Kevin M. Anderson, Ph.D, Coordinator

Center for Environmental Research at Hornsby Bend

Austin WATER

MISSION

Urban Ecology and Sustainability

- Community
- Education
- Research

PARTNERS

- Austin Water Utility
- University of Texas
- Texas A&M University

RESEARCH AREAS

- Soil Ecology, Sewage Recycling and Reuse
- Hydrogeology of the Alluvial Aquifer
- Riparian Ecology
- Avian Ecology

HBBO
Hornsby Bend Bird Observatory

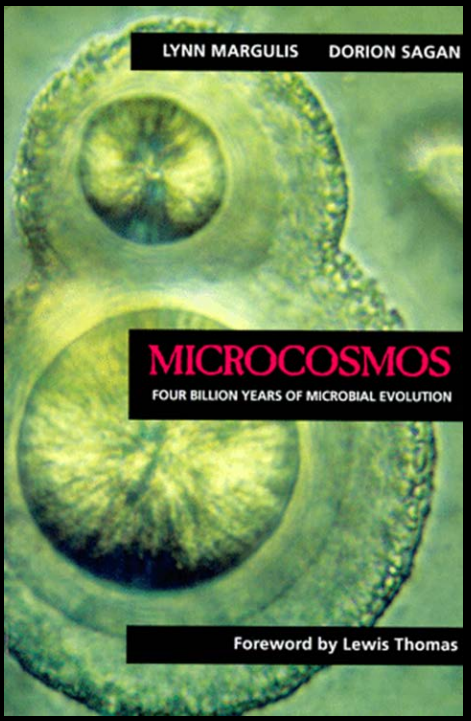
Texas Riparian Association

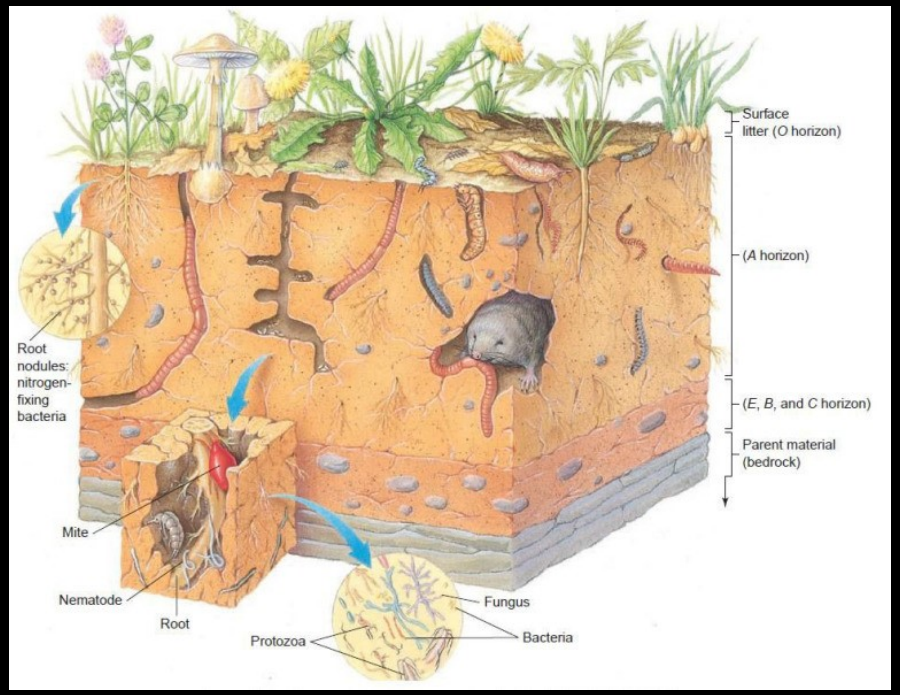
Center for Environmental Research at Hornsby Bend

Austin WATER

The Subterranean City: Soil and the Urban Microcosmos

Kevin M. Anderson, Ph.D.
Austin Water – Center for Environmental Research





The Subterranean City

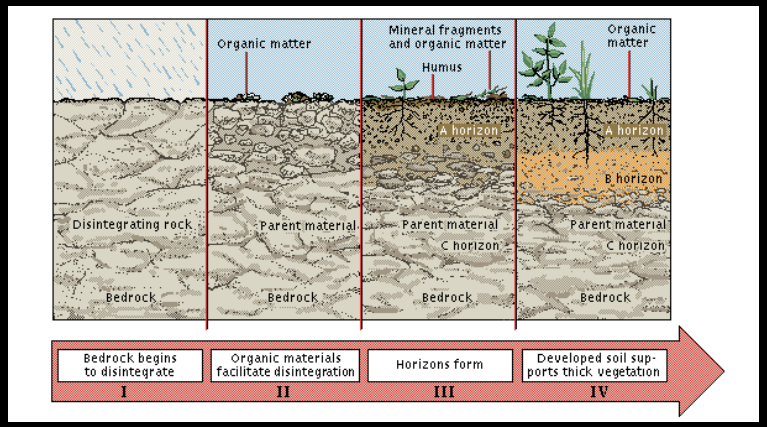
The Subterranean City

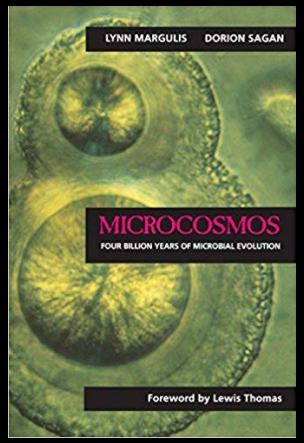
Soil and Texas

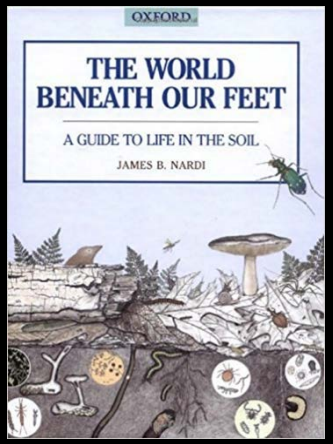
Urban Soil – Cycles and Services

Soil Ecology – Abiotic and Biotic Components

The Soil Food Web







NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

USDA United States Department of Agriculture

unlock the secrets in the soil

www.nrcs.usda.gov

"We know more about the movement of celestial bodies than about the soil underfoot."
-Leonardo da Vinci

Living in the soil are plant roots, bacteria, fungi, protozoa, algae, mites, nematodes, worms, ants, maggots, insects and grubs, and larger animals.

science of soil

soil is

made of about
45% minerals
25% water
5% organic matter
25% air

what's underneath

Healthy soil has amazing water-retention capacity.
Every **1%** increase in organic matter results in as much as **25,000** gal of available soil water per acre.

One teaspoon of healthy soil contains **100 million-1 billion** individual bacteria

All of the soil microbes in **1ac/ft** of soil weigh more than **2 cows**

Earthworm populations consume **2 tons** of dry matter per acre per year, partly digesting and mixing it with soil

what it does

Healthy soil is key to feeding **9 billion** by **2050**

Impoverished Soil Ecosystems of Texas

Farmland

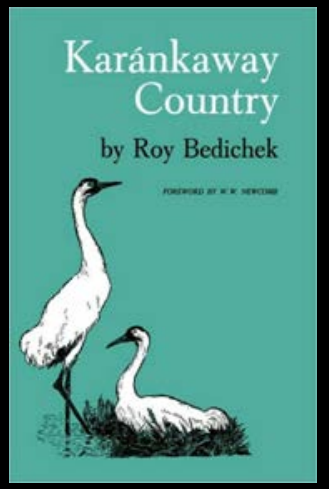
Rangeland

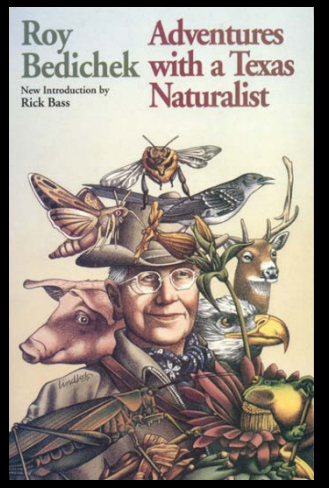
Wildland/Greenspace

Urban Landscapes

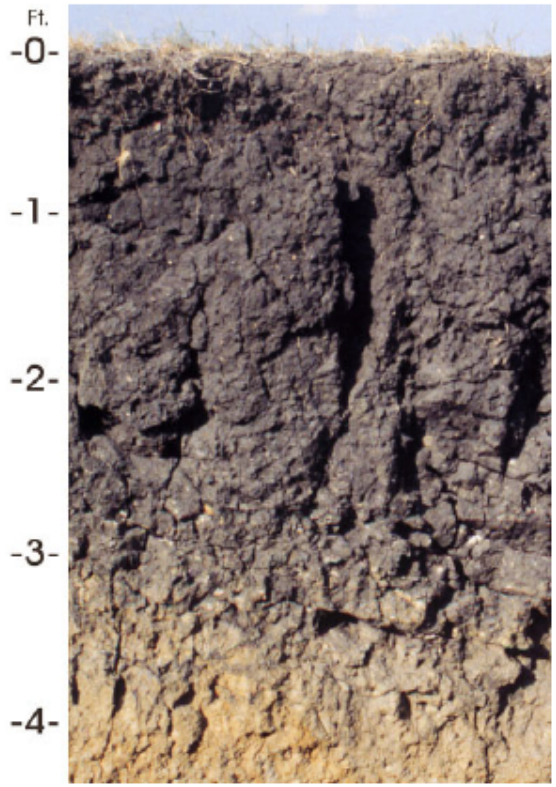
Roy Bedichek – Environmental Change in Texas

I have seen in my boyhood days the crown and upper slopes of gentle hills, on which the black soil is mixed with fragmented limestone, produce ninety bushels of oats to the acre. Now many of these slopes are all bleached out, pale as death, and really dead in so far as ability to support vegetable life is concerned. Many old-timers have seen bale-to-the-acre land in 1883 abandoned as worthless in 1903.





State Soil of Texas?



Houston Black Soil Profile
Surface layer: black clay
Subsoil - upper: black clay with slickensides
Subsoil - lower: black clay with slickensides and calcium carbonate
Substratum: light olive brown clay

The Houston Black series occurs on about 1.5 million acres in the Blackland Prairie, which extends from north of Dallas south to San Antonio. Because of their highly expansive clays, Houston Black soils are recognized throughout the world as the classic Vertisols, which shrink and swell markedly with changes in moisture content. These soils formed under prairie vegetation and in calcareous clays and marls. Water enters the soils rapidly when they are dry and cracked and very slowly when they are moist.

Houston Black soils are used extensively for grain sorghum, cotton, corn, small grain, and forage grasses. They also occur in several metropolitan areas, where their very high shrink-swell potential commonly is a limitation affecting building site development.

The Professional Soil Scientists Association of Texas has recommended to the State Legislature that the Houston Black series be designated the State soil. The series was established in 1902.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEXAS AGRICULTURAL EXPERIMENT STATION

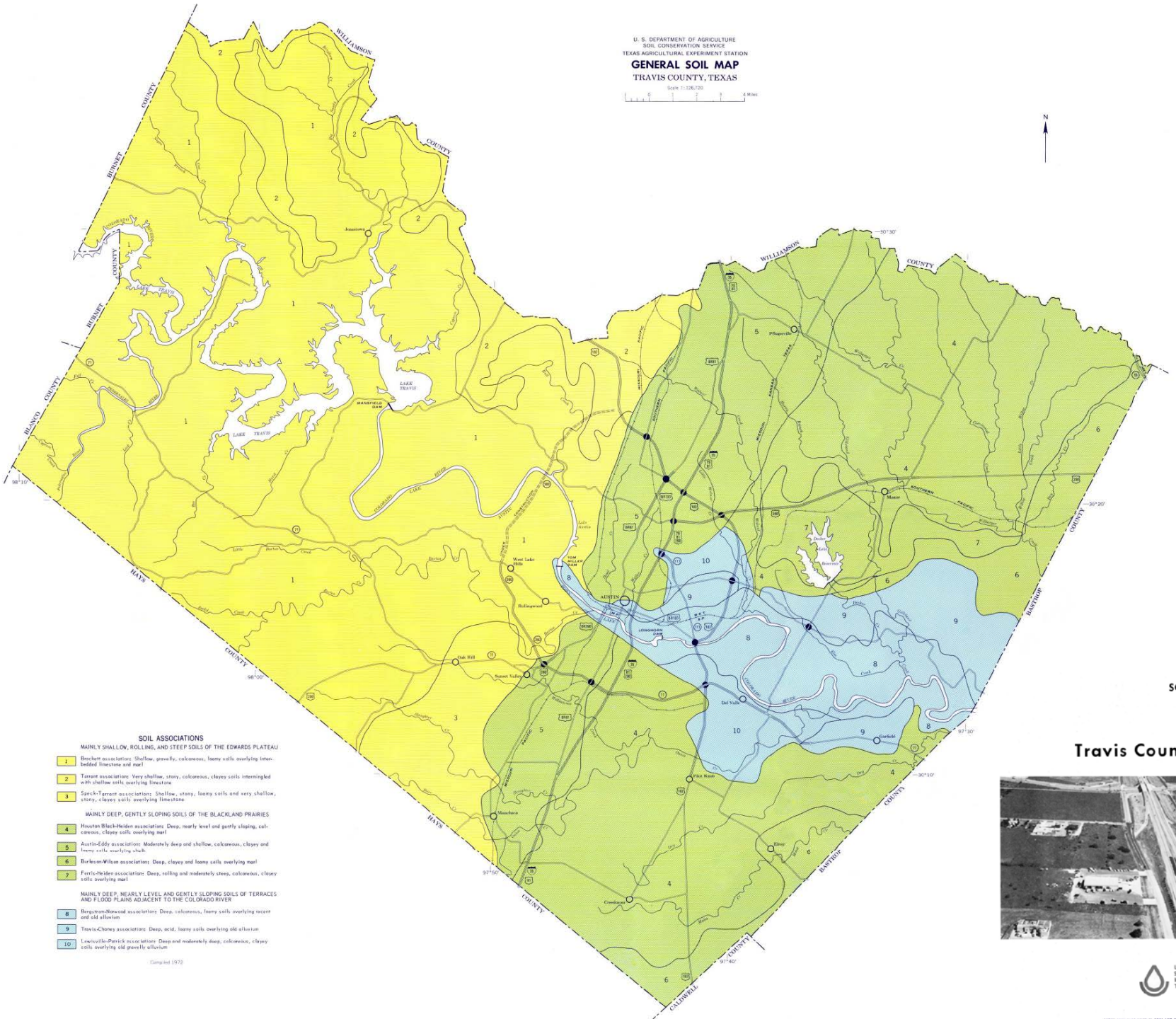
GENERAL SOIL MAP

TRAVIS COUNTY, TEXAS

Scale 1:126,720

0 1 2 3 4 Miles

N



SOIL ASSOCIATIONS

MAINLY SHALLOW, ROLLING, AND STEEP SOILS OF THE EDWARDS PLATEAU

1. Brackett association: Shallow, gravelly, calcareous, loamy soils overlying interbedded limestone and marl
2. Tarrant association: Very shallow, stony, calcareous, clayey soils intermingled with shallow soils overlying limestone
3. Speck-Tarrant association: Shallow, stony, loamy soils and very shallow, stony, clayey soils overlying limestone

MAINLY DEEP, GENTLY SLOPING SOILS OF THE BLACKLAND PRAIRIES

4. Houston Black-Heiden association: Deep, nearly level and gently sloping, calcareous, clayey soils overlying marl
5. Austin-Eddy association: Moderately deep and shallow, calcareous, clayey and loamy soils overlying chalk
6. Burleson-Wilson association: Deep, clayey and loamy soils overlying marl
7. Ferris-Heiden association: Deep, rolling and moderately steep, calcareous, clayey soils overlying marl

MAINLY DEEP, NEARLY LEVEL AND GENTLY SLOPING SOILS OF TERRACES AND FLOOD PLAINS ADJACENT TO THE COLORADO RIVER

8. Bergstrom-Norwood association: Deep, calcareous, loamy soils overlying recent and old alluvium
9. Travis-Chaney association: Deep, acid, loamy soils overlying old alluvium
10. Lewisville-Patrick association: Deep and moderately deep, calcareous, clayey soils overlying old gravelly alluvium

