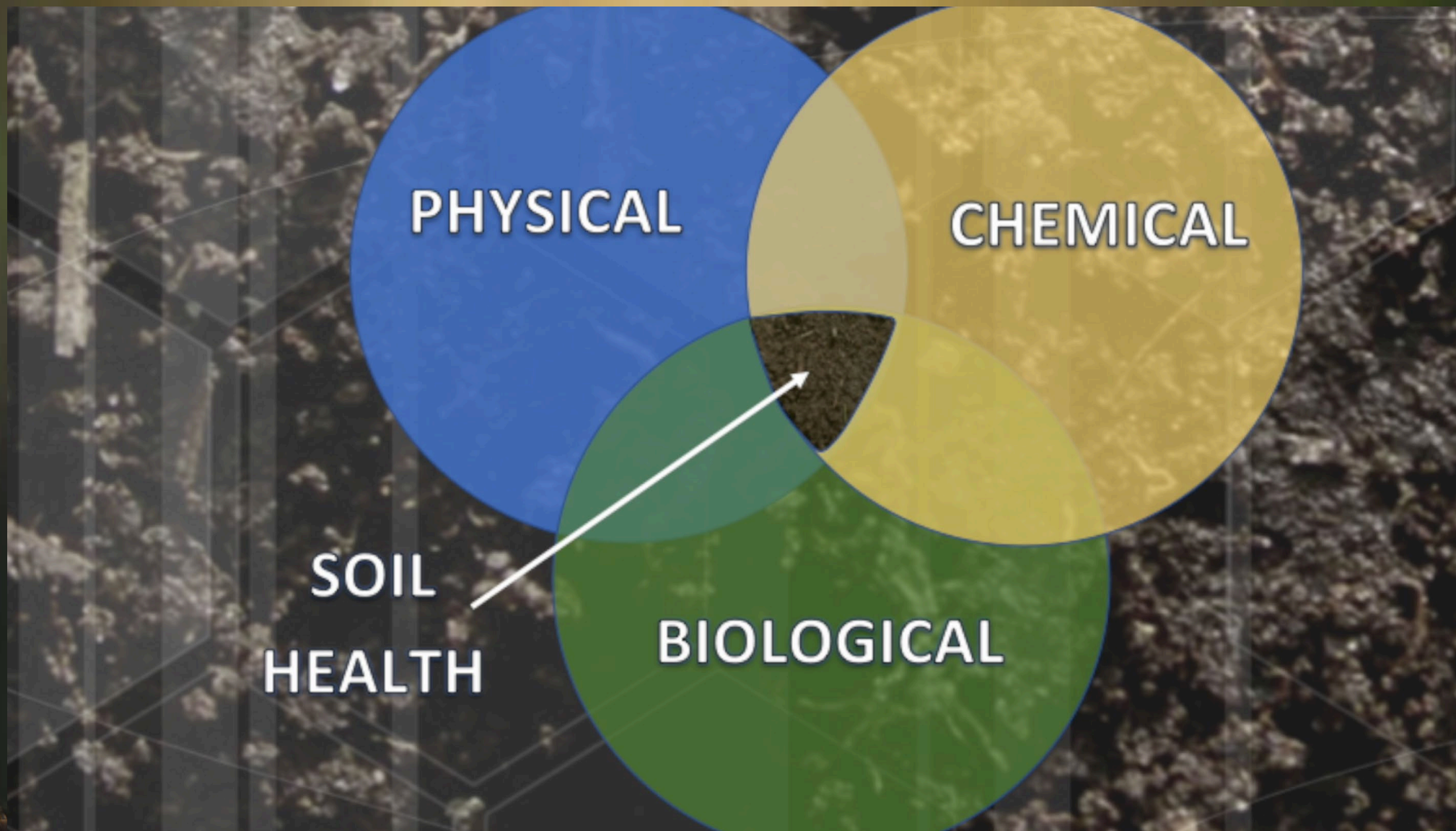


Soil Health - 3 Ways

Physical – Chemical - Biological







Soil Health and Nutrition in Food

Dead vs. Living Soil

Microbes in our Soil

Life in Compost

Summary of Soil Health Practices





WHAT IS SOIL HEALTH?

THE CONTINUED
CAPACITY OF THE SOIL
TO FUNCTION AS A
VITAL LIVING ECOSYSTEM
THAT SUSTAINS PLANTS,
ANIMALS, AND HUMANS

Why be concerned with soil life?

Healthy plants

- Don't need toxic chemicals to grow
- Have the proper balance of nutrients
- So they taste good and satisfy hunger

Flavor depends on the balance of ALL nutrients

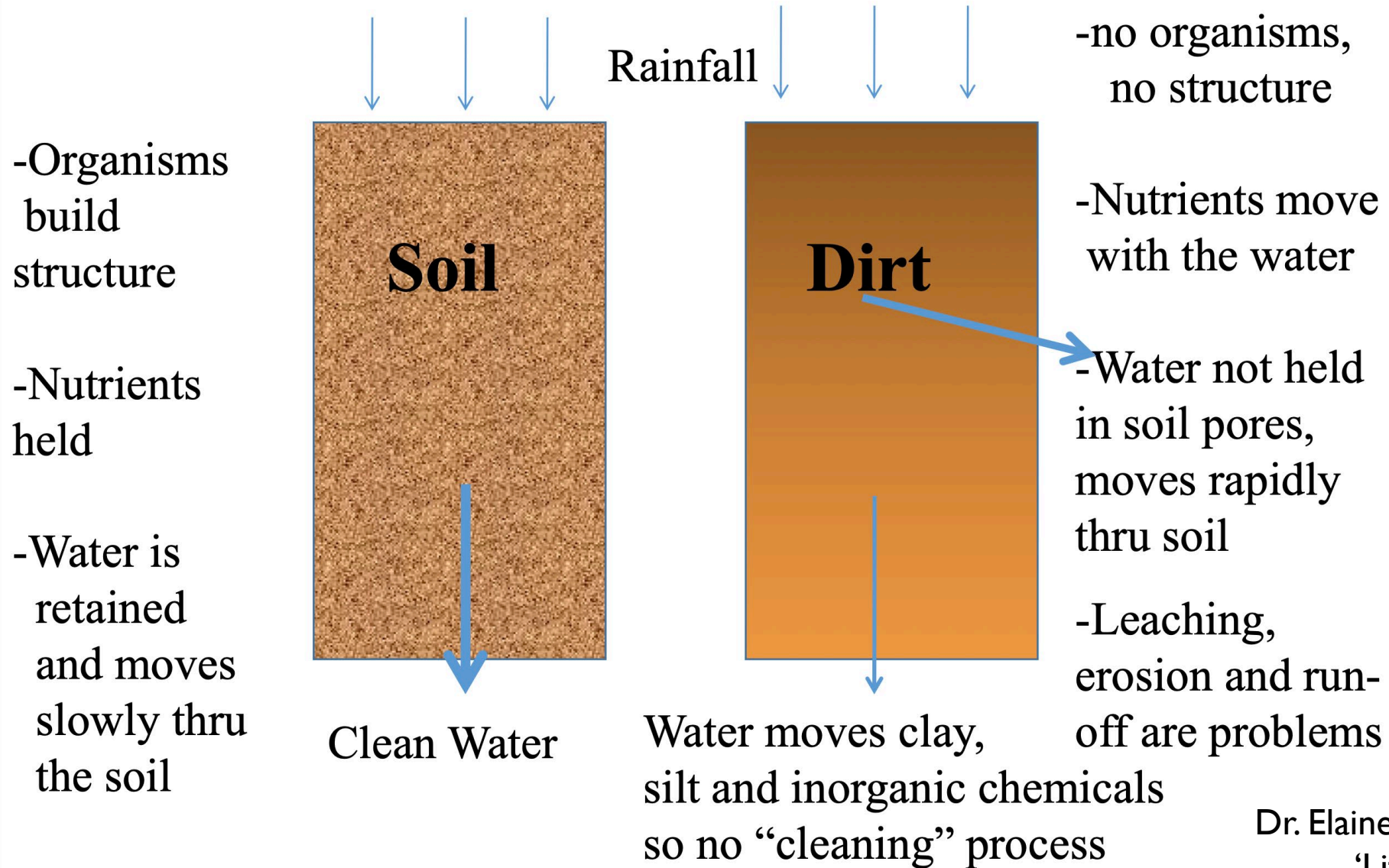
Where do plants get their nutrients?

All but two nutrients come from the soil.

So, human nutrition comes from soil.

Dr. Elaine Ingham's book:
'Life In Soil'

Soil vs Dirt: Clean water?



Dr. Elaine Ingham's book:
'Life In Soil'

JOHN KEMPF OF ADVANCING ECO-AGRICULTURE

- “BIOLOGY SUPERSEDES CHEMISTRY”
 - YOUR CROPS CAN BE SUCCESSFUL WITHOUT CHEMISTRY AS LONG AS YOU HAVE ABUNDANT MICROBIAL COMMUNITIES.
 - YOUR CROPS CAN NOT BE SUCCESSFUL WITHOUT BIOLOGY EVEN IF YOUR MINERALS ARE WELL BALANCED.

Soil Health and Nutrition in Food



**"In nature's economy
the currency is not
money - it is life."**

--Environmental Activist, Vandana Shiva

Vandana Shiva



Natural Resources Conservation Service

U.S. DEPARTMENT OF AGRICULTURE



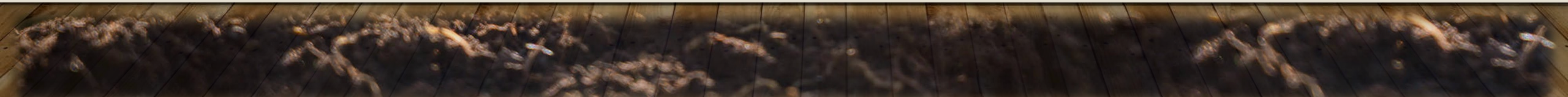
Soil Health

Soil is not an inert growing medium –it is a living and life-giving natural resource. It is teeming with billions of bacteria, fungi, and other microbes that are the foundation of an elegant symbiotic ecosystem.

