Life in the Soils Workshop- December 2019

The Universe Beneath our Feet.

Special Thanks to…

Based on work of Dr. Elaine Ingham

SOILFOODWEB

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St. Olaf College, Double Major in Biology and Chemistry
Master's, Texas A&M, Marine Microbiology

Ph.D., Colorado State University, Soil Microbiology
Research Fellow, University of Georgia

Assistant, Associate Professor, Oregon State University (1986 – 2001)

Rodale Institute, Chief Scientist 2011 - 2013

President, Soil Foodweb Inc., 1996 – present
Labs in many places around the world

CUSTOM FOODSCAPING

HAVE YOUR LANDSCAPE AND EAT IT TOO

Meet the Teacher

Who am I?

OM

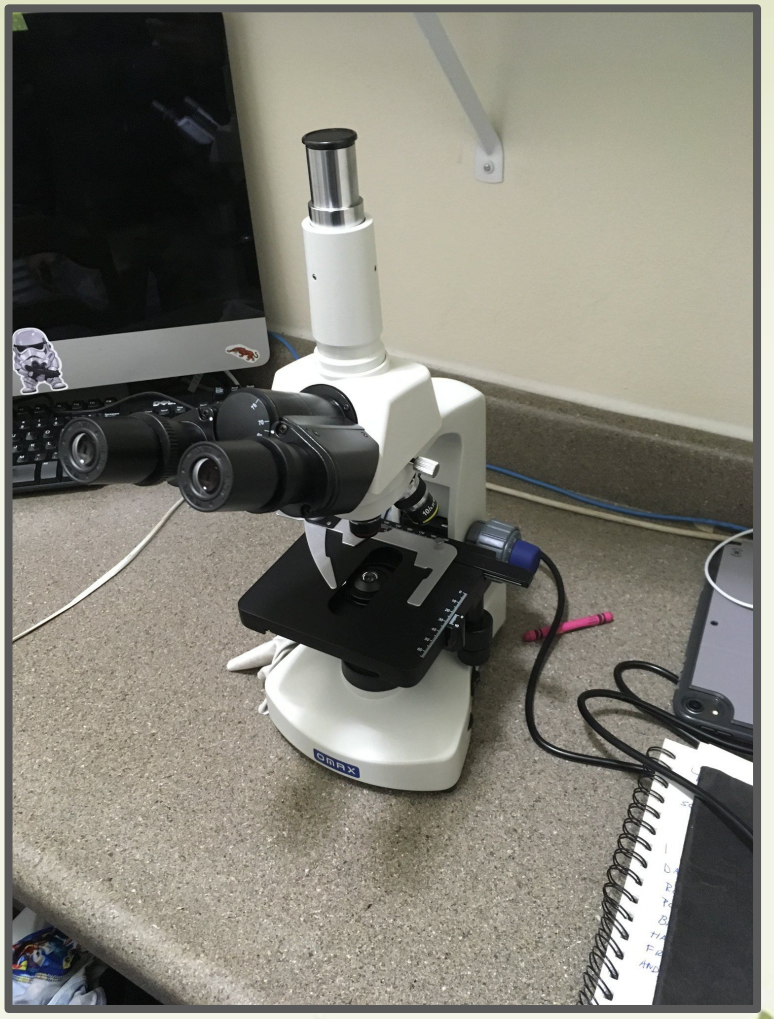
OZARK MOUNTAIN PERMACULTURE

What We'll Discuss

- The Soil Food Web
  - Characters
  - Functions
  - Negative impacts on Organisms
- Thermal Compost
  - Materials and Methods
- Vermicomposting

What We'll Discuss

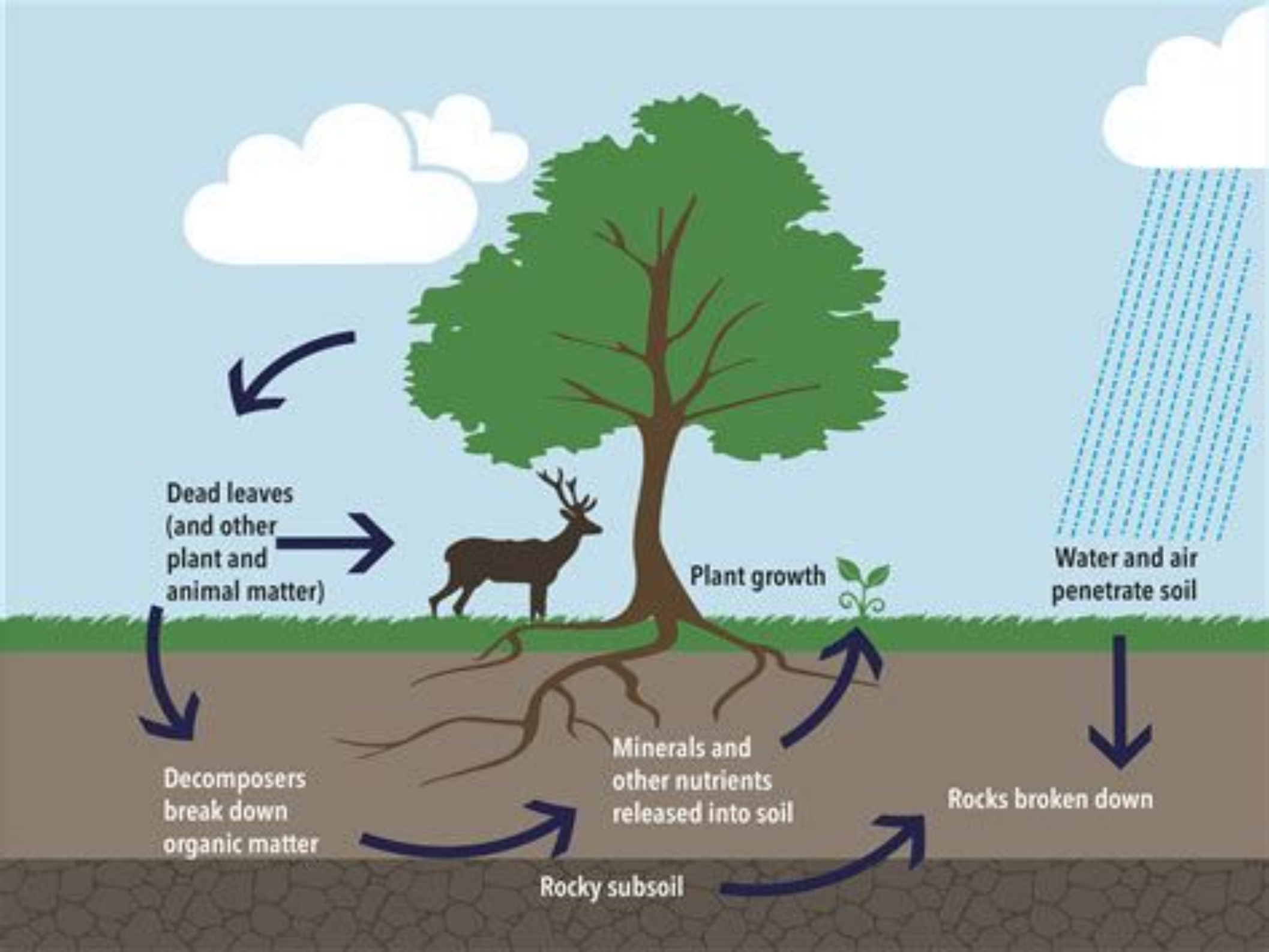
- Compost Tea
  - Benefits
  - how-to
- Keeping Life if the Soil
- Using a Microscope for the Garden and Farm.



Where do plants in the wild get their nutrients?

What is the Soil Food Web?

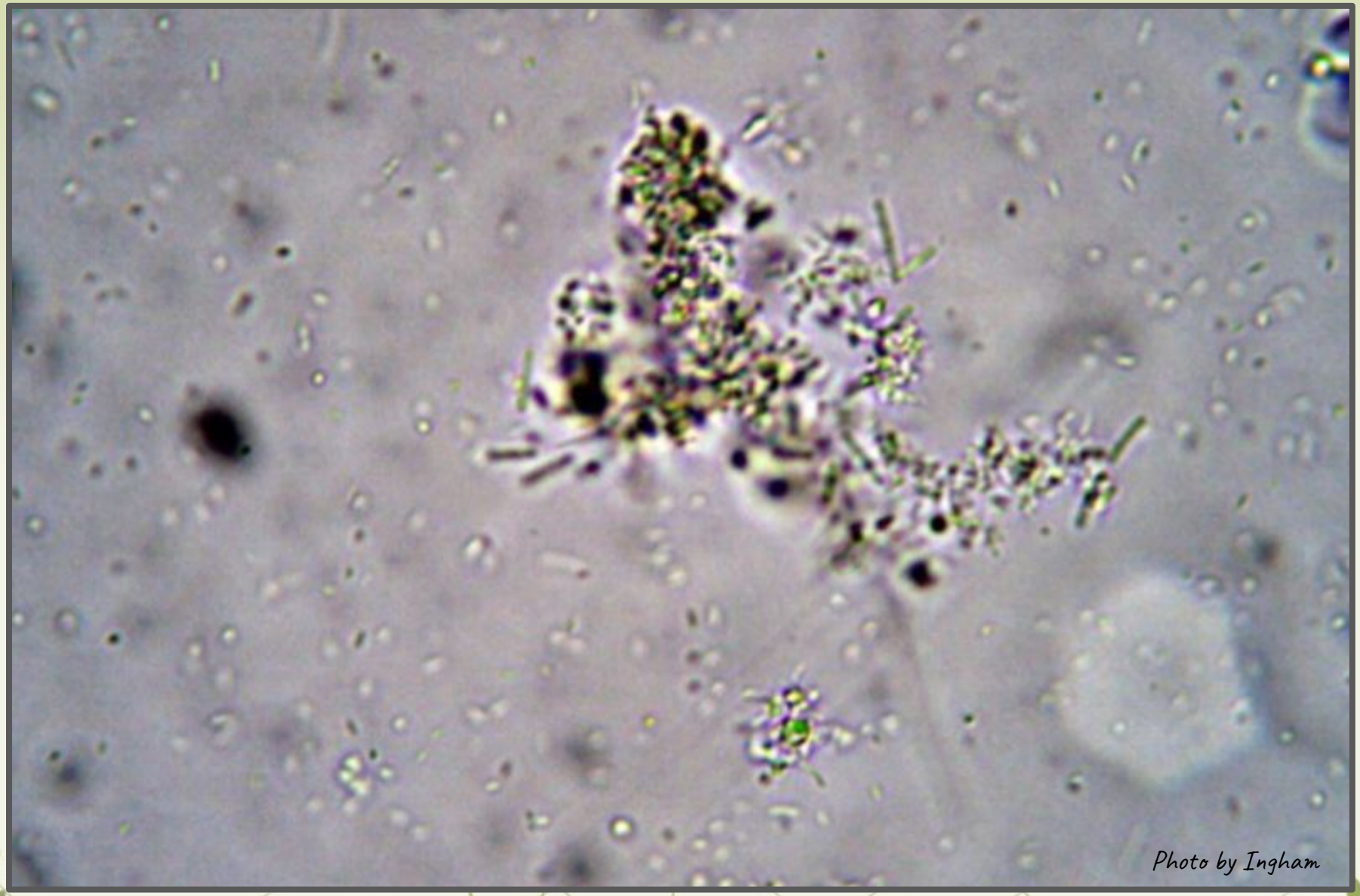
Why is it important?


Dead leaves (and other plant and animal matter)
Plant growth
Water and air penetrate soil
Decomposers break down organic matter
Minerals and other nutrients released into soil
Rocks broken down
Rocky subsoil

The Soil Food Web

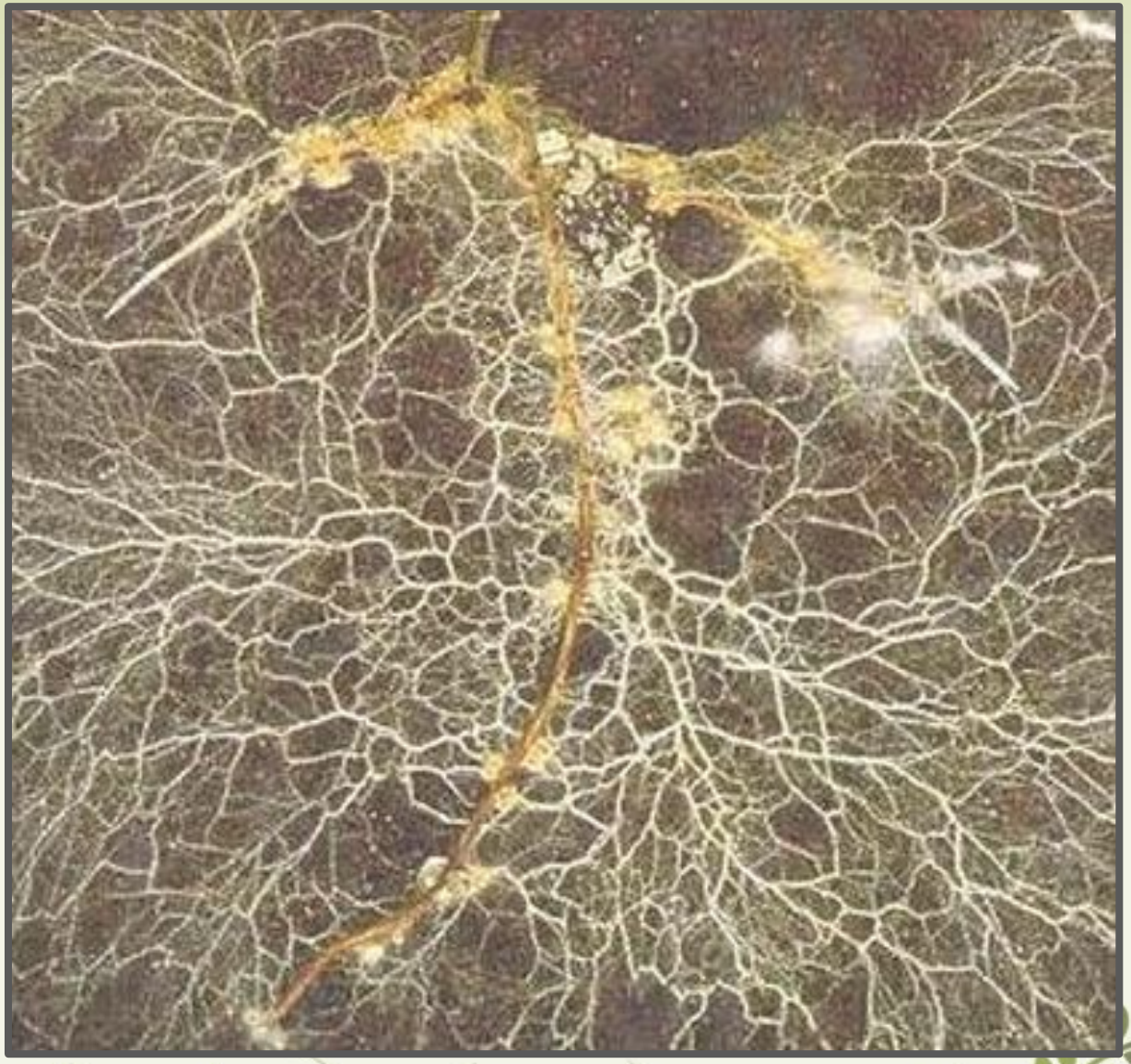
First trophic level:	Second trophic level:	Third trophic level:	Fourth trophic level:	Fifth & higher trophic level:
Photosynthesizers	Decomposing Mutualists Pathogens, Parasites Root-feeders	Shredders Predators Grazers	Higher level predators	Higher level predators