Compiled 1972

SOIL SURVEY OF

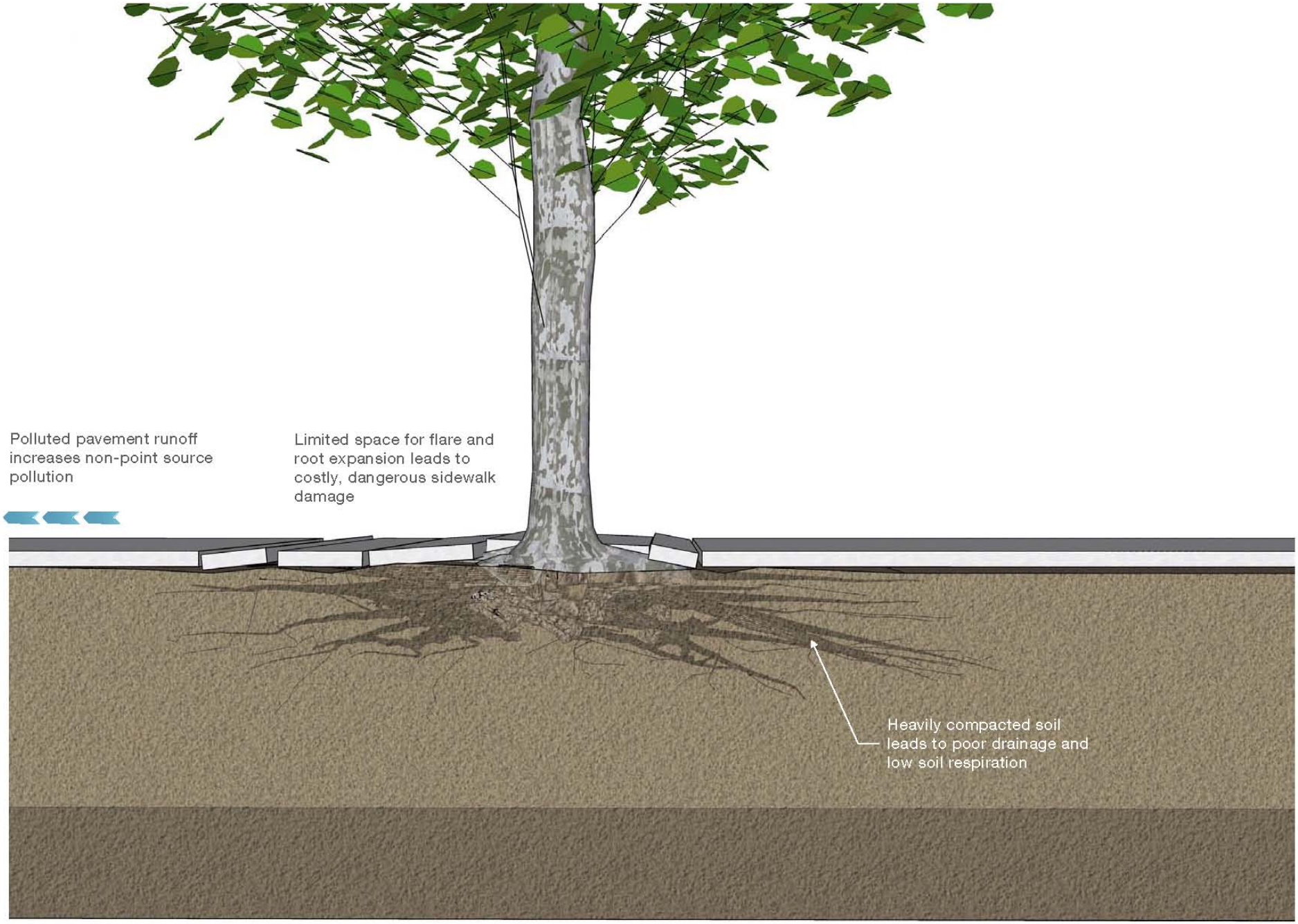
Travis County, Texas

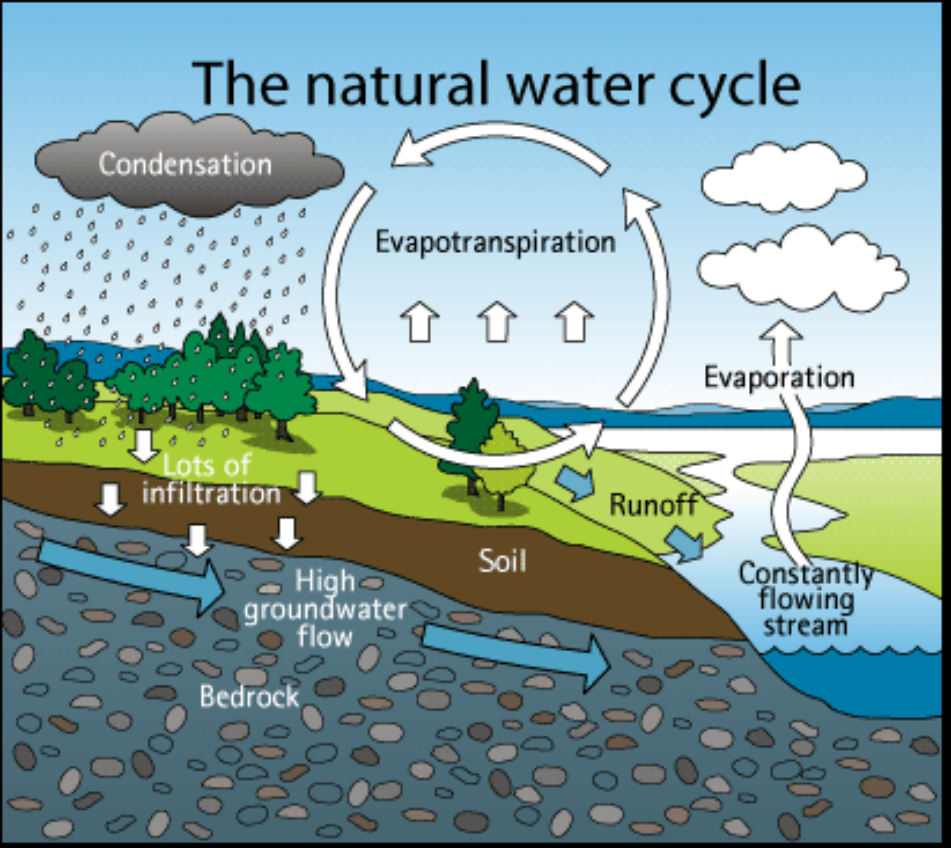
United States Department of Agriculture
Soil Conservation Service
In cooperation with
Texas Agricultural Experiment Station

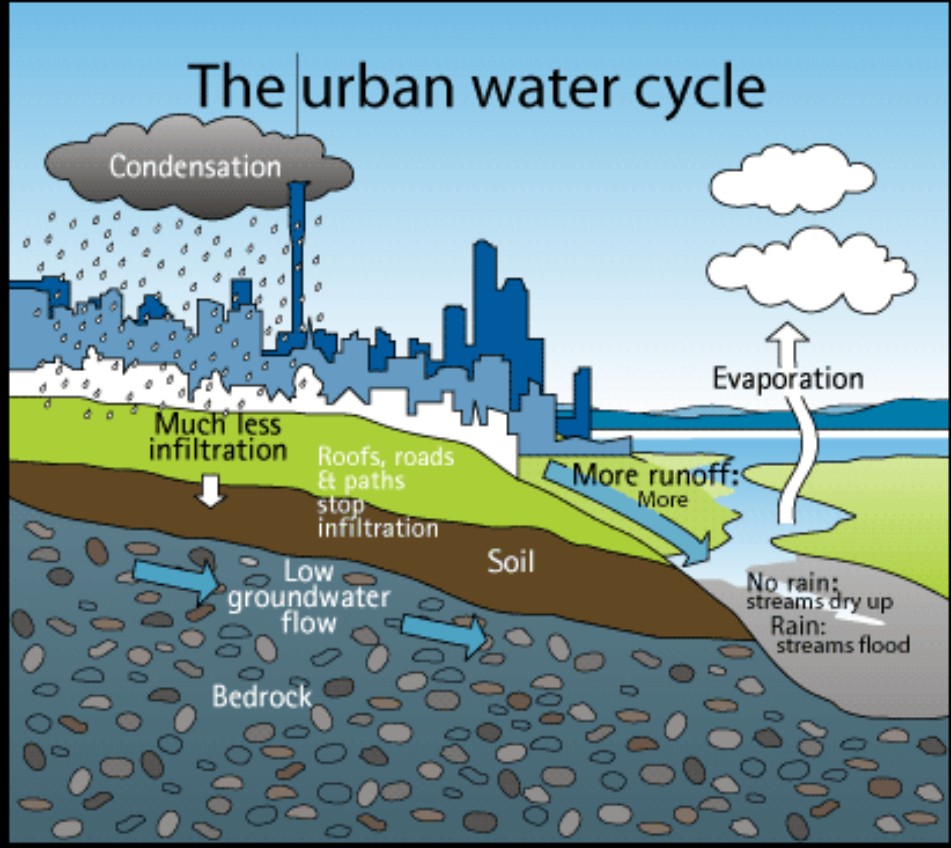
Issued June 1974

Urban Soil

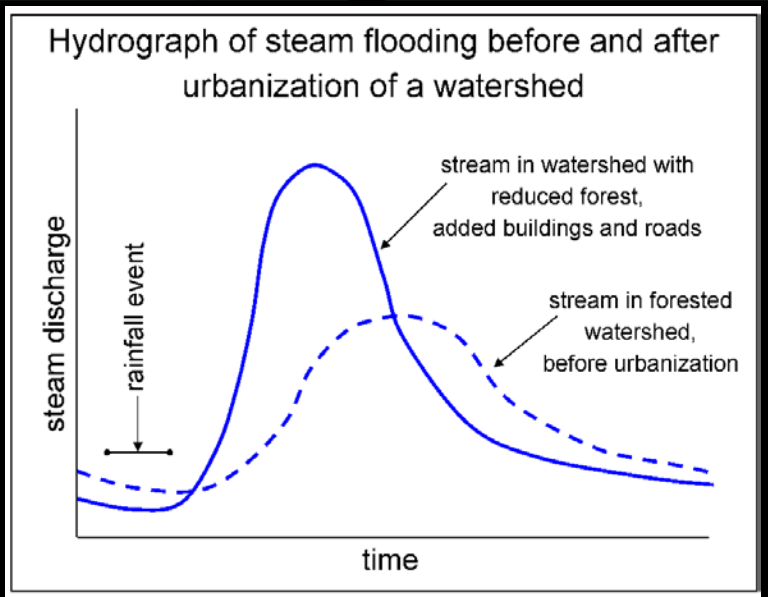
- Disturbance
- Compaction
- Low Organic Matter
- High pH
- Low water drainage
- Limited nutrient cycling
- Pollution
- High soil temperatures


Polluted pavement runoff increases non-point source pollution
Limited space for flare and root expansion leads to costly, dangerous sidewalk damage
Heavily compacted soil leads to poor drainage and low soil respiration

