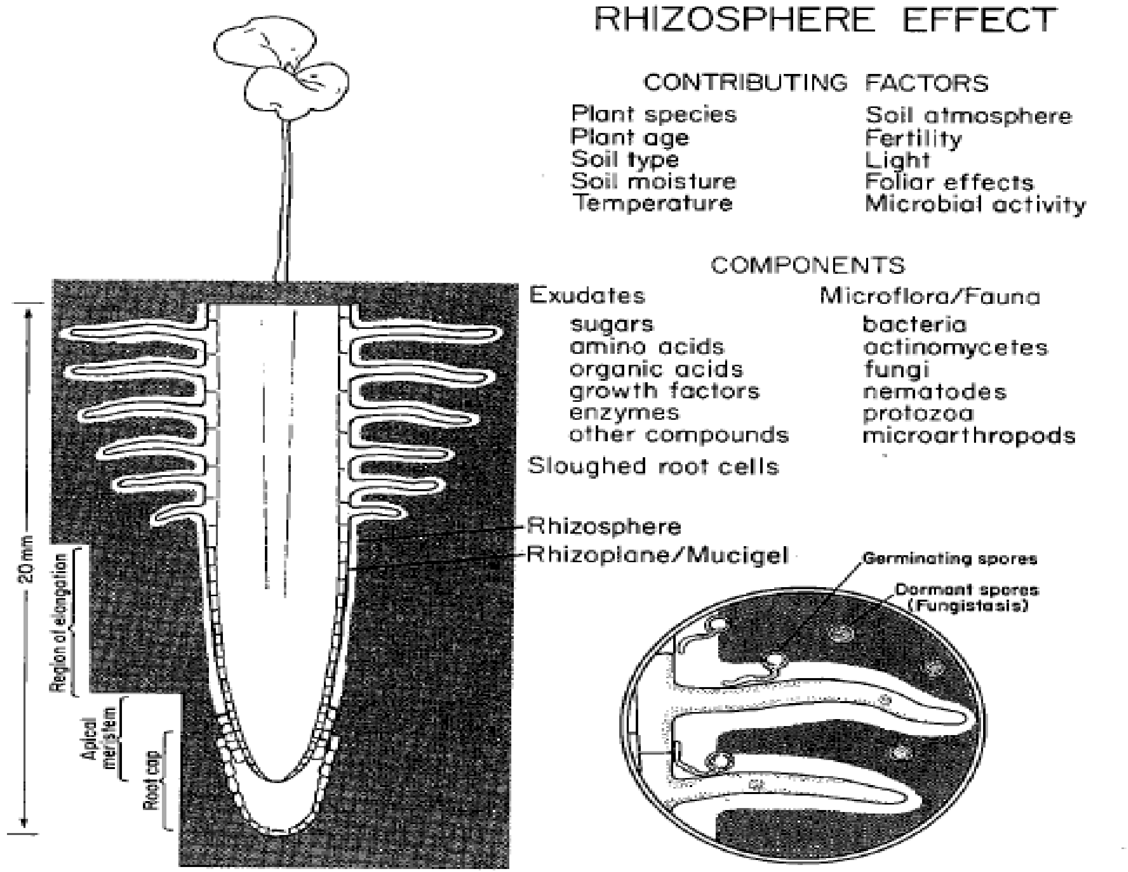


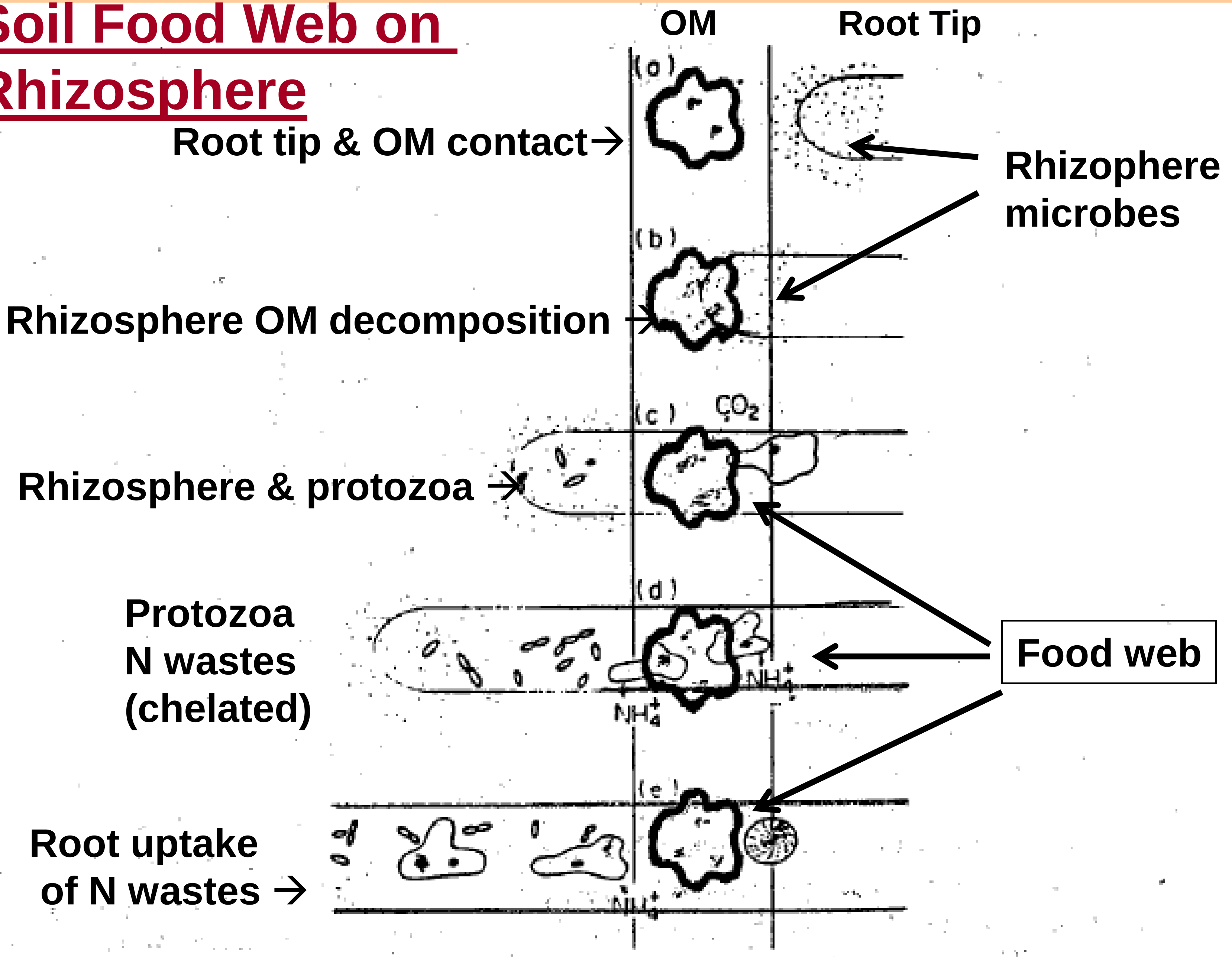
Fig. 1.2. Diagram of a young root featuring the rhizosphere and rhizoplane. Major organic materials released by the root, and groups of the microbiota affected are indicated along with factors governing the extent of root influence. *Inset* shows fungal spores germinating in the rhizosphere but not outside this nutrient zone

Curl, E.A. & B.T. Truelove, 1986, The Rhizosphere.

Watch short video "The Rhizosphere: an interaction between plant roots and soil biology" – see https://www.youtube.com/watch?v=tvA7CWSIbTc

Soil and Crop Nutrition Basics

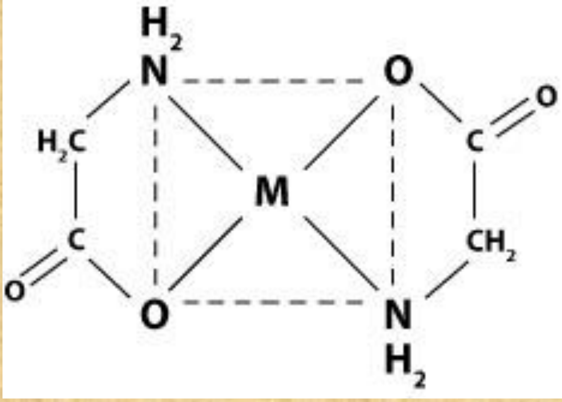
Soil Food Web on Rhizosphere



Soil Life & Plant Nutrition Basics

What Is Chelation ?

- a natural process by chelates, i.e., organic substances in the soil either applied or produced by plants and/or microorganisms
- elements are held more strongly by chelates than by binding of positive and negative charges
- chelates are smaller than the particles that make up humus



M = metals & trace elements

http://www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition

Soil Life & Plant Nutrition Basics

Significance of Soil Chelation ?

- ❖ Optimizes plant nutrition because
  - ▪ prevent mineral nutrients from forming unavailable chemical precipitates
  - ▪ root uptake of chelated nutrients is more efficient & requires less energy
  - ▪ consequently plants require lower soil nutrient levels
- ❖ Reduces toxicity of some metal ions to plants
- ❖ Prevents nutrient leaching losses because chelated nutrients are no longer water-soluble salts
- ❖ Suppresses the growth of plant pathogens.