Soil Health and Nutrition in Food



Testing shows that there is a huge variation in the vitamin and mineral content of food, regardless of variety, depending on where and how they were grown and harvested.



Declining Fruit and Vegetable Nutrient Composition: What Is the Evidence?

Donald R. Davis^{1,2,3}

[UT News](#) > [Press Releases](#) > Study suggests nutrient decline in garden crops over past 50 years

Study suggests nutrient decline in garden crops over past 50 years

Dec. 1, 2004

Dirt Poor: Have Fruits and Vegetables Become Less Nutritious?

SCIENTIFIC
AMERICAN®

Because of soil depletion, crops grown decades ago were much richer in vitamins and minerals than the varieties most of us get today

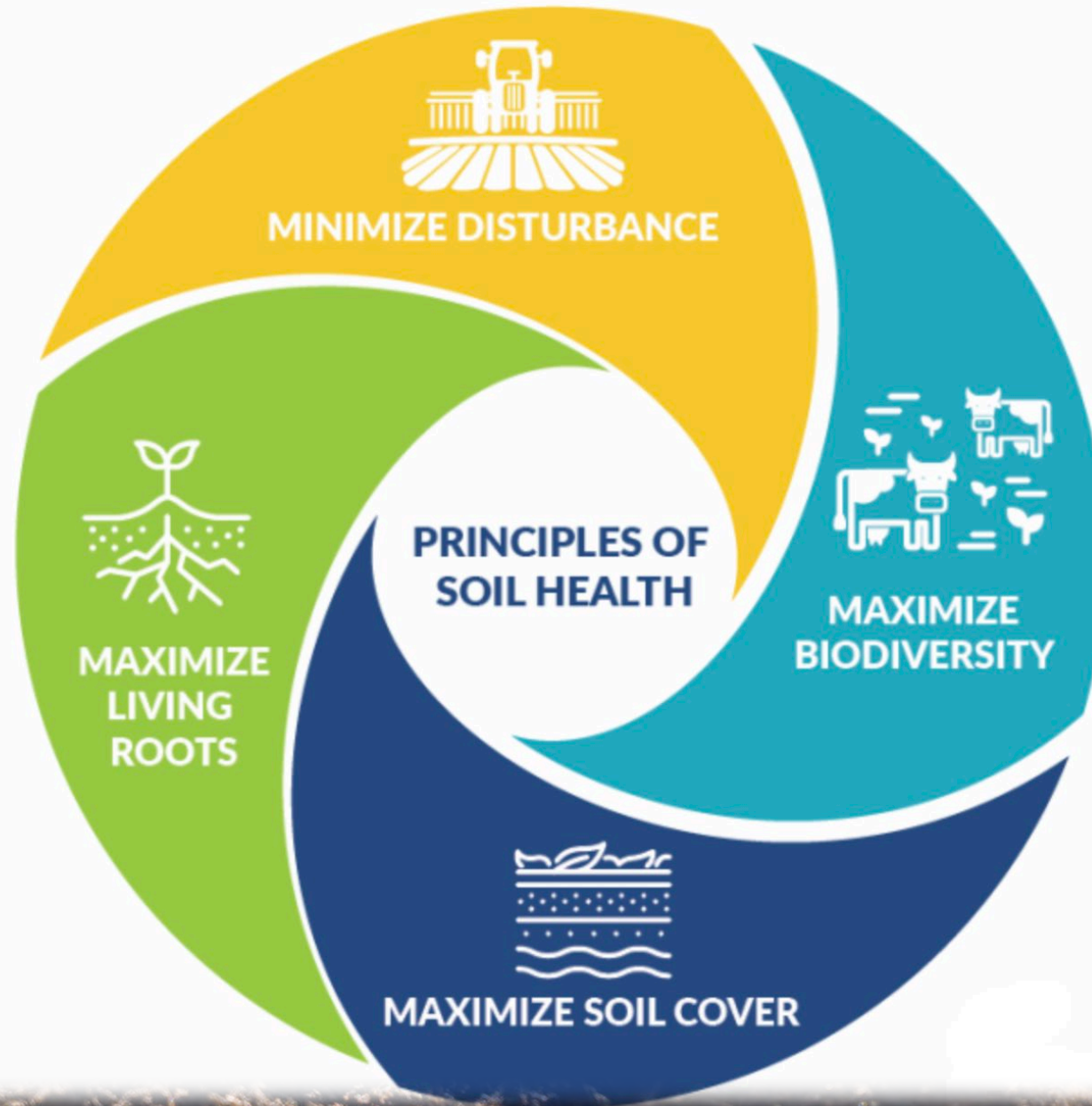
Changes in food composition for 43 garden crops from 1950 to 1999					
Vitamin C	Vitamin B2	Protein	Iron	Calcium	Phosphorus
					
15%	38%	6%	15%	16%	9%
Davis, D. R., Epp, M. D., & Riordan, H. D. (2004). Changes in USDA food composition data for 43 garden crops, 1950 to 1999. <i>Journal of the American College of Nutrition</i> , 23(6), 669-682					

Mineral	1914	1963	1992	% Decline
Calcium	13.5 mg.	7.0 mg.	7.0b mg.	-48.15
Phosphorus	45.2 mg.	10.0 mg.	7.0 mg.	-84.15
Iron	4.6 mg.	0.3 mg.	0.18 mg.	-96.09
Potassium	117.0 mg.	110.0 mg.	115.0 mg.	-1.71
Magnesium	28.9 mg.	8.0 mg.	5.0 mg.	-82.70

ORGANIC VS CONVENTIONAL

Vegetables Type of Soil Management	Minerals (in milliequivalents)						
	Calcium	Magnesium	Potassium	Sodium	Manganese	Iron	Copper
Snap Beans							
Organic	40.5	60.0	99.7	8.6	60.0	227.0	69.0
Conventional	15.5	14.8	29.1	0.0	2.0	10.0	3.0
Cabbage							
Organic	60.0	43.6	148.3	20.4	13.0	94.0	48.0
Conventional	17.5	15.6	53.7	0.8	2.0	20.0	0.4
Lettuce							
Organic	71.0	49.3	176.5	12.2	169.0	516.0	60.0
Conventional	16.0	13.1	53.7	0.0	1.0	1.0	3.0
Tomatoes							
Organic	23.0	59.2	148.3	6.5	68.0	1938.0	53.0
Conventional	4.5	4.5	58.6	0.0	1.0	1.0	0.0
Spinach							
Organic	96.0	293.9	257.0	69.5	117.0	1584.0	0.0
Conventional	47.5	46.9	84.0	0.8	1.0	19.0	0.5

Research conducted by Firman E. Bear at Rutgers University in the Natural Gardener's Catalog (1995)

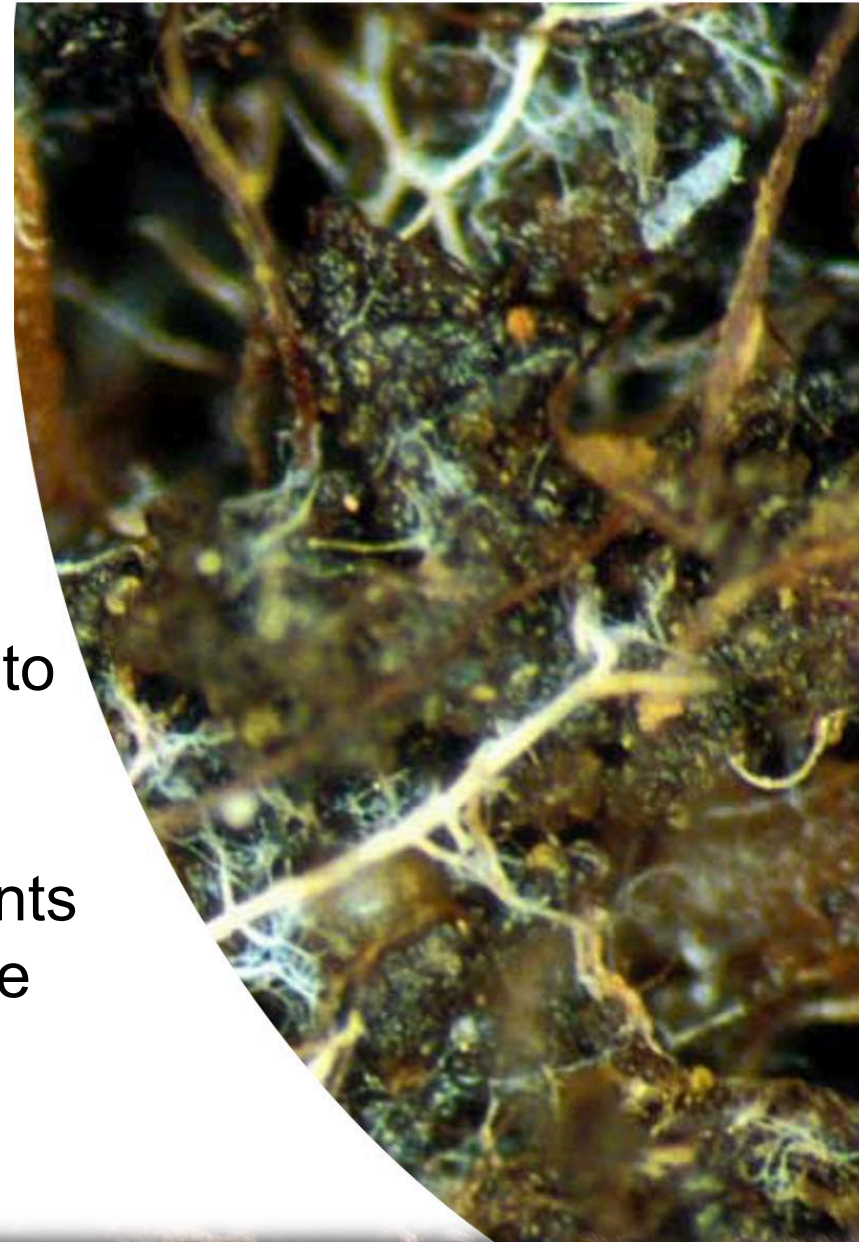


Rhizosphere is an area of high biological activity surrounding plant roots

- Most active part of the soil ecosystem
 - Most readily available food
 - Where peak nutrient and water cycling occurs

Microbial food is exuded by plant roots to attract and feed microbes.