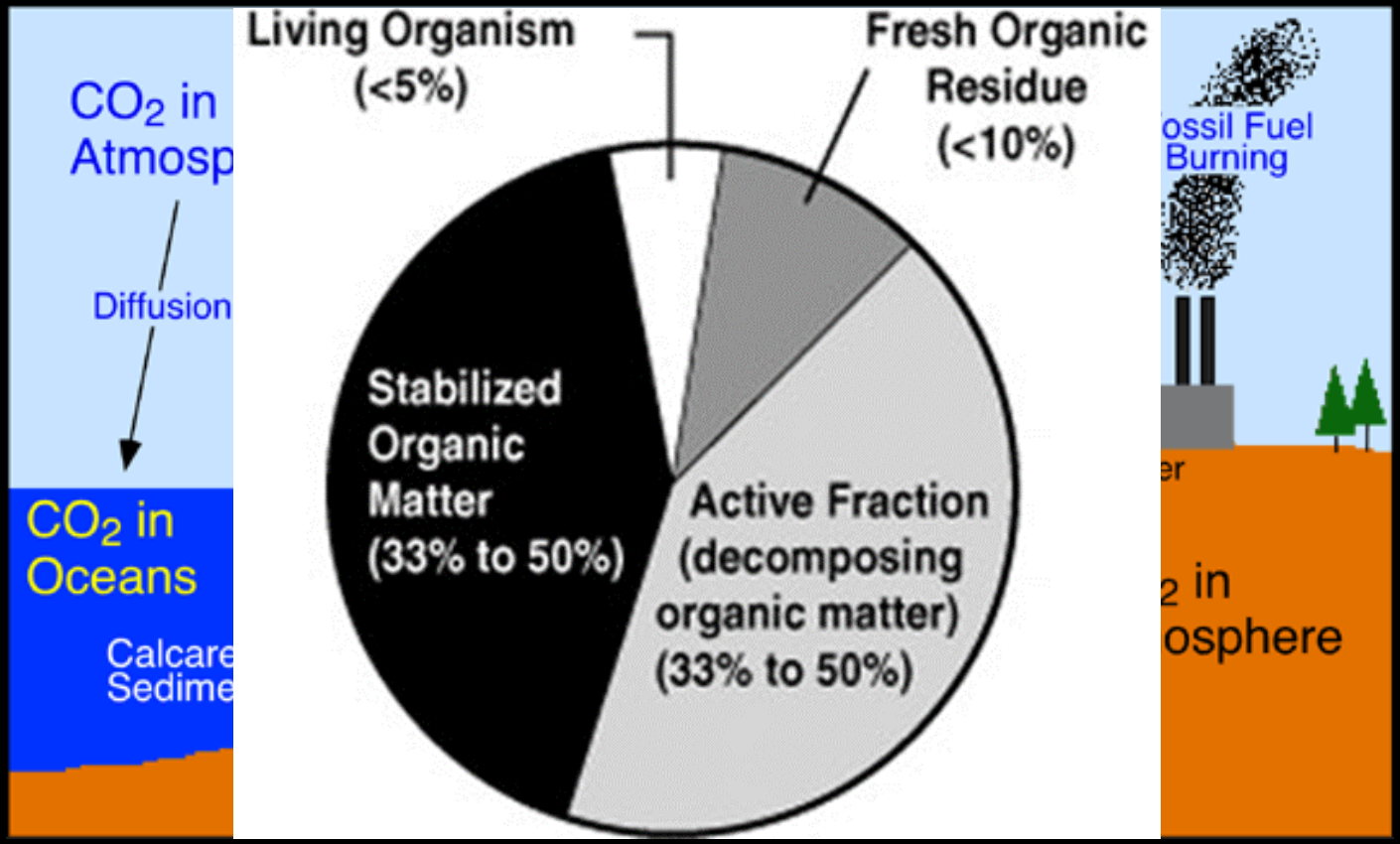




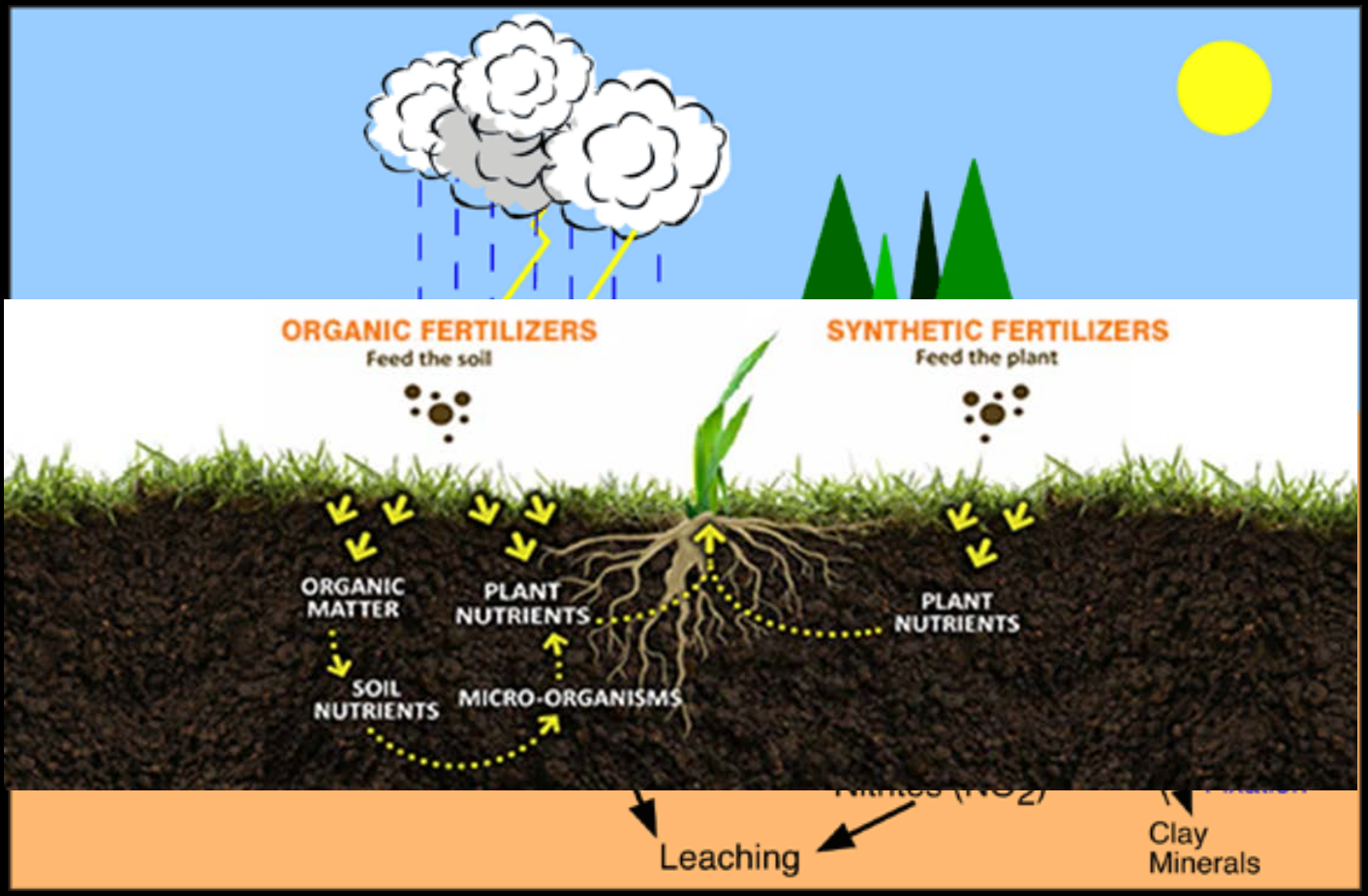
Urban Hydrology



The Carbon Cycle



The Nitrogen Cycle



Ecosystem Services

Hornsby Bend and the Urban soil ecosystem

Inputs – N and C drawn from soils – food, landscaping

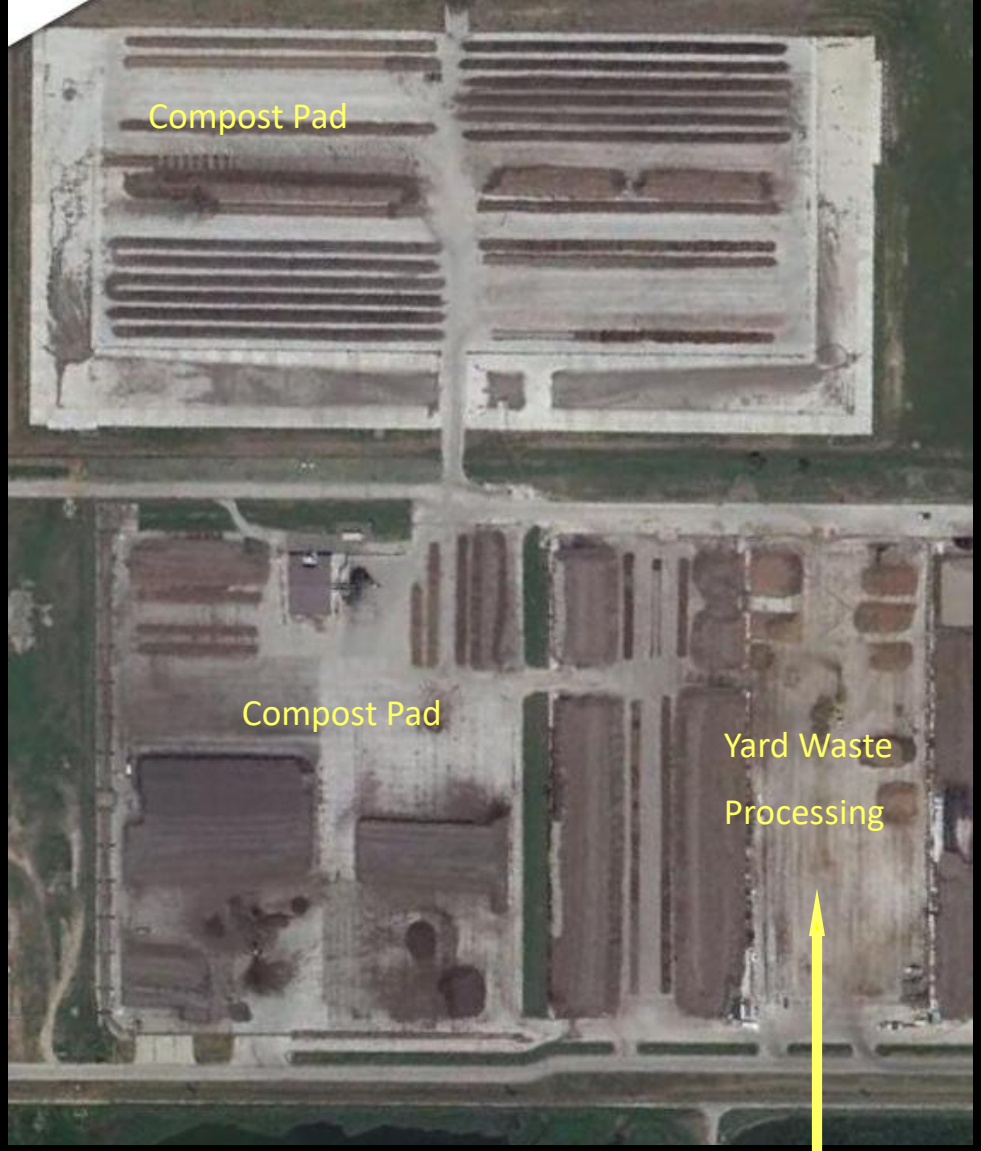
Outputs - N rich “wastes” and C “wastes”

Composting

3 parts yard waste [carbon]

1 part biosolids [nitrogen/phosphorus]

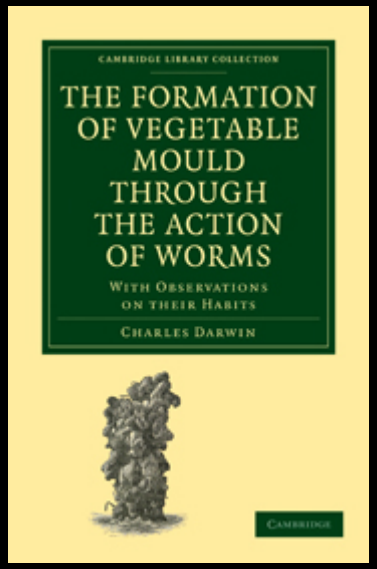
<u>Soil Organic Matter</u>



RESEARCH AREA – Soil Ecology and Urban Waste Recycling

Center for Environmental Research at Hornsby Bend

Austin WATER



RESEARCH AREA – Soil Ecology and Urban Waste Recycling

Center for Environmental Research at Hornsby Bend

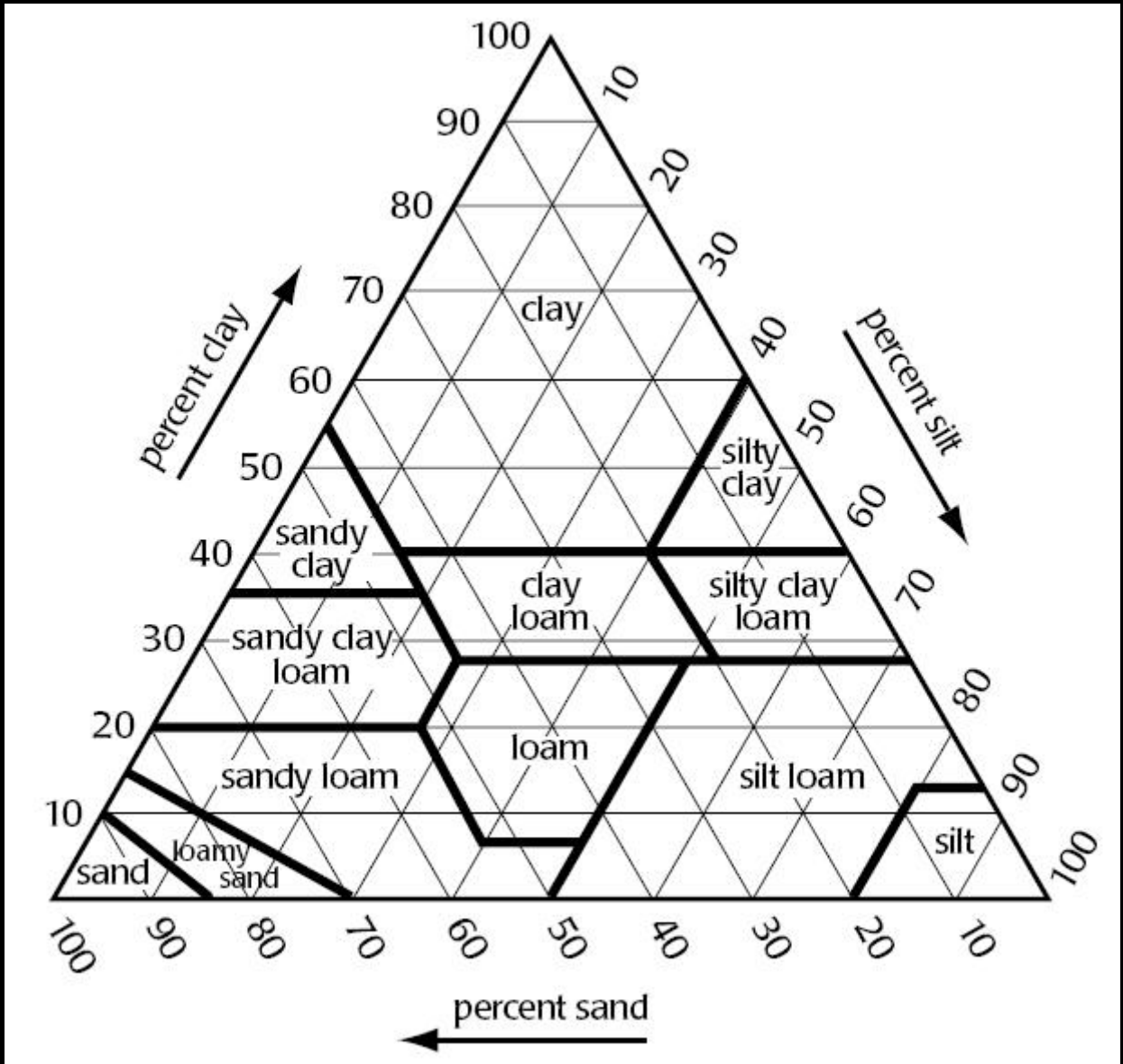
Austin WATER

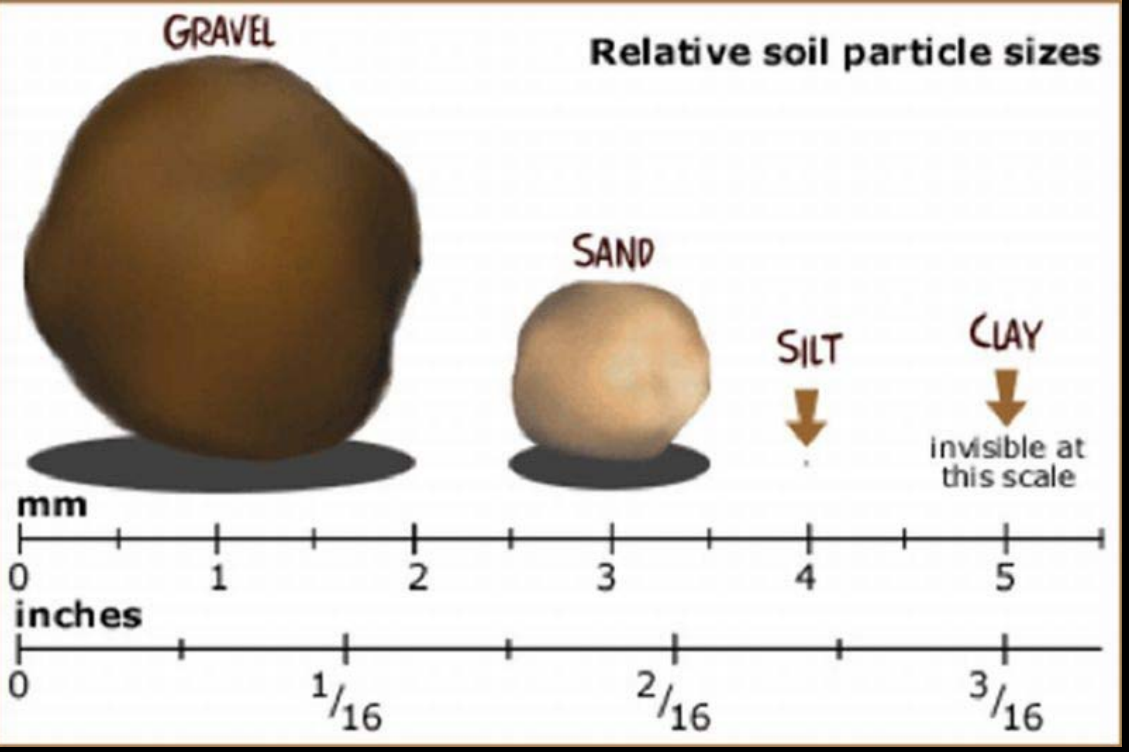
Earthworm populations were surveyed in soils from a variety of habitats associated with the Hornsby Bend Biosolids Management Plant, Austin, Texas, from November 2009 through March 2010. Seven species of terrestrial Oligochaeta, including one species new to science

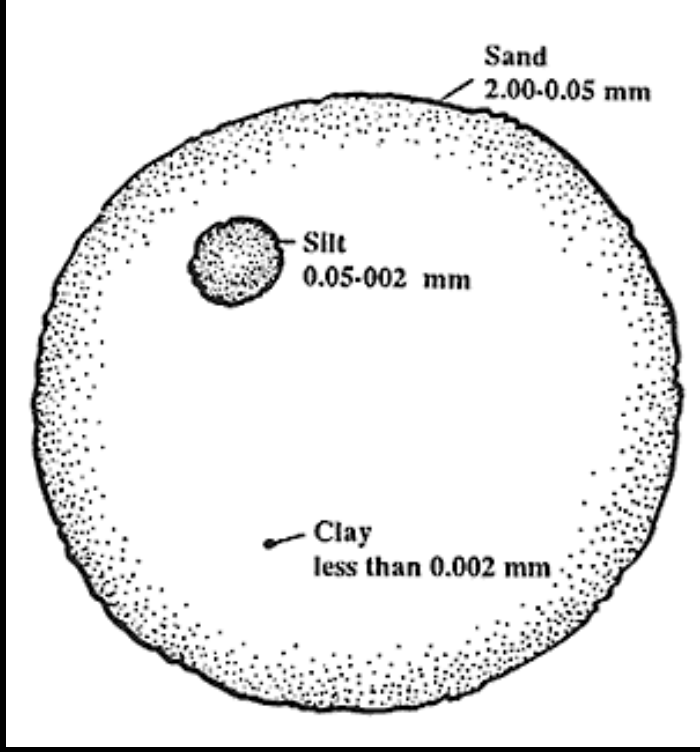
EARTHWORMS (OLIGOCHAETA: ACANTHODRILIDAE AND LUMBRICIDAE) ASSOCIATED WITH HORNSBY BEND BIOSOLIDS MANAGEMENT PLANT, TRAVIS COUNTY, TEXAS, USA.

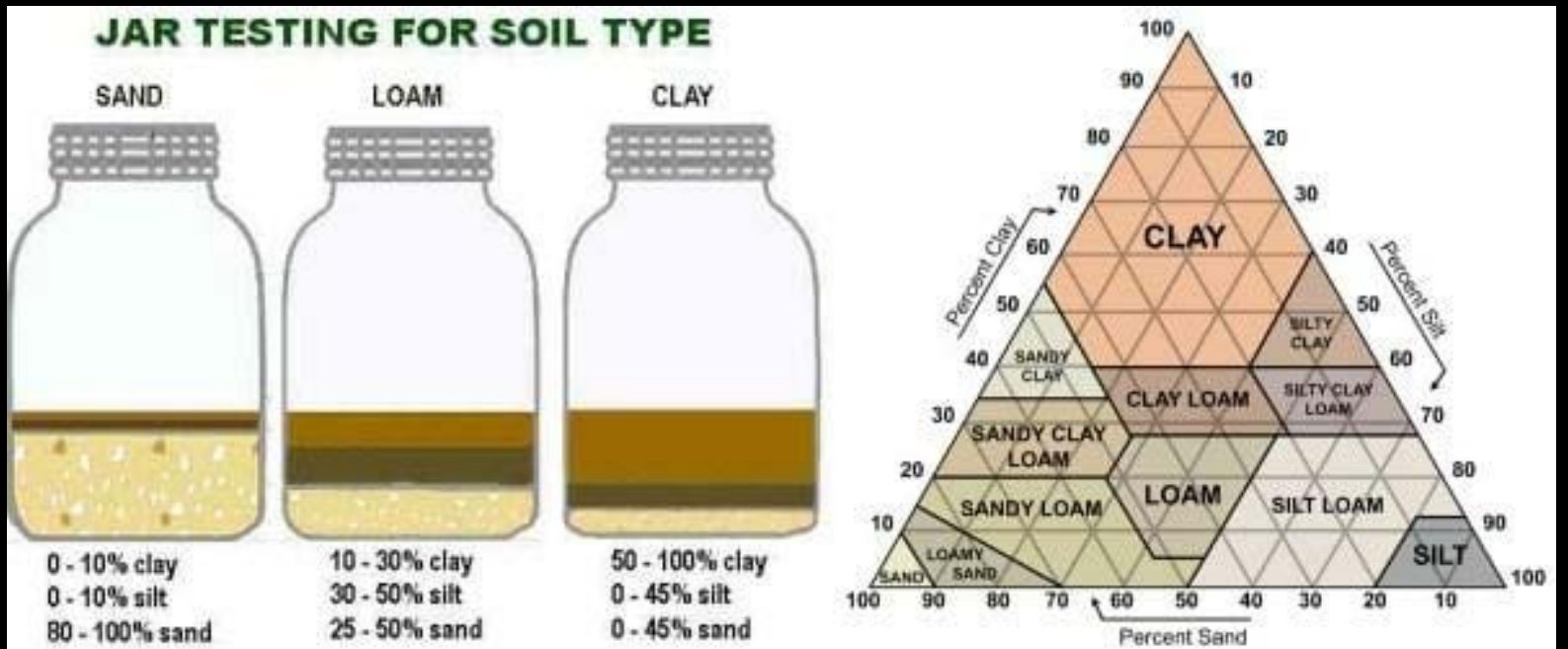
George A. Damoff
Stephen F. Austin State University, Arthur Temple College of Forestry and Agriculture