Bacteria



Mycorrhizal Fungi

- *Symbiotic association of the mycelium of a fungus with the roots of a seed plant*



Saprophytic Fungi

- *A fungus that grows on and derives its nourishment from dead or decaying organic matter*

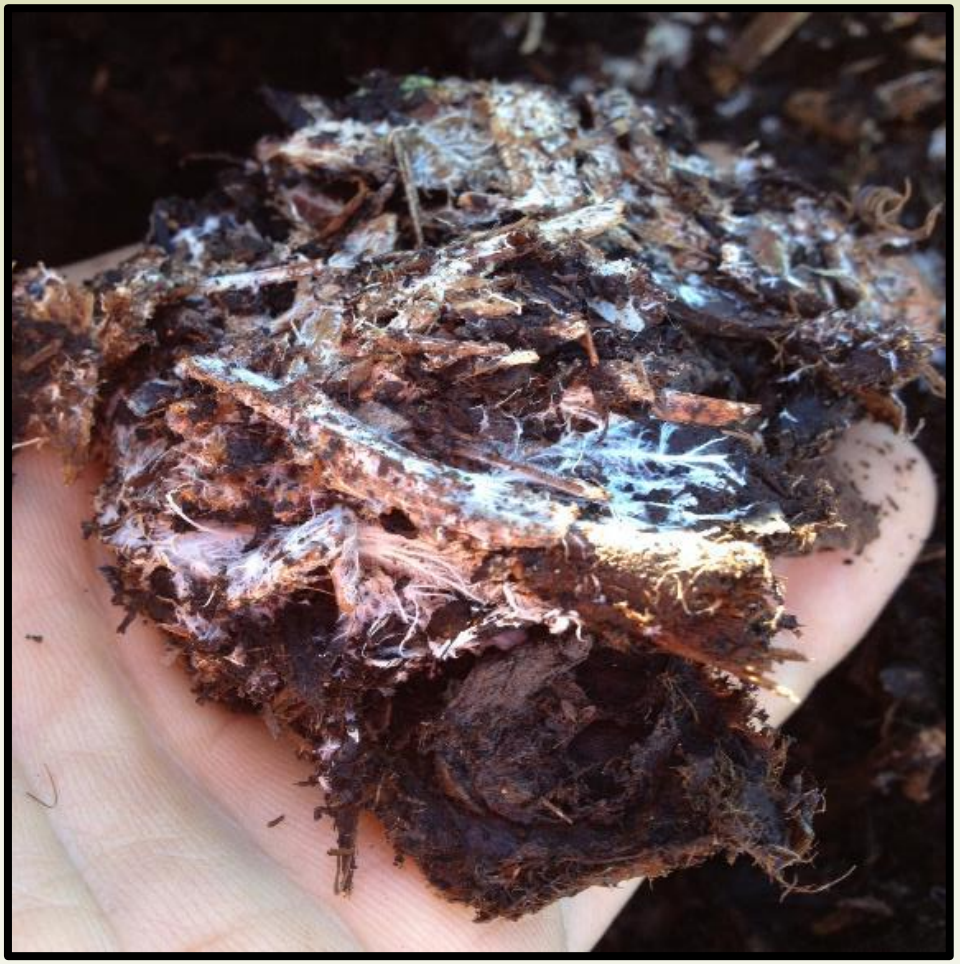


Photo by Troy Hinke

Photo by Troy Hinke

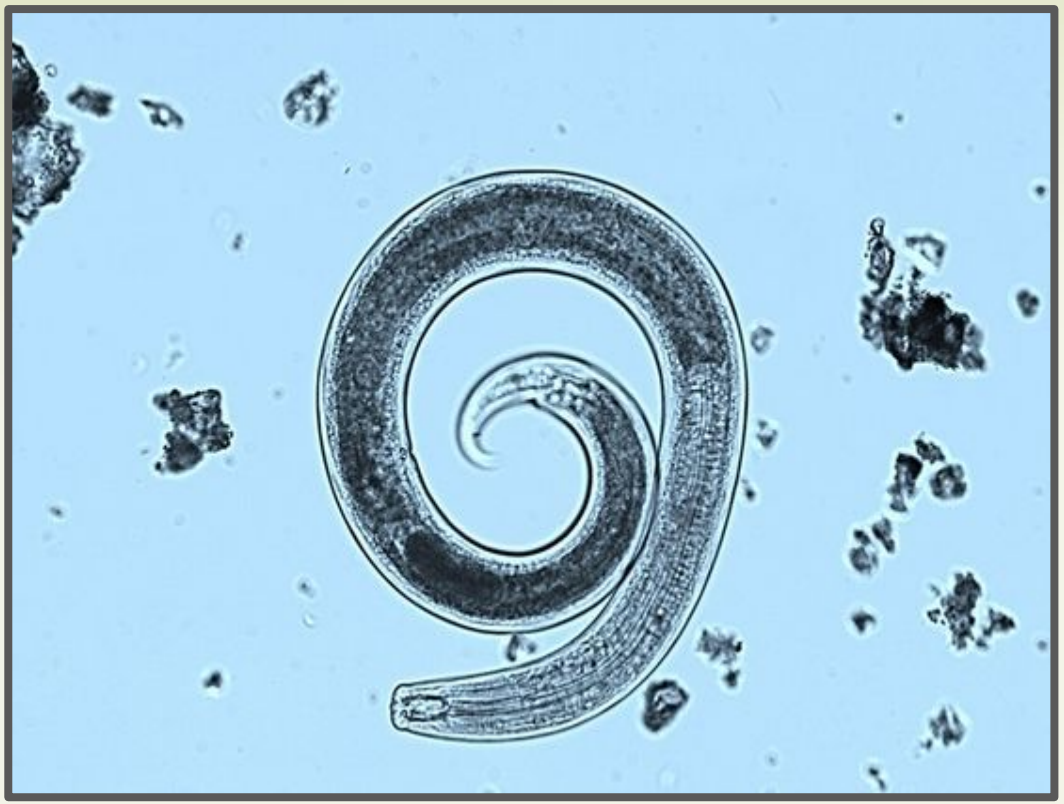
Protozoa

- *Single celled organisms that feed primarily on bacteria and sometimes fungi*

- **Amoeba/amoebae**
- **Flagellates**
- **Ciliates**

Nematodes

- **Bacterial-feeding nematodes**
- **Fungal-feeding nematodes**
- **Predatory nematodes**
- **Root-feeders**

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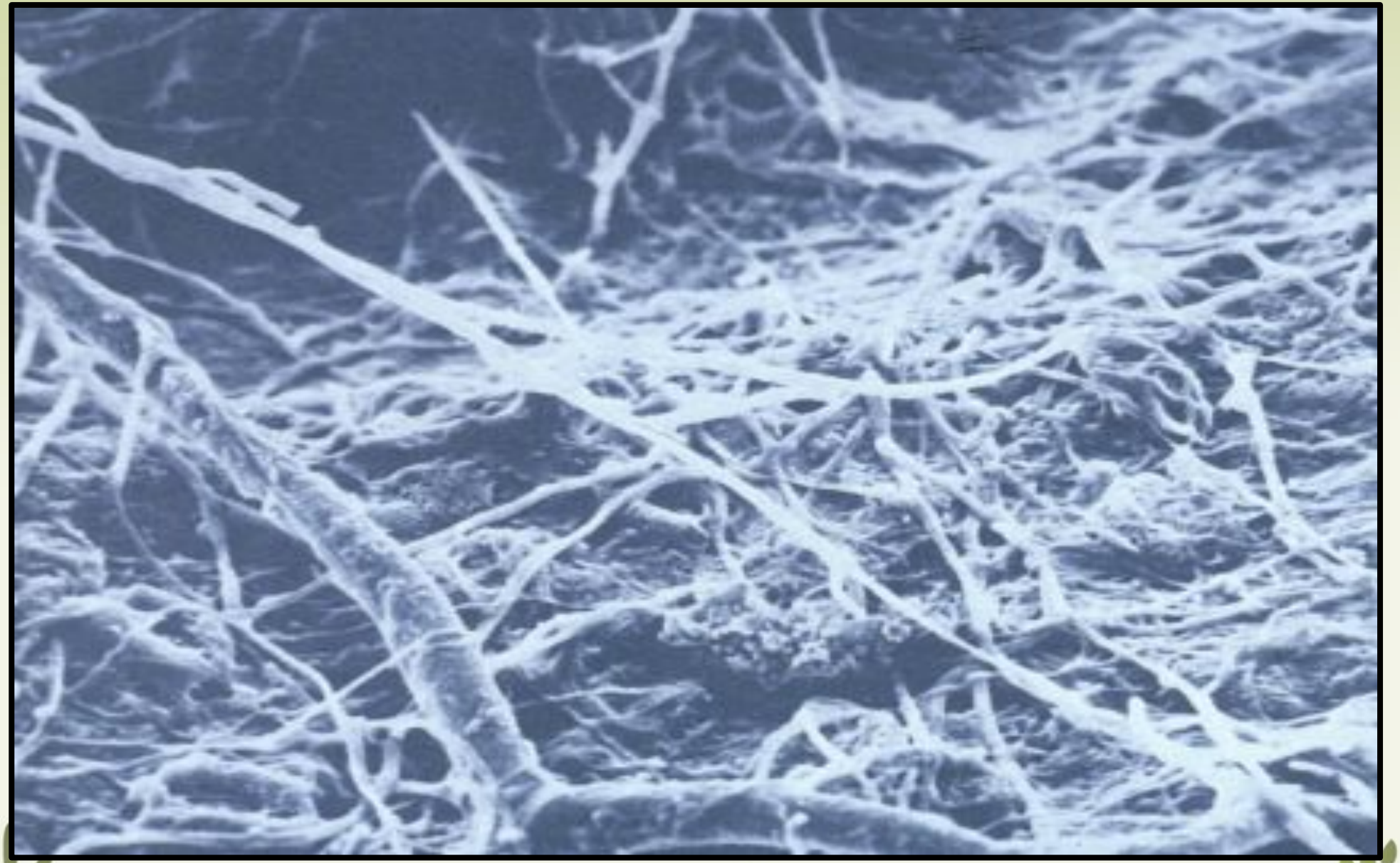
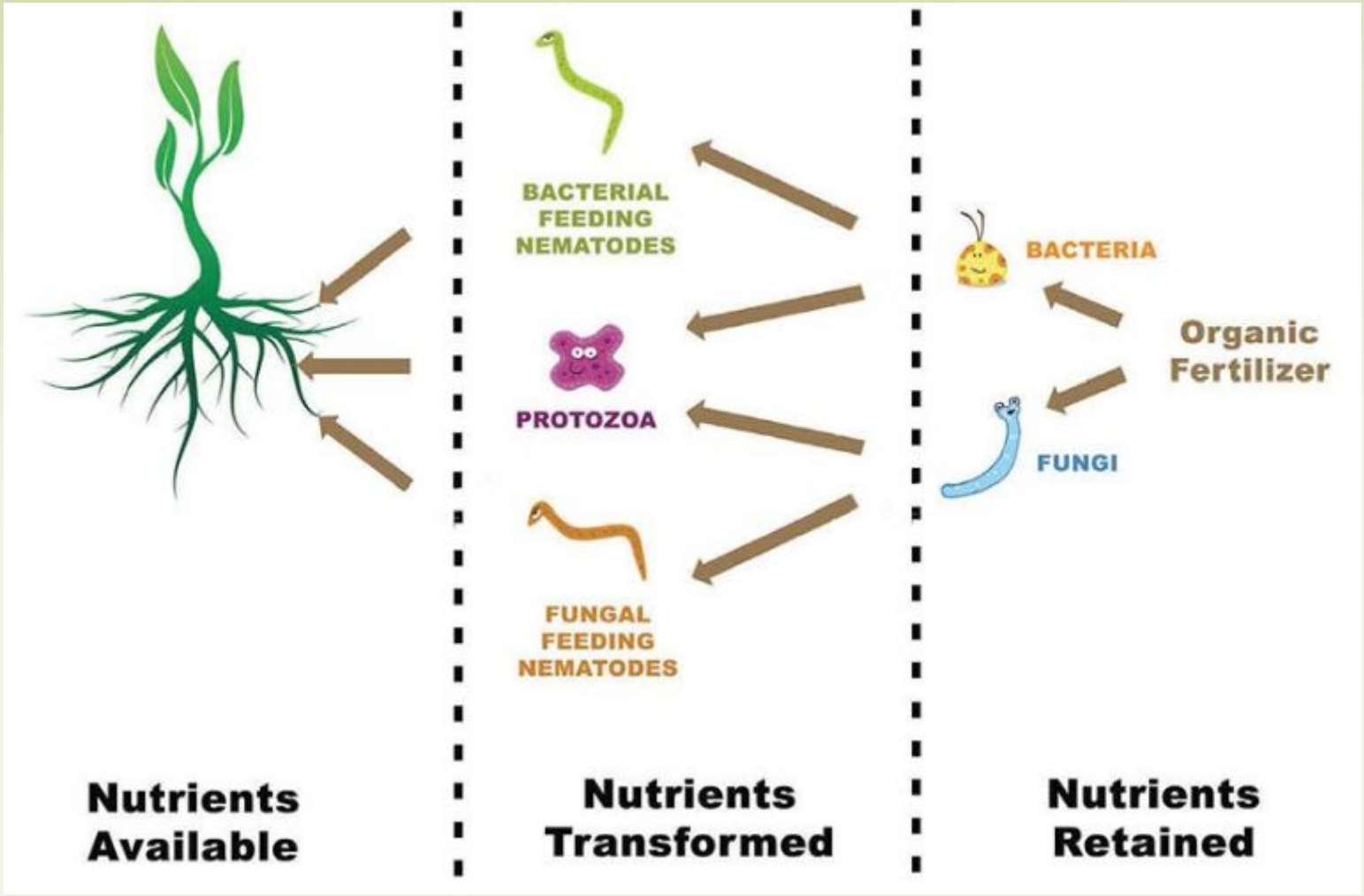


How do these microbes work with plants?