In exchange, these microbes provide nutrients to the plant at the **root-soil interface** where the plants can take them up.

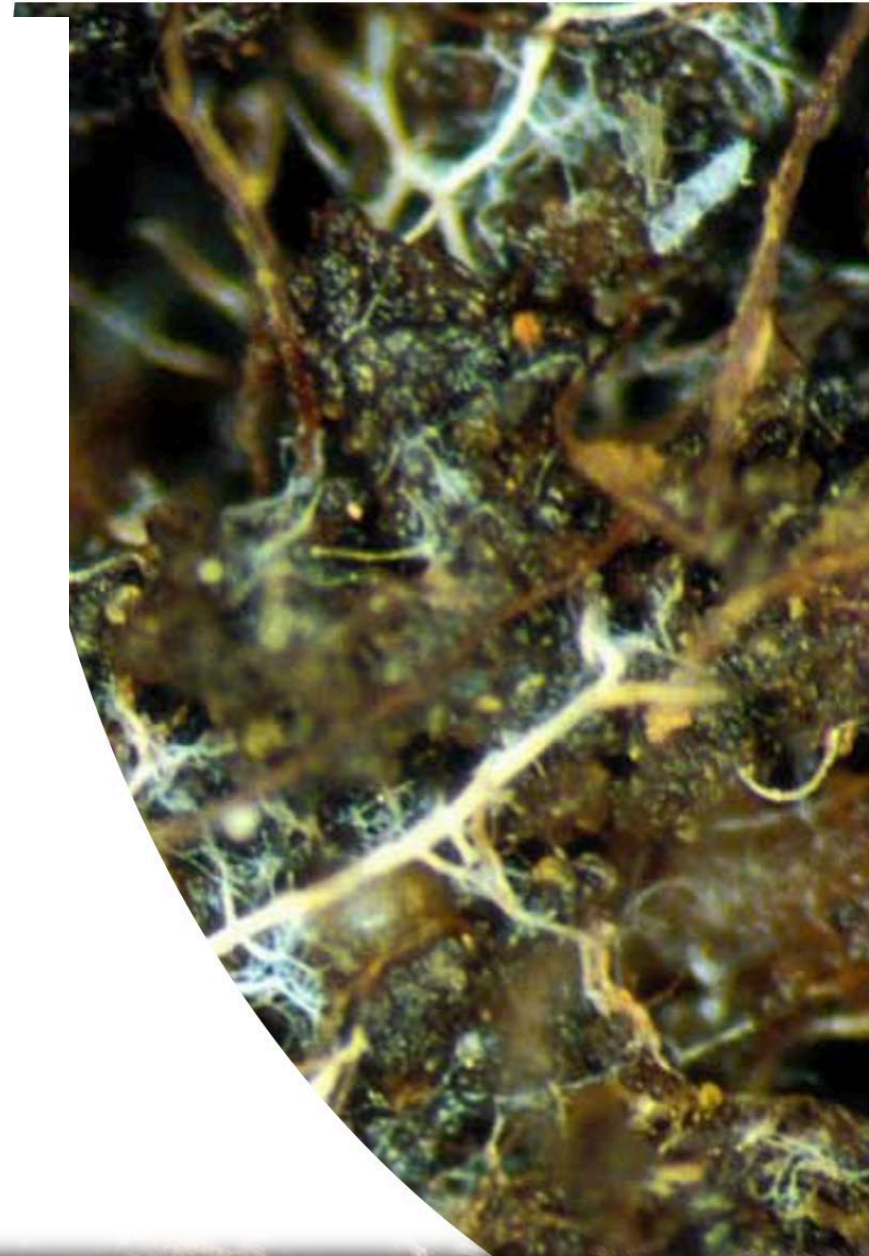


Living roots provide the easiest source of food for soil microbes.

To encourage this symbiotic relationship:

- Grow long-season crops
- Grow cover crop following a short-season crop

Sugars from living plant roots, recently dead plant roots, crop residues, and soil organic matter all feed the many and varied members of the soil food web.





Soil Health and Nutrition in Food

Dead vs. Living Soil

Microbes in our Soil

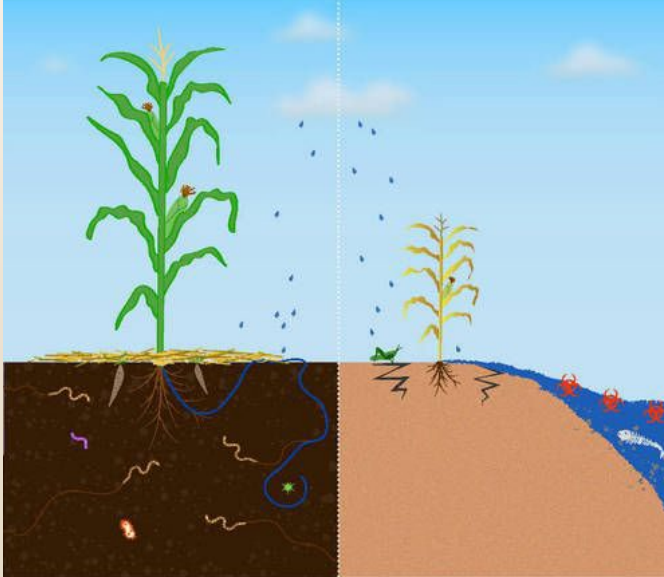
Life in Compost

Summary of Soil Health Practices

LIVING SOIL VS. DEAD SOIL

WHY SOIL MATTERS TO FARMERS AND THE ENVIRONMENT

An entire world that feeds us lives beneath our feet. Healthy soil holds a wealth of organic matter made up of worms, good bacteria, fungi and other microorganisms that work together to help crops thrive. When soil life is disturbed or unprotected, it becomes difficult for these natural soil builders to be productive and for farmers to grow their crops. Building rich, diverse, and healthy soil ecosystems is a critical life-giving farming practice. Luckily, caring for soil is one of the most effective time-tested ways farmers can increase crop yields while protecting our natural resources.



LIVING SOIL

EARTHWORMS - create vital water channels as they burrow through the soil. These channels allow rain to soak into the soil, where it can help crops grow. Earthworms also add important nutrients to the soil.

RESIDUE - or stubble from previous crops, acts like a garden mulch. It helps soil retain moisture, suppresses weeds, and prevents erosion and contaminated runoff and reduces flooding.

MICROORGANISMS - such as bacteria and fungi, help to filter contaminants and stabilize the soil to prevent erosion. They help form the glue that keeps soil intact.

COVER CROPS - are grown for the purpose of improving soil health. Cover crops deliver natural fertilizer to the soil, prevent erosion, and increase biodiversity. Their roots also create pores in the soil for better water infiltration.

DEAD SOIL

BARE SOIL - without any residue or cover is unprotected from the elements. As a result, it cracks and turns hard and dusty, more like concrete than soil. Water cannot reach the crops' roots to grow effectively. Instead, the chalky dirt becomes runoff that flows right off the field.

EROSION - is more likely to occur from unhealthy and unprotected soils. When soil from fields runs off into nearby streams, it can cause health problems and harm fish and other wildlife.

INCREASED CHEMICALS - like dangerous fertilizers and pesticides are notorious inputs that crops from unhealthy soils now rely on to grow. These chemicals can cause serious health and environmental problems if they contaminate water.

PESTS - such as insects or weeds, are more likely to invade fields when the soil ecosystem is too weak to defend itself.

Credit: David Swan, Nature Resources Defense Council
Reprinted with permission



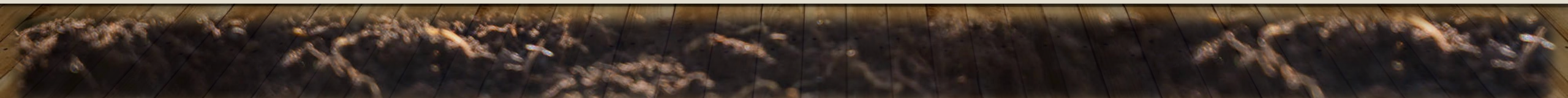
DEAD SOIL

BARE SOIL: UNPROTECTED, TURNS SOIL HARD, NON-POROUS

EROSION: NOTHING HOLDING SOIL IN PLACE

INCREASED CHEMICALS: DANGEROUS FERTILIZER AND PESTICIDE INPUTS THAT CROPS RELY ON TO GROW

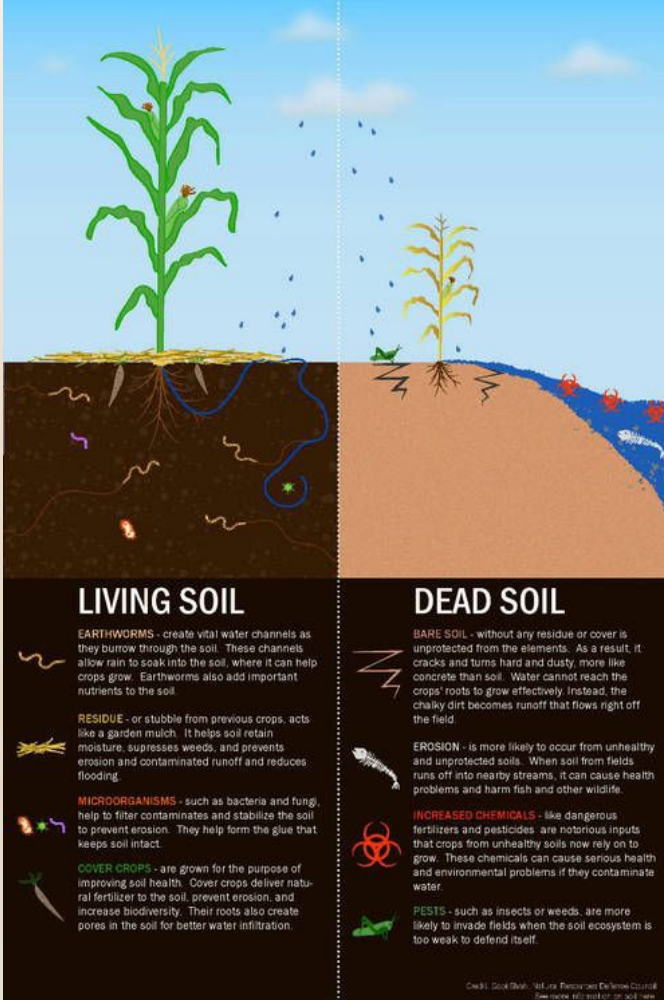
PESTS: INSECTS AND WEEDS MORE LIKELY TO INVAD