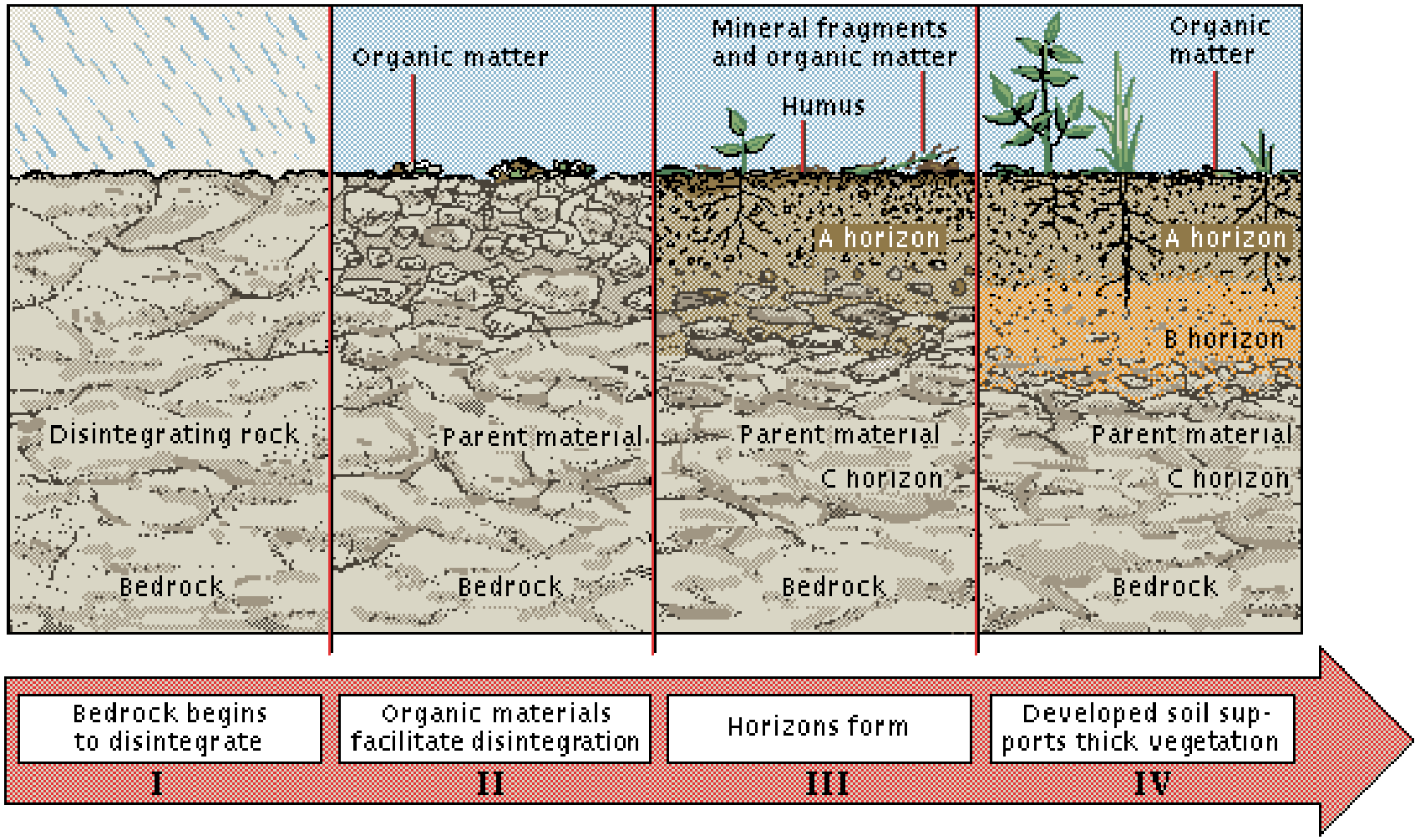
Soil Science
Abiotic Components




GRAVEL
Relative soil particle sizes
SAND
SILT
CLAY
invisible at this scale
mm
0
1
2
3
4
5
inches
0
1/16
2/16
3/16


Sand
2.00-0.05 mm
Silt
0.05-002 mm
Clay
less than 0.002 mm


JAR TESTING FOR SOIL TYPE
SAND
LOAM
CLAY
0 - 10% clay
0 - 10% silt
80 - 100% sand
10 - 30% clay
30 - 50% silt
25 - 50% sand
50 - 100% clay
0 - 45% silt
0 - 45% sand
Percent Clay
Percent Silt
Percent Sand
CLAY
SILTY CLAY
SANDY CLAY
CLAY LOAM
SILTY CLAY LOAM
SANDY CLAY LOAM
LOAM
SILT LOAM
SANDY LOAM
SILT
LOAMY SAND
SAND


Organic matter
Mineral fragments and organic matter
Humus
Organic matter
A horizon
A horizon
B horizon
Disintegrating rock
Parent material
Parent material
C horizon
Parent material
C horizon
Bedrock
Bedrock
Bedrock
Bedrock
Bedrock begins to disintegrate
Organic materials facilitate disintegration
Horizons form
Developed soil supports thick vegetation
I
II
III
IV

What is a soil profile?

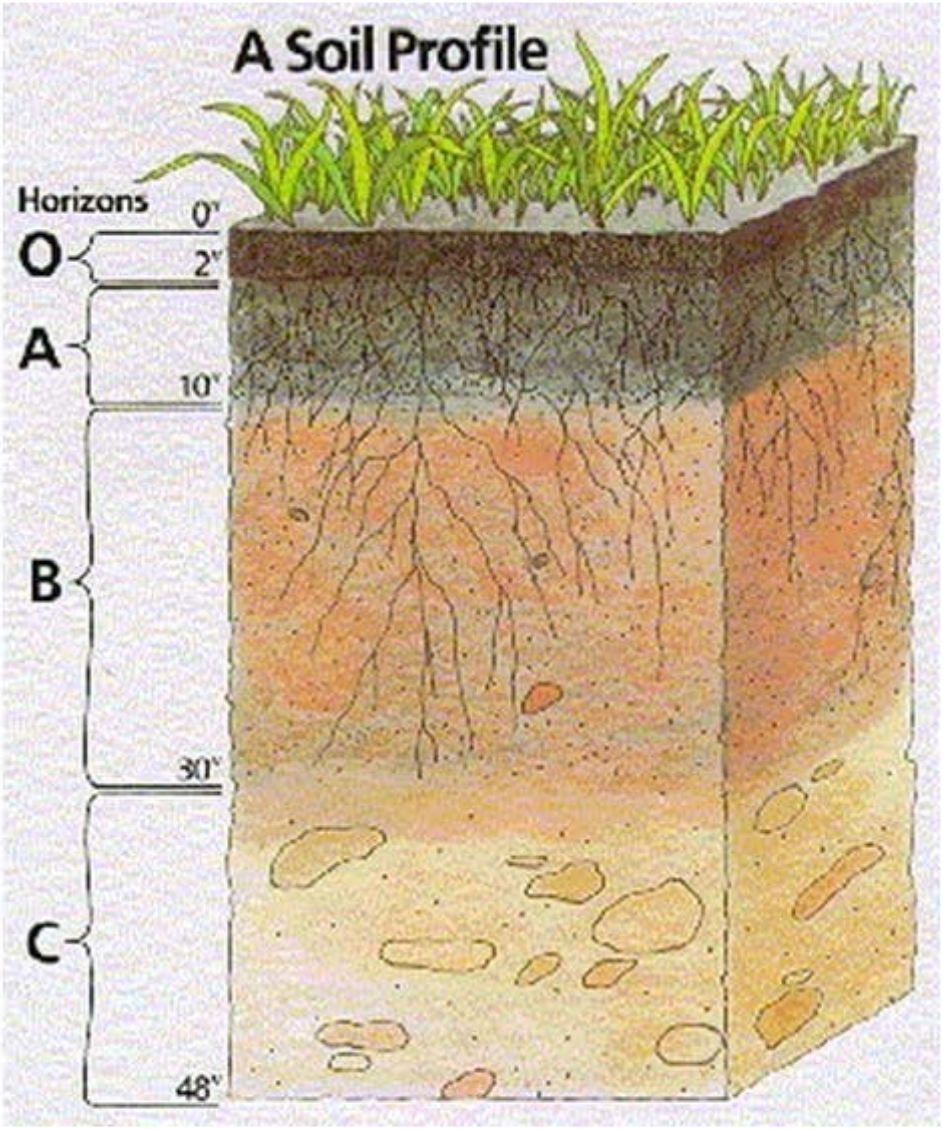
A soil profile consists of several **soil horizons**.

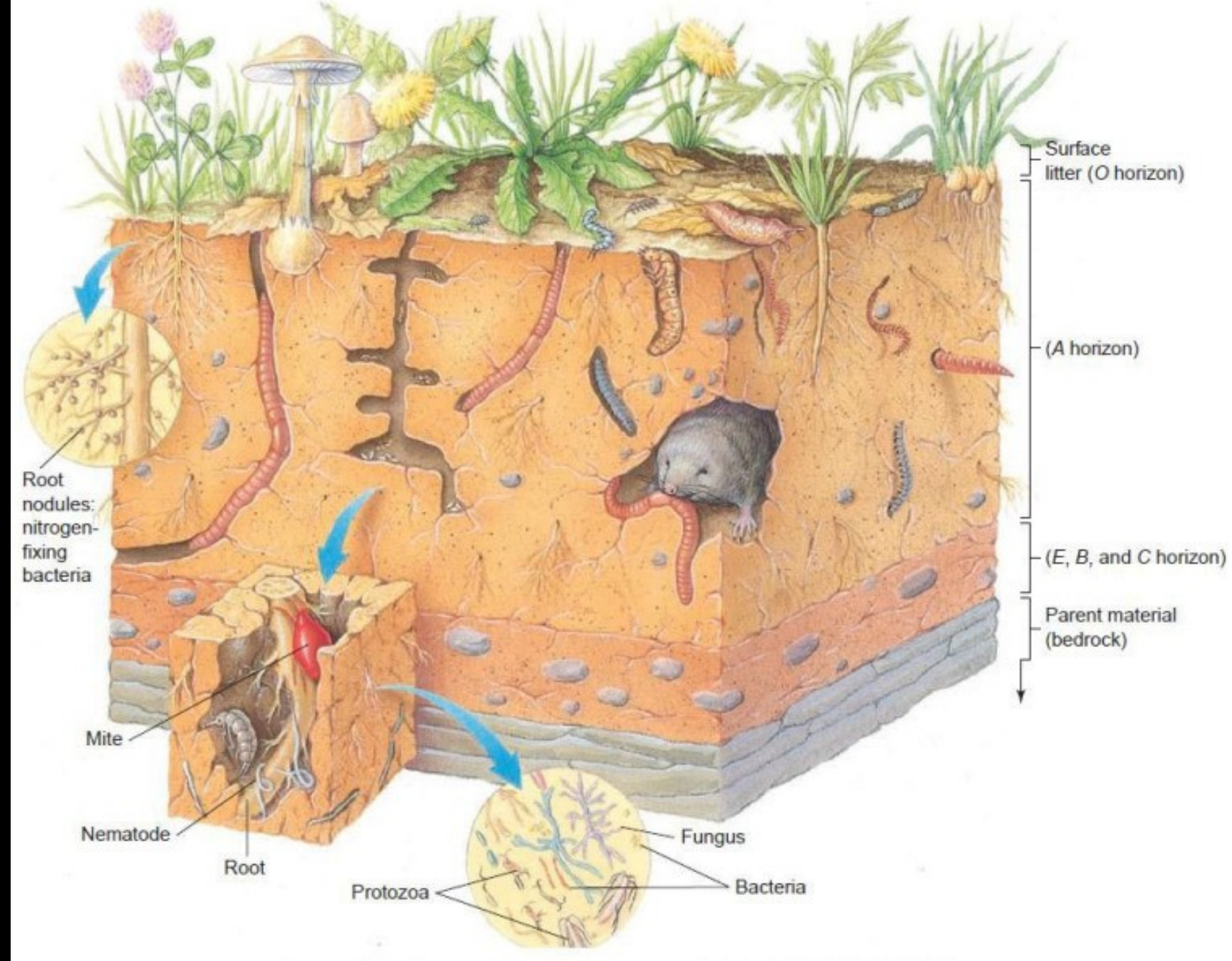
O horizon
- humus on the ground surface.

A horizon
- Top soil.
- Rich in organic matter. Typically dark color.
- Also called zone of **leaching**.

B horizon
- Subsoil.
- Also called zone of accumulation.
- May contain soluble minerals such as calcite in arid climates (caliche).

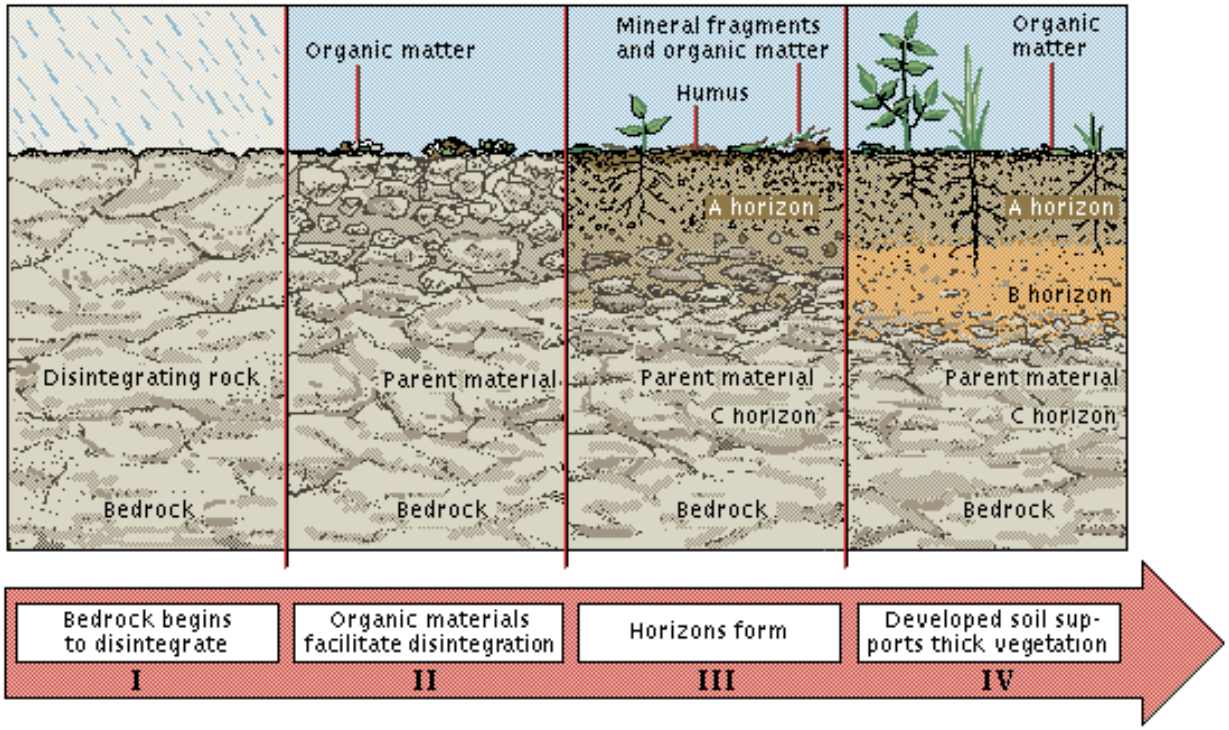
C horizon
- Weathered bedrock (rotten rock).
- Bedrock lies below the soil profile.