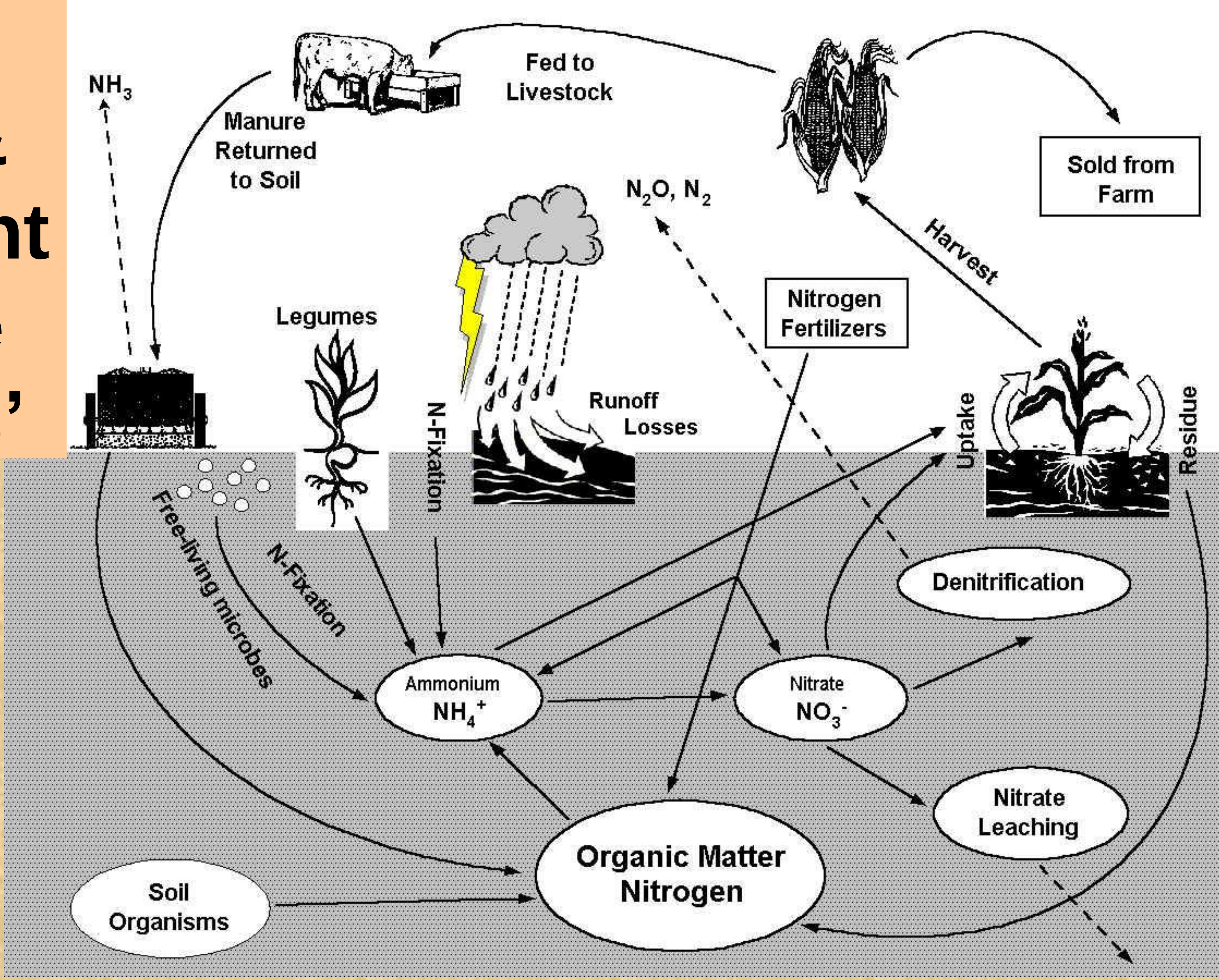
Ingham & Rollins, 2006. Adding Biology – http://www.soilfoodweb.com.au/

Management of Soil Life: Rhizoshere

- Negative Impacts
  - Excessive use of chemical soil fertilizers and pesticides
  - Soil fumigation
  - Soil salt concentrations (EC) above 100-350 ppm) hinders microbial chelation

- Positive Impacts
  - Soil organic matter additions & conservation
  - Plant root growth

Soil Life & Nutrient Cycle 'Tools'



- ❖ Soil ecosystems have functional properties & subsystems (e.g., nitrogen cycling) from soil life

Soil Life 'Tool" Example: Nitrogen-Fixing Bacteria Mutualism

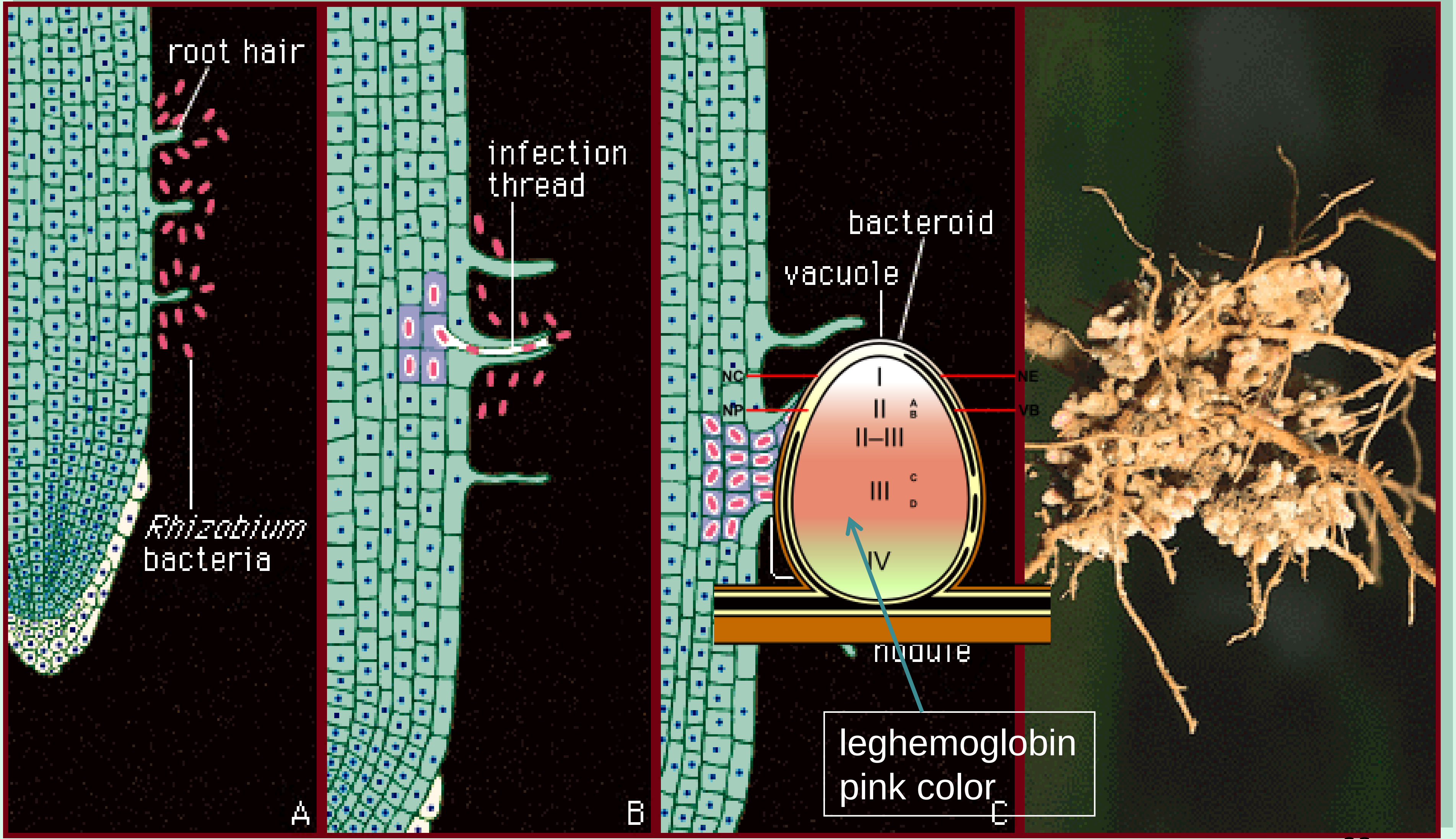
- Nodules formed where *Rhizobium* bacteria infected roots of legume crops
- Converts atmospheric nitrogen for plant uptake & use in protein synthesis

$$\underset{\text{(atmospheric)}}{\underset{\text{nitrogen}}{N_2}} + 12\ ATP \xrightarrow{\text{nitrogenase}} 2\ \underset{\text{ammonia}}{NH_3} + 12\ ADP + 12\ \underset{\text{(inorganic)}}{\underset{\text{phosphate}}{P_i}}$$

It takes 12 ATPs to provide sufficient energy to break the strong triple bond betwen the two nitrogen atoms of N_2 gas: $N \equiv N$