LIVING SOIL VS. DEAD SOIL

WHY SOIL MATTERS TO FARMERS AND THE ENVIRONMENT

An entire world that feeds us lives beneath our feet. Healthy soil holds a wealth of organic matter made up of worms, good bacteria, fungi and other microorganisms that work together to help crops thrive. When soil life is disturbed or unprotected, it becomes difficult for these natural soil builders to be productive and for farmers to grow their crops. Building rich, diverse, and healthy soil ecosystems is a critical life-giving farming practice. Luckily, caring for soil is one of the most effective time-tested ways farmers can increase crop yields while protecting our natural resources.



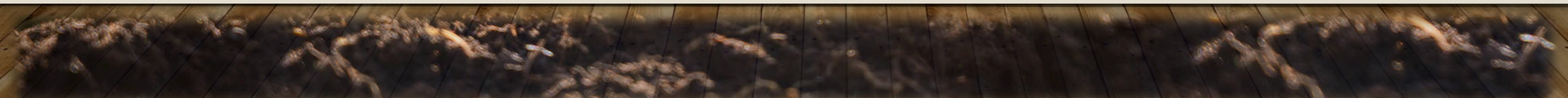
LIVING SOIL

EARTHWORMS: ADD NUTRIENTS, CREATE WATER CHANNELS

RESIDUE: FROM PREVIOUS CROPS, ACTS AS MULCH, ORGANIC MATTER

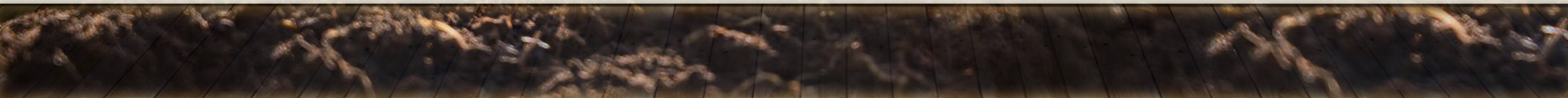
MICROORGANISMS: STABILIZE THE SOIL, FEEDS PLANTS

COVER CROPS: IMPROVE SOIL HEALTH, ADDS NUTRIENTS



Galego Court Community Gardens, Pawtucket RI

Buckwheat Cover Crop





August 8th , 2018

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Microbiologists estimate that there may be as many as 1,500,000 species of soil fungi, and 3,000,000 species of soil bacteria

... most agricultural soils have no more than 5,000 species present

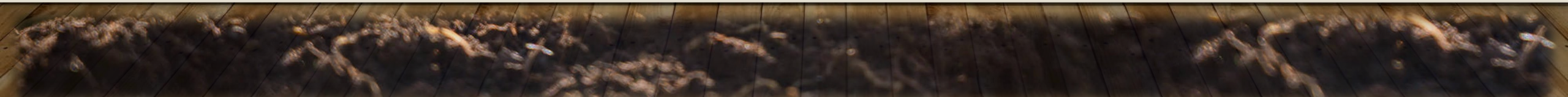


BIONUTRIENT
Food Association

Symbiotic Relationship

“In nature, plants produce sugar (through photosynthesis) that is then fed by the plant (through its roots) to beneficial micro-organisms; namely bacteria and fungi...

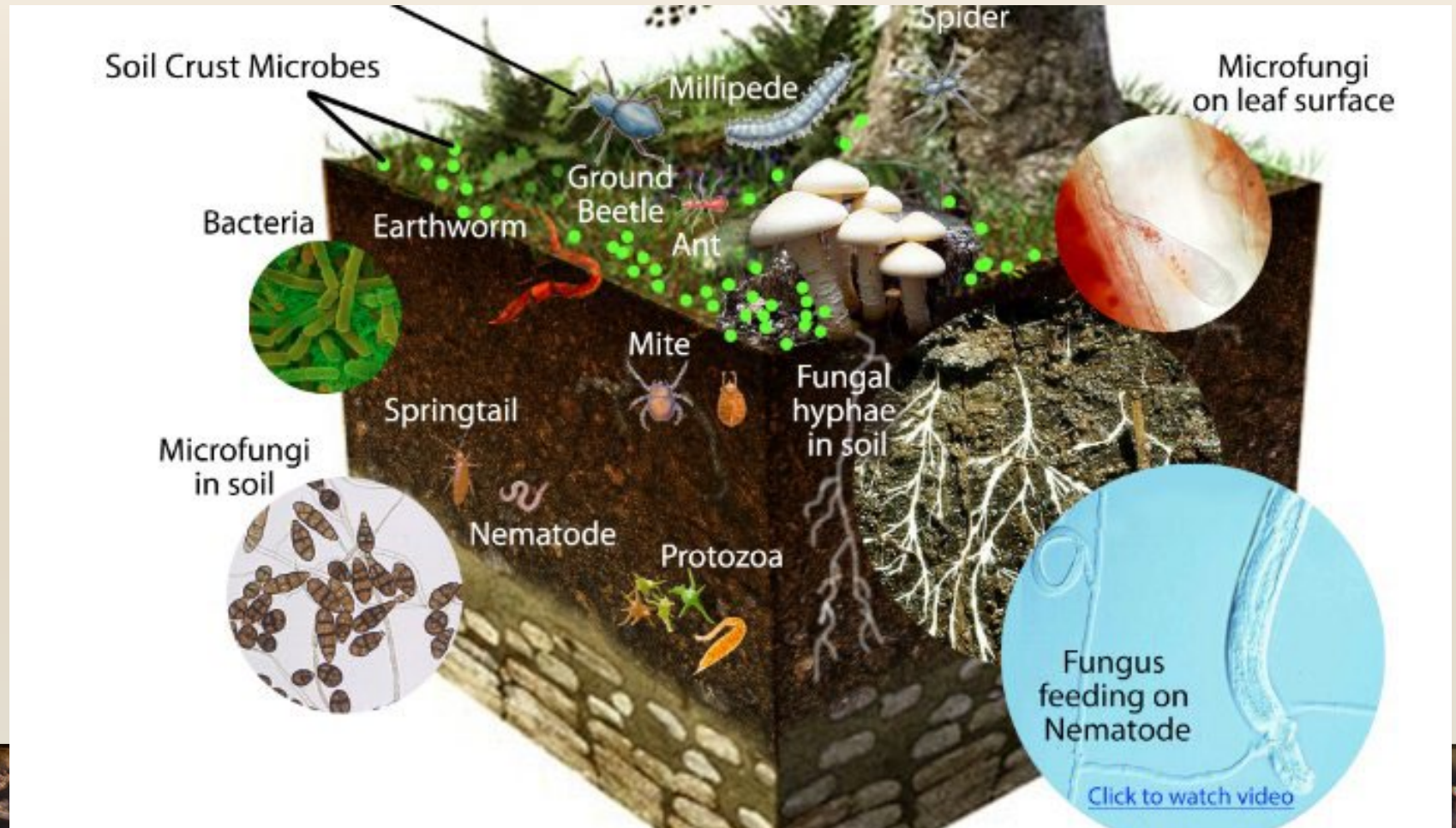
Visit <http://bionutrient.org>



Symbiotic Relationship

...These microbes use that sugar to reproduce and access minerals out of the soil. These minerals are digested and then fed back into the plant.

This symbiotic relationship is at the core of soil fertility.”



