THE SOIL FOOD WEB
Soil Biology and the Landscape
Components of Soil Organic Matter

- Decomposing organic matter (active fraction): 33% - 50%
- Stabilized organic matter (humus): 33% - 50%
- Fresh residue: <10%
- Living organisms: <5%
Rhizosphere
Microbial Biomass with Depth

Microbial Biomass Decreases With Depth

Depth (feet below soil surface)

-10
-5
0

Increasing total microbial biomass
Seasonal Microbial Activity

- Early summer
- Late summer
- First frost
- Last frost

Bacterial and Fungal Activity in a temperate grassland or cropland.
FOOD WEB & SOIL HEALTH
Biomass of Soil Organisms in Four Ecosystems
## Typical Numbers of Soil Organisms in Healthy Ecosystems

<table>
<thead>
<tr>
<th></th>
<th>Ag Land</th>
<th>Prairie</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria (organisms per gram (teaspoon) of soil)</td>
<td>100 mil. - 1 bil.</td>
<td>100 mil. - 1 bil.</td>
<td>100 mil. - 1 bil.</td>
</tr>
<tr>
<td>Fungi (in conifers)</td>
<td>Several yards</td>
<td>10s – 100’s of yds</td>
<td>1-40 miles (in conifers)</td>
</tr>
<tr>
<td>Protozoa</td>
<td>1000’s</td>
<td>1000’s</td>
<td>100,000’s</td>
</tr>
<tr>
<td>Nematodes</td>
<td>10-20</td>
<td>10’s – 100’s</td>
<td>100’s</td>
</tr>
<tr>
<td>Arthropods</td>
<td>&lt; 100</td>
<td>500-2000</td>
<td>10,000-25,000</td>
</tr>
<tr>
<td>Earthworms</td>
<td>5-30</td>
<td>10-50</td>
<td>10-50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0 in conifers)</td>
</tr>
</tbody>
</table>
Methods for Measuring the Food Web

Counting
- Direct counts of individuals
- Plate counts of colonies

Activity levels
- Respiration (CO$_2$ production)
- Nitrification rates
- Decomposition rates

Cellular constituents
- Biomass C, N, or P
- Enzymes
- Phospholipids
- DNA and RNA
Bacteria with fluorescent stain for counting
A Complex Food Web
Complexity of the Soil Food Web in Several Ecosystems
Two Bugs are Better Than One

Effects of bacteria and bacterial-feeding nematodes on blue grama grass growth
BACTERIA
Nitrogen-fixing Bacteria

Nodules formed where *Rhizobium* bacteria infected soybean roots.
Actinomycetes

• Bacterial cells
• Grow like fungal hyphae
Bacteria vs. fungi
FUNGI
Fungi and Soil Quality

- Decompose carbon compounds
- Improve OM accumulation
- Retain nutrients in the soil
- Bind soil particles
- Food for the rest of the food web
- Mycorrhizal fungi
- Compete with plant pathogens
Mycorrhizae

Tree root

Mycorrhizal structure

Fungal hyphae
Ectomycorrhizae
Arbuscular Mycorrhizae (AM)
Mushrooms:
The fruiting body of some fungi
Mycorrhizal Fungi
PROTOZOA

Ciliates • Largest of the three
• Move by means of hair-like cilia
• Eat the other protozoa and bacteria

Amoebae • Also large
• Move by means of a temporary foot (pseudopod)
• Include testate amoebae (with shell-like covering), and naked amoebae

Flagellates • Smallest of the three
• Move by means of a few ship-like flagella.
PROTOZOA
Flagellate
Ciliate
Amoebae
Mineralization and Immobilization

Organisms consume other organisms and excrete inorganic wastes.

Organic nutrients are stored in soil organisms and organic matter.

Inorganic nutrients are usable by plants, and are mobile in soil.

Organisms take up and retain nutrients as they grow.
Soil-Dwelling “Vampires”
NEMATODES
NEMATODES
Predatory Nematode
Root-feeding nematodes
Nematode Trappers

Fungal hyphal rings constrict when a nematode swims through.
ARTHROPODS
Mites and Biodiversity
Types of Arthropods

- Shredders
- Predators
- Herbivores
- Fungal-feeders
Shredders
Predators (1)
Predators (2): Pseudoscorpions
Predators (4): Centipedes
Predators (5): Scorpions
Predators (6)
Herbivores
Springtails (fungal feeders)

- Abundant in many soils.
- Feed on some disease-causing fungi.
- Jump by slamming their tail down.
What is in Your Soil?

Berlese funnel

Pitfall trap
EARTHWORMS
Earthworms bury litter
Earthworm burrow
Vertical burrows
Earthworm casts
Earthworm burrow opening
Earthworm burrow opening
Reproduction
Night crawlers and tillage

Without *Lumbricus terrestris*  
With *Lumbricus terrestris*