Simplified Equation For Nitrogen Fixation

Legume Root Nodules Development



Non-Legume N-Fixing Symbiont Plants: Florida Examples

Actinomyces *Frankia*

• Wax myrtle *(Morella cerifera)*
-native species

• Australian Pine *(Casuarina equisetifolia)*
-invasive secies

Blue-green algae

• Coontie *(Zamia floridana)*
-native species

• Mosquito fern *(Azolla pinnata)*
-native species

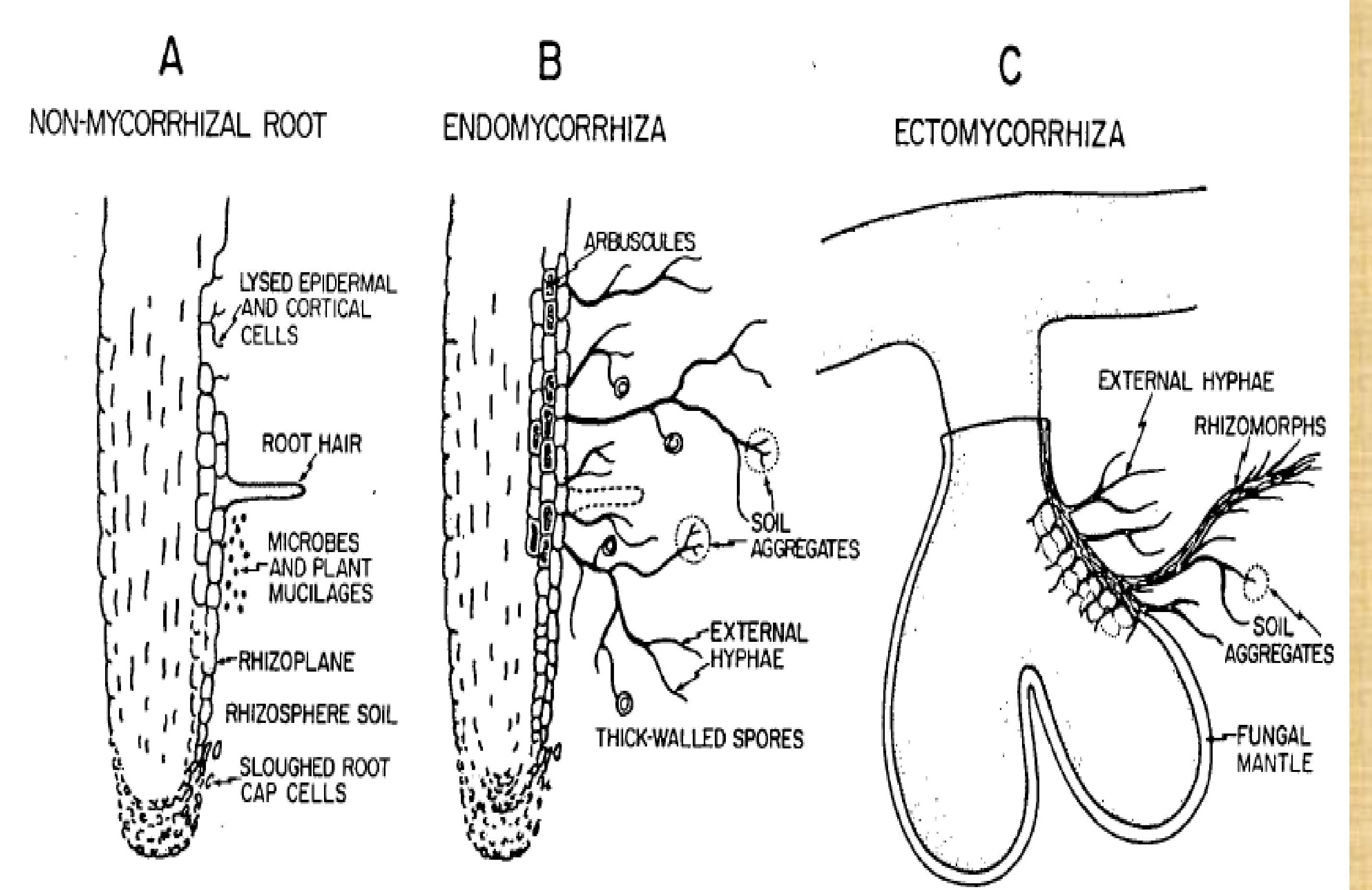
Management Factors With Impacts on Rhizobium Mutualism

- Negative Impacts
  - excessive N fertilizer use (<u>including compost additions)</u>
  - very low pH (4.7 or lower)
  - high soil surface temperatures and dessication
- Positive Impacts
  - inoculation of specific Rhizobium group required for different legume crop species at first planting of a location

Watch this short video “Nitrogen Fixation - Seven Wonders of the Microbe World” – see https://www.youtube.com/watch?v=4NKGS4bj7cc

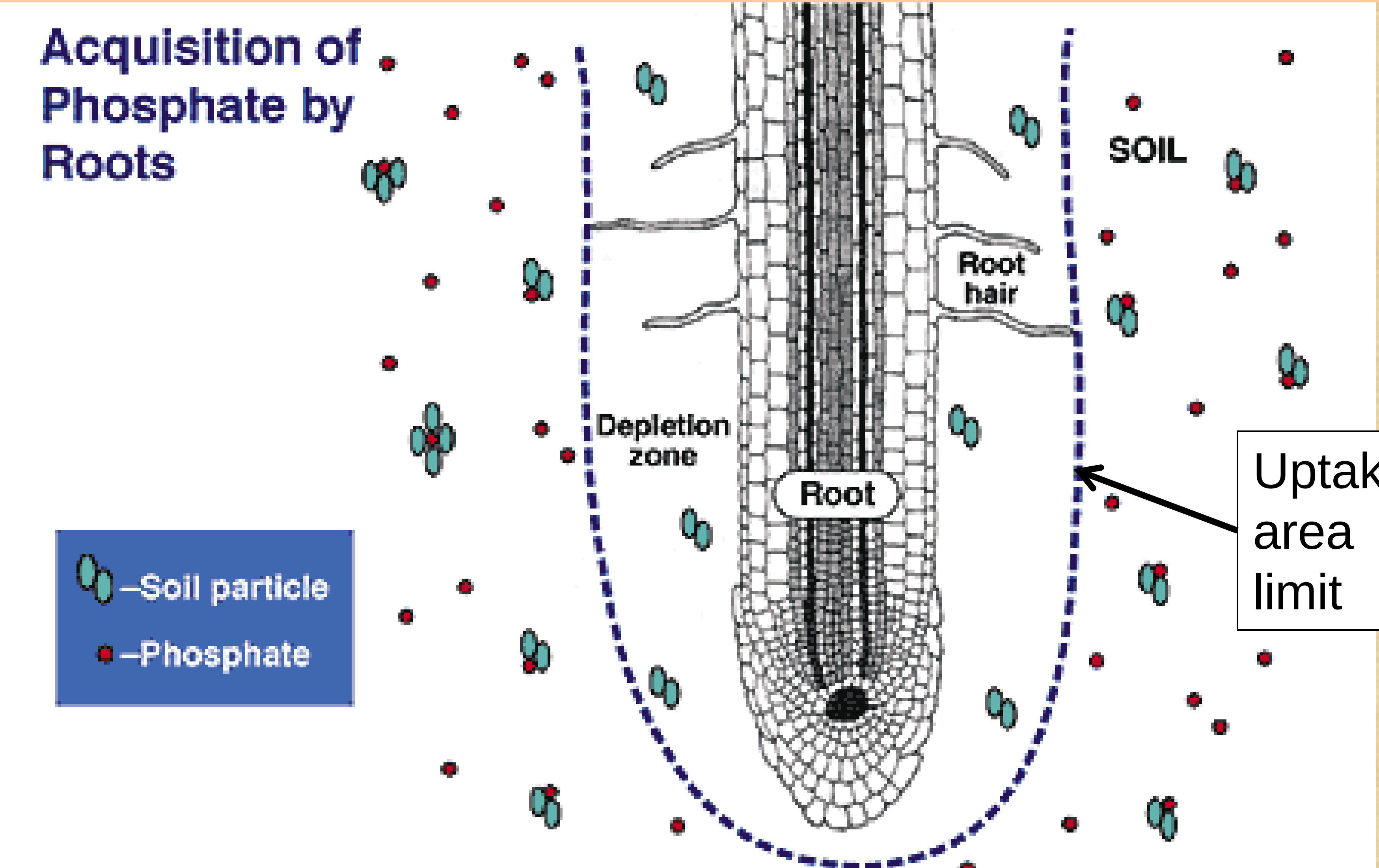
Soil Life ‘Tool’ Example: Mycorhizae

- ✓ Myco (fungi) + rhizae (root)
- ✓ Serves as an expanded root system that provides water and nutrient benefits to plant host
- ✓ More that 90 % of all plants are mycorrhizal



Pfleger and Linderman, 1994, Mycorrhizae and Plant Health.