CAKES AND COOKIES

- “Roots release ‘Cakes and Cookies’ to feed microbes to:
- protect the root system from diseases and pests
- enhance nutrient cycling
- build structure to allow roots to grow”
- From the book ‘Adding Biology by Dr. Elaine Ingham.
- *(Diagram Courtesy of Soil Foodweb)*



PLANTS FEED MICROBES

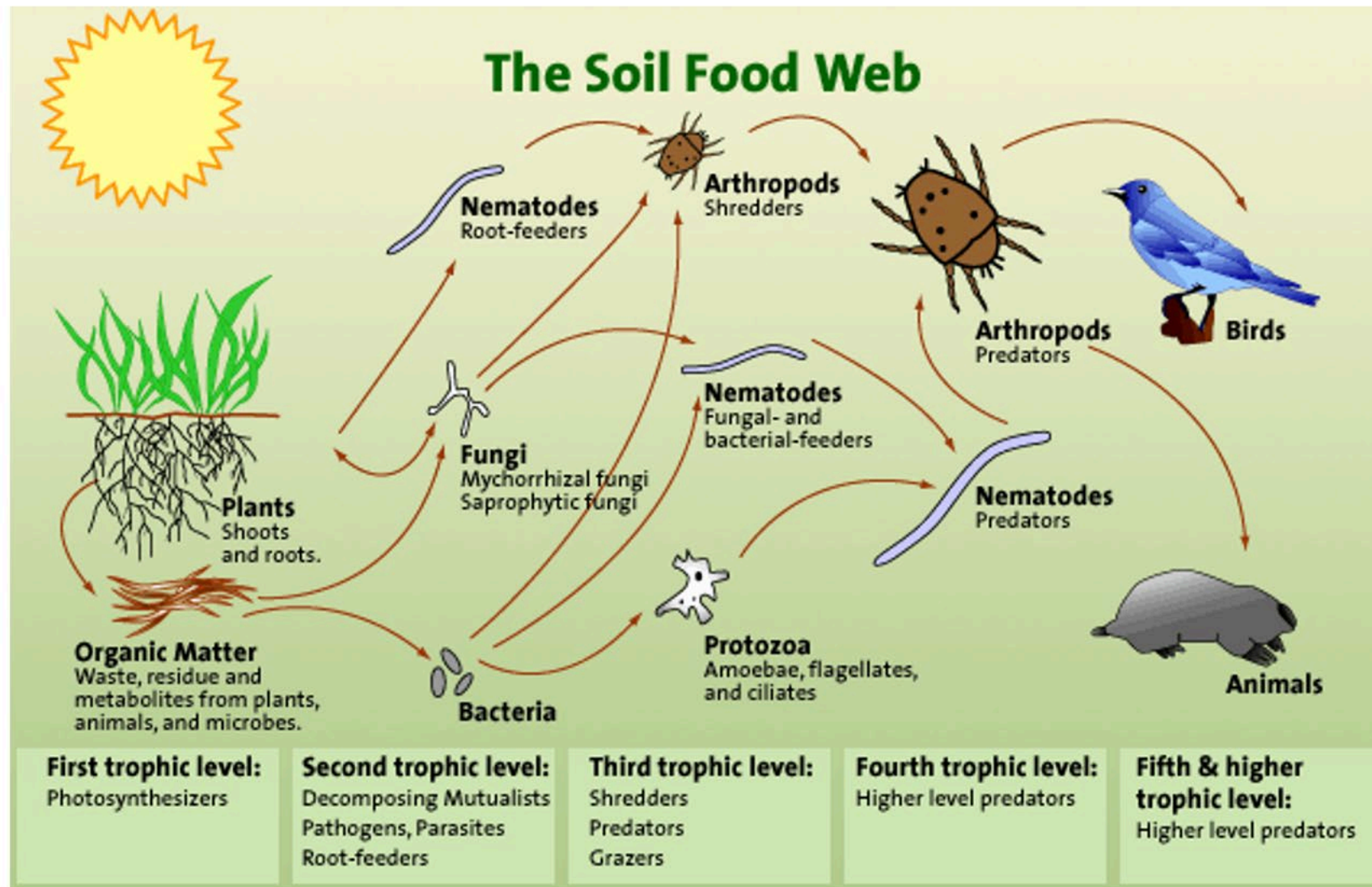
Exudates of Protein, Carbohydrates and Sugar

“Cake and Cookies”

Looking at research that the BFA has performed over the past 10 years, the resulting data shows that the main determinant of nutrient dense food is the health of the soil, namely the microbial population and diversity of microbes.

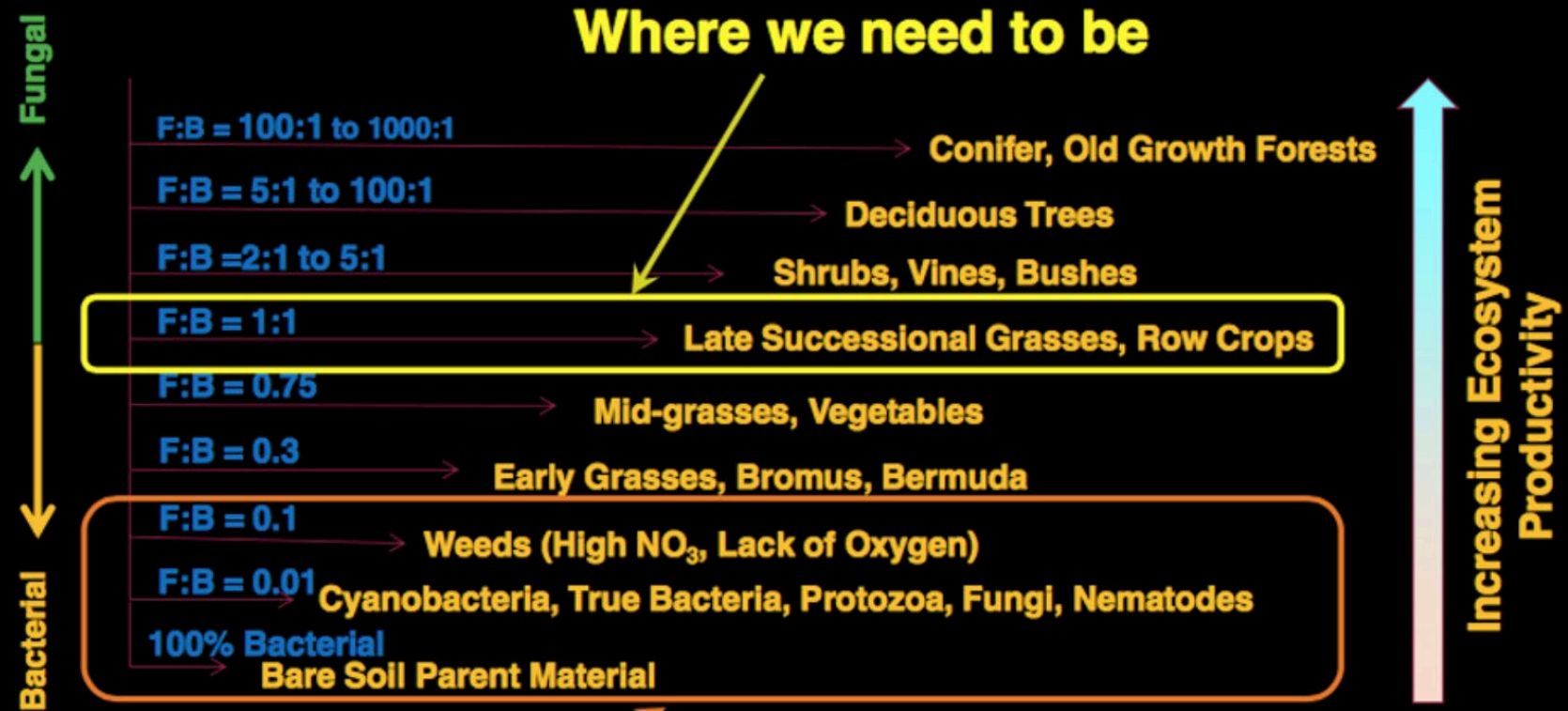


"The soil beneath us is alive! There are more organisms in a teaspoonful of healthy soil than there are people on earth."



USDA's Natural Resources Conservation Services 'Soil Biology Primer'

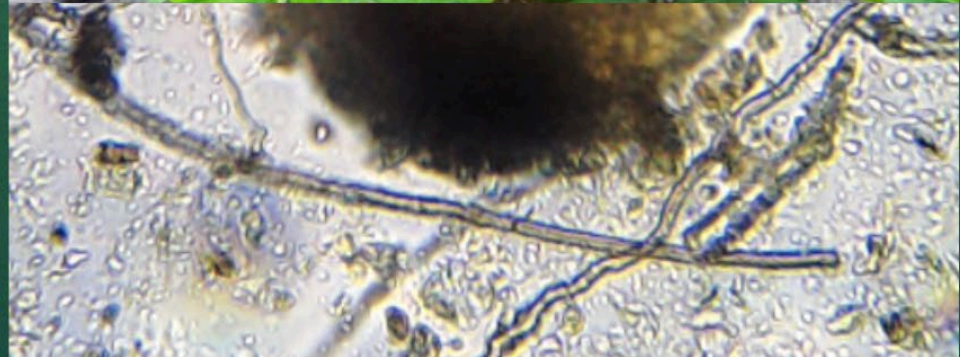
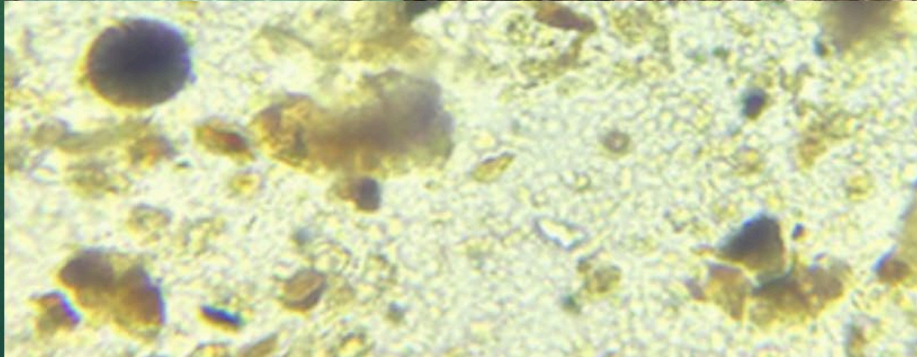
Different plants need different soil microbe communities