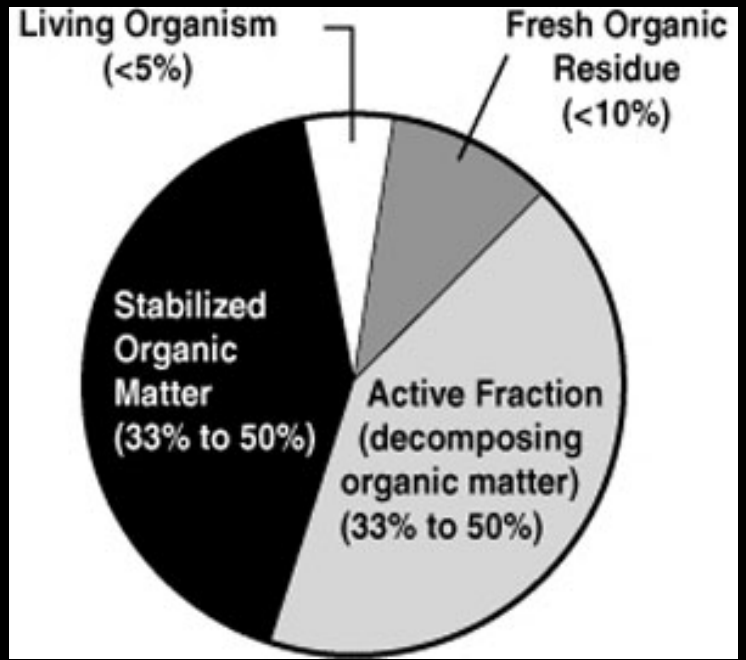


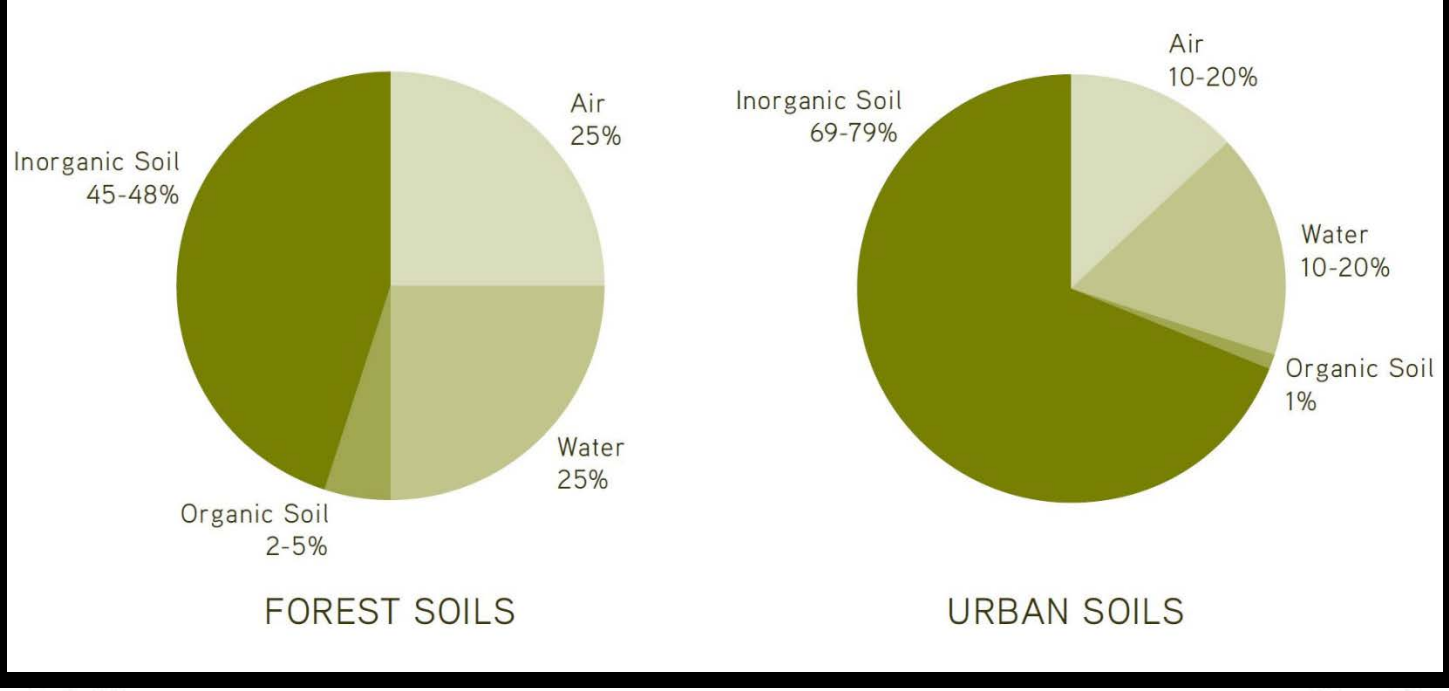

Surface litter (O horizon)
(A horizon)
(E, B, and C horizon)
Parent material (bedrock)
Root nodules: nitrogen-fixing bacteria
Mite
Nematode
Root
Protozoa
Fungus
Bacteria

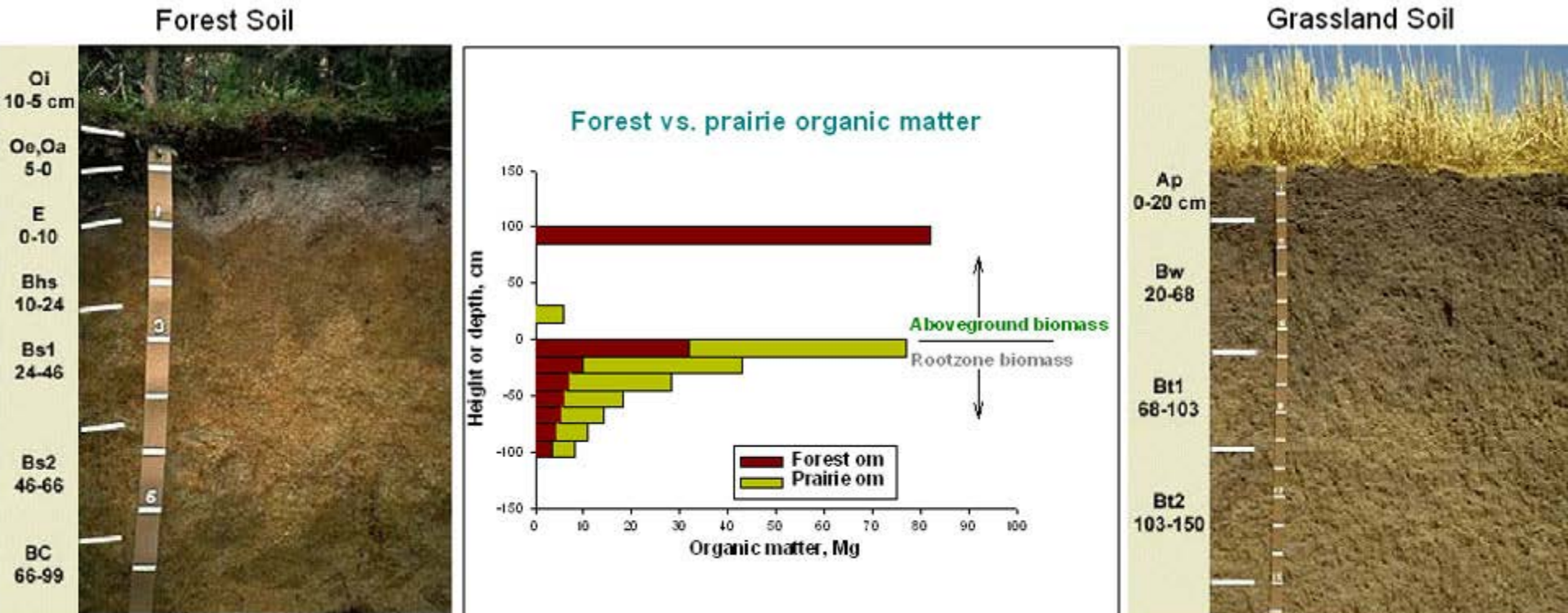
Soil Biotic Components

Organic Matter



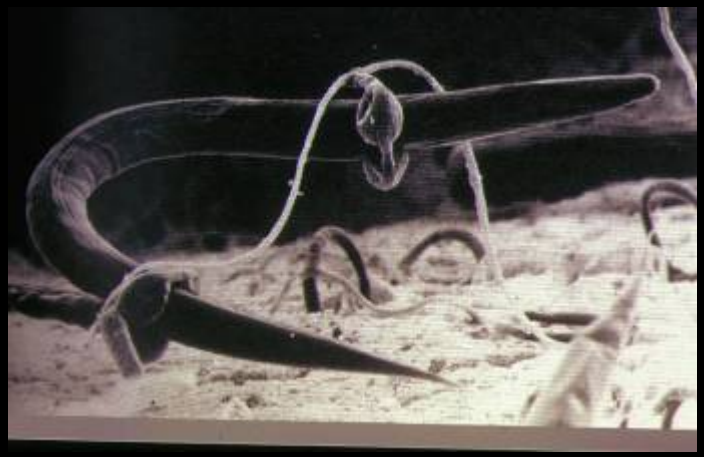


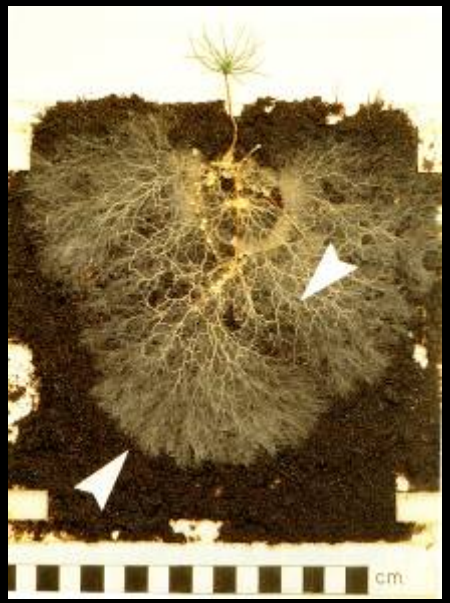

Air
25%
Inorganic Soil
45-48%
Water
25%
Organic Soil
2-5%
FOREST SOILS
Air
10-20%
Inorganic Soil
69-79%
Water
10-20%
Organic Soil
1%
URBAN SOILS

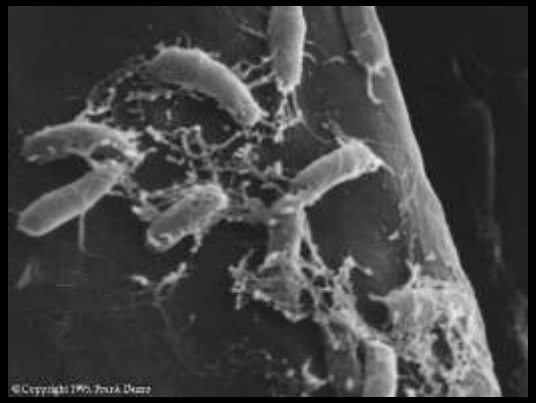

Forest Soil
Oi
10-5 cm
Oe,Oa
5-0
E
0-10
Bhs
10-24
Bs1
24-46
Bs2
46-66
BC
66-99
Forest vs. prairie organic matter
Height or depth, cm
Organic matter, Mg
Aboveground biomass
Rootzone biomass
Forest om
Prairie om
Grassland Soil
Ap
0-20 cm
Bw
20-68
Bt1
68-103
Bt2
103-150

Soil Biology

The Microcosmos – the majority of biomass on Earth





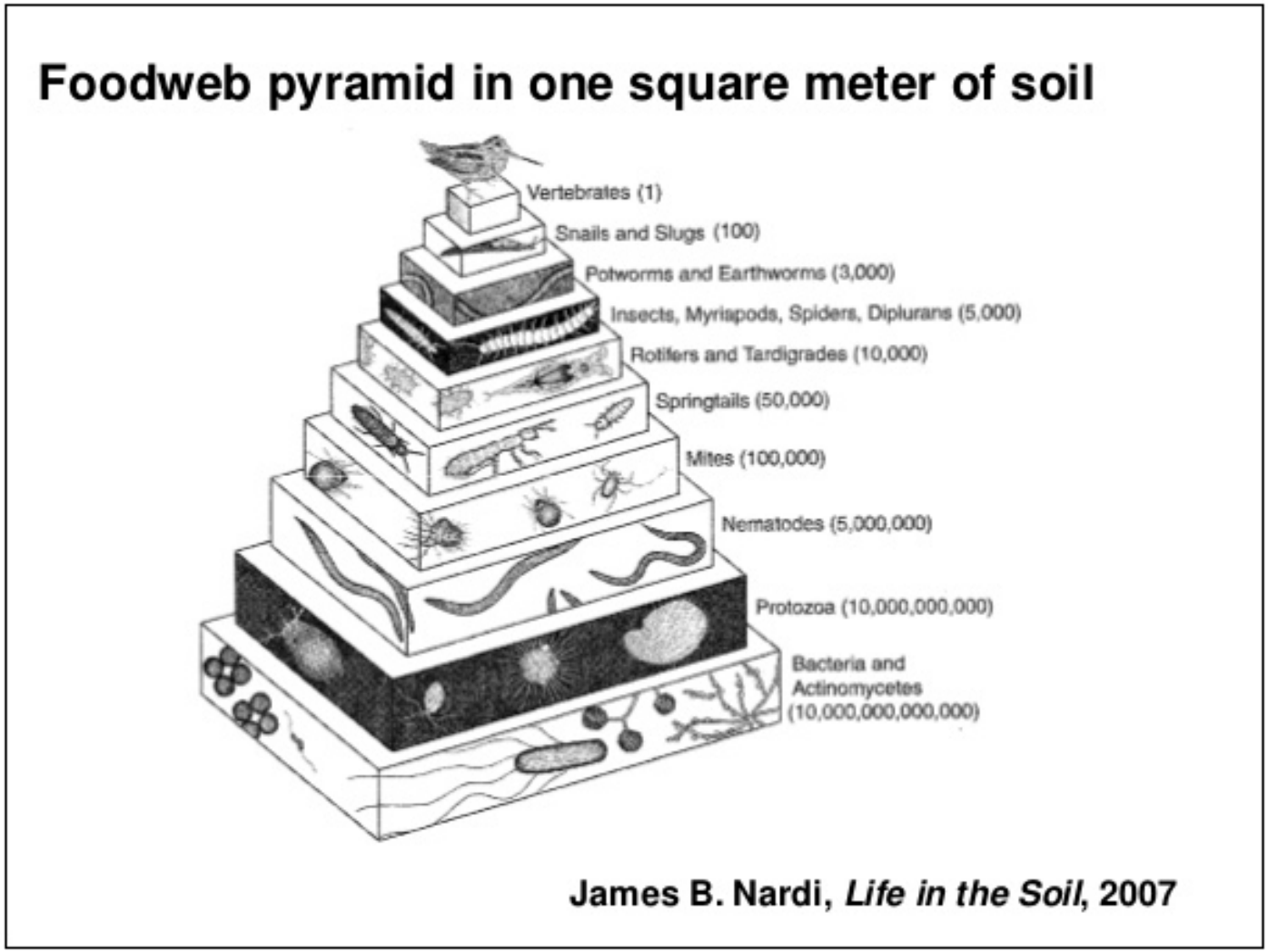


Scale

Macro

Meso

Micro



Number and Biomass of Soil Organisms

Organisms	Number/ yd^3	Number/ oz	Biomass (Lbs/Acre-6”)
Bacteria	Trillions	Millions +	400 – 4.000
Actinomycetes	Trillions	Millions	400 – 4.000
Fungi	Billions	Thousands +	500 – 5,000
Algae	Billions	Thousands	20 - 500
Protozoa	Billions	Thousands	15 – 150
Nematodes	Millions	Tens +	10 – 100
Earthworms	30 – 300		100 – 1,000

4% organic matter is 80,000 lbs per acre

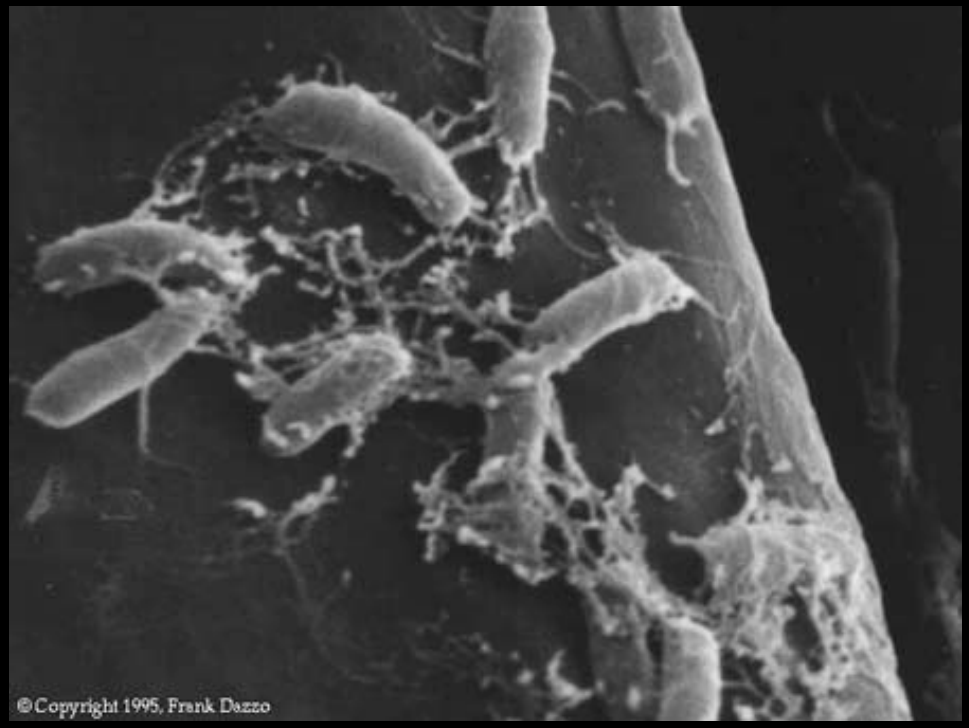
Decrease to 1% means loss of 60,000 lbs per acre

Microbial Biomass

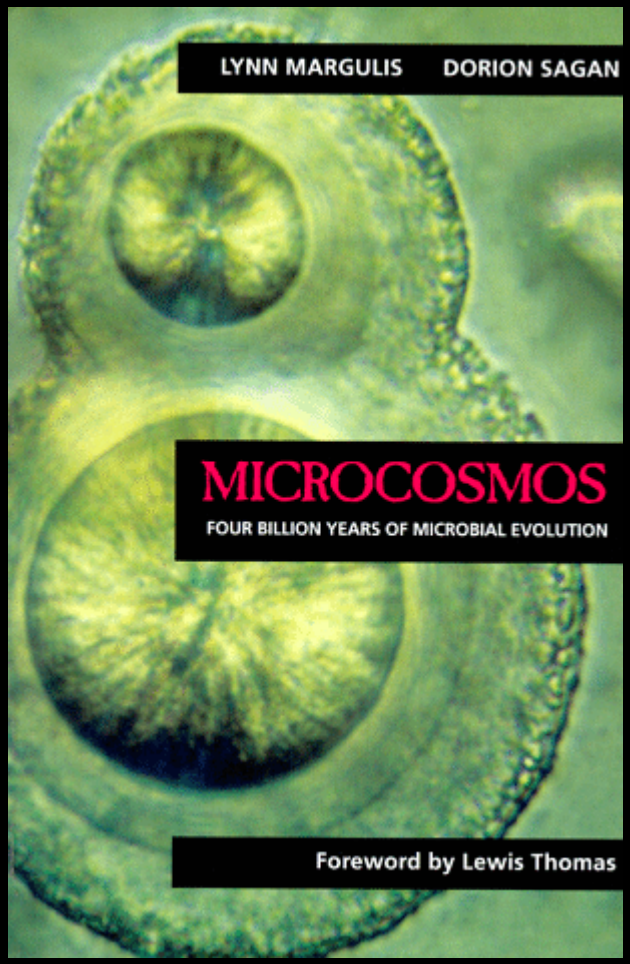
Although the 1998 estimates have been questioned in terms of ocean-dwelling microbes, the University of Georgia researchers suggested that the DRY biomass of bacteria is between 350,000 and 550,000 million tons.