Photo by Ingham


BACTERIAL FEEDING NEMATODES
PROTOZOA
FUNGAL FEEDING NEMATODES
BACTERIA
FUNGI
Organic Fertilizer
Nutrients Available
Nutrients Transformed
Nutrients Retained

Mycorrhizal Fungi
-- around roots & soil

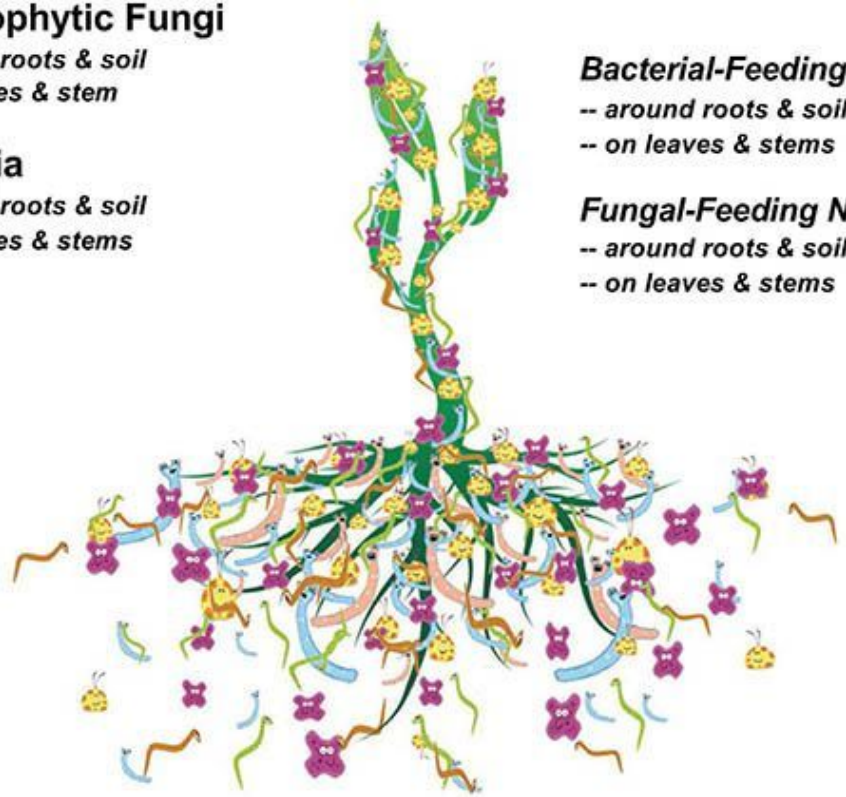
Saphrophytic Fungi
-- around roots & soil
-- on leaves & stem

Bacteria
-- around roots & soil
-- on leaves & stems

Protozoa
-- around roots & soil
-- on leaves & stems

Bacterial-Feeding Nematodes
-- around roots & soil
-- on leaves & stems

Fungal-Feeding Nematodes
-- around roots & soil
-- on leaves & stems




Mycorrhizal Fungi


Saprophytic Fungi

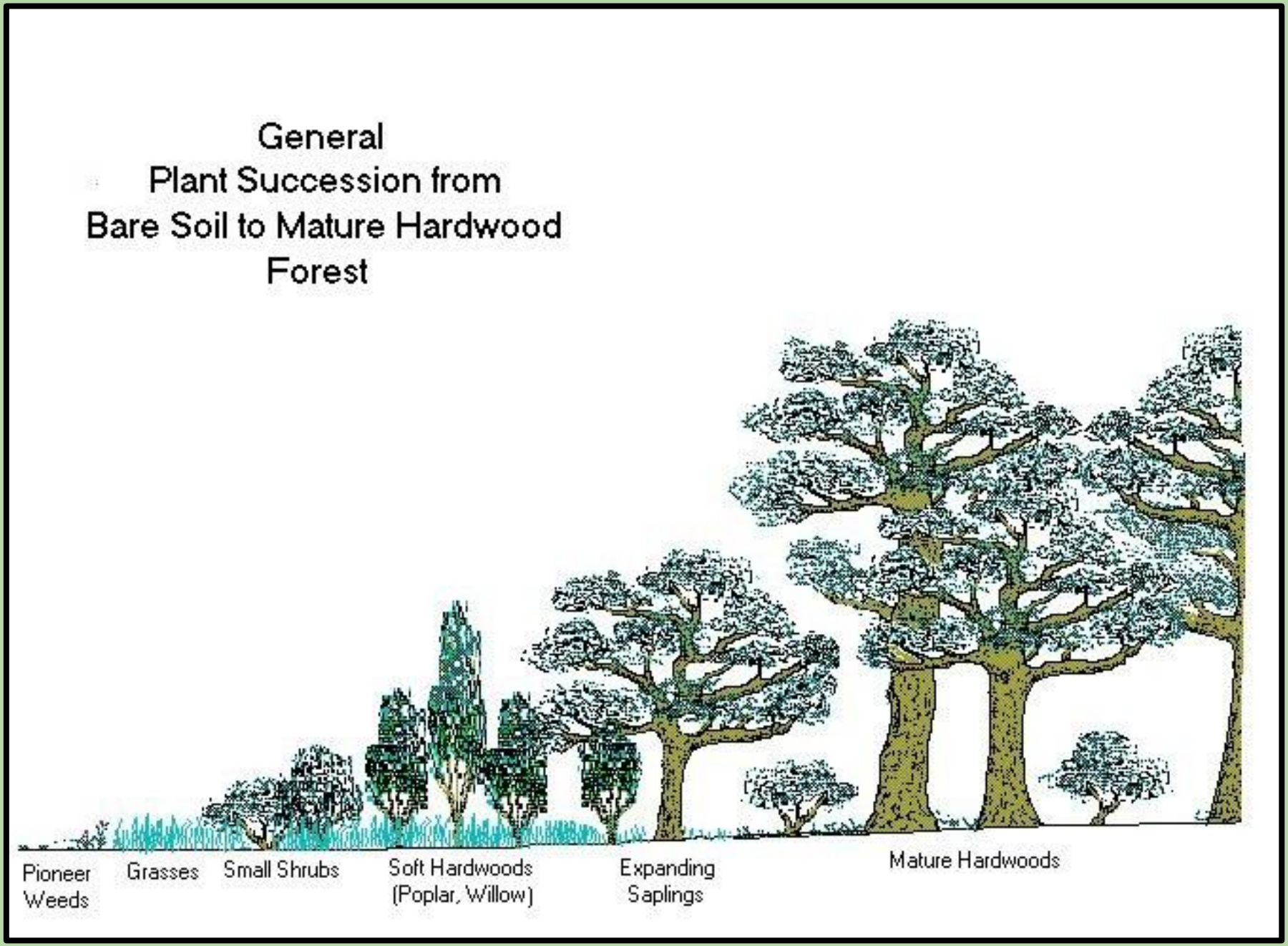

Bacteria


Protozoa


Bacterial Feeding Nematode


Fungal Feeding Nematode

Succession


General
Plant Succession from
Bare Soil to Mature Hardwood
Forest
Pioneer
Weeds
Grasses
Small Shrubs
Soft Hardwoods
(Poplar, Willow)
Expanding
Saplings
Mature Hardwoods

Soil biological succession causes plant succession

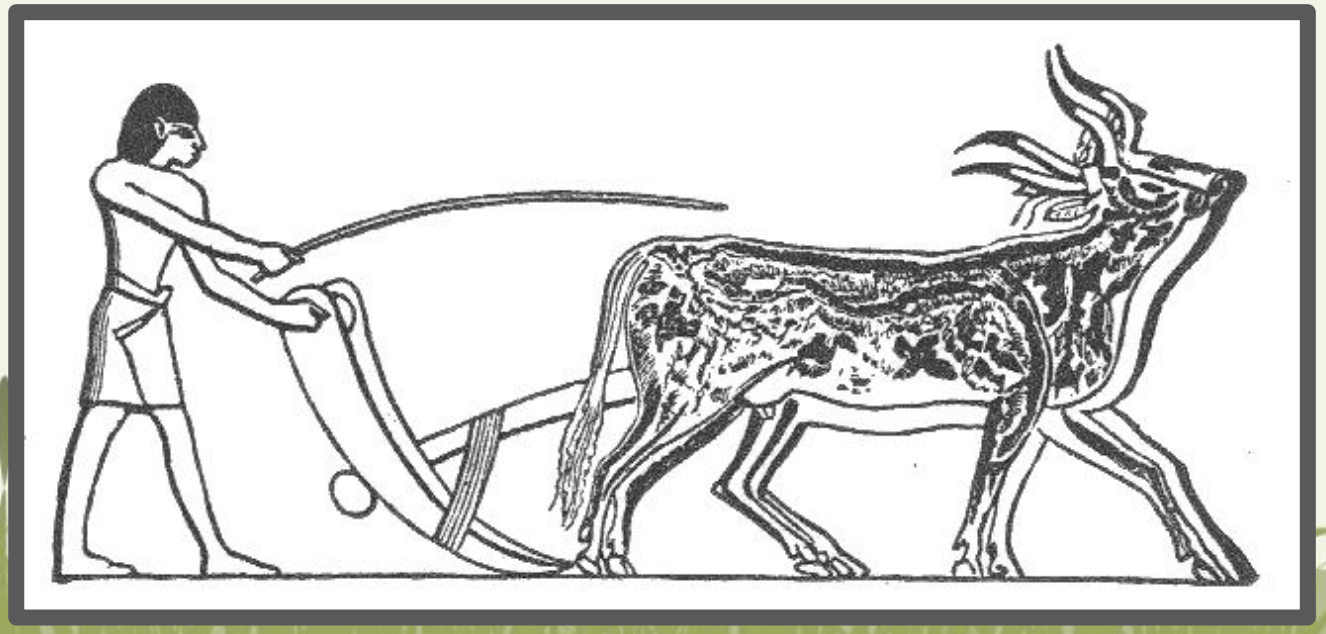
Bacteria …A few Fungi……Balanced ……..More Fungi…… Fungi

Bacteria:	**10 µg**	**100 µg**	**500**	**600 µg**	**500 µg**	**700 µg**
Fungi:	**0 µg**	**10 µg**	**250**	**600 µg**	**800 µg**	**7000 µg**

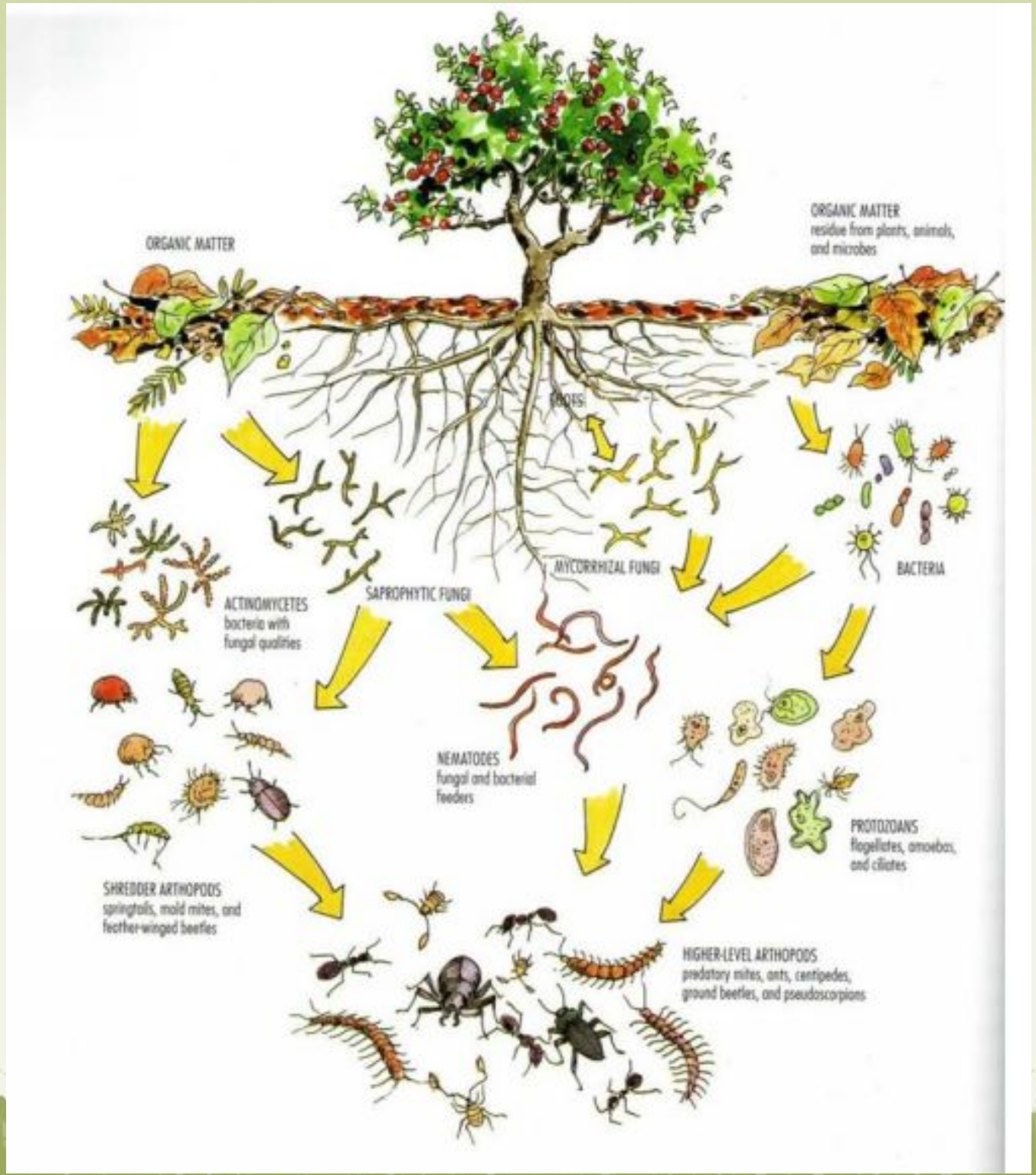
Photo by Ingham

Common Causes of Negative Impacts

- **Plowing and Tilling**
- **Chemical Use**
- **Compaction**
- **Bare Soil**



Peter M. Wild, Boston Tree Preservation


ORGANIC MATTER
ORGANIC MATTER
residue from plants, animals, and microbes
ROOTS
BACTERIA
MYCORRHIZAL FUNGI
SAPROPHYTIC FUNGI
ACTINOMYCETES
bacteria with fungal qualities
NEMATODES
fungal and bacterial feeders
PROTOZOANS
flagellates, amoebas, and ciliates
SHREDDER ARTHOPODS
springtails, mold mites, and feather-winged beetles
HIGHER-LEVEL ARTHOPODS
predatory mites, ants, centipedes, ground beetles, and pseudoscorpions

Getting Life Back in Your Soil

Compost

Actively Aerated Compost Tea

Methods of Composting

Thermophilic Compost

- Hot composting >131°F (stainless steel thermometer)

Static Compost

- Slow composting- most common for home gardeners

Vermicompost (worms!)