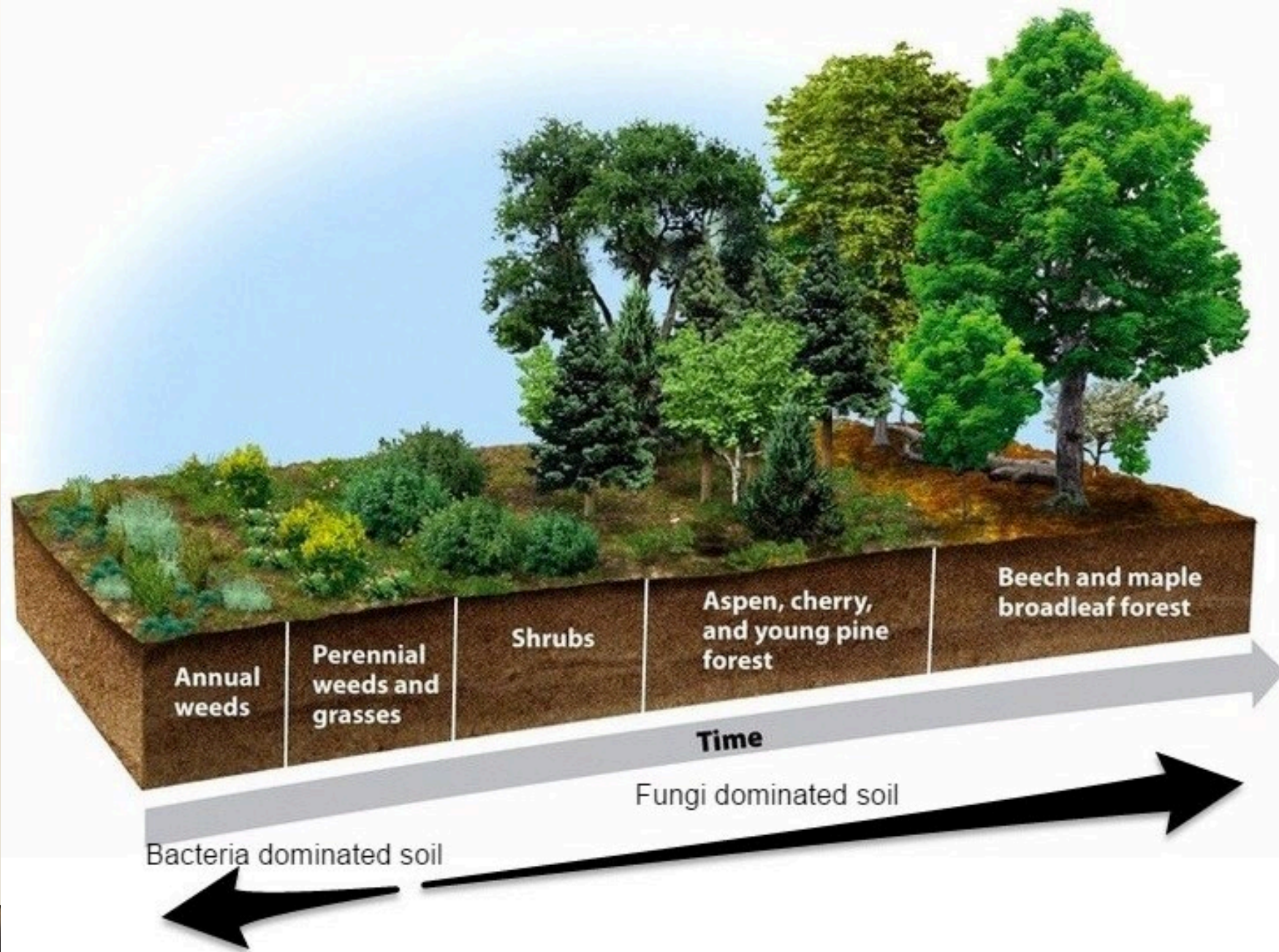


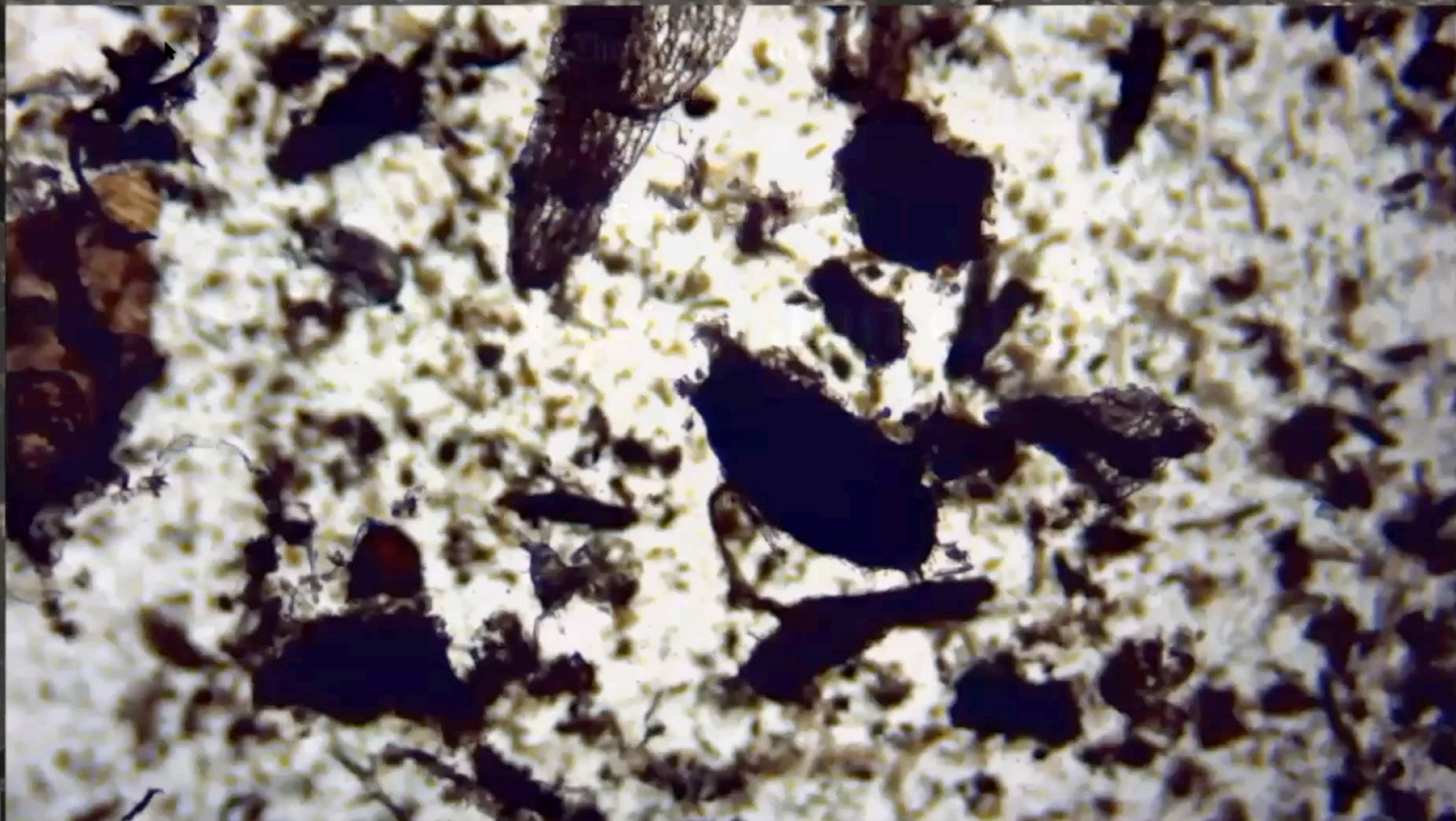
Where we are currently in agroecosystems!