Since the dry biomass of humans is only around 105 million tons, the bacteria on Earth weigh at least 3,000 times as much as all of humankind combined.

There are about 50 million bacterial cells in a single gram of soil, and estimates suggest that over 90% of all bacteria on Earth live in the soil.



Bacterial cells on clay particles



Microbial Evolution

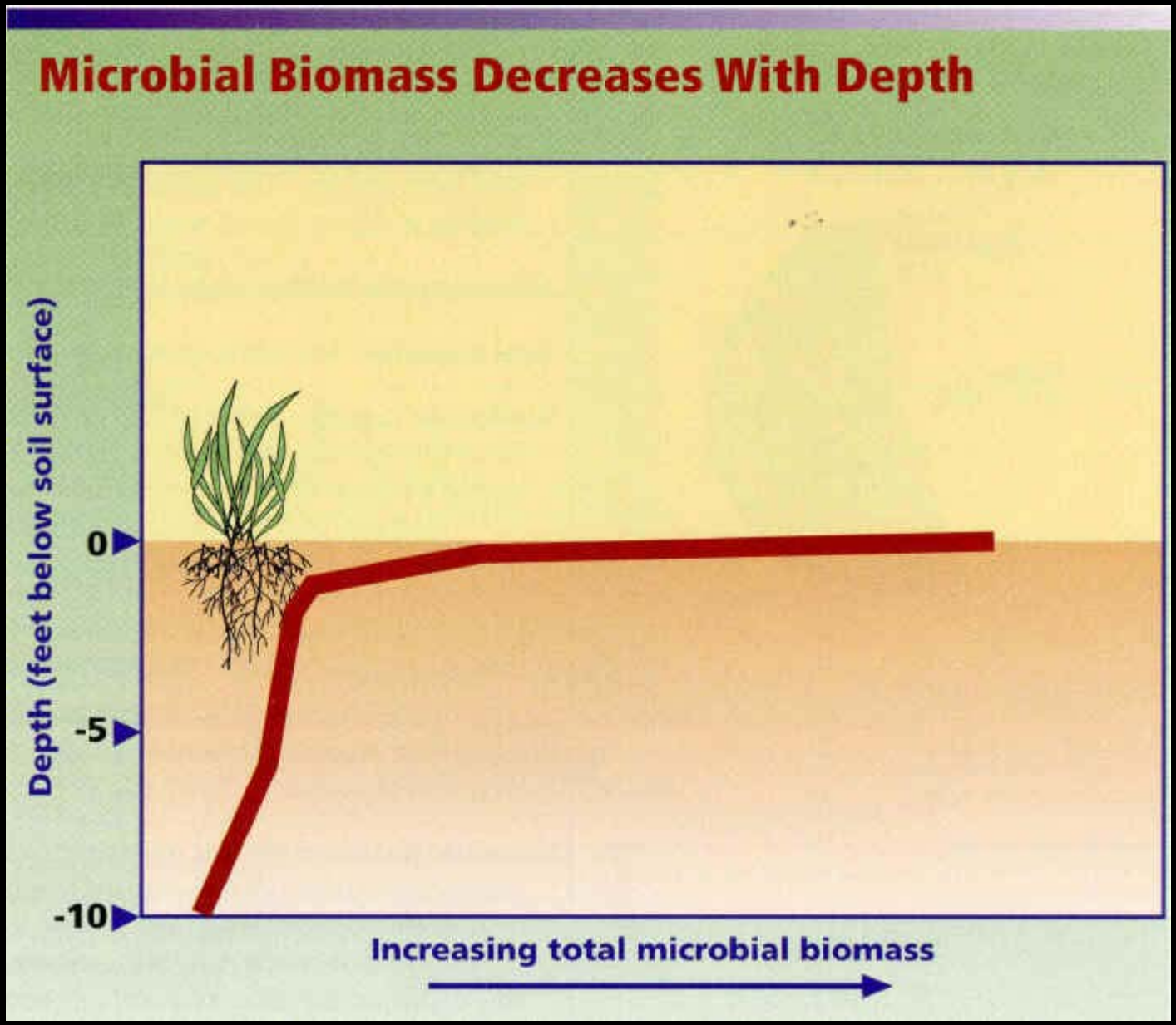
Symbiosis is a major driving force behind evolution. She considers Darwin's notion of evolution, driven by competition, as incomplete and claims that evolution is strongly based on cooperation, interaction, and mutual dependence among organisms.

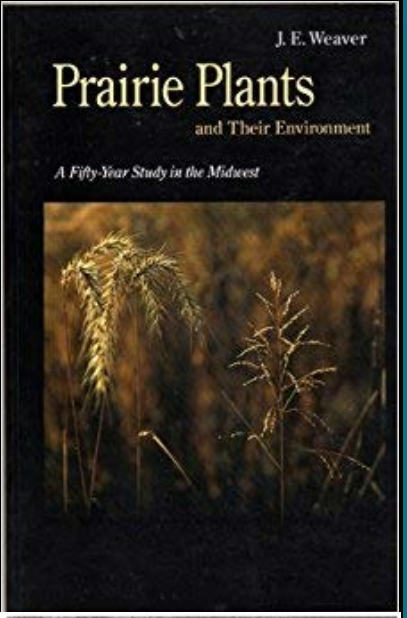
Endosymbiosis is any symbiotic relationship in which one symbiote lives within the tissues of the other, either in the intracellular space or extracellularly. Examples are rhizobia, nitrogen-fixing bacteria that live in root nodules on legume roots; nitrogen-fixing bacteria called *Frankia*, which live in alder tree root nodules; single-celled algae inside reef-building corals; and bacterial endosymbionts that provide essential nutrients to about 10%–15% of insects.

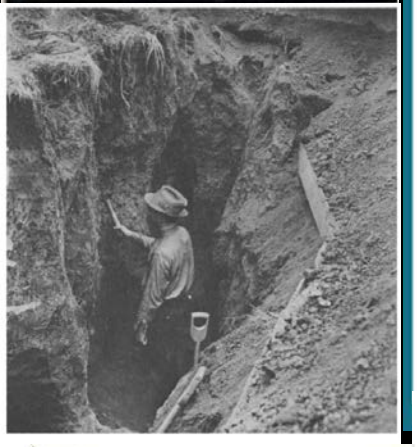
Ectosymbiosis, also referred to as *exosymbiosis*, is any symbiotic relationship in which the symbiont lives on the body surface of the host, including the inner surface of the digestive tract

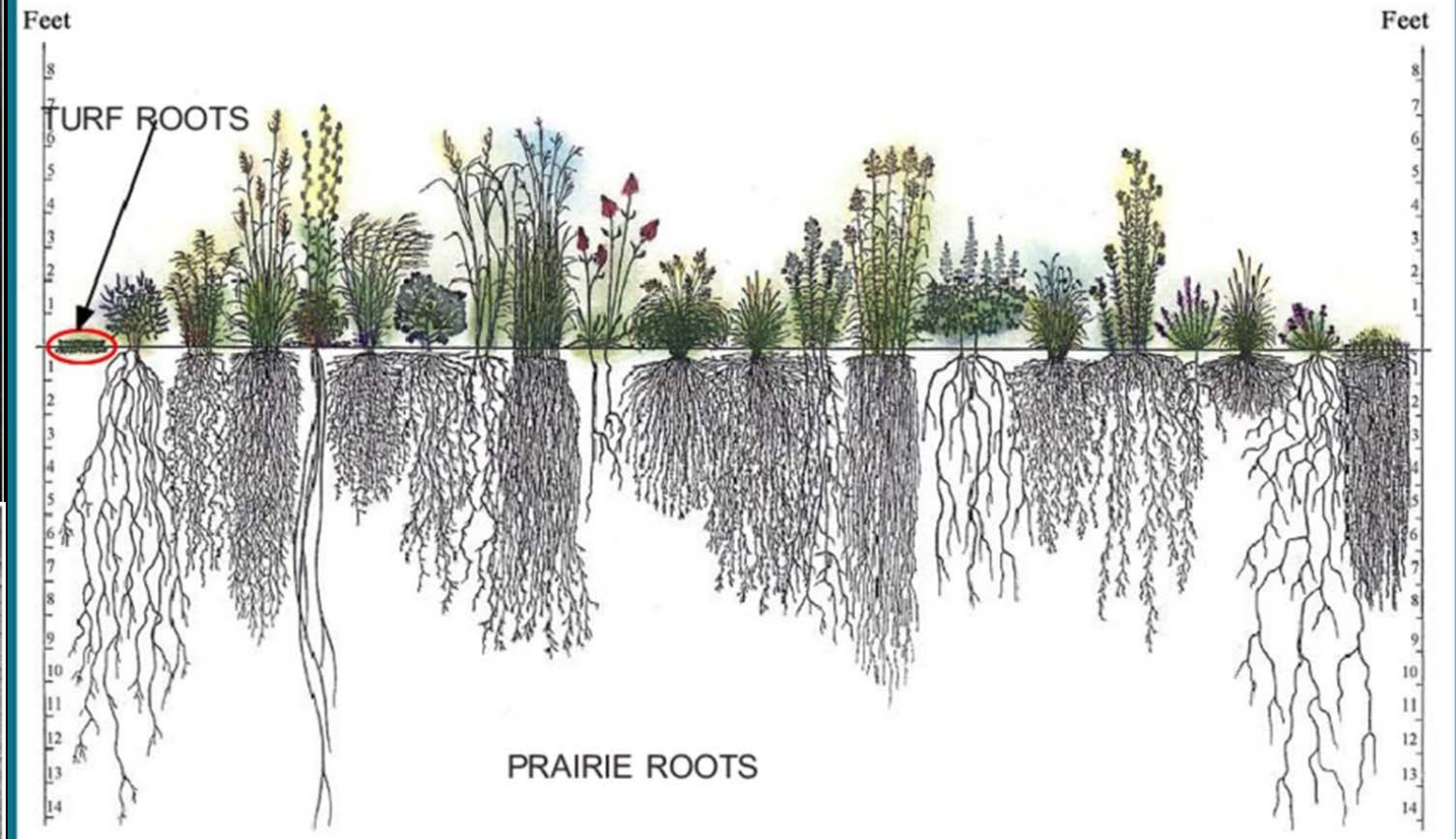
Ectosymbiosis

Microbial Biomass Decreases With Depth

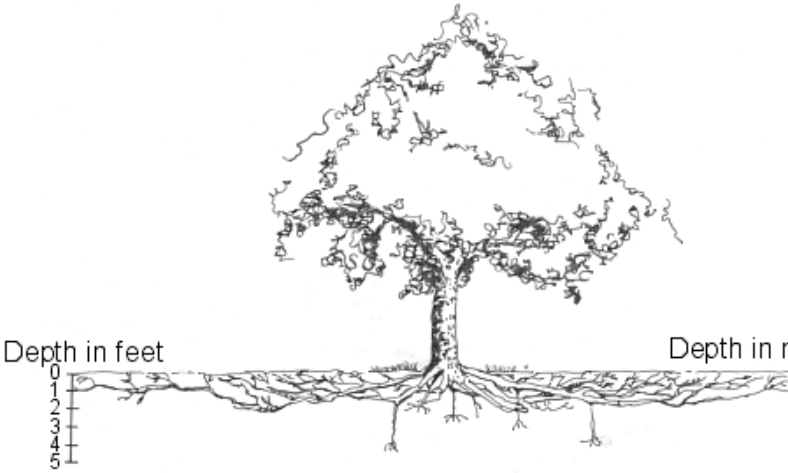






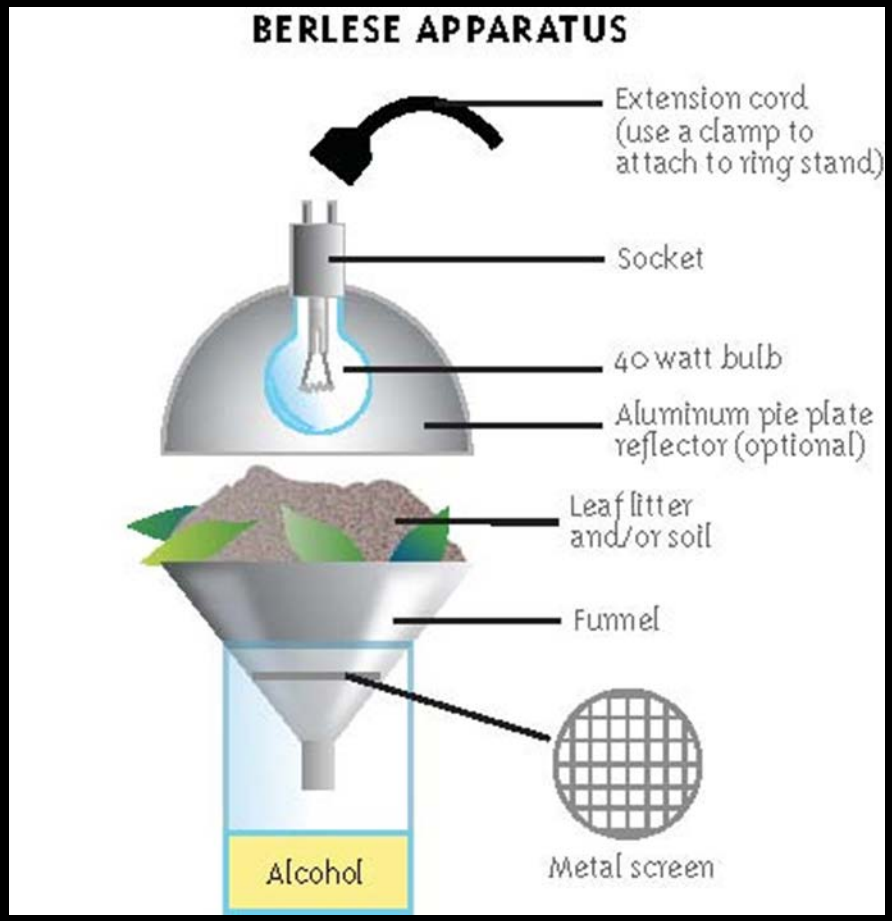


The roots of a tree extend far from the trunk and are found mostly in the upper 6 to 12 inches of soil.