- Great way to turn household food and paper waste into garden fertility
- Red wiggler worms, aka manure worms (Eisenia foetida)

Starting materials for all good compost

Brown materials 50%--more for fungal compost

-Examples: Wood chips, straw, sawdust, sticks, stalks, fallen leaves, paper/cardboard

Green materials 50%--more for bacterial compost

-Examples: Mowed grass, kitchen scraps, hay, any plant matter pulled green

High Nitrogen (if thermophilic) 10-20% of pile

-Examples: animal manure, leguminous plants, alfalfa

AVOID INDUSTRIAL MANURE


Photo by Troy Hinke

Vermicomposting

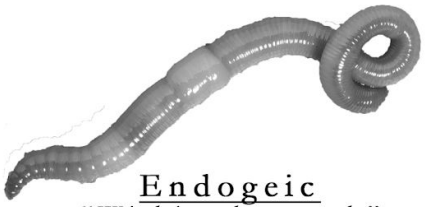
Earthworm Types

Intestines of the Earth

Anecic

"Out of the earth"

-Capable of burrowing up to 6 feet below the surface
-Build permanent burrows in mineral layers of the soil
-Drag organic material from the surface into the burrow for food
-Examples: Nightcrawlers, bait worms, dew worms



Endogeic

"Within the earth"

-Build non-permanent burrows in the upper mineral layer of soil
-Feed on organic material
-Live in the soil but are usually not noticed until after a heavy rain when they come to the surface

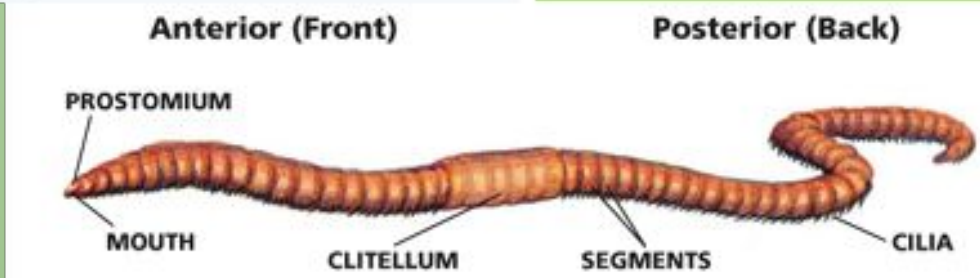
Epigeic

""Upon the earth"

-Live on the soil surface
-Form no permanent burrows
-Feed on decaying organic matter
-Examples: Red worm, manure worm, brandling worm, red wiggler and compost worm

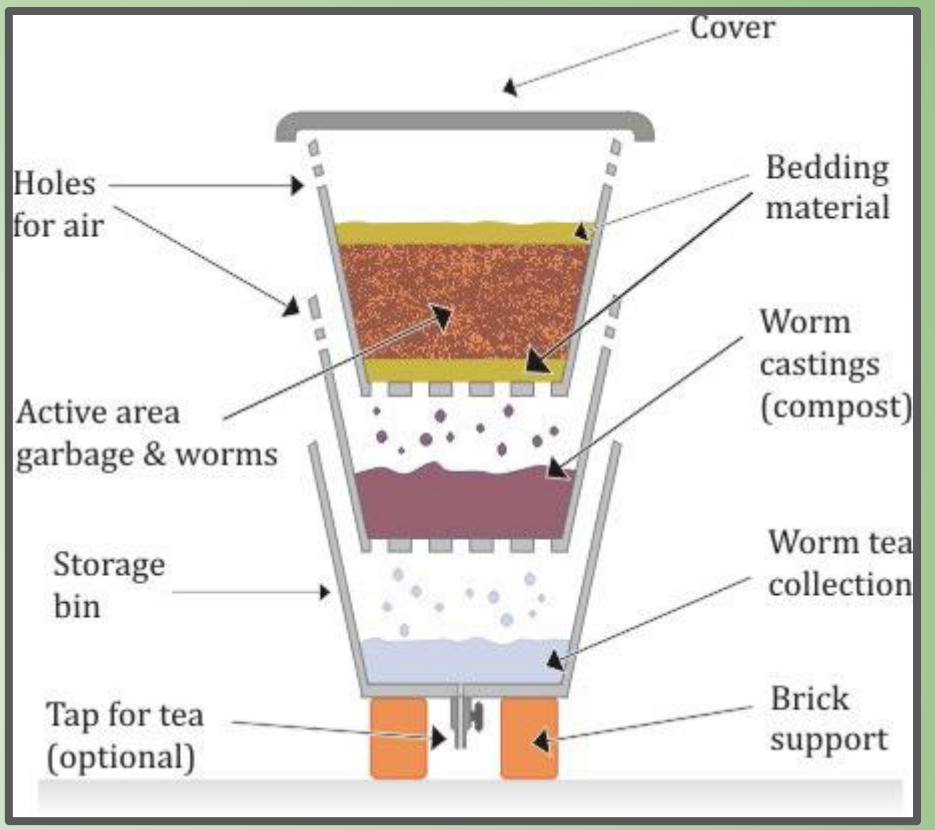
red wiggler worms

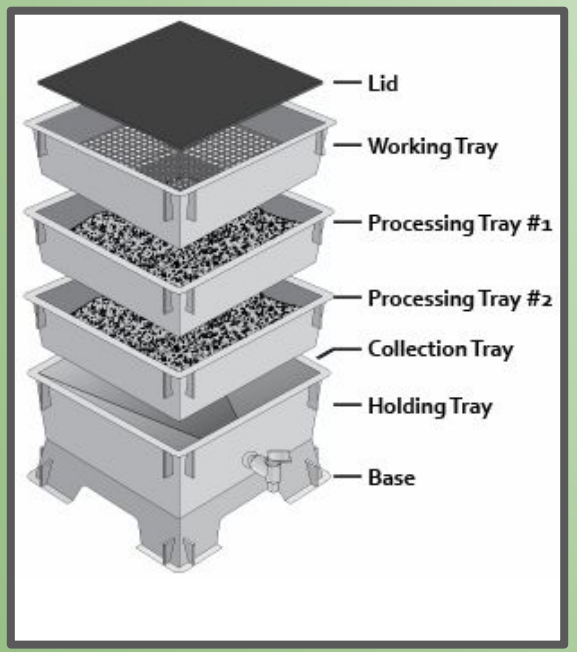
(Eisenia foetida)

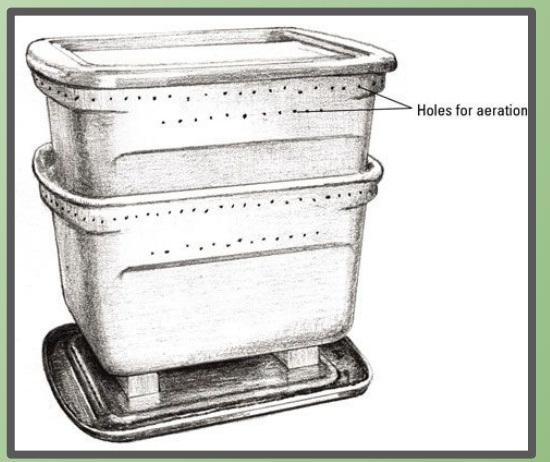


Worm Bins


Urban Worm Bag


Cover
Holes for air
Bedding material
Worm castings (compost)
Active area garbage & worms
Storage bin
Worm tea collection
Tap for tea (optional)
Brick support


Lid
Working Tray
Processing Tray #1
Processing Tray #2
Collection Tray
Holding Tray
Base


Holes for aeration

Commerical Worm Bins

Temperature, Location, Moisture, & Oxygen!!!

Kitchen corner

Outside back door

Patio

Basement

Garage

Laundry room

Moisture in the 80-90% range is probably too high.

The pros have vermicomposts in the 50-60% range.

URBAN WORM COMPANY

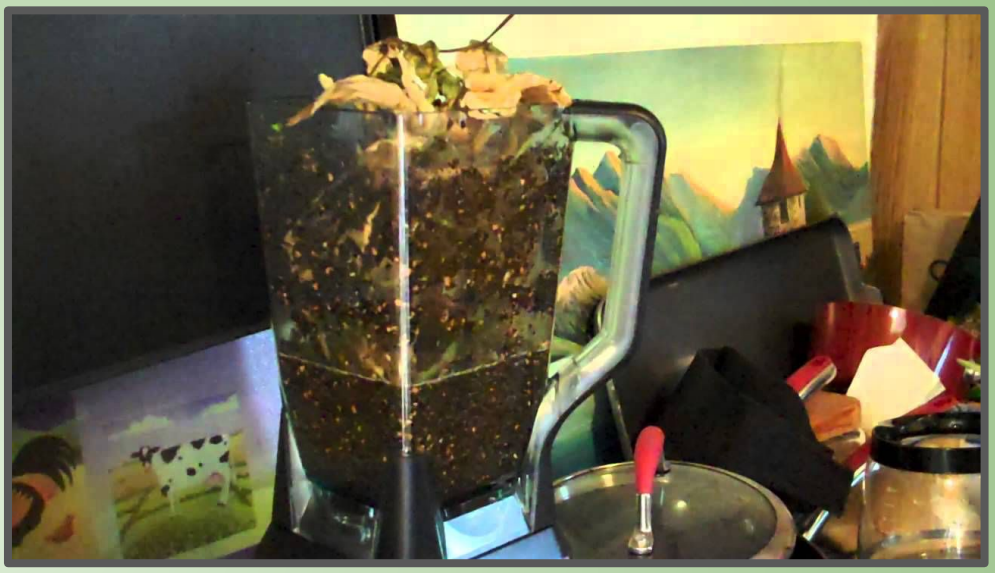
Bedding Material

- Shredded brown cardboard
- Shredded paper (not bleached white office paper)
- Shredded newspaper (not colored)
- Aged compost
- Aged horse or cow manure
- Coco coir
- Peat moss
- Straw and hay
- Fall leaves and other yard waste
- Wood chips

Worms

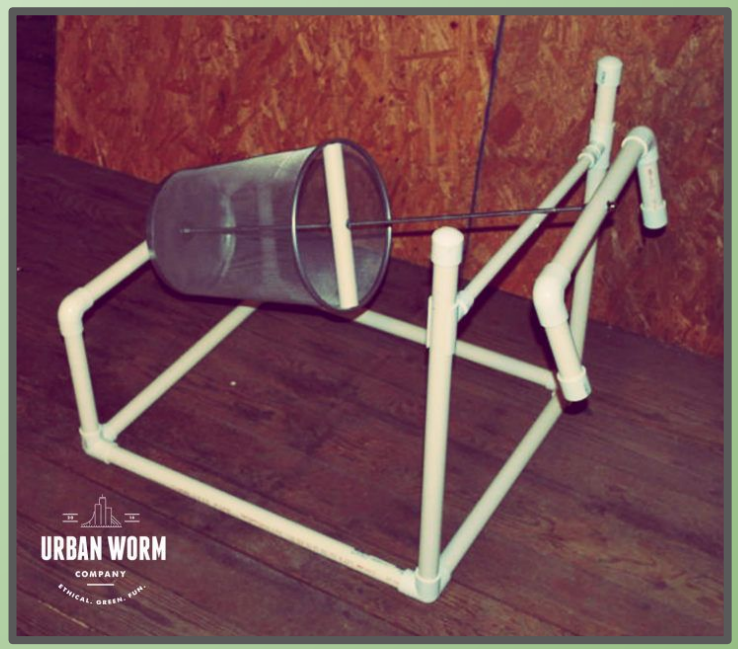
MIDWEST worms

Feeding Your Worms



Harvesting

"Freestyle" harvesting is a great way to spend some time investigating your worm population up close. Be on the lookout for little yellow/gold egg casings!

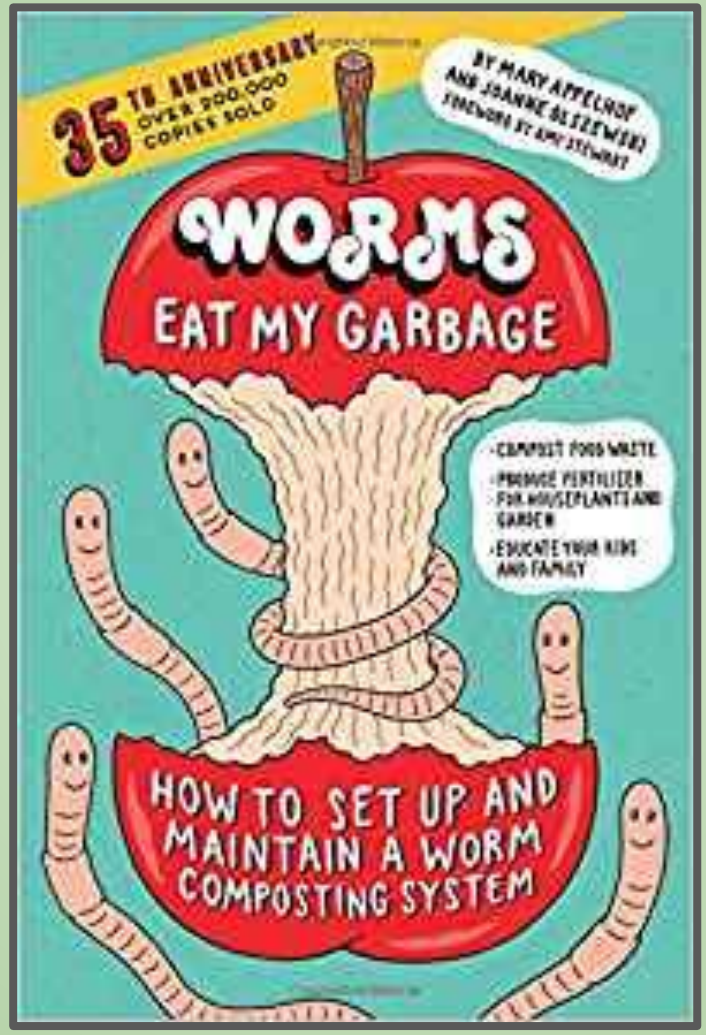


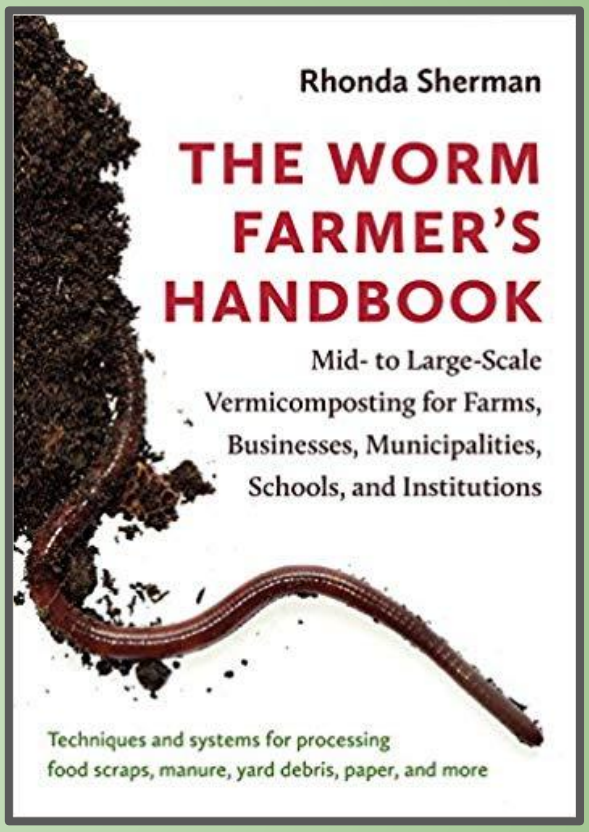
Worm Bin Troubleshooting		
Problems	**Causes**	**Solutions**
Bin smells bad	Overfeeding	Stop feeding for 2 weeks
	Non-compostables present	Remove non-compostables
	Food scraps exposed to air	Bury food completely
	Bin too wet	Mix in dry bedding; leave lid off
	Not enough air	Drill more holes in bin
Bin attracts flies	Food scraps exposed to air	Bury food completely
	Rotten food	Avoid putting rotten food in bin
	Too much food	Don't overfeed worms.
Worms are dying	Bin too wet	Mix in dry bedding; leave lid off
	Bin too dry	Thoroughly dampen bedding
	Extreme temperatures	Move bin where temp. is between 59°F and 77°F
	Not enough air	Drill more holes in bin
	Not enough food	Add more bedding and food
Worms are crawling away	Bin conditions are not right	See solutions above; leave lid off and worms will burrow back into bedding
Mold is forming	Conditions are too acidic	Cut back on acidic foods; remove mold; moisten bread products
	Bin is too wet	Mix in dry bedding; leave lid off
Bedding is drying out	Too much ventilation	Mist bedding; keep lid on
Liquid collecting in bottom	Poor ventilation; over-watering	Leave lid off for a couple of days; add dry bedding
	Feeding too much watery scraps	Cut back on coffee grounds and food scraps with high water content; mix with bedding material before feeding

https://homegrown.extension.ncsu.edu/wp-content/uploads//2018/07/Worms-can-recycle-your-garbage_NC-State-Extension-vermicomposting-fact-sheet.pdf

Worm Resources

NC STATE UNIVERSITY





Take a little

COFFEE BREAK

Compost Teas and Extracts

Actively Aerated Compost Tea

-Brewed for 12-72 hours (brew at same ambient temp as plants)