Elaine Ingham- www.soilfoodweb.com

Different plants need different soil microbes

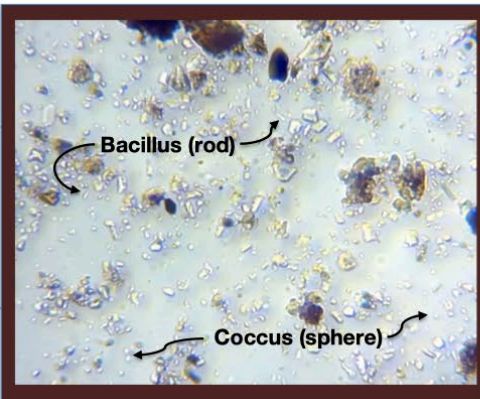




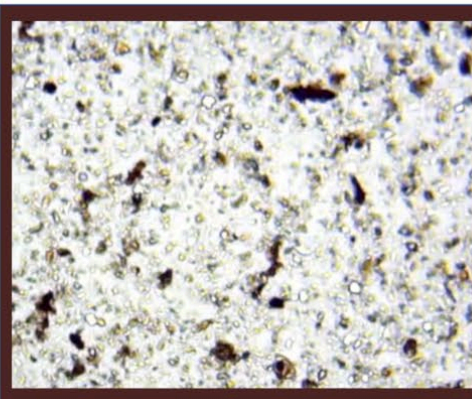




Baby pot worm, Nematode, Fungal Hyphae



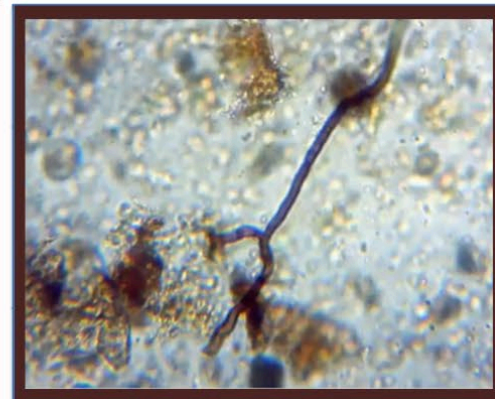
BACTERIA



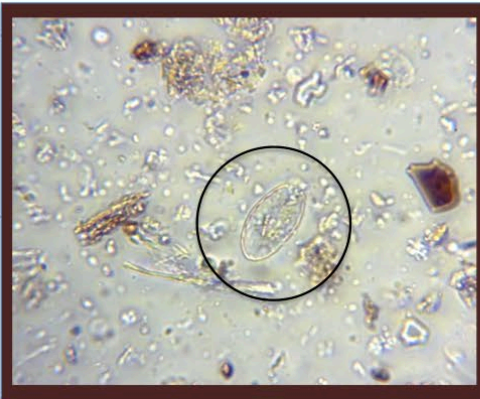
BACTERIAL DOMINANT SOIL



FUNGAL DOMINANT SOIL



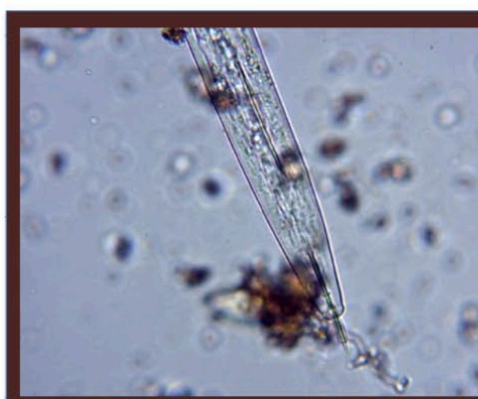
FUNGAL HYPHAE



TESTATE AMOEBA



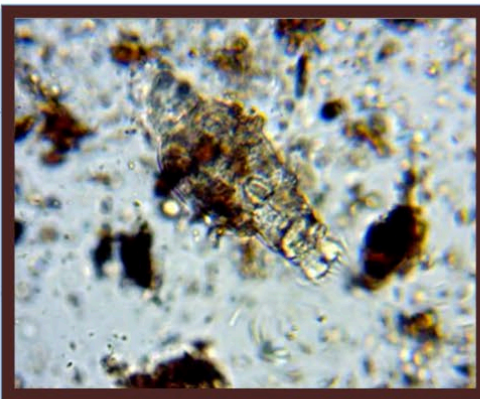
BACTERIAL FEEDING NEMATODE



FUNGAL FEEDING NEMATODE



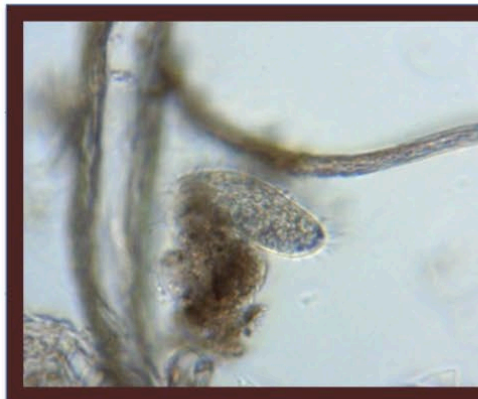
MICROARTHROPOD



ROTIFER



INSECT LARVAE



CILIATE



STALKED CILIATE

Microbes that thrive in anaerobic conditions



CILIATE 200X

Microbes that thrive in anaerobic conditions



CILIATES 100X

Microbes that thrive in anaerobic conditions



Ciliates taking over

Microbes that thrive in anaerobic conditions



VORTICELLA (STALKED CILIATE)

Microbes that thrive in anaerobic conditions



VORTICELLA (STALKED CILIATE)

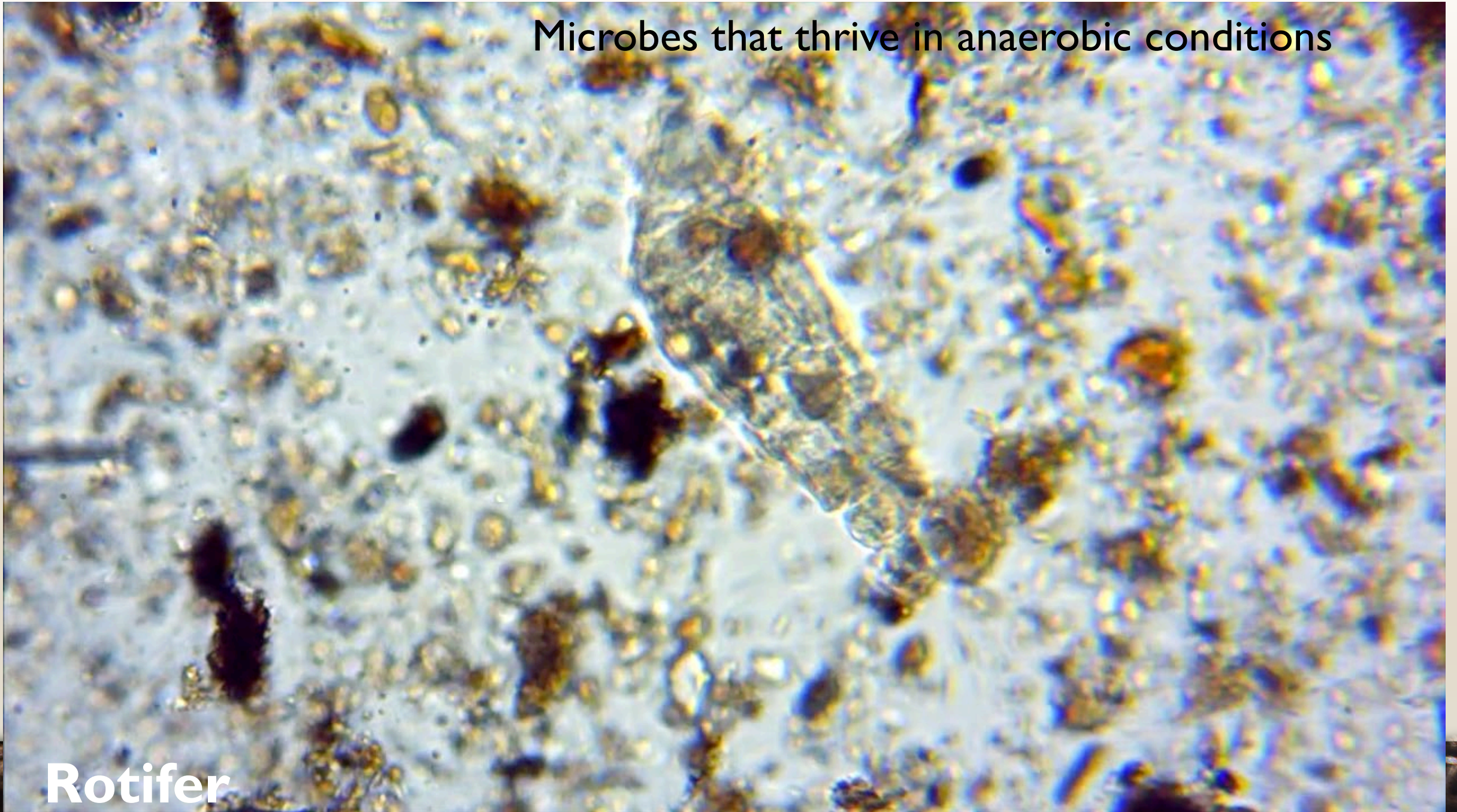
Microbes that thrive in anaerobic conditions



Insect Larvae

Microbes that thrive in anaerobic conditions

Rotifer



Microbes that thrive in anaerobic conditions

Aquatic Rotifer





Microscopy Training at Bard College at Simon's Rock

ADDING BIOLOGY

In Soil and Hydroponic Systems

For Conventional, Sustainable and Organic
Plant Growing Systems

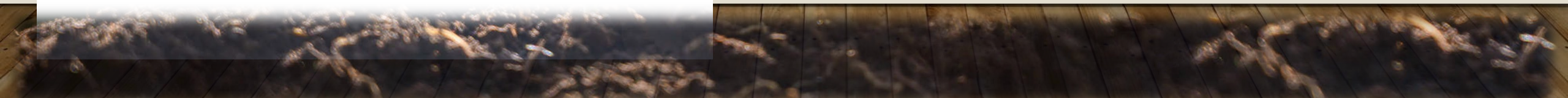
*Outdoor Applications and Indoor Controlled Environments
In Soil and Soilless Media*

Elaine R. Ingham, Ph.D.

Carole Ann Rollins, Ph.D.

“The only way to get things back in balance is to introduce the full spectrum of beneficial biology back into our growing systems through inocula such as occur in properly made compost, worm castings and compost teas.”

Dr. Elaine Ingham



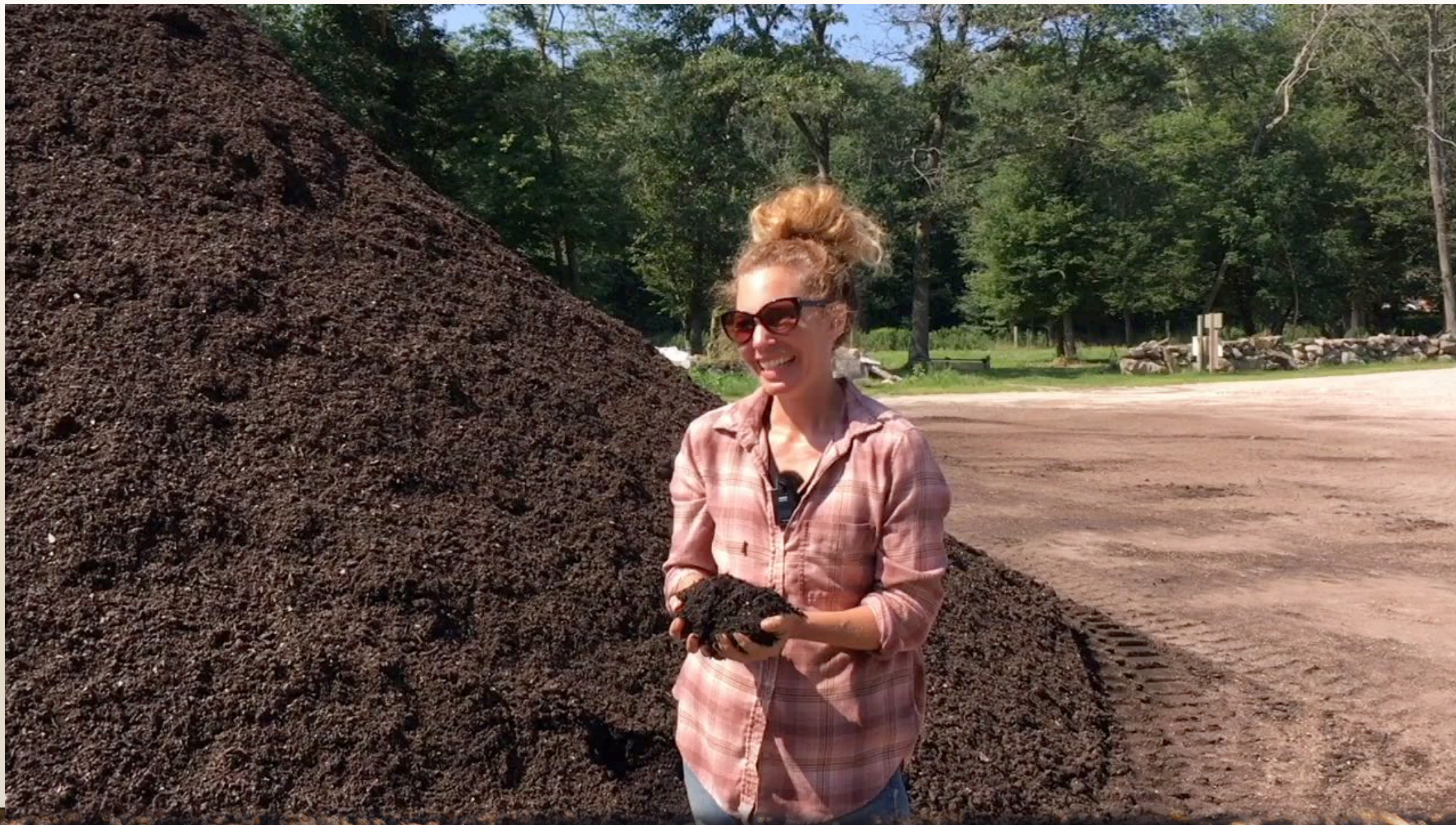
Build up the Soil Food Web by:

Add organic matter in the form of compost and mulches



Soil Health and Nutrition in Food
Dead vs. Living Soil
Microbes in our Soil
Life in Compost
Summary of Soil Health Practices





COMPOST UNDER THE MICROSCOPE

The background of the slide features a close-up, top-down view of dark, rich soil. A single wooden plank runs horizontally across the bottom of the frame. A warm, golden-yellow light emanates from the top center, creating a soft glow and lens flare effects across the upper portion of the image.

Soil Health and Nutrition in Food

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Soil Health

Build up soil and sequester carbon by:

1. Minimize or avoid chemical, physical and biological stressors



Build up soil and sequester carbon by:

1. Minimize or avoid chemical, physical and biological stressors

Chemical: artificial pesticides and fertilizers

- Actively destroy soil life
- Destabilize and degrades soil structure
- Halt soil carbon building processes

Physical: manual tilling



Soil Health
“Rototilling is equally damaging to the soil as spraying chemicals.”



Over time, high concentrations of mineral salts from synthetic fertilizers will:

- decrease microbial diversity
- alter soil pH, and damage soil structure



Build up soil and sequester carbon by:

2. Use plant diversity to increase soil diversity

MONOCULTURE vs POLYCULTURE

- Definition: growing only one species in a crops in the same space

Definition: using multiple crops in the same space, in imitation of the diversity of natural ecosystems



Build up soil and sequester carbon by:

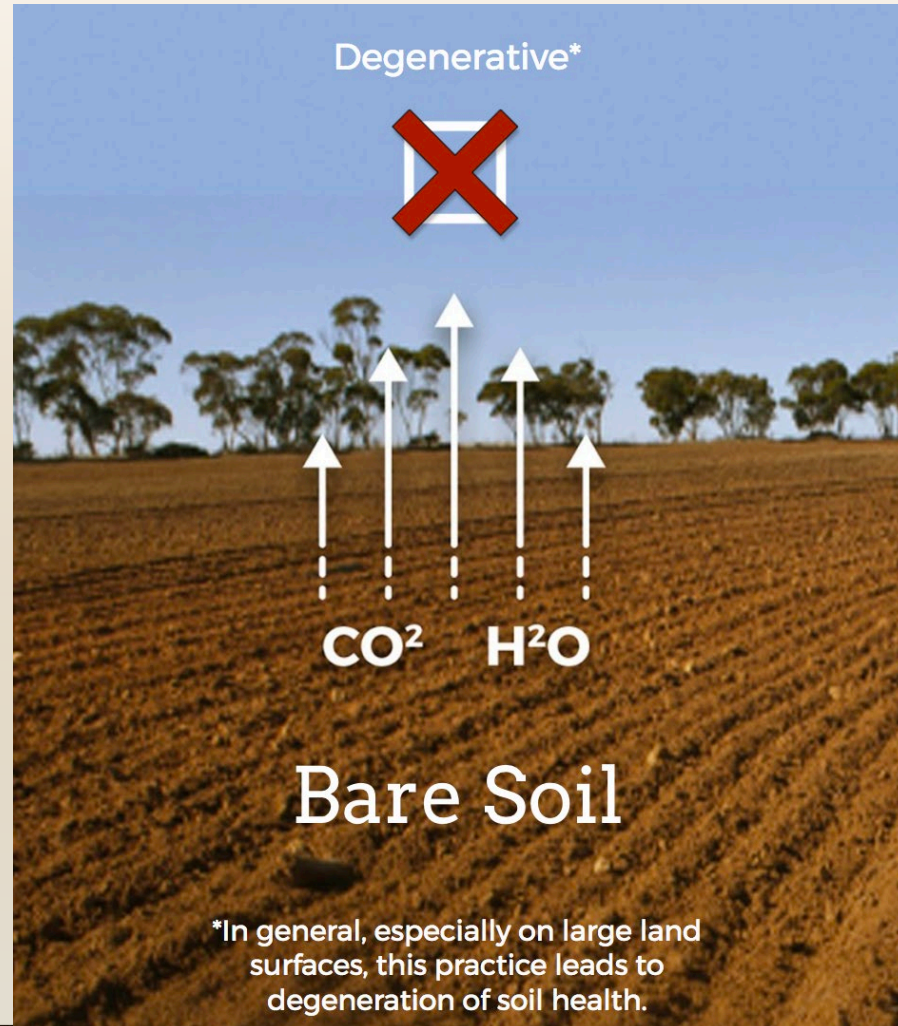
3. Keep living roots in the soil year-round to feed your soil

- Perennial plants
- Groundcovers
- Cover Crops
- Intercropping



Build up soil and sequester carbon by:

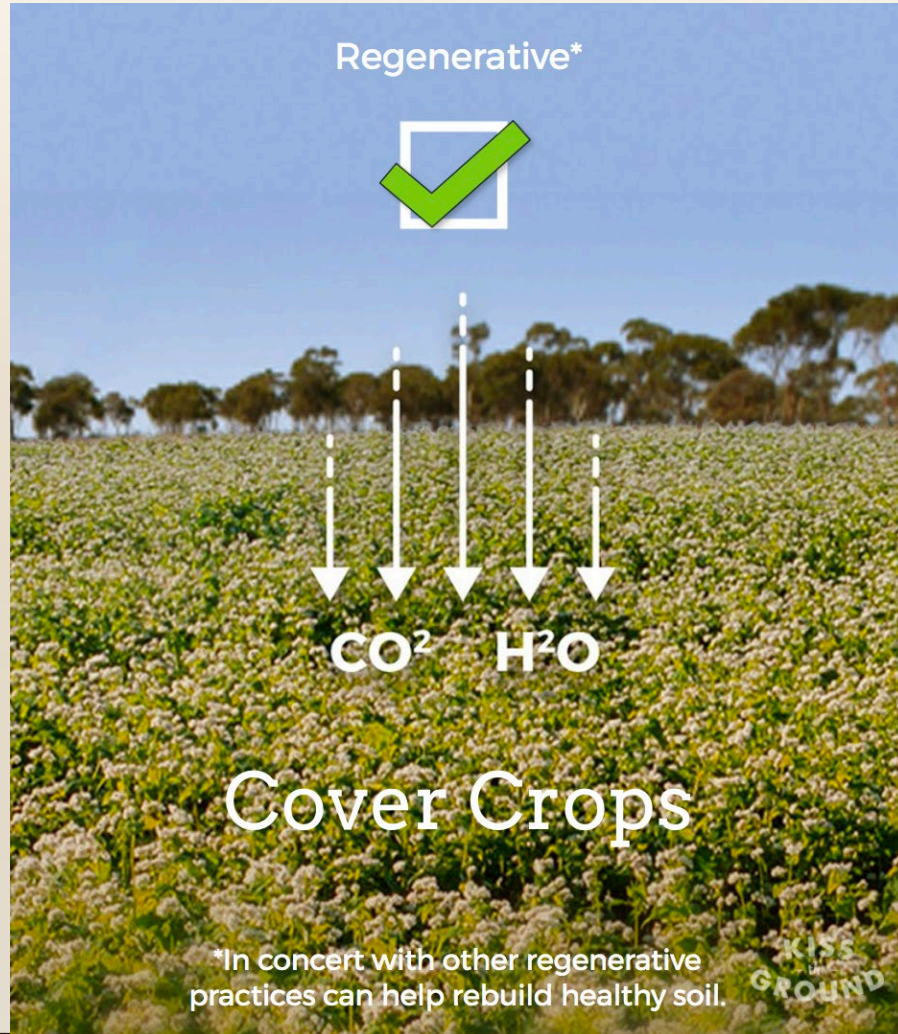
4. Keep the soil covered as much as possible



If you can see the soil, it is losing carbon, vitality, life.

Build up soil and sequester carbon by:

4. Keep the soil covered as much as possible



The most effective way to regenerate soil is to maintain living cover of diverse plants as the year as possible.

**“Essentially all life depends
on the soil. There can be
no life without soil and
no soil without life;
they have evolved together.”**

Charles E Kellogg,
USDA Yearbook of Agriculture, 1938