Root Tip and Root Hairs

Collecting Mesoscale Organisms

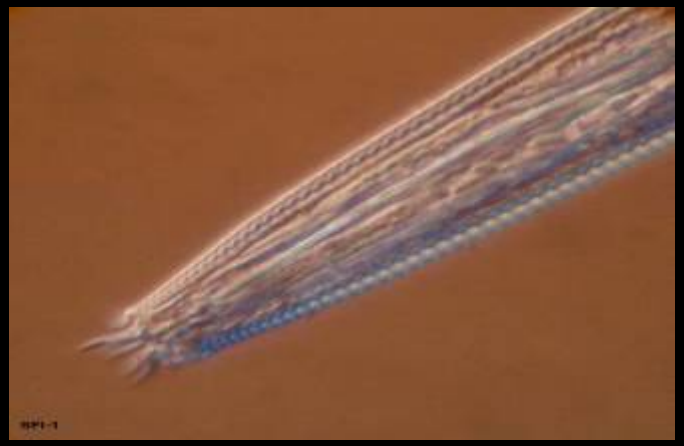


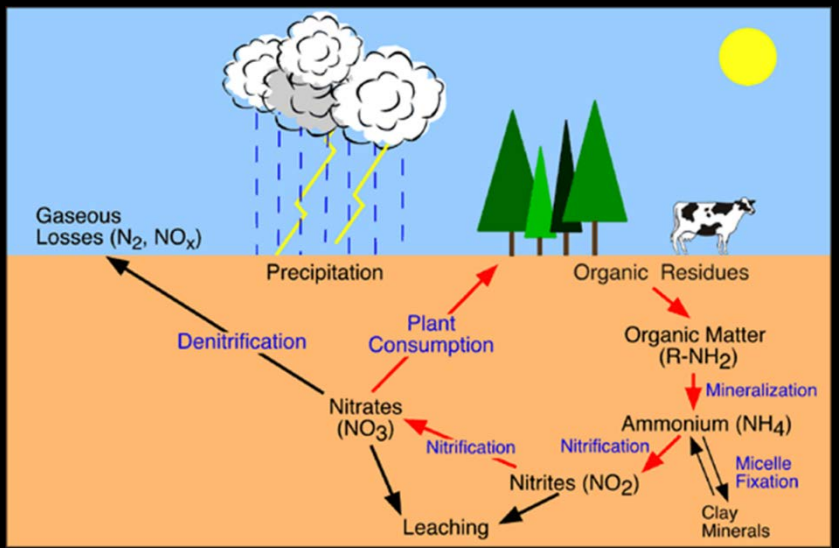
Nematodes

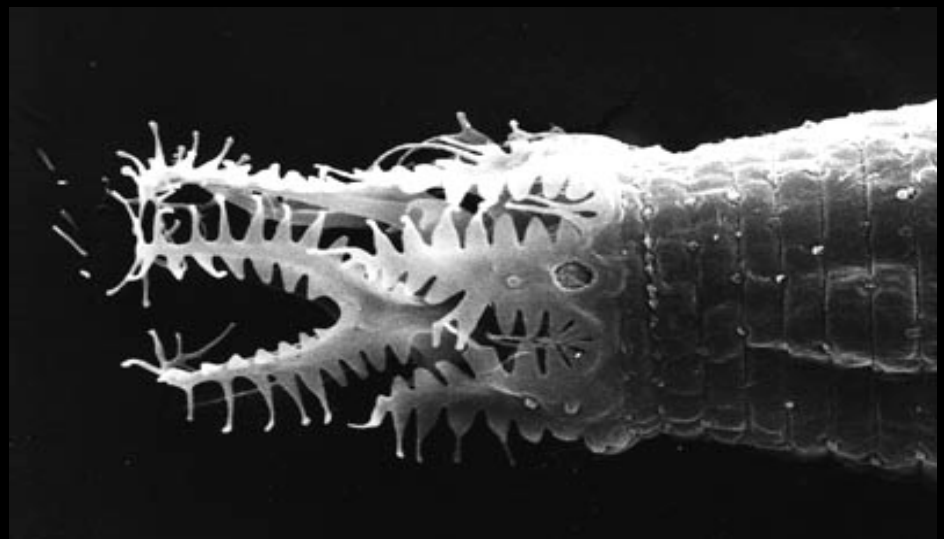
Example of a species of beneficial nematode that feeds on bacteria and not plant roots.

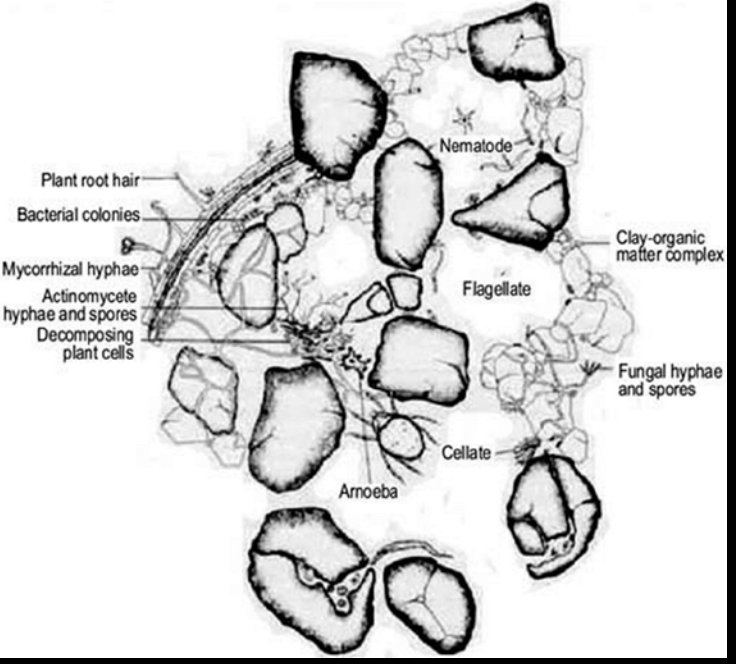
Bacteria are high in protein that in turn is high in nitrogen.

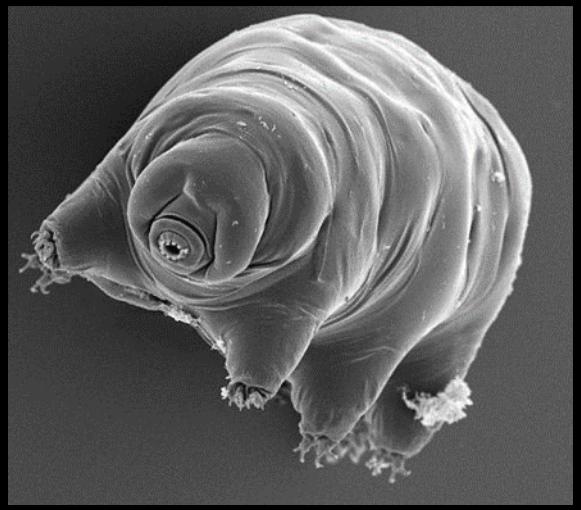
When nematodes like this eat bacteria they digest the protein and convert it to nitrogen which is excreted as a body waste product back into the soil in a form that becomes available to plants.











Mites, Springtails, and Water Bears

Collembola - Springtails

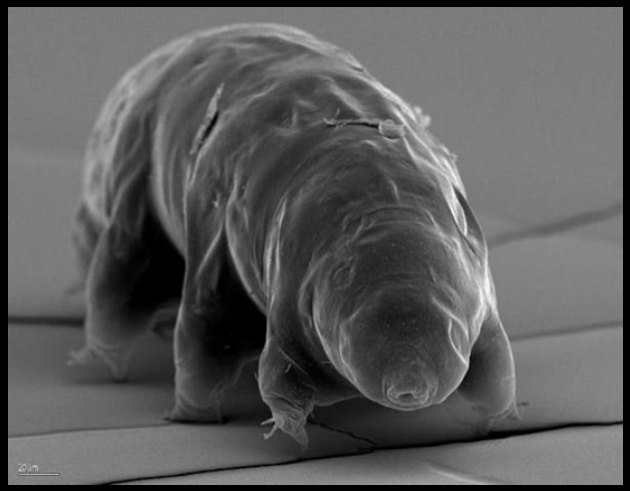
tiny six-legged, shrimp-like springtails, or Collembola. Ranging from 0.25-10mm in length, there are typically around 10,000 per square meter of soil, rising to as many as 200,000 per square meter in some places. The 6,000 known species of these wingless arthropods can be found in all manner of habitats all over the world, from beaches and cliffs to the Antarctic and the highest mountain ranges on Earth.

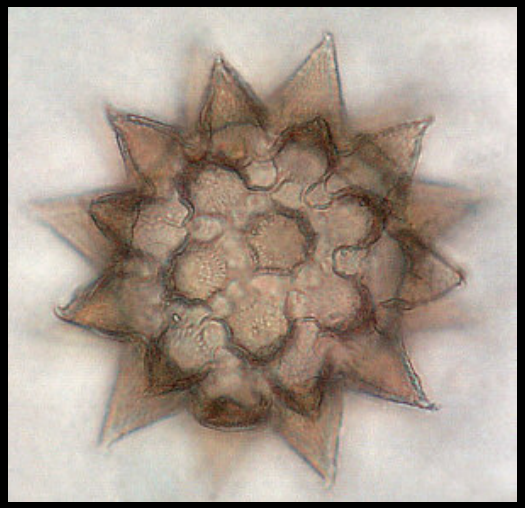
Tardigrades (commonly known as water bears)

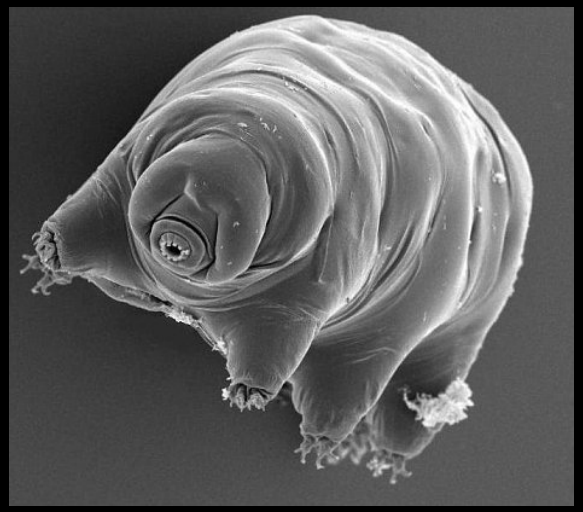
The name Tardigrada means "slow walker"

Extremophiles

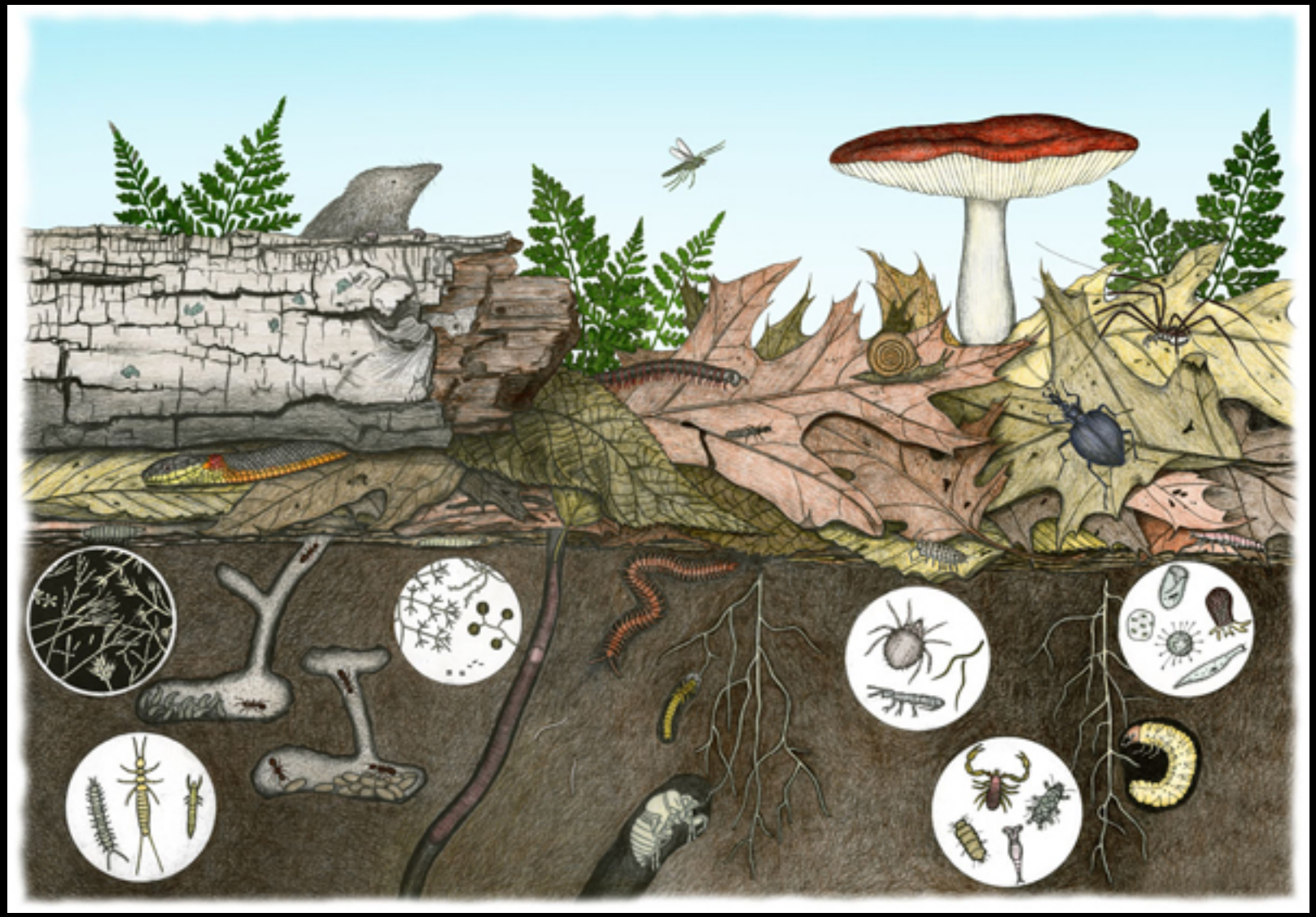
- They can shrivel to less than 1% water and stay in suspended animation.
- When dehydrated, they enter into a dormant state in which the body contracts and metabolism ceases.
- Some can survive temperatures of more than -200°C and temperatures above the boiling point of water.
- 3,000 of them were dried out and fired into space to see if they could handle the cosmic rays and the vacuum of space. Amazingly, after ten days, some of them did. They became the first animals to survive exposure in space without protection.





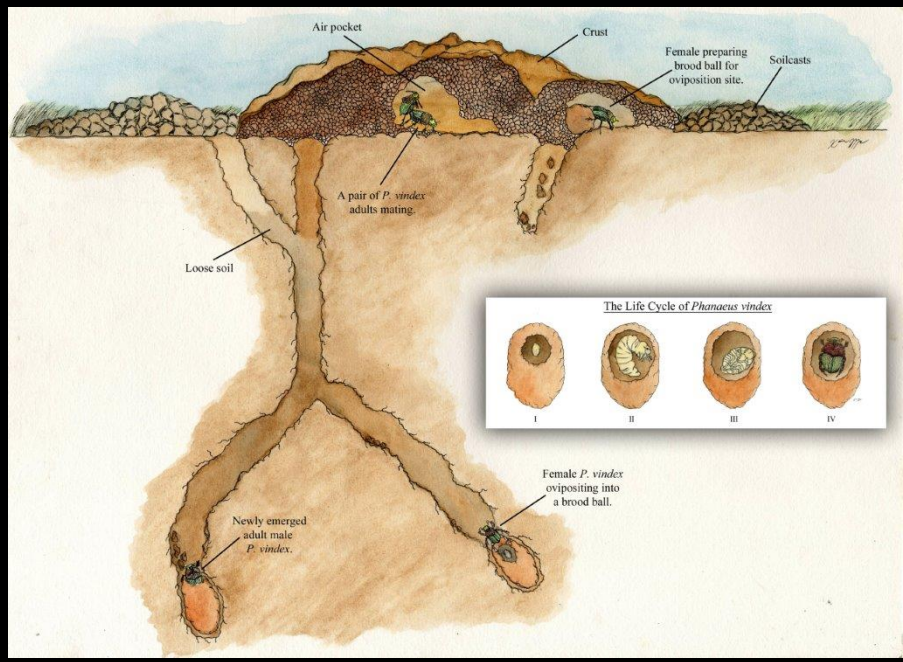


Macroscale Organisms



Dung Beetles

Dung Beetle Activity



The Coleopterists Bulletin, 59(2):400–401. 2005.