-Foods added for microbe reproduction

Compost Extract

-Ready to use immediately

-Usually less microorganisms

-Foods may be added after extraction

Quality is everything
Biology defines Quality

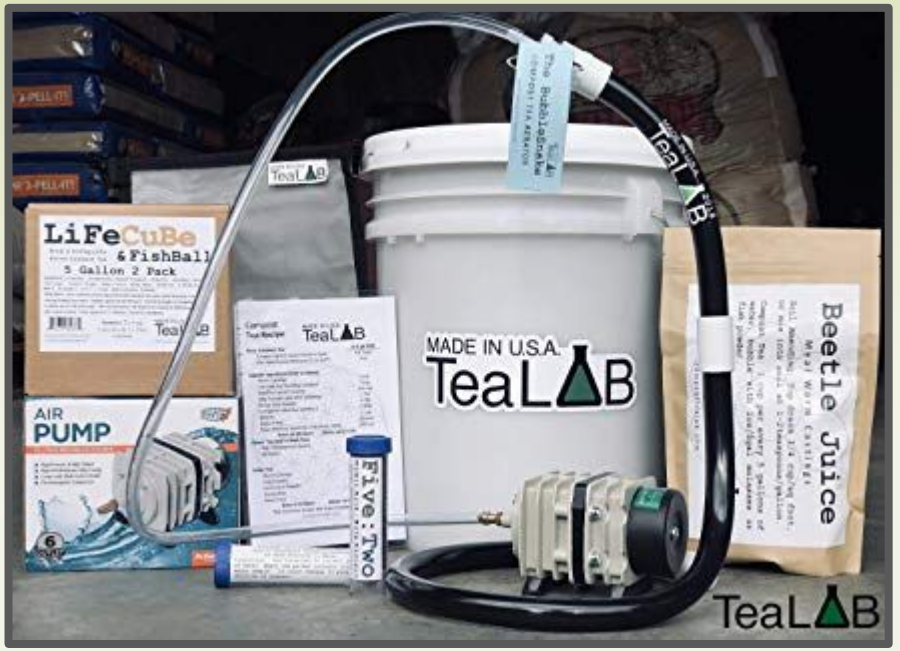
Compost Teas and Extracts

Start with quality compost & quality water

-Need full array of soil food web characters

Compost Teas and Extracts

Materials needed for brewing



-Container, water, compost, brew bag, and commercial air pumps -If using tap water let water sit out for 24-48 hours to off-gas chlorine or chloramine

Large Compost Tea Brewers

Compost Teas and Extracts

Foods for microorganisms

- Fungal foods
  - soluble kelp/seaweed (salt free), humic acid (not from leonardite), fish hydrolosate (not fish emulsion), steel cut oats/oatmeal, feather meal
- Bacterial foods

*Add a handful of straw to increase levels of protozoa

-**Bucket Brewer** (5 Gallon): 714 GPH or 1110 GPH

-**Medium Brewer** (15-3- Gallon): 1110 GPH or 1452 GPH

-**Barrel Brewer** (30-50 Gallon): 1110 GPH or 1452 GPH

- **5 Gallon Brewer:** 500 GPH - 1000 GPH
- **15 Gallon Brewer:** 1000 GPH - 1500 GPH
- **30 Gallon Brewer:** 1250 GPH - 1500 GPH
- **50 Gallon Brewer:** 1250 GPH - 2000 GPH

GPH = Gallons (of air pumped) Per Hour

Compost Teas and Extracts

Rule of Thumb Brew Times- average temps between day and night

50-65 degrees F = 72 hours
66-80 degrees F = 48 hours
81-95 degrees F = 24 hours
96+ degrees F = 12 hours

Basic Biologic Compost Tea Recipe				
Gallons of Water	5	15	30	50
Compost and/or Worm Castings	4 cups	8 cups	12 cups	16 cups
Fish and/or Mollass-es (Liquid/Powder)	2oz / 2TBSP	4oz / 1/4cup	8oz / 1/2cup	16oz / 1 cup

example recipe: A 5 gallon brew could use 2 cups of compost, 2 cups of casting (for 4 cups total), and 1oz of powdered fish and 1oz of molasses (for 2oz total).

Basic Compost Tea					
Gallons of Water	1	5	15	30	50
Compost or Worm Castings	1 cup	4 cups	8 cups	12 cups	16 cups
Fish Hydrolysate	1 tsp	1 tbsp	2 tbsp	1/4 cup	1/2 cup
Soluble Kelp	1 tsp	1 tbsp	2 tbsp	1/4 cup	1/2 cup
*Azomite	1 tsp	1 tbsp	2 tbsp	3 tbsp	1/4 cup
* Soft Rock Phosphate	1 tsp	1 tbsp	2 tbsp	1/4 cup	1/2 cup

- Use on vegetable crops, lawns, flower gardens, softwood trees and shrubs, berries, or to control pest and pathogen outbreaks
- Do not add soft rock phosphate if applying to blueberries
- Aerate for 12 - 24 hrs; apply as a soil drench

Application of Compost Teas and Extracts

When?

-Seed, First true leaves, 1 and 2 months later

-At signs of pests and/or disease

How much?

- 5-10 gallons per acre

-Foliar application: at least 5 gallons of tea per acre for every 5 feet of tree height

Ways to apply

-Sprayers with diaphragm pumps, such as some backpack sprayers, rather than piston pumps


115V AC or 12V
Whisper Quiet Operation
Solid-cone Spray Nozzle
180º Easy Turn Handle
15 Gallon Tank
Quik-connect Fittings
18" Spray Gun
Mounted on Steel Cart
10" Pneumatic Tires
50 feet 3/8" Braided PVC Hose

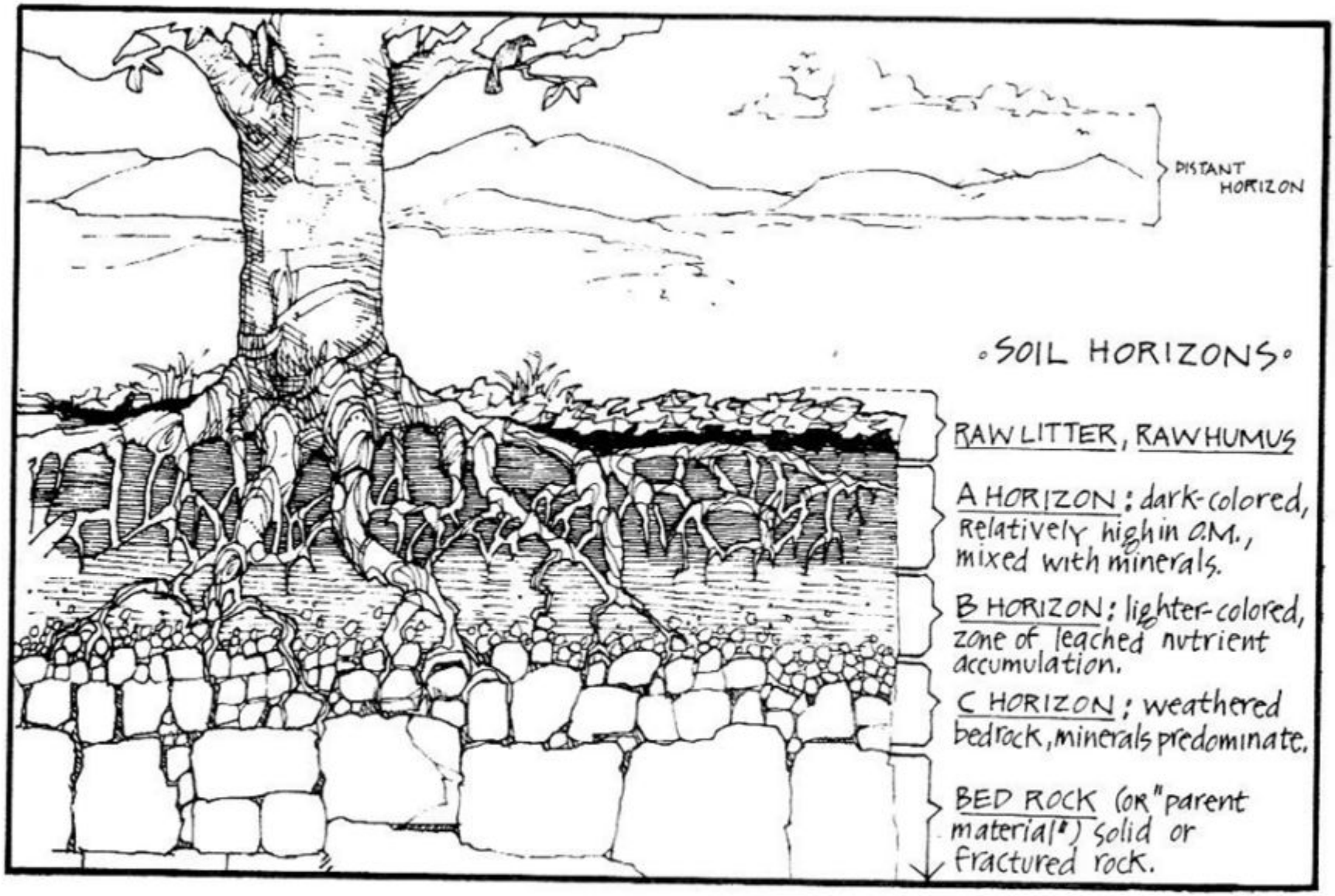
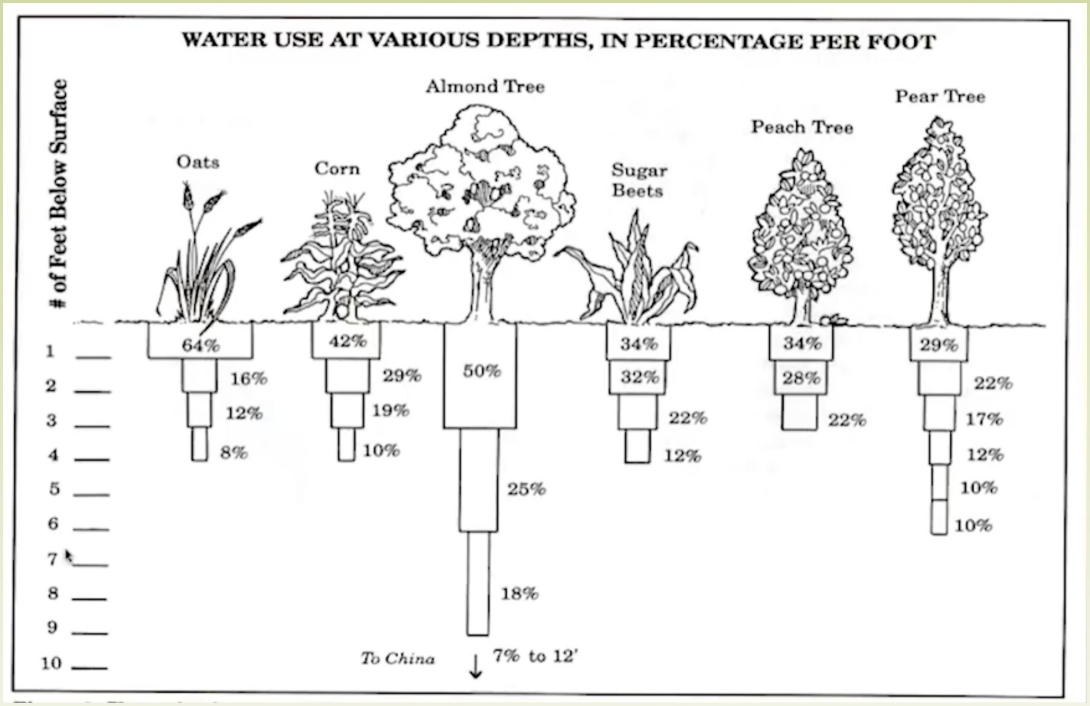
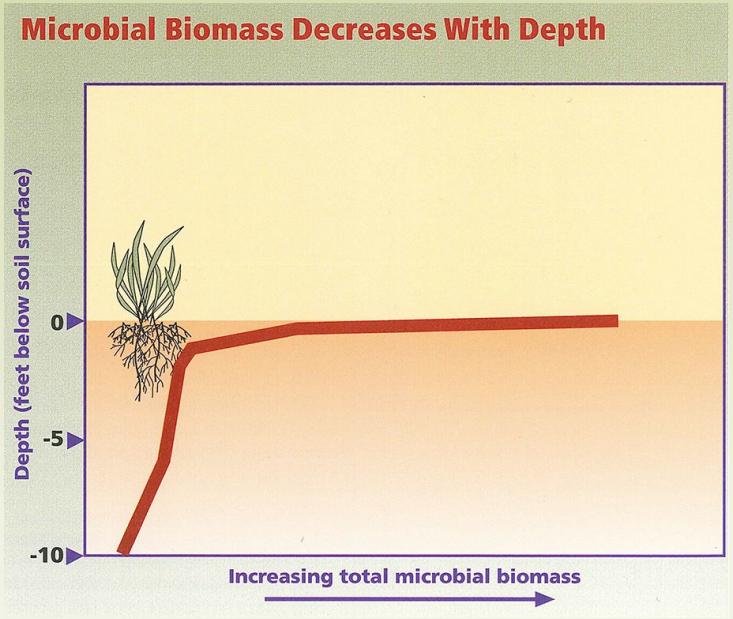
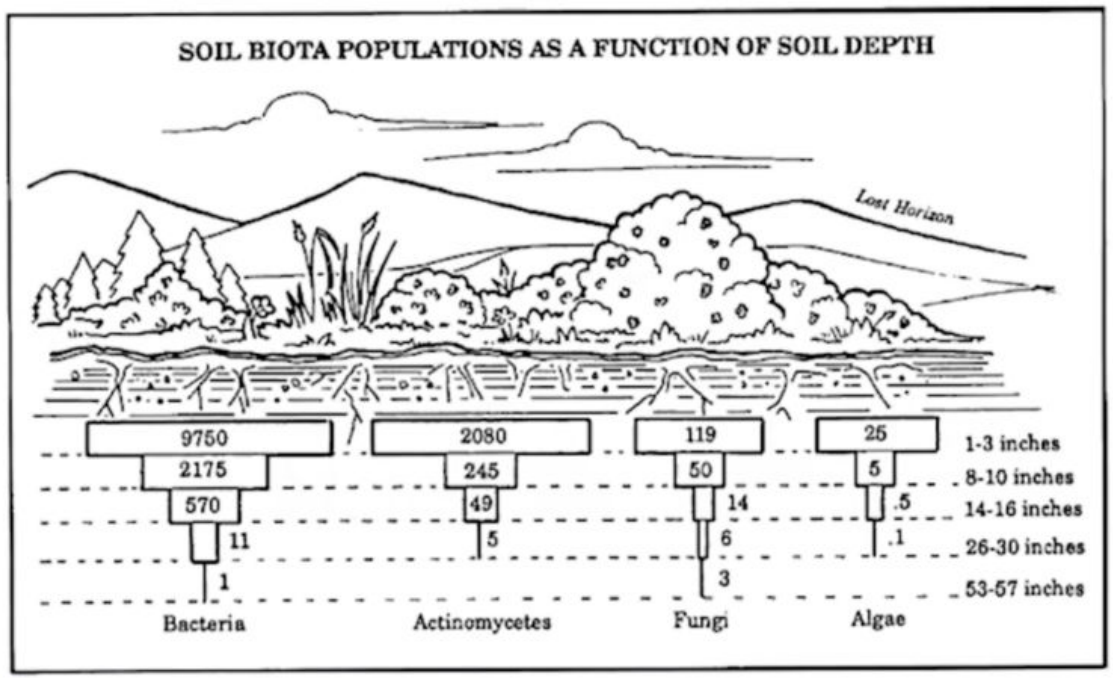