Mycorhizae Mutualism Basics

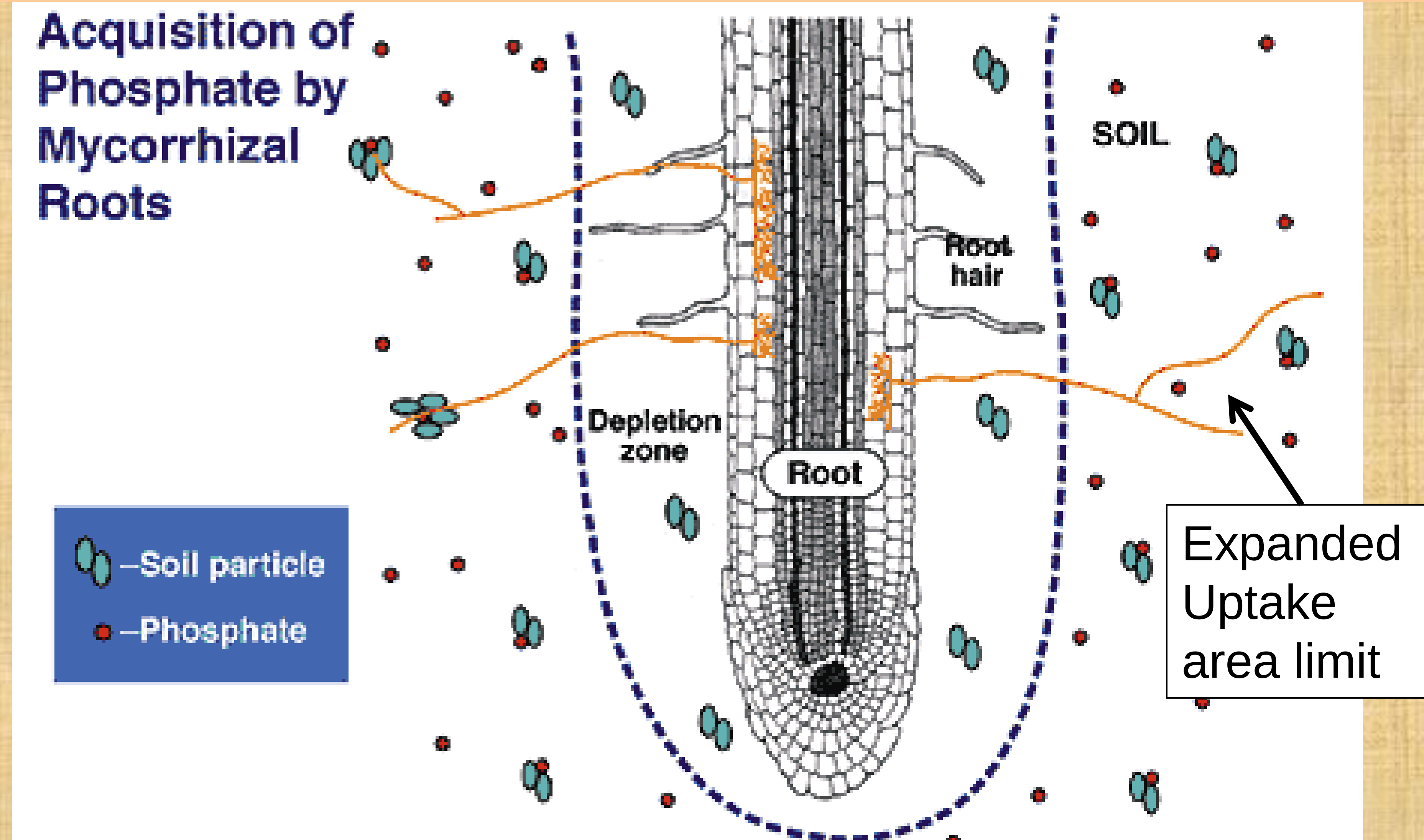


Uptake area limit

Roots Without Mycorrhizae

Source: Harrison et al 1999

Mycorhizae Mutualism Basics



Roots <u>With</u> Mycorrhizae

Source: Harrison et al 1999

Management Factors With Impacts on Mycorrhizae Mutualism

- Negative Impacts
  - excessive P fertilizers (including compost additions)
  - soil disturbance and/or tillage
  - fallow soils
- Positive Impacts
  - Mycorrhizae maintenance in soil require annual replenishment of soil spores via infection of living roots
  - Use of mycorrhizae inoculant in transplants

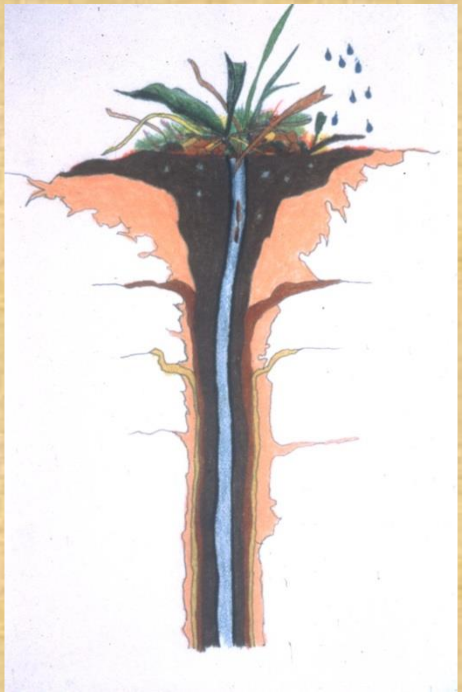
Watch this short video “Mycorrhizae on the farm” – see https://www.youtube.com/watch?v=LbQq4dQ3OfY

Soil Life 'Tool' Example: Earthworms

- Earthworms dramatically alter soil properties for growing conditions favorable for crop plants

Earthworm Basics

- Stimulate microbial activity
- Mix and aggregate soil
- Increase infiltration
- Improve water-holding capacity
- Provide channels for root growth
- Bury and shred plant residue
- Casts at the soil surface are evidence of earthworms shredding, mixing, and burying surface residue

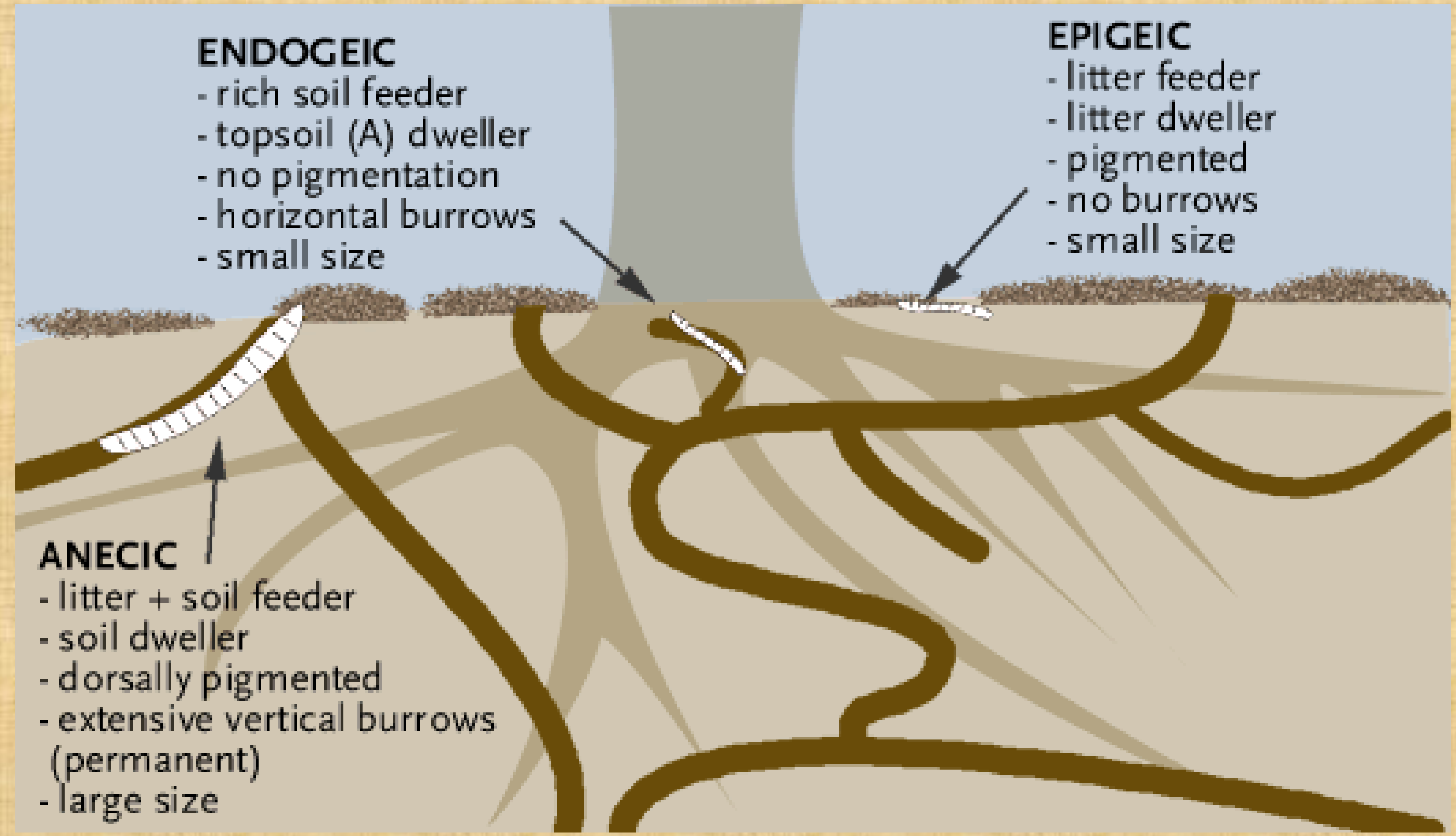


Earthworm castings

Earthworm burrow

Earthworm Basics

Earthworms are classified in ecological groups



Use of multi-species of earthworm enhances potential benefits

Earthworm Management

- Negative Impacts
  - ✓ Excessive tillage
  - ✓ Chemical fertilizers and pesticides
- Positive Impactts
  - ✓ Introduction
    - Nightcrawler spp more than shallow-dwelling spp respond to additions
  - ✓ Food supply
    - Adding organic matter
  - ✓ Mulch protection
    - Leaving a surface mulch, by no-till or other conservation tillage systems with plenty of residue cover
  - ✓ Chemical environment
    - Soil pH should be maintained between 6.0 and 7.0 for optimum conditions, although lower pHs are tolerated by most species.