SCIENTIFIC NOTE

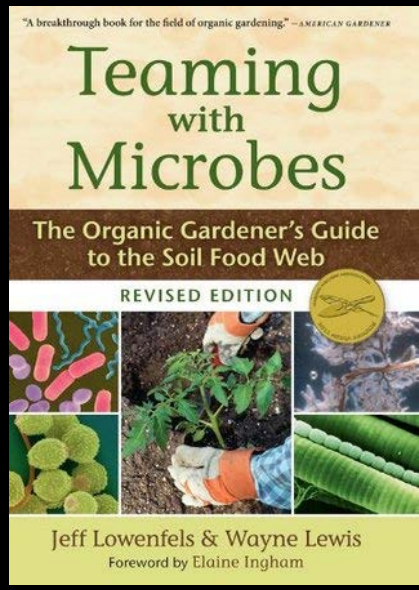
Observations of Urban Dung Beetles Utilizing Dog Feces (Coleoptera: Scarabaeidae)

This note presents a compilation of observations of dung beetles found utilizing dog dung in Austin, Texas. A total of 1,272 dung beetles representing sixteen species were found between September 1999 and January 2004. Locations where beetles were collected or observed ranged from approximately 25 km east to 12 km west, and 12.3 km south to 10.95 km north of the State Capitol building. Identifications were made using keys published by Howden and Cartwright

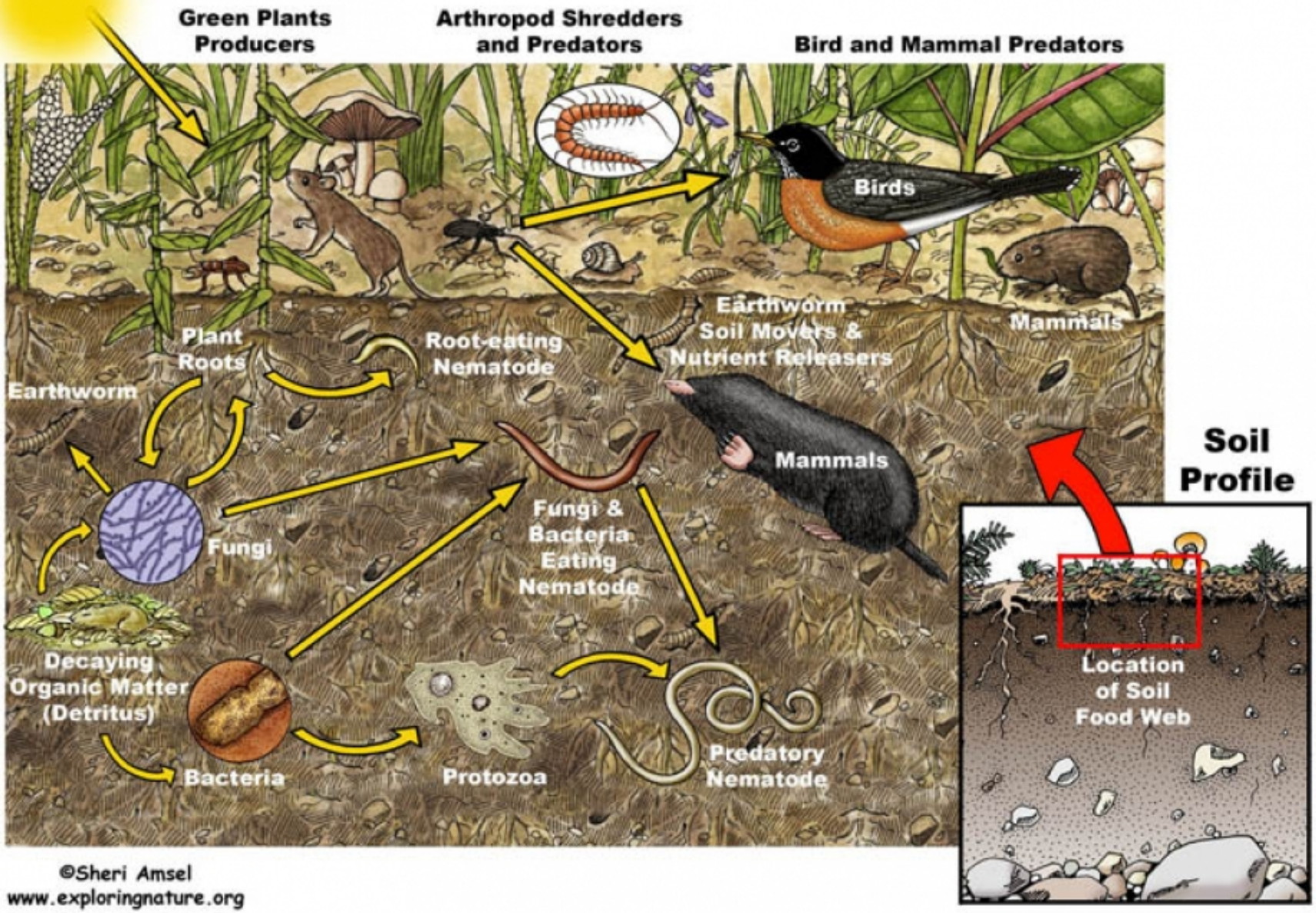
Soil Ecology and the Aerial City

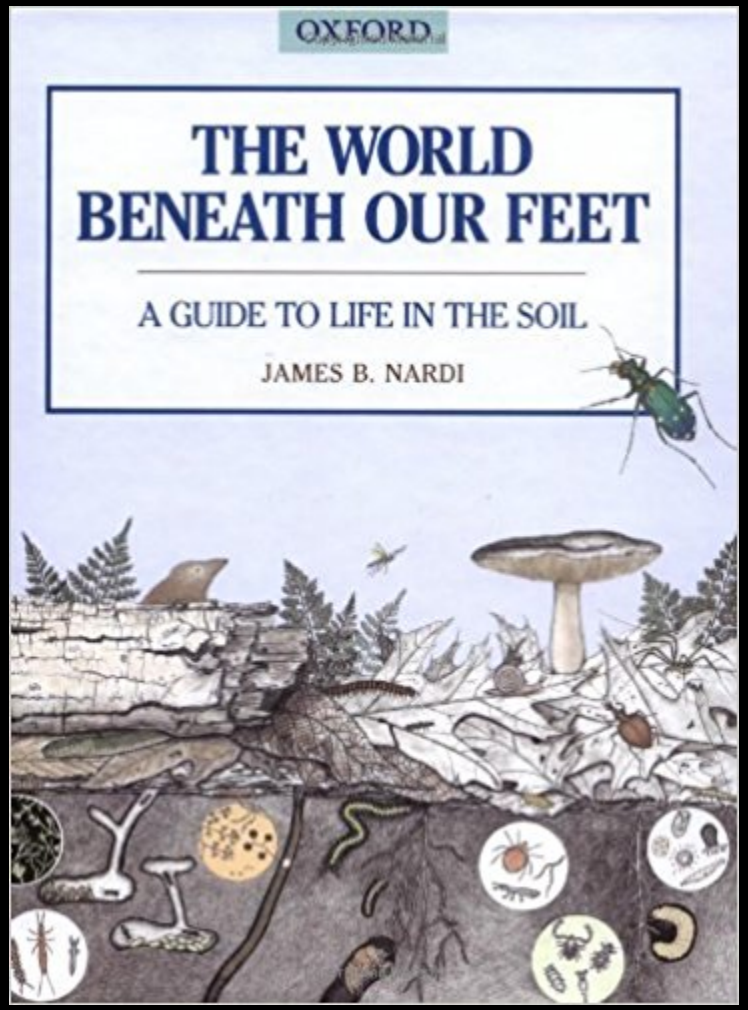
Butterflies on coyote dung – Hornsby Bend

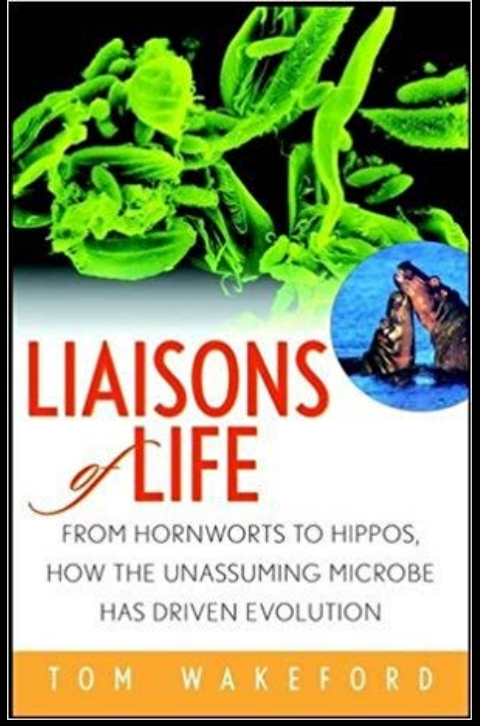
Dr. Elaine Ingham - www.soilfoodweb.com

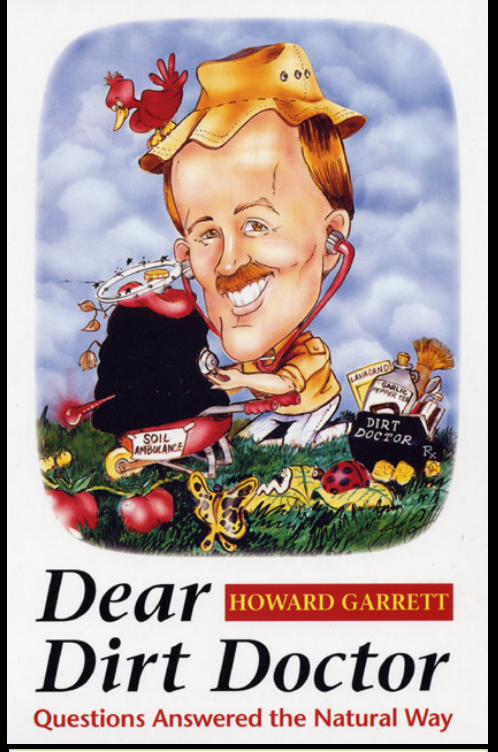


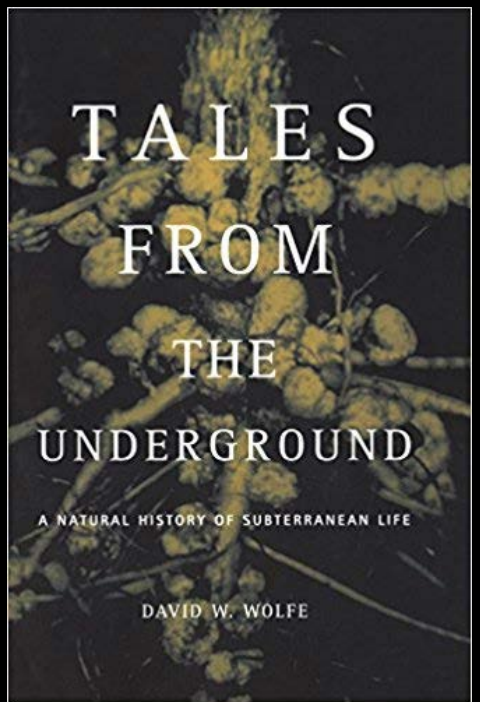
Soil Food Web

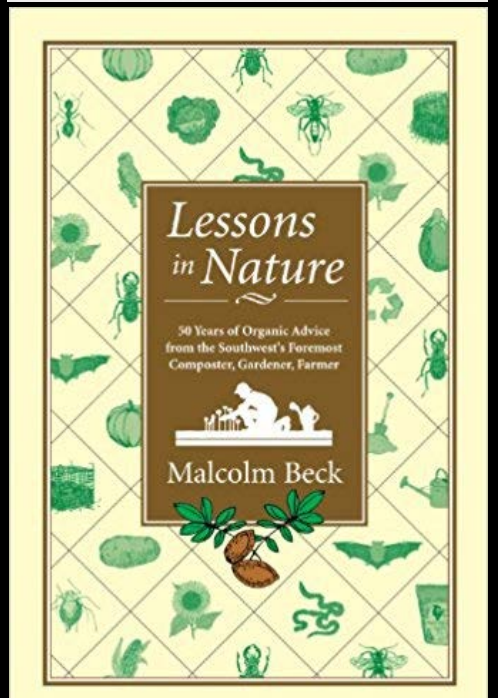










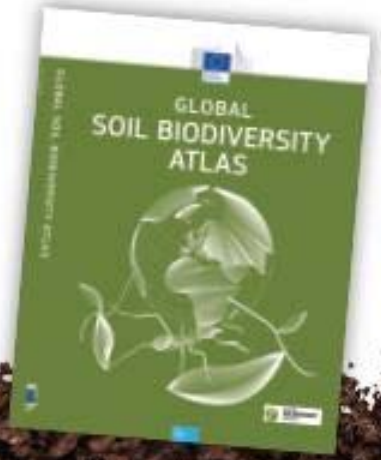


Learn More About Soil Ecology

The Global Soil Biodiversity Initiative

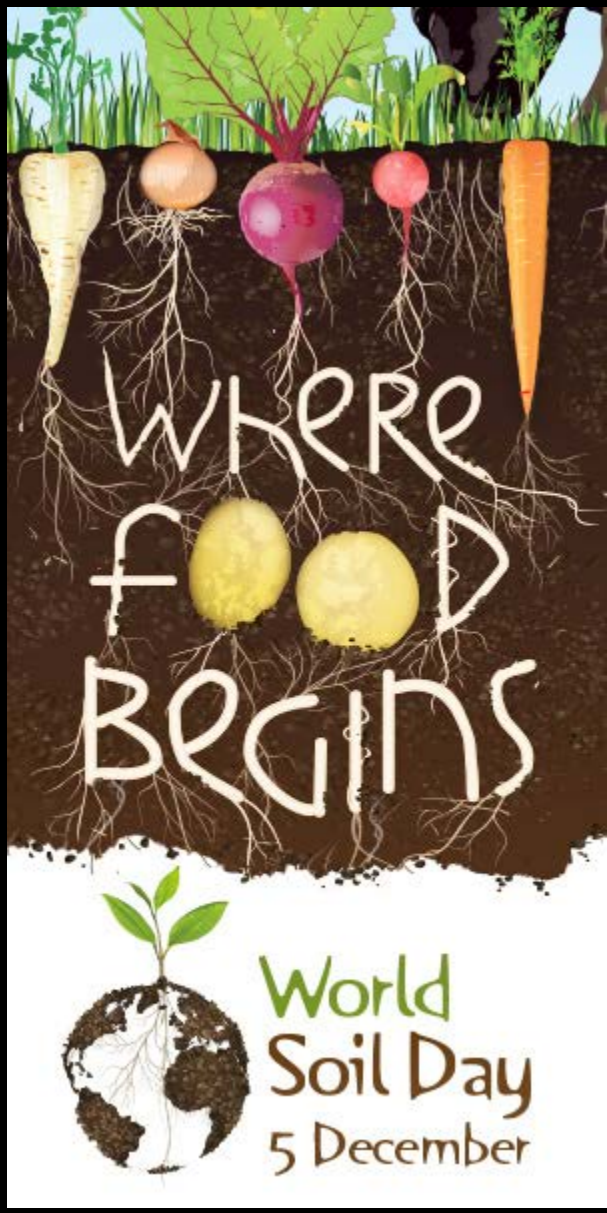
GLOBAL
SOIL BIODIVERSITY
INITIATIVE

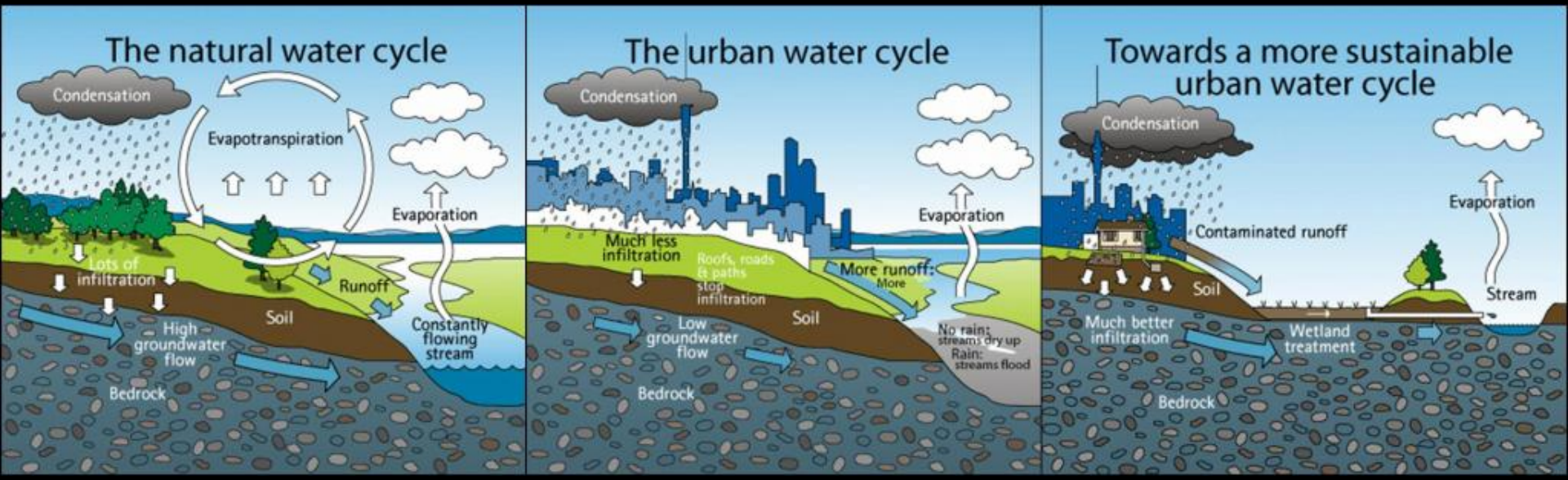
European
Commission



Exploring The Hidden Biodiversity in Central Park Soils 2012


Food and Agriculture Organization
of the United Nations
World Soil Day
5 December
THERE ARE MORE ORGANISMS IN ONE TABLESPOON OF HEALTHY SOIL...
...THAN THERE ARE PEOPLE ON EARTH


WHERE FOOD BEGINS
World
Soil Day
5 December


The natural water cycle
Condensation
Evapotranspiration
Evaporation
Lots of infiltration
Runoff
Soil
High groundwater flow
Constantly flowing stream
Bedrock
The urban water cycle
Condensation
Evaporation
Much less infiltration
Roofs, roads & paths stop infiltration
More runoff: More
Soil
Low groundwater flow
No rain: streams dry up
Rain: streams flood
Bedrock
Towards a more sustainable urban water cycle
Condensation
Evaporation
Contaminated runoff
Soil
Stream
Much better infiltration
Wetland treatment
Bedrock


Applause

Questions?