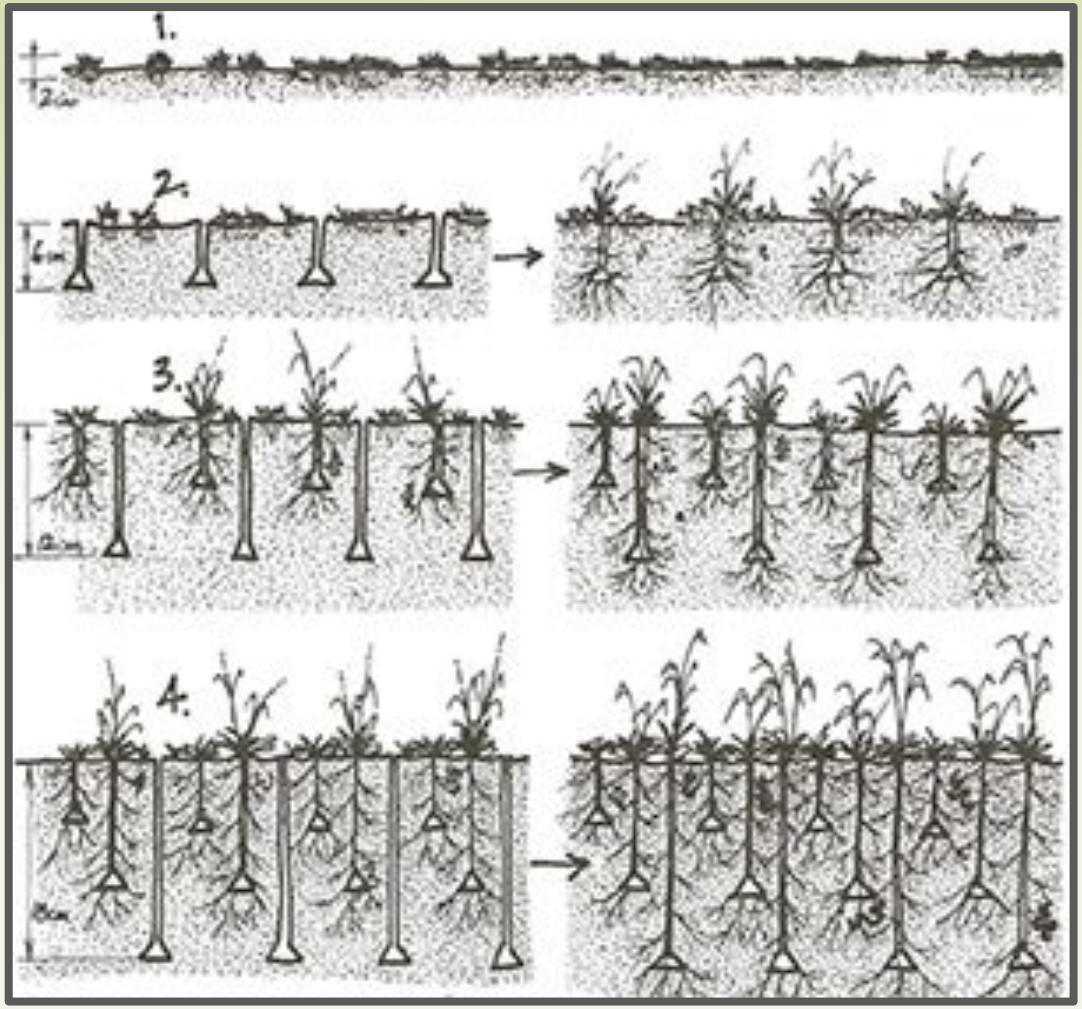
Figure 3.9 As edible landscapers, we are most concerned with the quality of soil in horizon "A."

Credit: Roots Demystified


WATER USE AT VARIOUS DEPTHS, IN PERCENTAGE PER FOOT
# of Feet Below Surface
Oats
Corn
Almond Tree
Sugar Beets
Peach Tree
Pear Tree
64%
16%
12%
8%
42%
29%
19%
10%
50%
25%
18%
34%
32%
22%
12%
34%
28%
22%
29%
22%
17%
12%
10%
10%
To China
7% to 12'


Microbial Biomass Decreases With Depth
Depth (feet below soil surface)
0
-5
-10
Increasing total microbial biomass


SOIL BIOTA POPULATIONS AS A FUNCTION OF SOIL DEPTH
Lost Horizon
9750
2175
570
11
1
2080
245
49
5
119
50
14
6
3
25
5
.5
.1
1-3 inches
8-10 inches
14-16 inches
26-30 inches
53-57 inches
Bacteria
Actinomycetes
Fungi
Algae



Results – Rodale Hydroponics

All photos by Troy Hinke

Keeping Life in Your Soil

Cover Crops and Ground Cover

Cover Crop Chart

GROWTH CYCLE
A = Annual
B = Biennial
P = Perennial

RELATIVE WATER USE
= Low
= Medium
= High

PLANT ARCHITECTURE
= Upright
= Upright-Spreading
= Prostrate

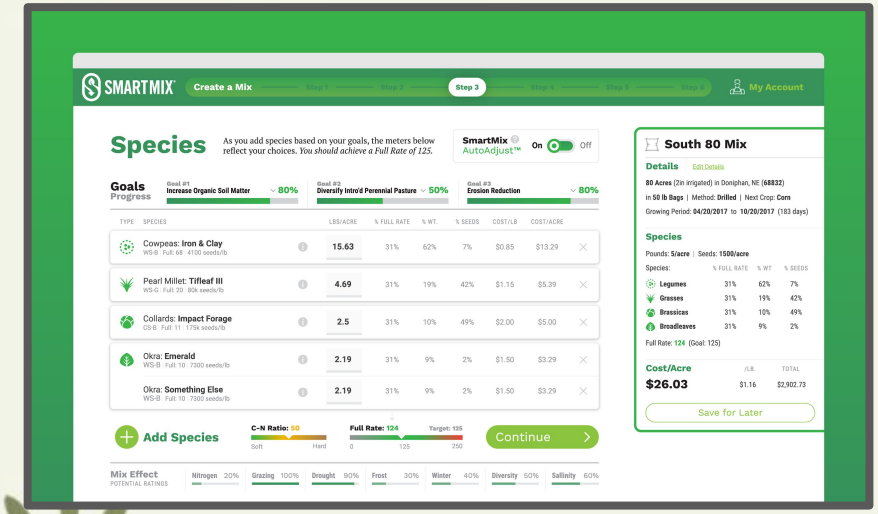
----------Cool Season---------- ----------Warm Season----------

---Grass---		----------Broadleaf----------						---Grass---
A Barley								A Pearl millet
A Oat	A Phacelia						A Amaranth	A Foxtail millet
A/P Ryegrass	A Flax		----------Legumes----------				A Buckwheat	A Proso millet
A Wheat	A Spinach	B Turnip	A Field pea	A Berseem clover	A/P Medic	A Chickpea	A Sunflower	A Sudan grass
A Cereal rye	A Kale	A Radish	A Lentil	B/P Red clover	P Birdsfoot trefoil	A Cowpea	A Safflower	A Teff
A Triticale	A/B Canola	B Beet	A Lupin	P White clover	P Sainfoin	A Soybean	A Squash	A Grain sorghum
A Annual fescue	A/P Mustard	A/B Carrot	A/B Vetch	A/B Sweetclover	P Alfalfa	A Mung bean	P Chicory	A Corn

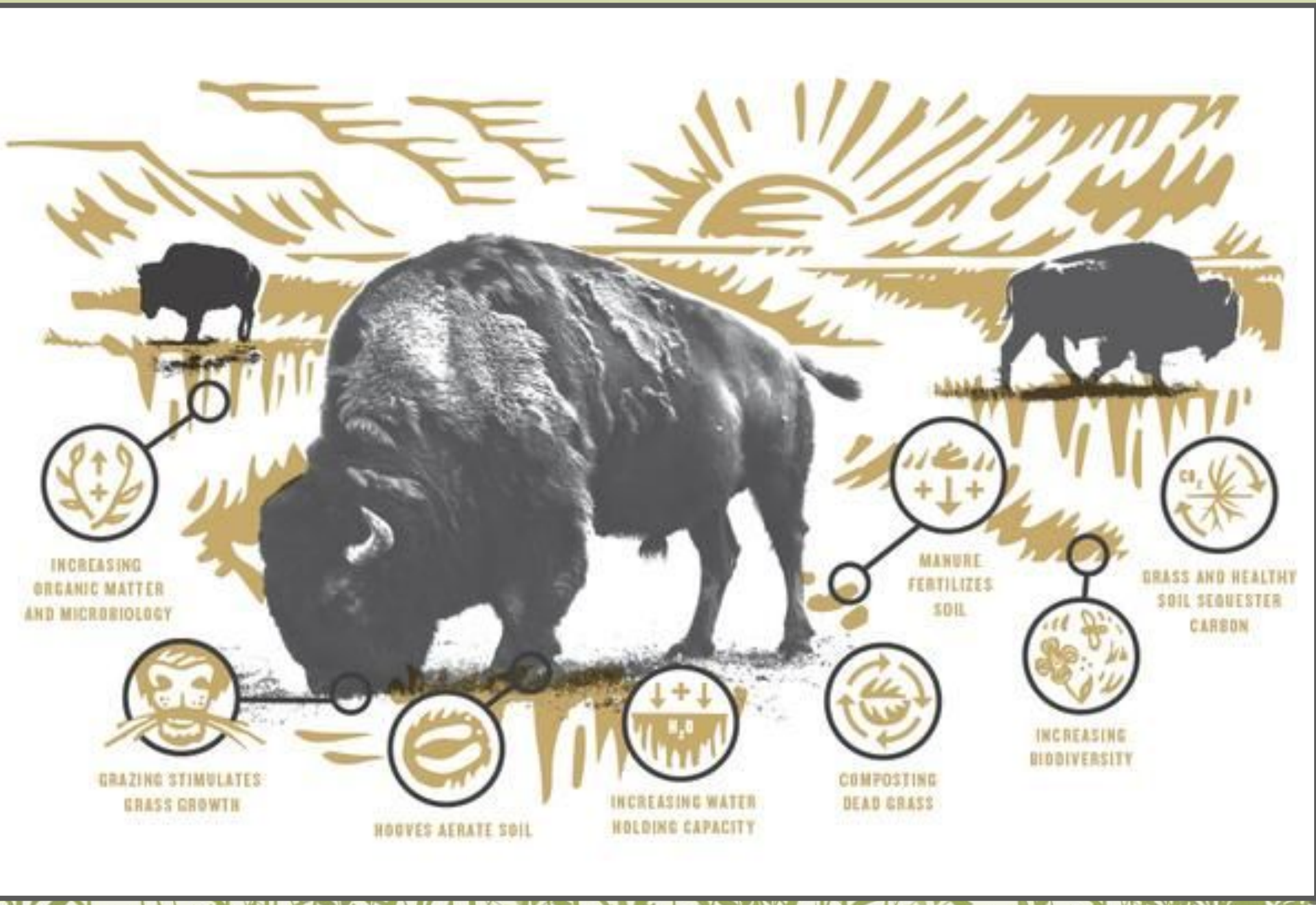
V 1.3. May 2012

◈ *Additional Information*

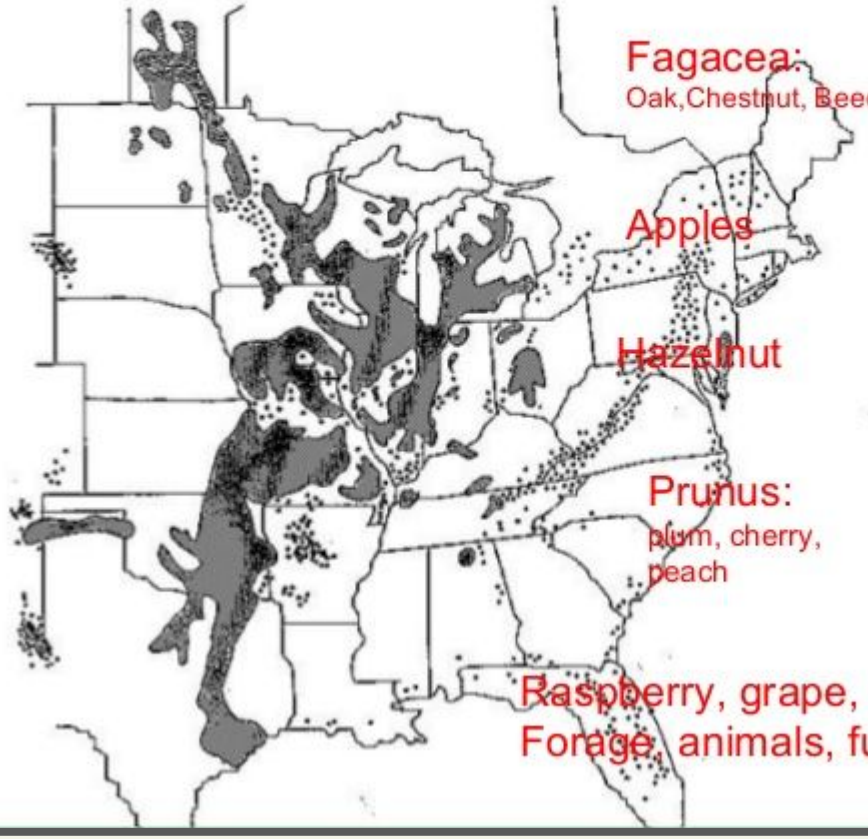

Plot-seeder


SMARTMIX
Create a Mix
Step 3
My Account
Species
As you add species based on your goals, the meters below reflect your choices. You should achieve a Full Rate of 125.
SmartMix AutoAdjust™ On Off
Goals Progress
Goal #1 Increase Organic Soil Matter 80%
Goal #2 Diversify Intro'd Perennial Pasture 50%
Goal #3 Erosion Reduction 80%
TYPE SPECIES LBS/ACRE % FULL RATE % WT. % SEEDS COST/LB COST/ACRE
Cowpeas: Iron & Clay 15.63 31% 62% 7% $0.85 $13.29
Pearl Millet: Tifleaf III 4.69 31% 19% 42% $1.15 $5.39
Collards: Impact Forage 2.5 31% 10% 49% $2.00 $5.00
Okra: Emerald 2.19 31% 9% 2% $1.50 $3.29
Okra: Something Else 2.19 31% 9% 2% $1.50 $3.29
Add Species
C-N Ratio: 50
Full Rate: 124
Target: 125
Continue
Mix Effect
POTENTIAL RATINGS
Nitrogen 20%
Grazing 100%
Drought 90%
Frost 30%
Winter 40%
Diversity 50%
Salinity 60%
South 80 Mix
Details
Edit Details
80 Acres (2in irrigated) in Doniphan, NE (68832)
in 50 lb Bags | Method: Drilled | Next Crop: Corn
Growing Period: 04/20/2017 to 10/20/2017 (183 days)
Species
Pounds: 5/acre | Seeds: 1500/acre
Species: % FULL RATE % WT % SEEDS
Legumes 31% 62% 7%
Grasses 31% 19% 42%
Brassicas 31% 10% 49%
Broadleaves 31% 9% 2%
Full Rate: 124 (Goal: 125)
Cost/Acre
$26.03
/LB $1.16
TOTAL $2,902.73
Save for Later

Inoculated Paths


INCREASING ORGANIC MATTER AND MICROBIOLOGY
GRAZING STIMULATES GRASS GROWTH
HOOVES AERATE SOIL
INCREASING WATER HOLDING CAPACITY
COMPOSTING DEAD GRASS
MANURE FERTILIZES SOIL
INCREASING BIODIVERSITY
GRASS AND HEALTHY SOIL SEQUESTER CARBON