Earthworms and Crop Management, Purdue Univ. Extension
http://www.ces.purdue.edu/extmedia/AY/AY-279.html

Composting as a 'Tool'

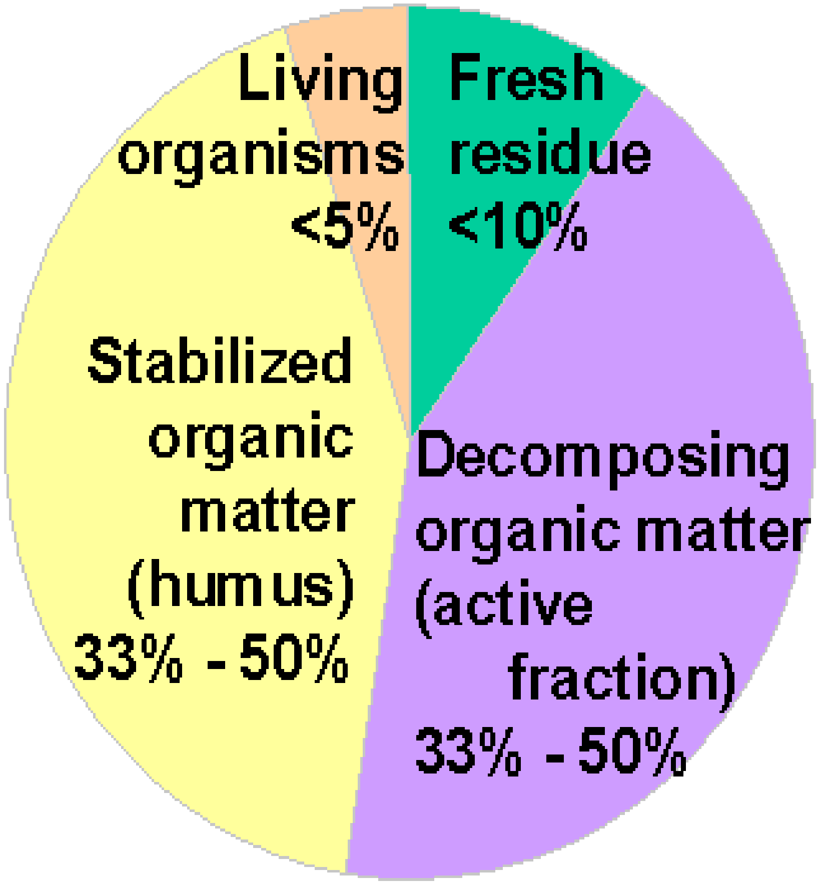
- Art & science of producing stable organic matter soil amendment by:
  - mixing organic materials properly
  - monitoring resultant biological activity
- Types
  - aerobic
  - anaerobic
  - worm (vermicomposting)
- Adds biological inoculum, as well as nutrients and organic matter, to restore the soil life

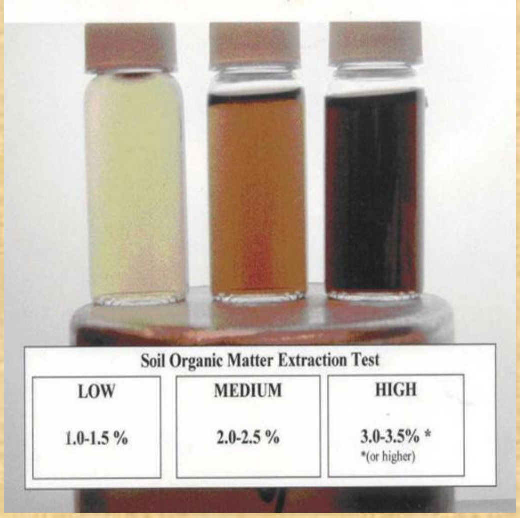
Soil Organic Matter as a 'Tool'

- Contributes the most to soil fertility & health.
- Range of values
  - Temperate soils have higher OM levels (5-10%)
  - Tropical soils generally have 0.5-1.0% (this is us)
- Incorporation of compost into soils provides beneficial soil life and a complete nutrient package. As OM decomposes the nutrients are released into the soil, becoming available to plants.
- High OM levels encourage greater biodiversity in the soil and discourages diseases and soil pests (like nematodes) via emergent property of population homeostasis.

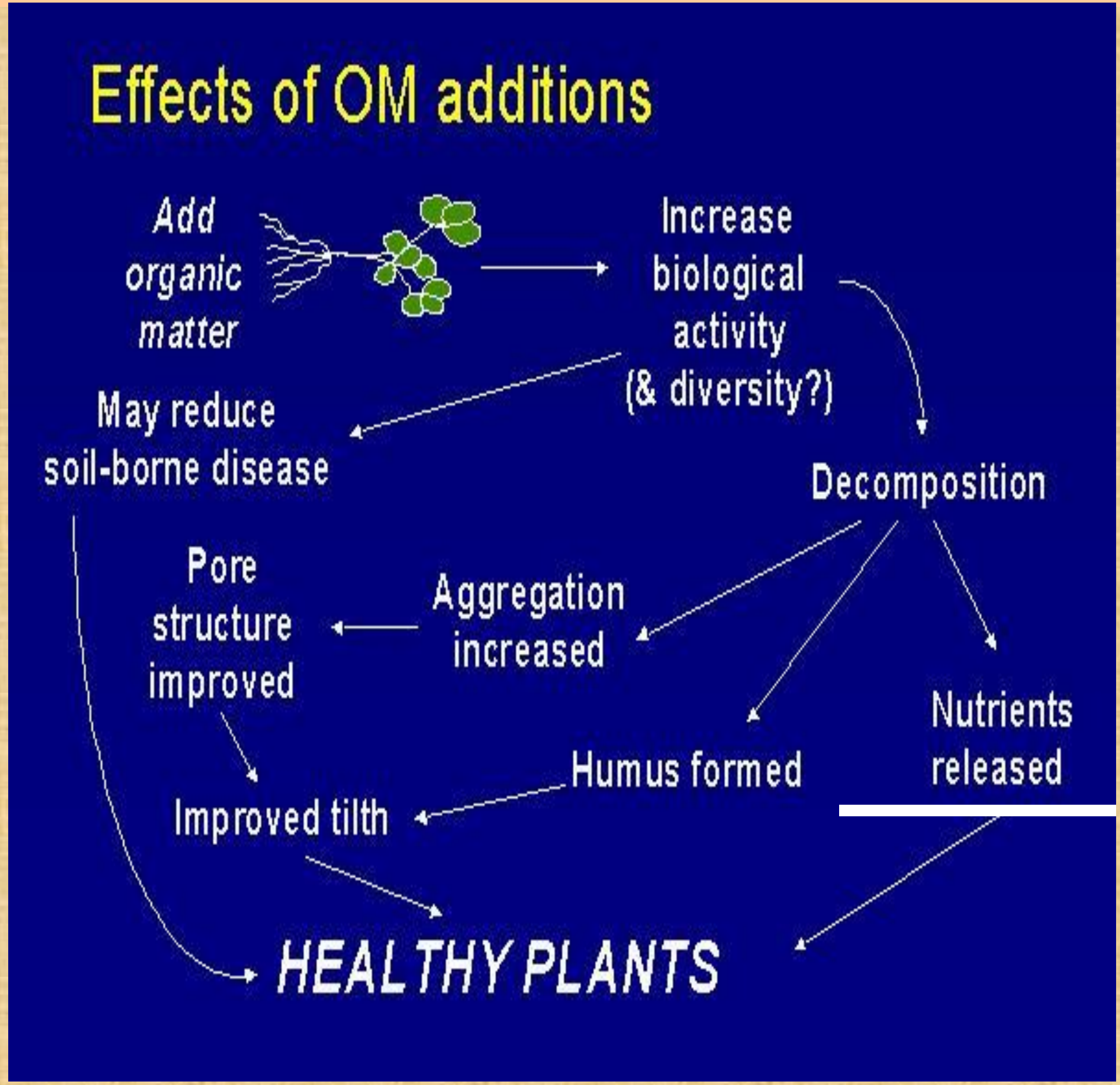
Soil Organic Matter Basics

- Soil Organic matter encompasses all *organic components* of a soil:
  - Fresh residues
  - Decomposing organic matter
  - Stable organic matter
  - Living organisms





Soil Organic Matter Basics

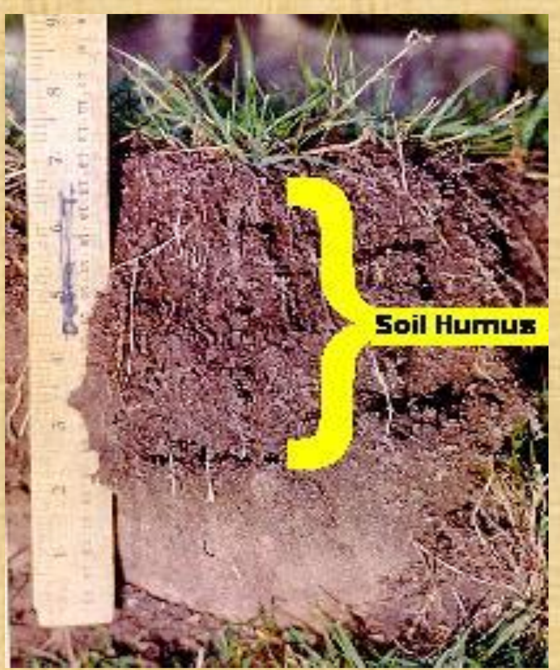


Watch these short videos: "Soil Organic Carbon" – see https://www.youtube.com/watch?v=Ymy0IO7nizw and "Soil Organic Matter and Nutrition" – see https://www.youtube.com/watch?v=PpVGTfx0R6c

Humus Basics

✓ Newly-formed humus =

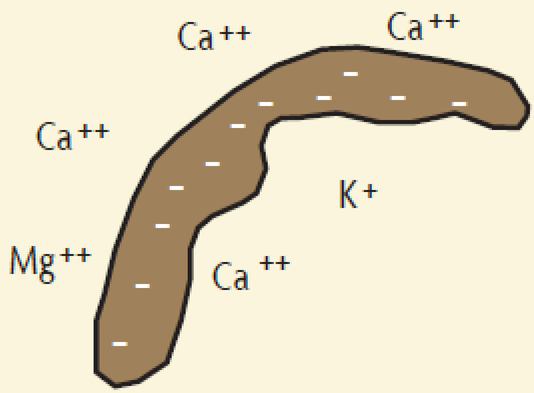
- combination of resistant materials from the original plant tissue,
- compounds synthesized as part of the microorganisms' tissue which remain as the organisms die. (Fluvic and Humic Acid)
- humus is resistant to further microbial attack- N and P are protected from ready solubility.



