Biological Methods of Soil Analysis

Sue Grayston
Department of Forest & Conservation Sciences
Faculty of Forestry & Faculty of Land & Food Systems
Room 3006 FSC
(sue.grayston@ubc.ca)

Biological Methods of Soil Analysis

- Soil Sampling
- Week 1. Soil fauna
- Week 2. Soil symbiotic associations: mycorrhizae and N-fixing nodules
- Week 3. Biological function in soils: enzyme assays and stable isotope analyses (demo lab)

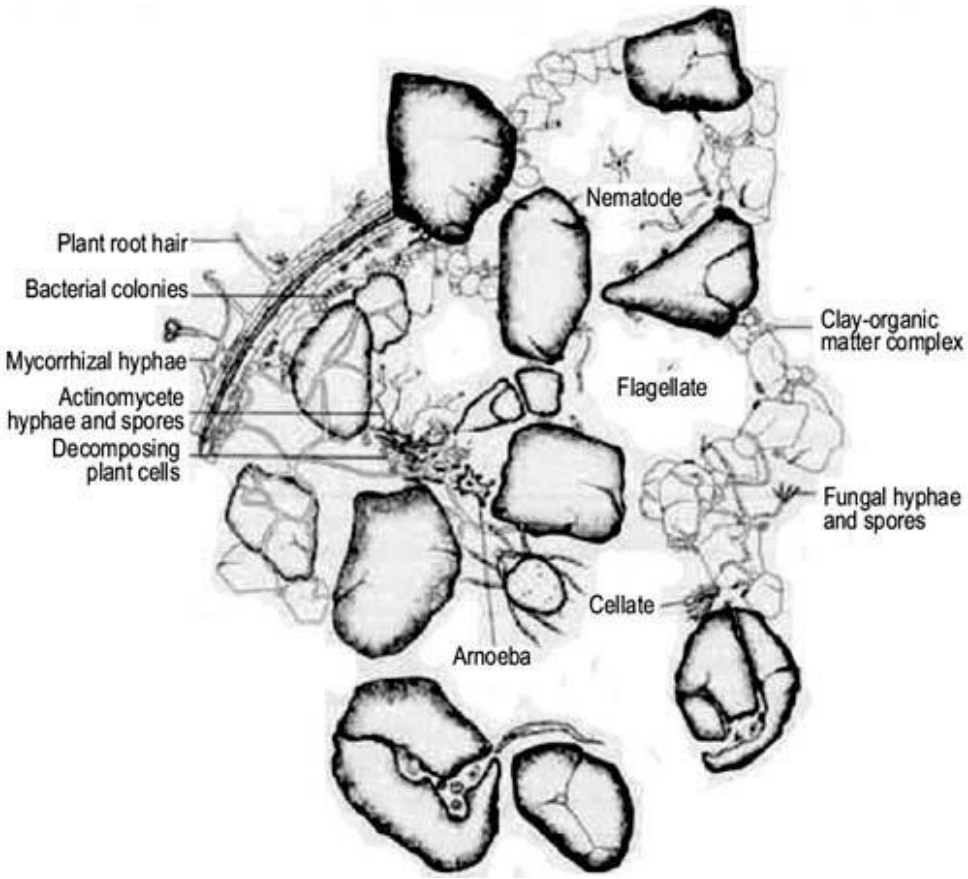
Sampling for Soil Biological Analysis

• Soil organisms - major factor in soil formation - their effects determine many differences between soils.

• Soil macrofauna “ecosystem engineers” - important in soil aggregation and porosity as a consequence of their burrowing and mixing activities. This in turn affects the environment (aeration, soil moisture, etc.) for other soil organisms.

• Organic materials in and on the soil are broken down and transformed – mainly by soil organisms – into nutrient elements,
- in turn taken up by plants and microorganisms.

• Organisms are also responsible for chemical weathering of rocks.



Soil Biodiversity

- Soil biodiversity- important but poorly understood component of terrestrial ecosystems.
- Soil organisms carry out a range of processes that are important for soil health and fertility in soils
- Soil biodiversity - organisms that spend all or a portion of their life cycles within the soil or on its immediate surface (including surface litter and decaying logs)

Soil biodiversity: categories and characteristics

• **Category**	**Characteristics**	**Organisms**
• Permanent	Entire life cycle in the soil	Mites, springtails (Collembola), earthworms
• Temporal	Part of life cycle in the soil	Insect larvae
• Periodical	Frequently enter into the soil	Some insects and larvae
• Transitory	An inactive phase in the soil (egg, pupa & hibernation) but not an active period	Some insects
• Accidental	Animals fall down or are transported by runoff	Insect larvae

Location of soil organisms

• Most in top 30 cm soil, (contains the most food (C and nutrients) in the form of OM and other organisms). May move lower if conditions harsh