Oak Savanna, Barrens, and Prairie Complexes in Eastern United States



Fagacea:
Oak,Chestnut, Beech

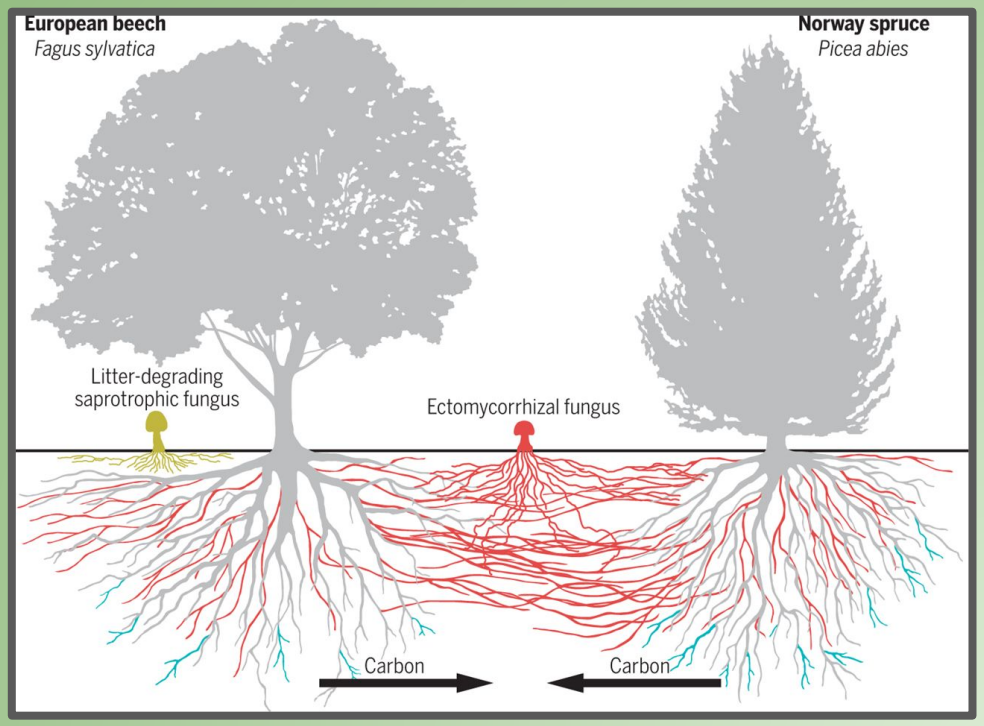
Apples

Hazelnut

Prunus:
plum, cherry, peach

Raspberry, grape, currant

Forage, animals, fungi


European beech
Fagus sylvatica
Norway spruce
Picea abies
Litter-degrading saprotrophic fungus
Ectomycorrhizal fungus
Carbon
Carbon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Food Forests' Living Web

A Web of Life

A food forest is designed to link food crops together in a web of life similar to that of other forests.

Our web engages plants, animals, and fungi to help with gardening tasks. We grow a whole forest, not just food, and we get pest control, weed control, fertilizers, water storage, and a beautiful space for people.

All fruits start as pollinated flowers.

Ladybugs and green lacewing larva protect budding fruit from aphids and thrips.

Seedbugs save leaves from leafhoppers.

Helping Flowers Become Fruit

The food forest builds habitat for predators and pollinators that tend our flowers and fruits as they grow.

Building Soil

Worms, fungi, and other soil life eat dead leaves, creating top soil full of precious nutrients that plants can absorb easily.

Slowing Water to Protect Soil

Layers of plants slow down speeding raindrops to lessen their impact.

Rain drops can fall at 30 miles per hour, breaking apart and crushing exposed soil.

Mulch, such as leaves and woodchips, protects the soil's delicate networks of roots, sand, organic matter, and hyphae (fungal roots).

A plum tree may take 5 to 10 years to mature, and with care it can produce plums for decades.

Storing Water

Good soil structure provides air space for soil life and acts as a sponge, storing water for our dry summers.

Cleaning Water

Like a carbon filter used to clean water, soil with a lot of organic content (carbon) cleans stormwater.

Roots pull up minerals trapped in rocks.

Groundwater

Take a little

COFFEE BREAK

Introduction to the Microscope

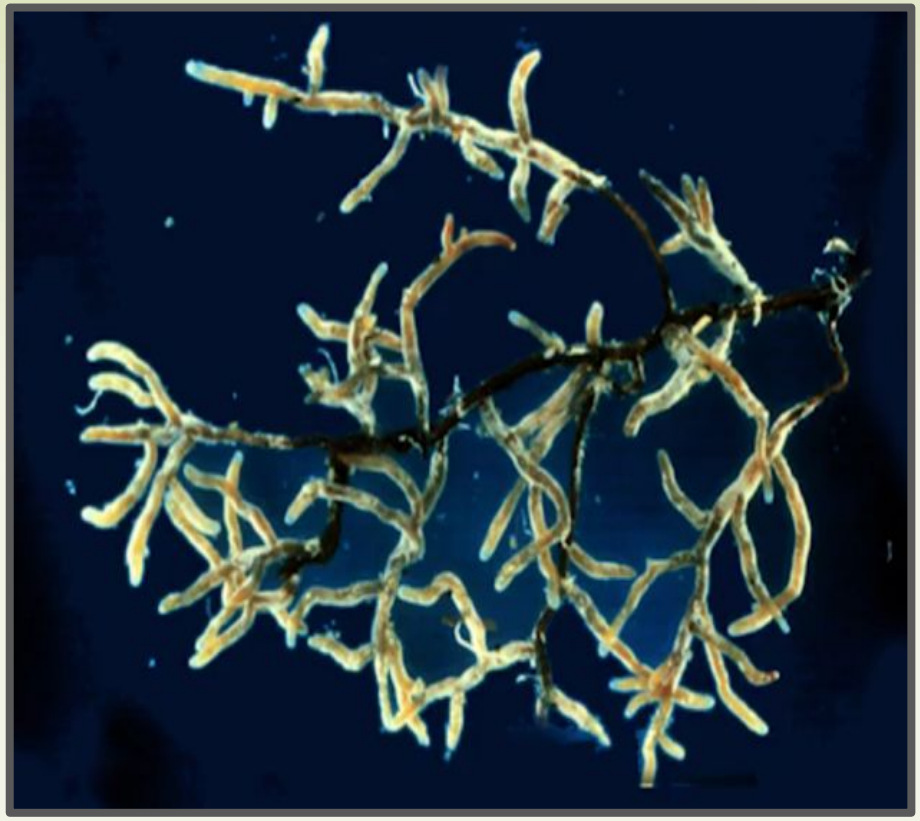


Photo by Troy Hinke

Trinocular Compound LED Microscope
Model M8311 Series

Microscope specifications recommended for viewing soil microbiology-

The microscope viewing system is called Shadowing or Differential Interference Contrast Microscopy, as opposed to Phase Contrast.

Eyepieces: binocular, 10x WF (Wide Field) (15x or 20x eyepieces are often sold as an "upgrade" but rarely improve image quality.)	**Abbe condenser:** 1.25 N.A. (Numerical Aperture) **Iris diaphragm** is essential
Objective lenses: 4x, 10x, 40x (100x objective lenses, or others greater than 40x, are not used for viewing soil) Some microscope enthusiasts say they use the 20x most often. The 20x objective lens is not always included with the scope, you can ask to have the seller switch the 100x objective lens for a 20x, (the 100x is more expensive, so it is also to the seller's benefit to make the switch).	**Stage:** Adjustable stage (Mechanical Stage) **Light source:** high intensity, minimum 20W halogen, or LED.

Bacteria

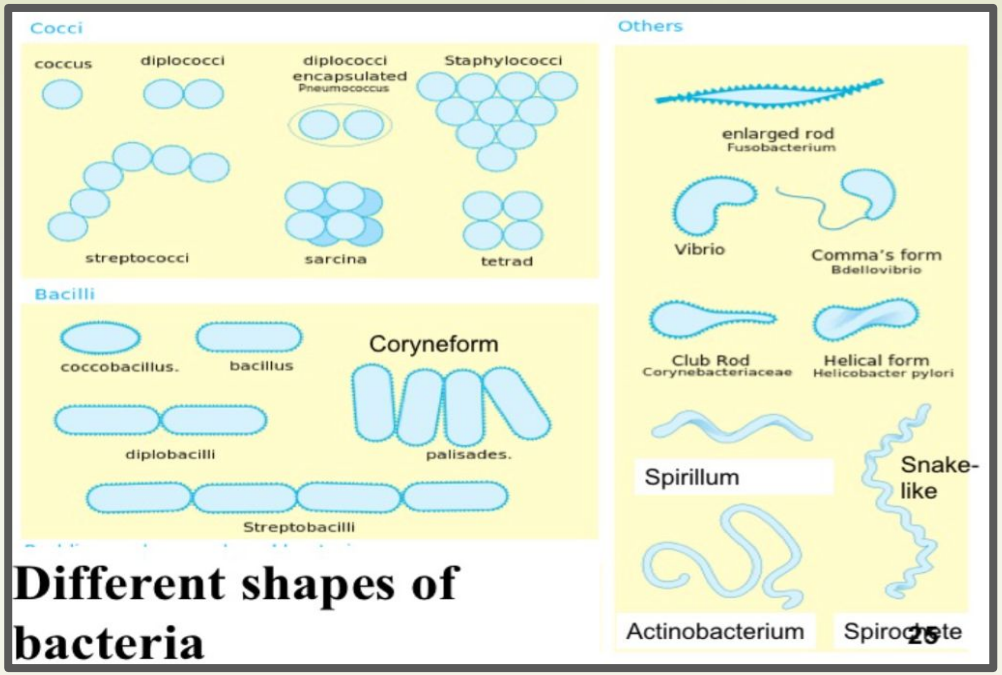
- Rod (bacillus): long, short, fat, thin
- Round (cocci) shape: tiny, small, medium, large
- Coccobacilli (round rods)

  Single: Double (two in chain called diplo-); Linked in chains (called strepto-); Motile or not

  Palisade or picket fence: Corynebacteria

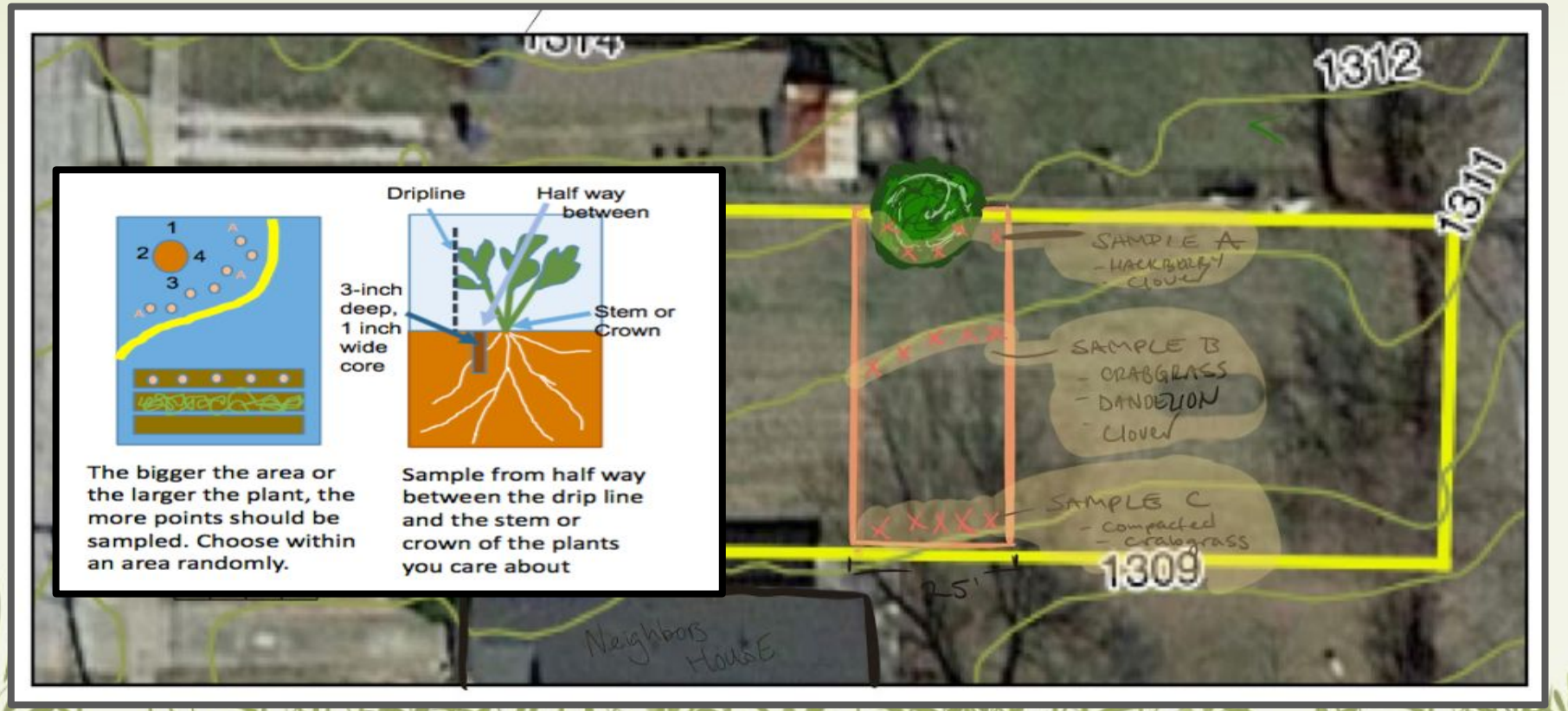
  Big fat, very square rods are the best Bacillus sp

  Long slender rods: Lactobacillus
- Comma shaped (vibrio)
- Spirilla (cork-screw shape, stiff, motile)
- Spirochetes (move like snakes; flexible)



Different shapes of bacteria

Collecting your Samples



Fungi

Large Diameter

Even Septa

Look for GOOD GUYS

DIVERSITY

COLOR

Photo by Troy Hinke

Hyphae

- Strands or threads, parallel lines, may branch
- Septa, no structures inside hyphae,
- No shredding, wisps, fragments, clear breaks
- Not crystalline, rarely curled
- Diameters

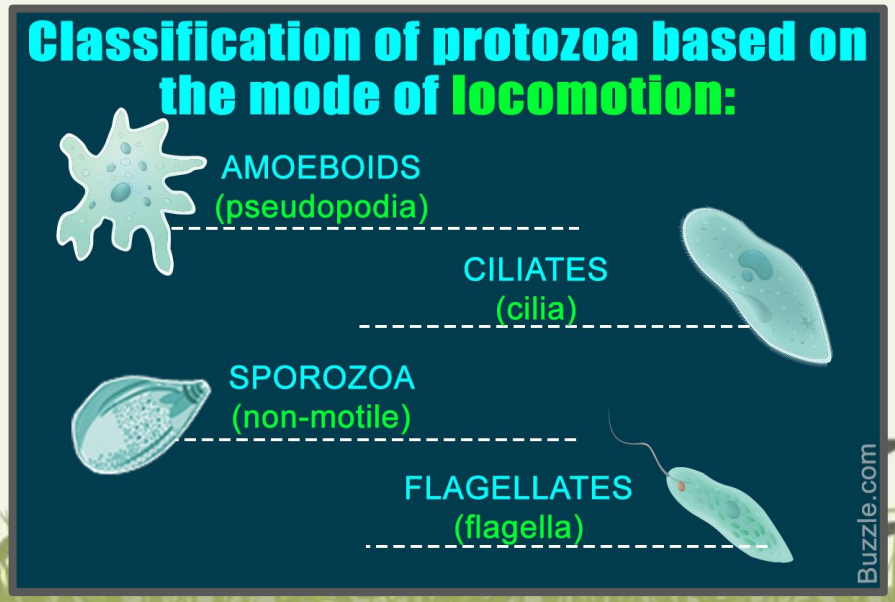
- Measure length of hypha based on how much of the field it stretches across: e.g., 0.1, 0.5, 1
- Diameter: Actinobacteria 1 -1.5 µm
  Oomycetes 1.5 – 2.0 µm
  Ascomycetes 2.0 - 2.5 µm
  Basidiomycetes > 3 µm
- Beneficial hyphae are generally wide diameter, colored (tan, honey, golden, red, brown. etc)
- Uniformly septate vs adventitious
- Hyphae stay uniform along whole strand