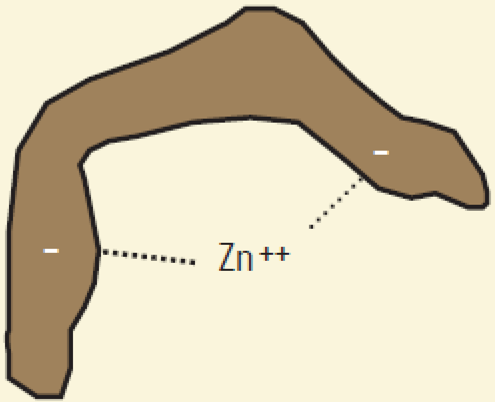
Watch this short video "Humus" – see https://www.youtube.com/watch?v=gRpcVhUmfCs

Humus Basics

OM

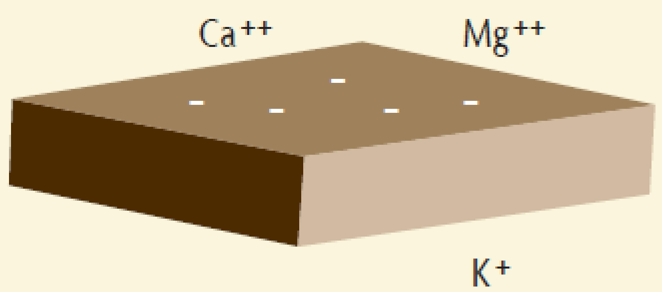


a) cations held on humus



c) cations held by organic chelate

Mineral



b) cations held on clay particle

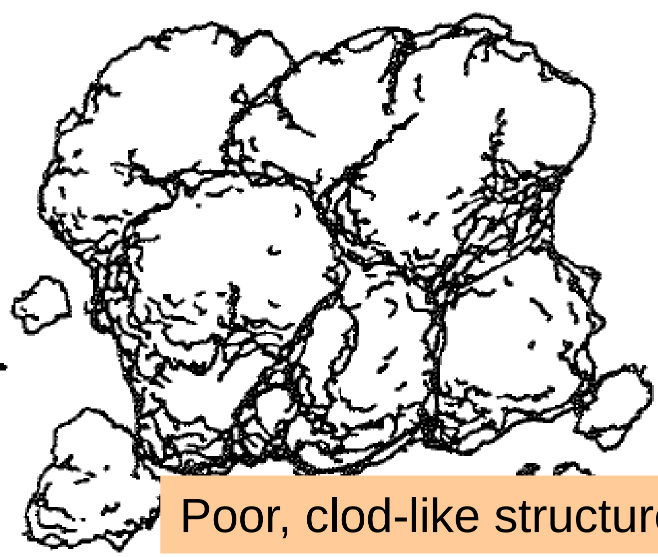
OM adds to soil nutrient holding capacity w/ Cation Exchange Capacity (CEC)

OM adds to soil nutrient holding capacity w/ chelation

Humus Basics

- Increases soil structure and aggregation
  - how components are held together not just composition
  - good “tilth” indicator for improved crop growth
  - improved by root growth, OM, & soil life
  - reduced by compaction and increased density

Good, crumb-like structure



Poor, clod-like structure

Gershuny & Smillie, 1995, Soul of Soil.

Cover Crops as a 'Tool' for Soil Organic Matter Management

- Use is critical for many Florida soils, especially for sandy soils which typically have low inherent soil fertility, do not retain much water or nutrients, and are often prone to excessive nutrient leaching losses.

- Benefits also include soil pests control and providing insectary plants.

http://edis.ifas.ufl.edu/aa217

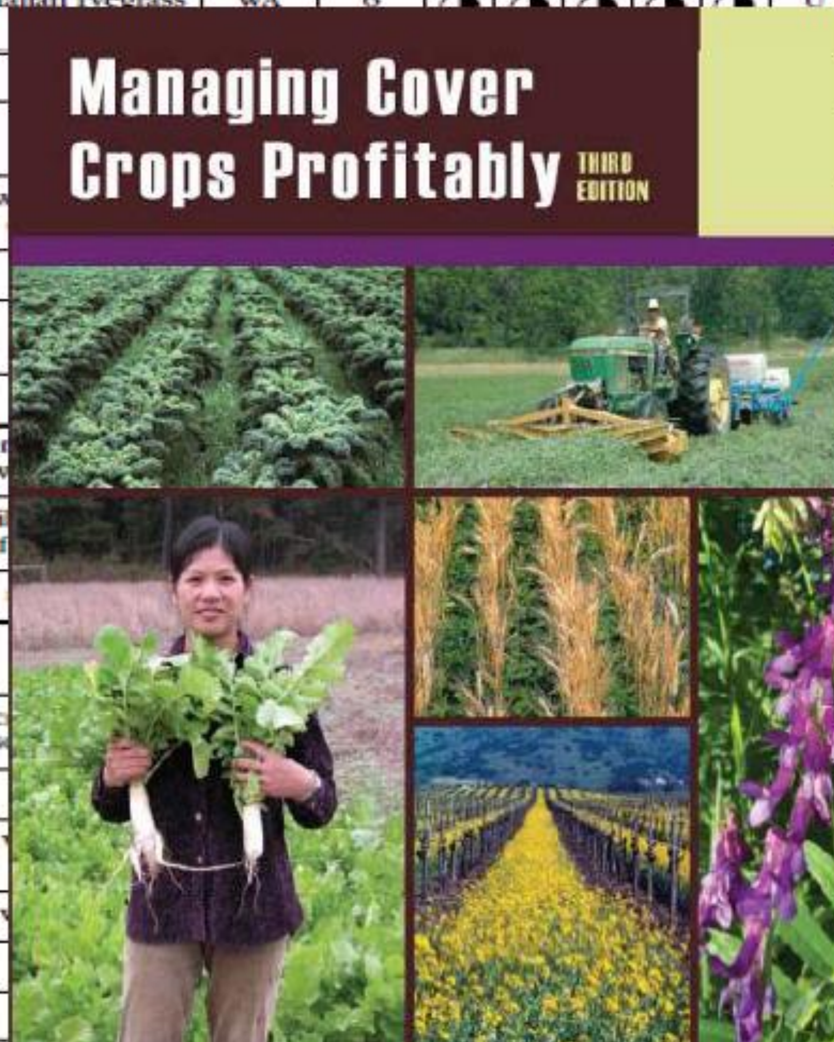
Sun Hemp, *Crotalaria juncea*

Sudax, hybrid of sorghum x sudan grass

Managing cover crops profitably, 3rd edition

Chart 3A CULTURAL TRAITS

Group	Species	Aliases	Type[1]	Hardy through Zone[2]	Tolerances	Habit[3]	pH (Pref.)	Best Established[4]	Min. Germin. Temp.
NONLEGUMES	Annual ryegrass p. 74	Italian ryegrass	WA	6		U	6.0–7.0	ESp, LSu, EF, F	40F
	Barley p. 77						6.0–8.5	F, W, Sp	38F
	Oats p. 93						4.5–7.5	LSu, ESp W in 8+	38F
	Rye p. 98						5.0–7.0	LSu, F	34F
	Wheat p. 111						6.0–7.5	LSu, F	38F
	Buckwheat p. 90						5.0–7.0	Sp to LSu	50F
	Sorghum-sudan. p. 106						6.0–7.0	LSp, ES	65F
BRASSICAS	Mustards p.81						5.5–7.5	Sp, LSu	40F
	Radish p. 81						6.0–7.5	Sp, LSu, EF	45F
	Rapeseed p. 81						5.5–8	F, Sp	41F
LEGUMES	Berseem clover p. 118						6.2–7.0	ESp, EF	42F
	Cowpeas p. 125						5.5–6.5	ESu	58F
	Crimson clover p. 130						5.5–7.0	LSu/ESu	
	Field peas p. 135						6.0–7.0	F, ESp	41F
	Hairy vetch p. 142						5.5–7.5	EF, ESp	60F
	Medics p. 152						6.0–7.0	EF, ESp, ES	45F
	Red clover p. 159						6.2–7.0	LSu; ESp	41F
	Subterranean cl. p. 164	subclover	CSA	7		P/SP	5.5–7.0	LSu, EF	38F



https://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition

Soil Quality

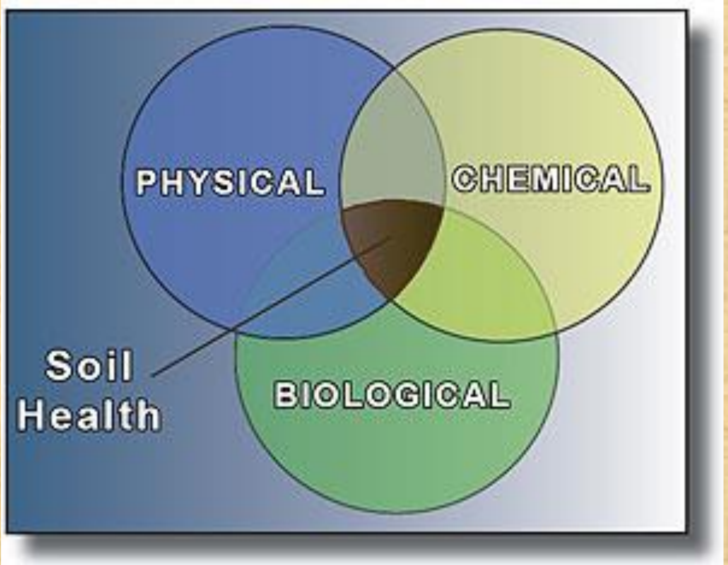
- Soil quality is the capacity of soils within landscapes to sustain biological productivity, maintain environmental quality, and promote plant and animal health.