• “Ecosystem engineers” - produce physical structures – modify accessibility of a resource for other organisms. E.g. earthworms, termites, ants - produce a wide variety of organo-mineral “biogenic structures”, e.g. excretions, nests, mounds, macropores, galleries, caverns

Functional role of structures is important - sites where certain pedological processes occur: stimulation of microbial activity; formation of soil structure; SOM dynamics; exchange of water and gases

Root using an earthworm gallery to penetrate into soil

Granular casts produced by mites, millipedes, small earthworms

Forest soil sampling

- Forest soil sampling – importance of LFH
- Other data to be collected
- Spatial variability
- How to collect for different soil organisms

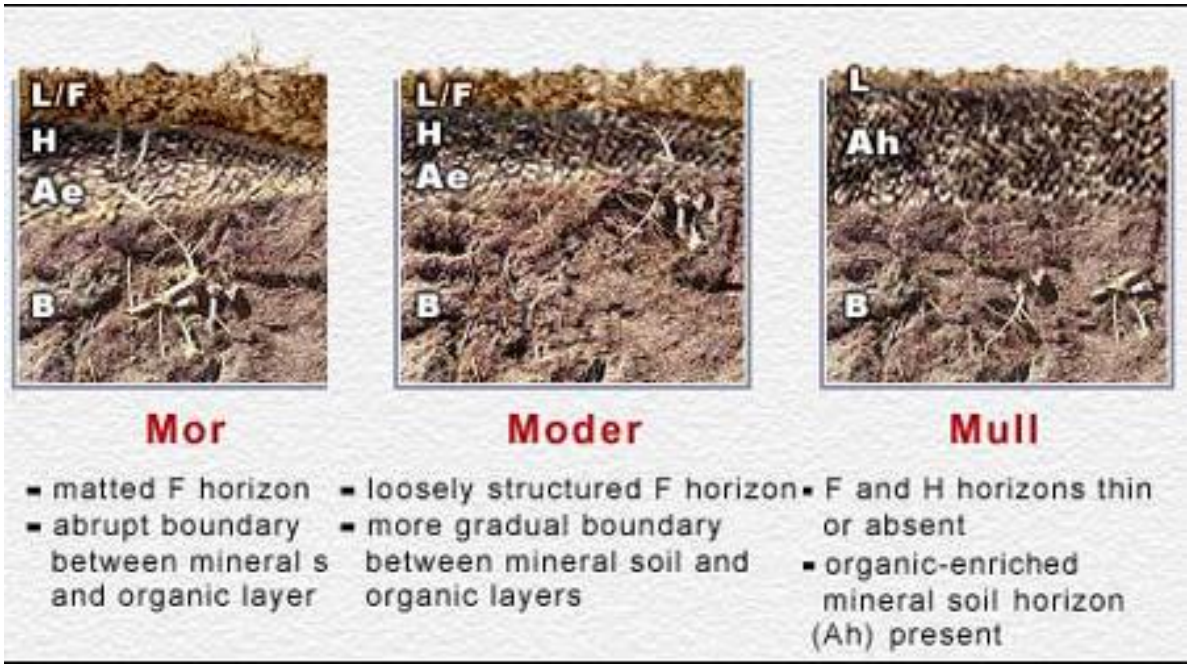
Upper horizons

Forest floor
L (litter) - organic horizon characterized by accumulation of organic matter derived mainly from litter residues (leaves, twigs, and woody material).
Original structures are easily recognizable.
F (formultning) - organic horizon characterized by accumulation of partly decomposed (e.g., occupation by filamentous fungi) organic matter.
Some of the original structures are difficult to recognize.
H (humus) - organic horizon characterized by accumulation of decomposed organic matter
Organic structures are unrecognizable.

Ah – upper mineral soil horizon enriched in organic matter

http://www.landfood.ubc.ca/soil200/classification/soil_horizon.htm

Humus forms


L/F
H
Ae
B
L/F
H
Ae
B
L
Ah
B
Mor
Moder
Mull
- matted F horizon
- abrupt boundary between mineral s and organic layer
- loosely structured F horizon
- more gradual boundary between mineral soil and organic layers
- F and H horizons thin or absent
- organic-enriched mineral soil horizon (Ah) present

Humus forms

Criteria	MOR	MODER	MULL
Mode of decomposition	Predominantly fungal	Soil fauna, bacteria, and fungi	Soil fauna including earthworms & bacteria
Structure of F horizon	Matted, fungal hypha common to abundant	Loose, few fungal hyphae, insect droppings visible	**F** horizon usually thin or absent
Intermixture of mineral particles with humic material	Uncommon, usually a sharp boundary between organic and mineral horizons	Often some mineral particles mixed in the **H** horizon	Characterized by a high degree of incorporation of organic matter into the mineral soil Ah always present
Rates of organic matter decomposition & nutrient cycling	Relatively slow	More rapid	Very rapid
Nutrient availability	Low to medium	Medium to high	High
Origin of plant materials	Coniferous and bryophytic	Coniferous, deciduous, bryophytic	Deciduous and herbaceous