Protozoa

- Flagellates - aerobic
  - Round, pear, teardrop, banana
  - Rolling, bumbling motion, one to several flagella
  - Cysts – single layer outer membrane, small, round
- Amoebae - aerobic
  - Very slow oozing movement
  - Testate amoebae
  - Cyst – double outer membrane
- Ciliates – indicate anaerobic
  - Very fast, many cilia (short hairs) may cover whole body or only part, larger than other protozoa usually
- High numbers reduce bacterial numbers

101

Photo by Ingham



Nematodes

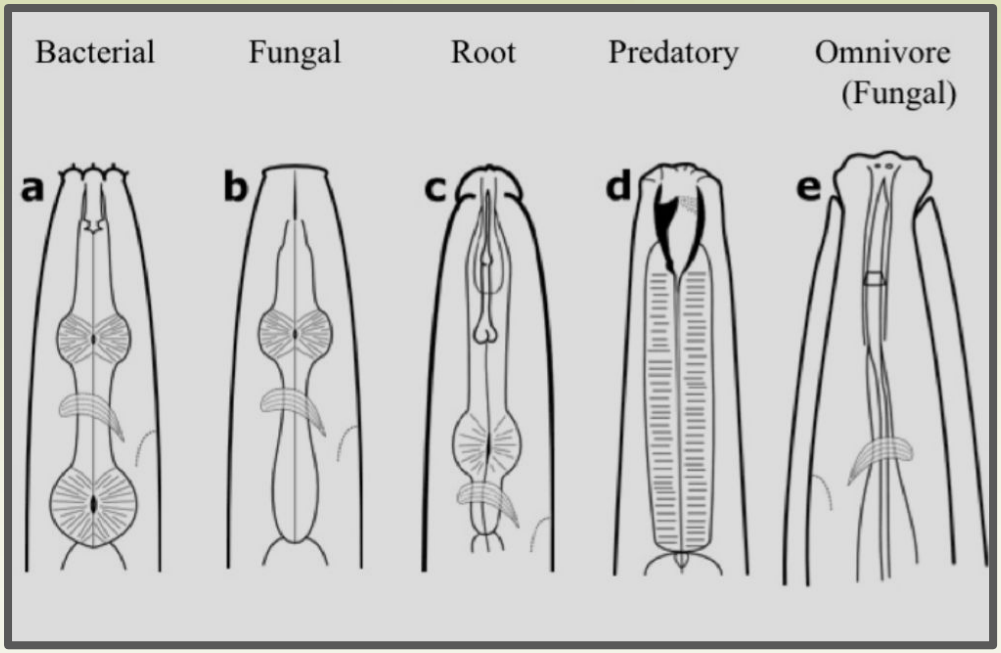
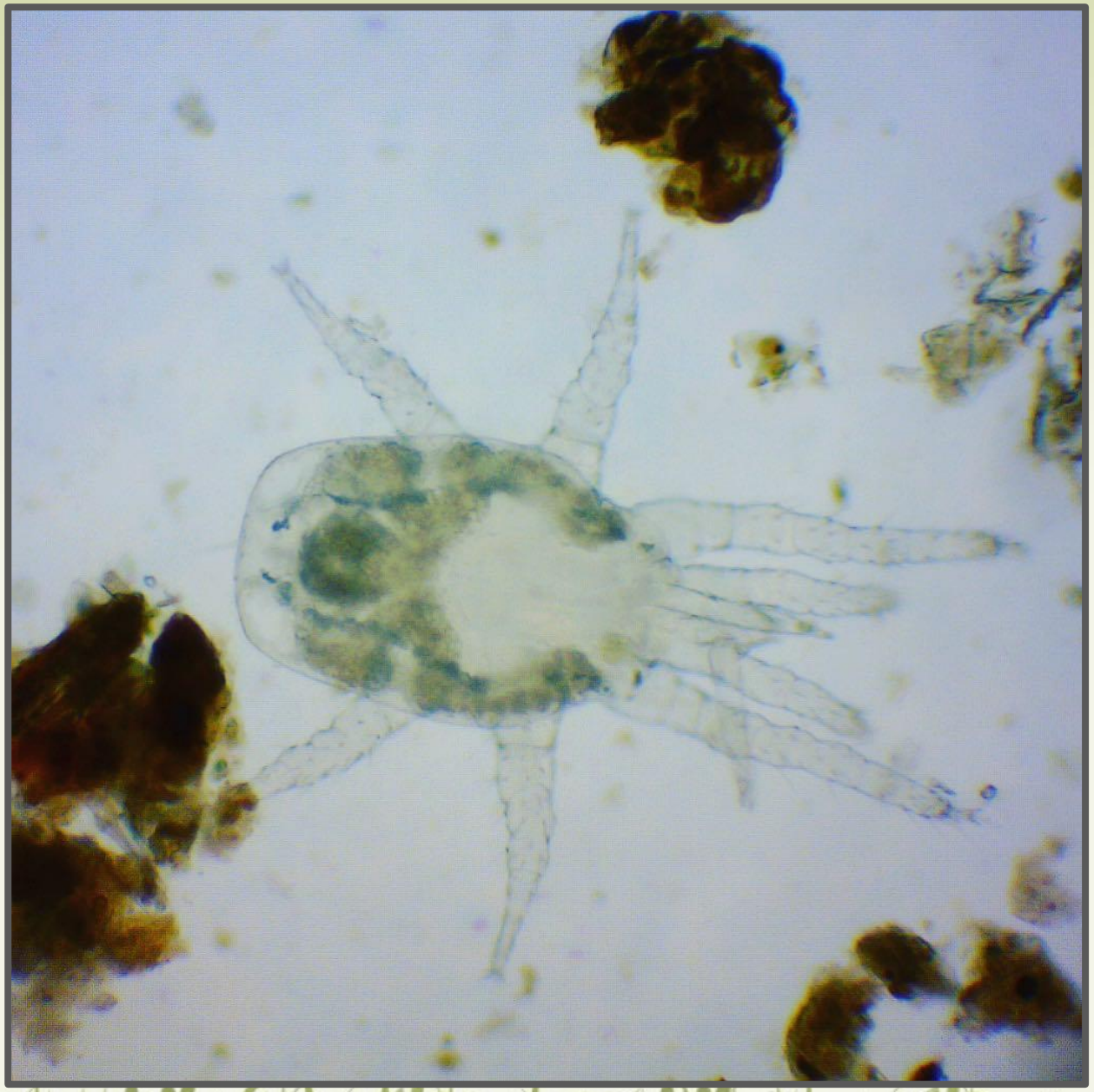


Photo by Ben Tegeler 100X



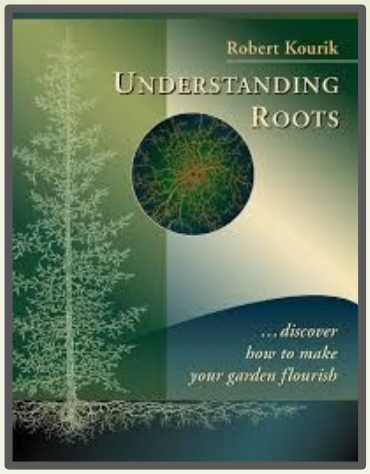
Microscope Demonstration

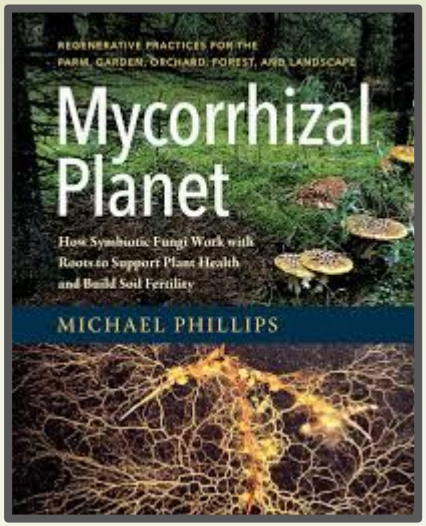

dirt
THE HIDDEN HALF OF NATURE
GROWING A REVOLUTION

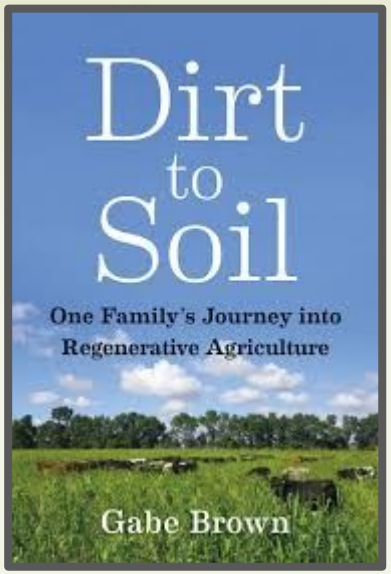

TEAMING WITH FUNGI
The Organic Grower's Guide to Mycorrhizae
JEFF LOWENFELS
TEAMING WITH MICROBES
The Organic Gardener's Guide to the Soil Food Web
JEFF LOWENFELS & WAYNE LEWIS

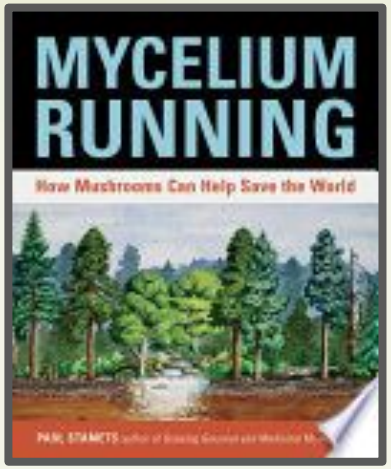

RADICAL MYCOLOGY

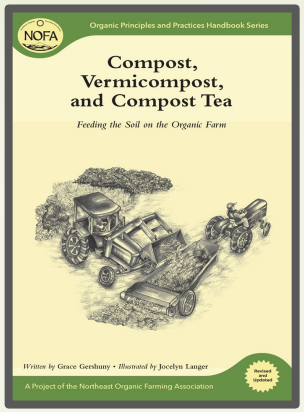

Compost Teas for the Organic Grower
Eric Fisher

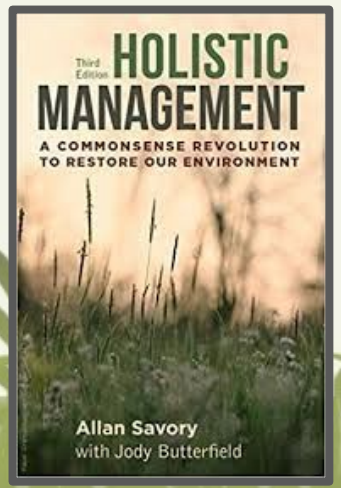

Robert Kourik
UNDERSTANDING ROOTS
...discover how to make your garden flourish

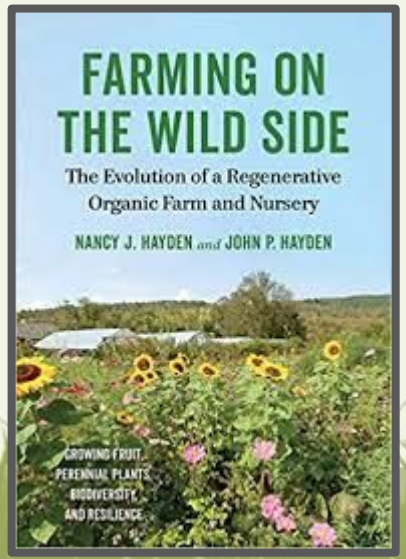

REGENERATIVE PRACTICES FOR THE FARM, GARDEN, ORCHARD, FOREST, AND LANDSCAPE
Mycorrhizal Planet
How Symbiotic Fungi Work with Roots to Support Plant Health and Build Soil Fertility
MICHAEL PHILLIPS

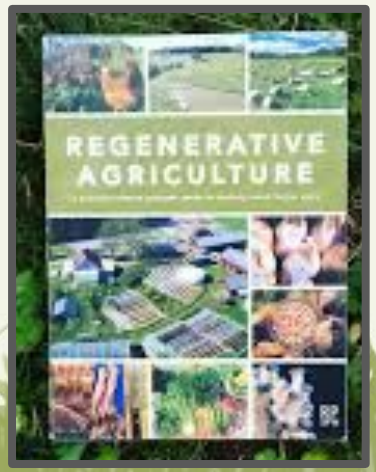

Dirt to Soil
One Family's Journey into Regenerative Agriculture
Gabe Brown

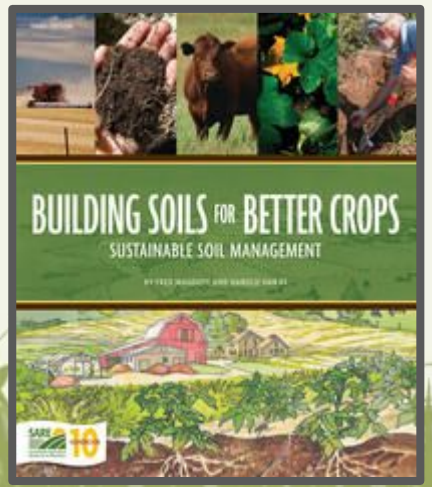

MYCELIUM RUNNING
How Mushrooms Can Help Save the World

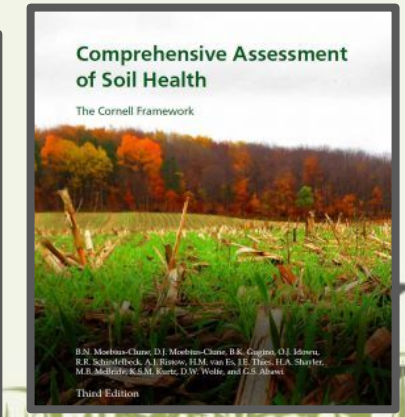

NOFA
Organic Principles and Practices Handbook Series
Compost, Vermicompost, and Compost Tea
Feeding the Soil on the Organic Farm
A Project of the Northeast Organic Farming Association


Third Edition
HOLISTIC MANAGEMENT
A COMMONSENSE REVOLUTION TO RESTORE OUR ENVIRONMENT
Allan Savory
with Jody Butterfield


FARMING ON THE WILD SIDE
The Evolution of a Regenerative Organic Farm and Nursery
NANCY J. HAYDEN and JOHN P. HAYDEN
GROWING FRUIT PERENNIAL PLANTS BIODIVERSITY AND RESILIENCE


REGENERATIVE AGRICULTURE


BUILDING SOILS FOR BETTER CROPS
SUSTAINABLE SOIL MANAGEMENT


Comprehensive Assessment of Soil Health
The Cornell Framework
Third Edition

Suggested Readings

Soil Biology Primer- can be found online in a PDF format for free

10 Steps to Gardening with Nature by Elaine R. Ingham, PhD and Carole Ann Rollins, PhD

Worms Eat My Garbage by Mary Appelhof

Teaming with Microbes by Jeff Lowenfel and Wayne Lewis

Mycellium Running by Paul Stamets

https://padlet.com/jacquelinefletcher6/af4qzns9lz3j

The soil is the great connector of lives, the source and destination of all. It is the healer and restorer and resurrector, by which disease passes into health, age into youth, death into life. Without proper care for it we can have no community, because without proper care for it we can have no life.

Wendell Berry, The Unsettling of America: Culture and Agriculture

Thanks!!!

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