Poor tilth Good tilth

http://soils.usda.gov/sqi/index.html

Soil Health Definition

- Definitions
  - Interactions between soil quality and plant/animal/human quality
  - Sustaining and ***improving soil quality over*** the long term



http://soilhealth.cals.cornell.edu/about/index.htm

Watch the short video “The Science of Soil Health Video Series Trailer” – see https://www.youtube.com/watch?v=IHOF6NfLm7M&list=PL4J8PxoprpGa3wFYSXFu-BW_mMatleIt0

Watch the short video “Soil health lesson in a minute: how healthy soil should look” – see https://www.youtube.com/watch?v=4NKGS4bj7cc

Alternative Soil Test ‘Tool’ Example

“The **Solvita® soil-life test kit** provides an important new tool for gardeners, farmers and scientists to evaluate soil microbial respiration rate in an efficient and cost-effective manner. Soil respiration is an important aspect of soil quality and a good indicator of soil fertility.”

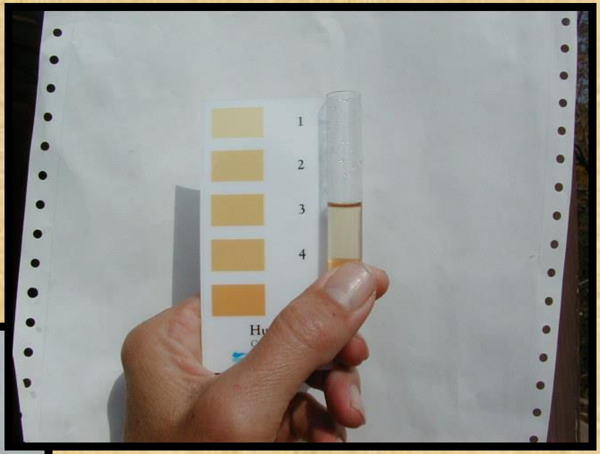
“The Solvita test enables you to:

- estimate annual nitrogen release based on soil biological activity
- evaluate organic matter sufficiency of soils
- make overall judgements to fit into "soil quality" interpretation

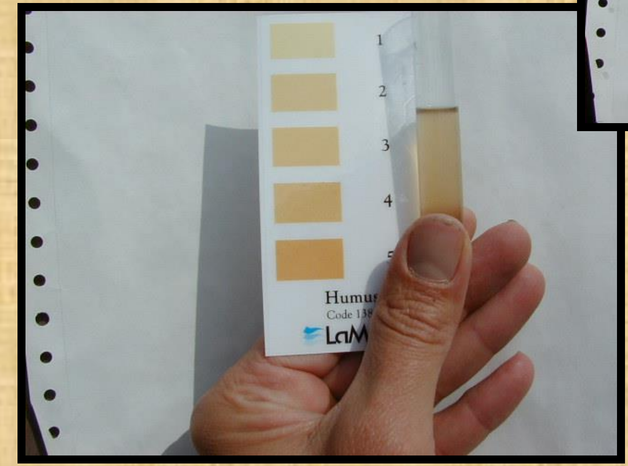
Watch the video “Solvita CO2-Burst Test for Soil Health“ – see http://www.bing.com/videos/search?q=youtube+solvita&view=detail&mid=FC15D03BA6FEFC2B711EFC15D03BA6FEFC2B711E&FORM=VIRE

Alternative Soil Test ‘Tool’ Example

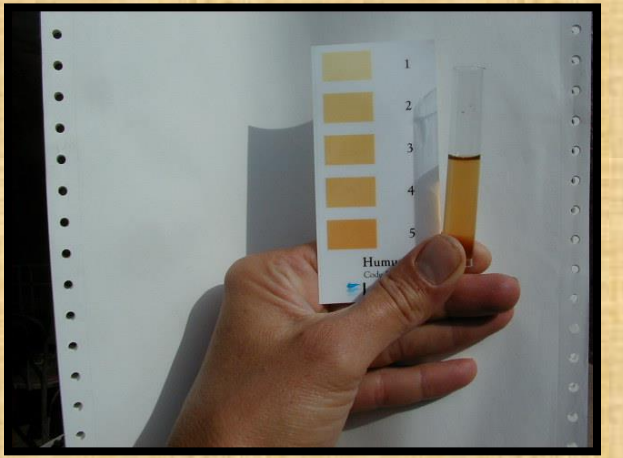
Humus Testing using LaMotte humus index test



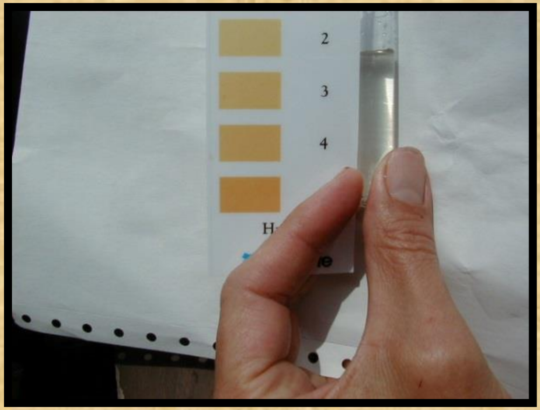
Newer garden soil with mulch = 1.0



Improved garden soil = 3.0



Fresh worm compost = 5



Near-by Ag field (with subsoil) = 0

Alternative Soil Test ‘Tool’ Example: “Soil Foodweb” (a.k.a., Biodiversity)

Soil Foodweb Analysis

Report prepared for:

-
David Drell
6150 Hearst Rd
Willits, CA 95490-9211 USA
(707) 459-4110
wece@sbcglobal.net

Report Sent: 12/02/2005
Sample#: 01-101703
Unique ID: 05 Brookside schoolyard
Plant: variety
Invoice Number: 0
Sample Received: 11/23/2005

For interpretation of this report please contact:
Local Advisor: or regional lab
Soil Foodweb, Inc
info@soilfoodweb.com
(541) 752-5066
Consulting fees may apply

Organism Biomass Data		Dry Weight	Active Bacterial (µg/g)	Total Bacterial (µg/g)	Active Fungal (µg/g)	Total Fungal (µg/g)	Hyphal Diameter (µm)
Results		0.820	65.7	674	64.1	378	3
Comments		In Good Range	Excellent	Excellent	Excellent	Excellent	
Expected Range	Low	0.45	1	175	1	175	
	High	0.85	5	300	5	300	

		Protozoa Numbers/g			Total Nematodes #/g	Percent Mycorrhizal Colonization	
		Flagellates	Amoebae	Ciliates		ENDO	ECTO
Results		5610	**1688**	70	**7.38**	**5%**	**0%**
Comments		High	Low	Good	Low	Low	Low
Expected Range	Low	5000	5000	50	10	40%	40%
	High			100	20	80%	80%

Organism Biomass Ratios		Total Fungal to Total Bacterial	Active to Total Fungal	Active to Total Bacterial	Active Fungal to Active Bacterial	Plant Available N Supply
Results		**0.56**	0.17	**0.10**	0.98	50-75
Comments		Low	Good	Low	Good	
Expected Range	Low	0.8	0.15	0.15	0.75	
	High	1.5	0.2	0.2	1.5	

Nematodes per Gram of Soil
Identification to genus

Bacterial Feeders		
Cephalobus		0.34
Fungal Feeders		
Chrysonemoides		0.17
Epidorylaimus		0.17
Fungal/Root Feeders		
Aphelenchoides	Foliar nematode	0.17
Aphelenchus		0.67
Ditylenchus	Stem & Bulb nematode	4.04
Filenchus		0.17
Root Feeders		
Pratylenchus	Lesion nematode	0.34