LFH

- For each layer
- Depth (cm)
- Structure (loose, friable, firm, matted, greasy)
- Mycelium, fecal, root abundance (none, few, common, abundant)

Mineral soil

- For each horizon
- Depth (cm)
- Colour
- Texture (texture key)
- Coarse fragment content (none, few, common, abundant) and shape (rounded, sub-angular, angular)
- Root abundance (none, few, common, abundant)

Other data

- Important to record site details and vegetation, date, environmental conditions.
- Labeling of samples vital.
- Describe ecology and soils.
- Site: aspect, slope, elevation, meso-slope position, successional stage, stand structural stage, soil moisture and nutrient regime.
- Soil: humus form and mineral soil – soil order, parent material, rooting depth, drainage.
- Trees canopy and seedlings, BEC zone, location of trees, understory plant abundance and indicator values

Forest soil sampling for organisms

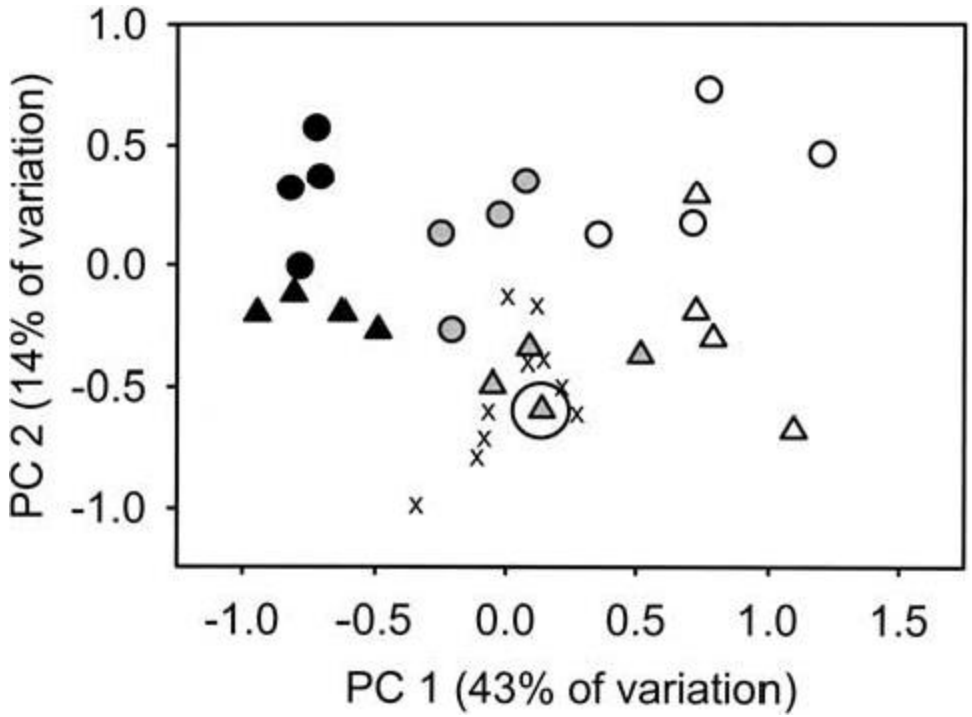
Sampling approach differs for extraction of soil macrofauna, mesofauna and microbes

- Microbes, ten (3 cm) cores extending 10 cm below the lower boundary of the organic horizon removed randomly. Forest floor and mineral horizons separated in the field and the samples from the four cores composited.

- Meso-faunal analysis, four (3 cm) cores through LFH layers into first 3 cm of mineral soil at the same locations. Forest floor and mineral portions of the core separated in the field, and packed in separate plastic bags.

- Macro-faunal analysis, blocks (20 cm x 20 cm x ~6 cm) collected at the same locations used for the other sampling.

Microbial (PLFA) composition under cedar and hemlock in F, H1, H2



X- Uncomposited sub-samples - used to test the validity of compositing samples for microbial analysis

Sample pre-processing

- Samples taken for faunal analyses kept cool during transport and stored at 4° C.
- Microbial samples are placed on ice in field, refrigerated within hours, transported to lab within 2 days.
- Soils for microbial analysis sieved through a 2-mm mesh immediately on return to the lab. Sub-samples stored at -20°C for molecular analysis, enzyme assays; 4°C for culturing, counts, microbial biomass; freeze-dried for PLFA.
- Faunal and microbial samples kept at 4°C analyzed within 1-2 weeks