728 SW Wake Robin Avenue Corvallis, OR 97333-1612 USA
(541) 752-5066 | info@soilfoodweb.com
www.soilfoodweb.com

01-101703: Page 1 of 2

CORNELL SOIL HEALTH TEST REPORT

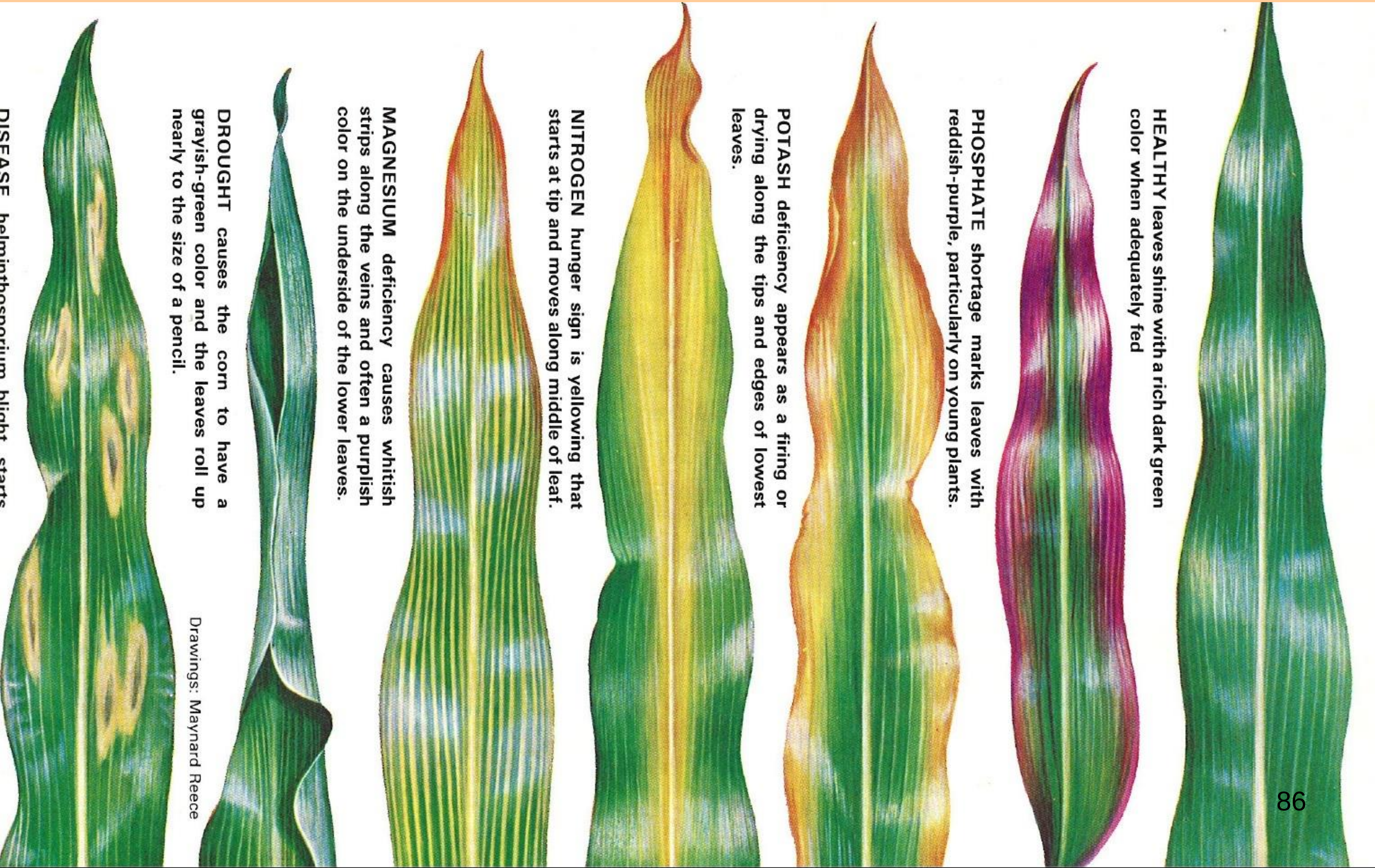
FARM NAME/FARMER: GATES FARM	SAMPLE ID: D901	DATE:
ADDRESS:	E-MAIL:	PHONE:
FIELD/TREAMENT: PLOW TILL NO COVER CROP	AGENT:	SLOPE:
TILLAGE: / /	DRAINAGE:	SOIL SERIES:
CROPS: / /	SOIL TEXTURE: SILTY	

	INDICATORS	VALUE	RATING	CONSTRAINT	PERCENTILE RATING*
PHYSICAL	Aggregate Stability (%)	17.0	1.0	aeration, infiltration, rooting	
PHYSICAL	Available Water Capacity (m/m)	0.18	2.0	water retention	
PHYSICAL	Surface Hardness (psi)	147	7.0		
PHYSICAL	Subsurface Hardness (psi)	266	6.0		
BIOLOGICAL	Organic Matter (%)	2.4	1.0	energy storage, C sequestration, water retention	
BIOLOGICAL	Active Carbon (ppm)	557	2.0	soil biological activity	
BIOLOGICAL	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	4.0	1.0	N supply capacity, N leaching potential	
BIOLOGICAL	Root Health Rating (1-9)	5.5625	5.0		
CHEMICAL	pH (see CNAL Report)	7.2	10.0		
CHEMICAL	Extractable Phosphorus (see CNAL Report)	9.85	10.0		
CHEMICAL	Extractable Potassium (see CNAL Report)	52.375	7.5		
CHEMICAL	Minor Elements (see CNAL Report)		10.0		50th Percentile →BETTER
	OVERALL QUALITY SCORE (OUT OF 100)		LOW		52.1

Ratings on this report are based on generalized crop production standards for New York. For crop specific nutrient

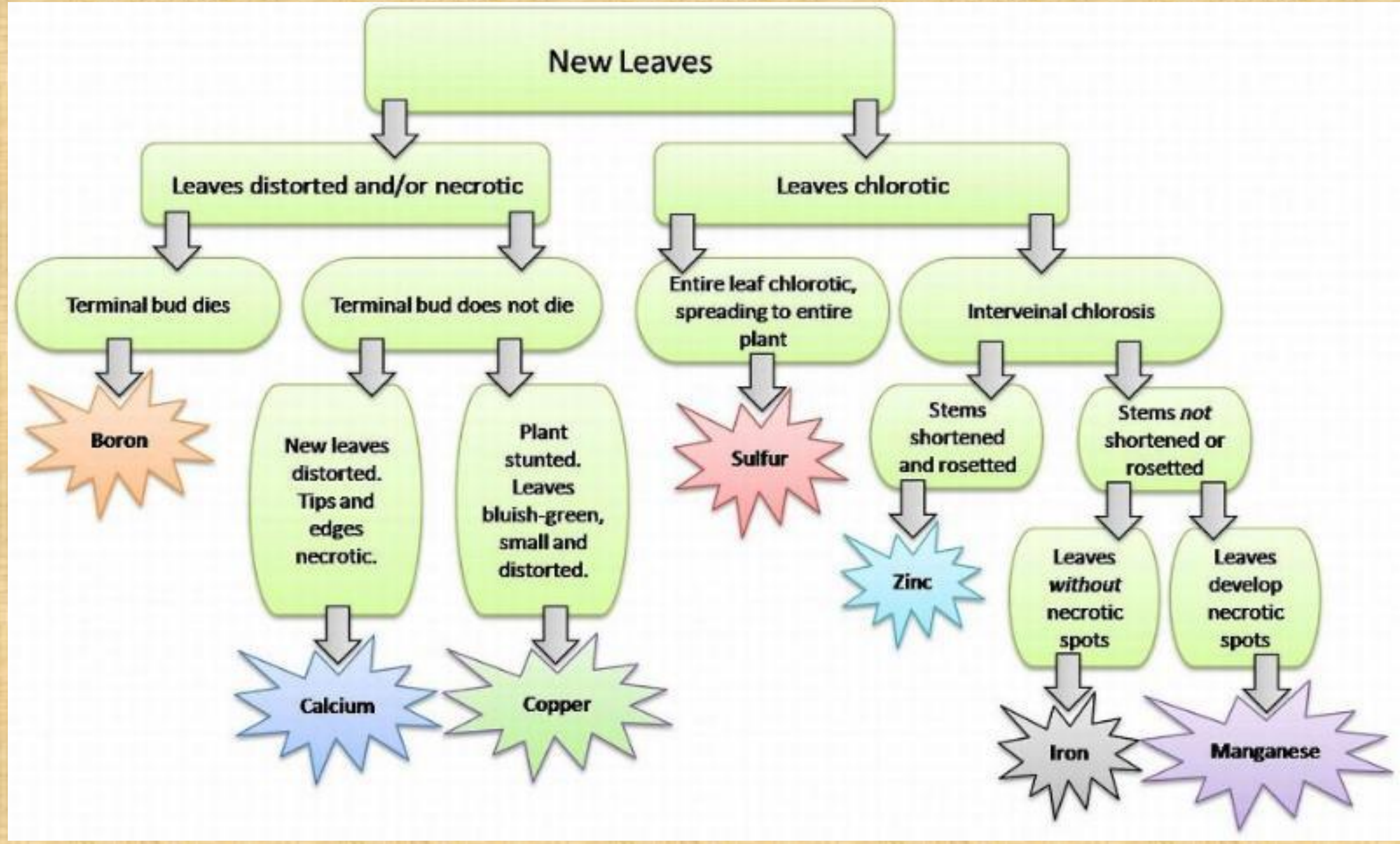
Alter-native Soil Test "Tool' Example "Soil Health"

Plant Nutrition Deficiency Visual Diagnosis ‘Tool’: Corn Example



NUTDEF Plant Nutrient Deficiency Database

Visual Diagnosis "Tool"



http://hort.ufl.edu/database/nutdef/index.shtml

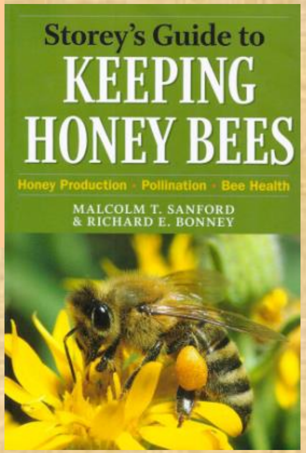
Agroecosystem Level 'Tools'

FARMSCAPING

- **"Farmscaping" is a whole-farm approach for <u>insect pest management & pollinator conservation.</u>**
- **It can be defined as the use of hedgerows, insectary plants, cover crops, and water reservoirs to attract and support populations of beneficial organisms such as insects, bats, and birds of prey.**

http://extension.oregonstate.edu/sorec/sites/default/files/farmscaping.pdf

Pollinator “Tools”



- Urban beekeeping uses vacant lot resources, thus increasing urban crop yields and providing local fresh honey too.

Watch a short video - https://www.pbs.org/newshour/show/urban-beekeeping-rising-trend-major-cities

https://dug.org/app/uploads/2016/08/16-Beekeeping-Policy-copy.pdf

- About 130 food crops are pollinated by bees
- Providing habitat for native bees also increases urban populations of pollinators

https://xerces.org/2017/12/26/addressing-conservation-in-urban-areas/

- UF/IFAS Bee College Education Resource

http://entnemdept.ufl.edu/honeybee/


Whew!
Let's take a break!
10 minutes