VIRTUAL SOIL SCIENCE
LEARNING RESOURCES
FROM THE GROUND TO THE WEB

Photo: Novak Rogic

Soil 4 Youth

Teaching Activity Resource Sheets

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Introduction

Hello, and welcome to the Soil 4 Youth Teaching Activity Resource Sheets – a compilation of soil science activities for high school students. The overriding objective of all of these soil activities is to introduce youth to some of the complexities of soil management, and foster an appreciation for soil as a valuable resource.

Each activity includes:

- learning objectives
- list of materials
- description of set-up and description of principles being demonstrated
- photo/illustrations

The activities are outlined in very general lesson plan outlines, and the majority of these activities can be altered to suit any particular grade. Incorporating these activities into the classroom can help teachers to meet the BC Prescribed Learning Outcomes (PLOs) for the following courses: Science 8-10, Earth Science 11, Biology 11, Chemistry 11, Science and Technology 11, Geography 12, Sustainable Resources 11/12 and Geology 12.

This compilation is only a small part of a long list of possible soil teaching tools for youth – may these teaching tools be only the beginning of more soil activity ideas to come!

Table of Contents

1. Soil Hand Texturing

Learning Objectives:

- Observe the differences between fine and coarse textured soil
- Determine which soil texture (fine vs. coarse) has better drainage and nutrient holding abilities
- Become familiar with the tests used by soil scientists to work through a hand-texturing key (as would be used in the field)

Materials:

- A dry, coarse soil (preferably sieved to the 2.0-0.5 mm diameter range)
- A dry, fine soil (preferably sieved to <0.5 mm diameter)
- Two other dry, sieved soils of known textures (to be used as “Mystery Soils”)
- Water bottles

Activity Description:

Outline the idea that plants need 3 main things to grow: air, water, and nutrients. The soil regulates the belowground accessibility of these components to uptake by plants, and the texture of the soil plays a large role in this. Texture is the size of the mineral particles in the soil, and it is comprised of 3 main class sizes:

1) Sand: 2.0-0.5 mm diameter
2) Silt: 0.5-0.002 mm diameter
3) Clay: <0.002 mm diameter

The diameter information is not terribly important; what is important is that clay is much finer than sand, and a fine textured soil has different properties than a coarse textured soil. (These properties are outlined in more detail on page 4.) This means that knowing the soil texture can provide soil scientists with valuable information about a particular soil. There are lab methods that exist to work out the exact percentages of each size class, but in the field, soil scientists rely on the **hand-texturing method**. In this lesson, students will practice the hand-texturing method on samples of known texture, and then put their skills to the test in identifying some “mystery samples”.

Photos: Dru Yates

Figure 1. The student above has made a ball/cast of the soil (left) and a worm (right) to test for differences in soil texture.

To begin, place the equivalent of about a teaspoon of soil in the palm of your hand. Pick out and discard coarse fragments and large pieces of organic matter. Then, add some water to moisten the soil; having the soil too wet makes it hard to manipulate, so add the water drop by drop, and work the soil with the fingers of your other hand to obtain a moist, workable putty.

Students can then work through the “Key for Soil Texture Determination” (page 7). By working through this key, students can try different hand-texturing tests (as shown in Figure 1) in order to end up at a particular soil texture type. Some tests to help students work through this key are outlined on page 5.

Hand-texturing takes a lot of practice! Once students have had a chance to work through a few known samples, have them move on to two “mystery samples”, where they need to use their newly acquired texturing skills figure out the texture of the soil. Have students record their observations in the table on page 6 as they work through the texture key.

Why is Soil Texture Important?

Coarse soils are grainy, and have larger mineral particles than fine soils. You can use the worksheets on pages 8 and 9 to show how coarse soil (page 9) has larger spaces in between particles than the fine soil (page 8). These spaces are called “pores”, and the larger pores means that water will be able to flow through the coarse soil much easier. Coarse soils have good drainage, in comparison to fine soils, but they also have poor water retention and require more irrigation during dry months.

Using the particle size worksheets again, you can then show how the fine soil has more surface area than the coarse soil. There are more reactive surfaces in the fine soil, and so more nutrients are attracted to the soil surface, where they are held and kept available for uptake by plants. Organic matter, like compost, has high surface area, and so adding organic matter to a coarse soil can increase its fertility. Not to mention that organic matter contains its own nutrients!

A great follow-up question to this lesson is to ask: If I tell you that the Fraser River Valley has some of the best agricultural soils in Canada, what can you infer about the texture of this soil? *A: Fine. Largely silty.* Why is it so “good”? *A: Mostly because of the high nutrient retention capacity (high CEC) lending to good fertility. Also, water retention is good in the dry summer.*

Key to Hand-Texturing

(From "Field Methods for Describing Terrestrial Ecosystems", 1998)

Graininess Test

Rub the soil between your fingers. If sand is present, it will feel "grainy": you will be able to feel the individual grains. Determining whether sand constitutes more or less than 50% of the sample is the first decision in the key.

Moist Cast Test

Compress some moist soil by clenching it in your hand. If the soil holds together (i.e., forms a "cast"), then test the durability of the cast by tossing it from hand to hand. The more durable it is, the more clay is present.

Stickiness Test

Moisten the soil thoroughly and compress it between thumb and forefinger. Determine degree of stickiness by noting how strongly the soil adheres to the thumb and forefinger when pressure is released, and how much it stretches. Stickiness increases with clay content.

Worm Test

Roll some moist soil between the palms of your hands to form the longest, thinnest worm possible. The more clay present, the longer, thinner and more durable the worm will be.

Soapiness Test

Work a small amount of wet soil between your thumb and fingers. Silt feels slick and not too sticky (i.e., clay) or grainy (i.e., sand); the greater the dominance of a slick feel, the greater the silt content. Silt particles are distinguished as fine "grittiness", unlike sand, which is distinguished as individual grains (i.e., graininess). Clay has no grittiness.

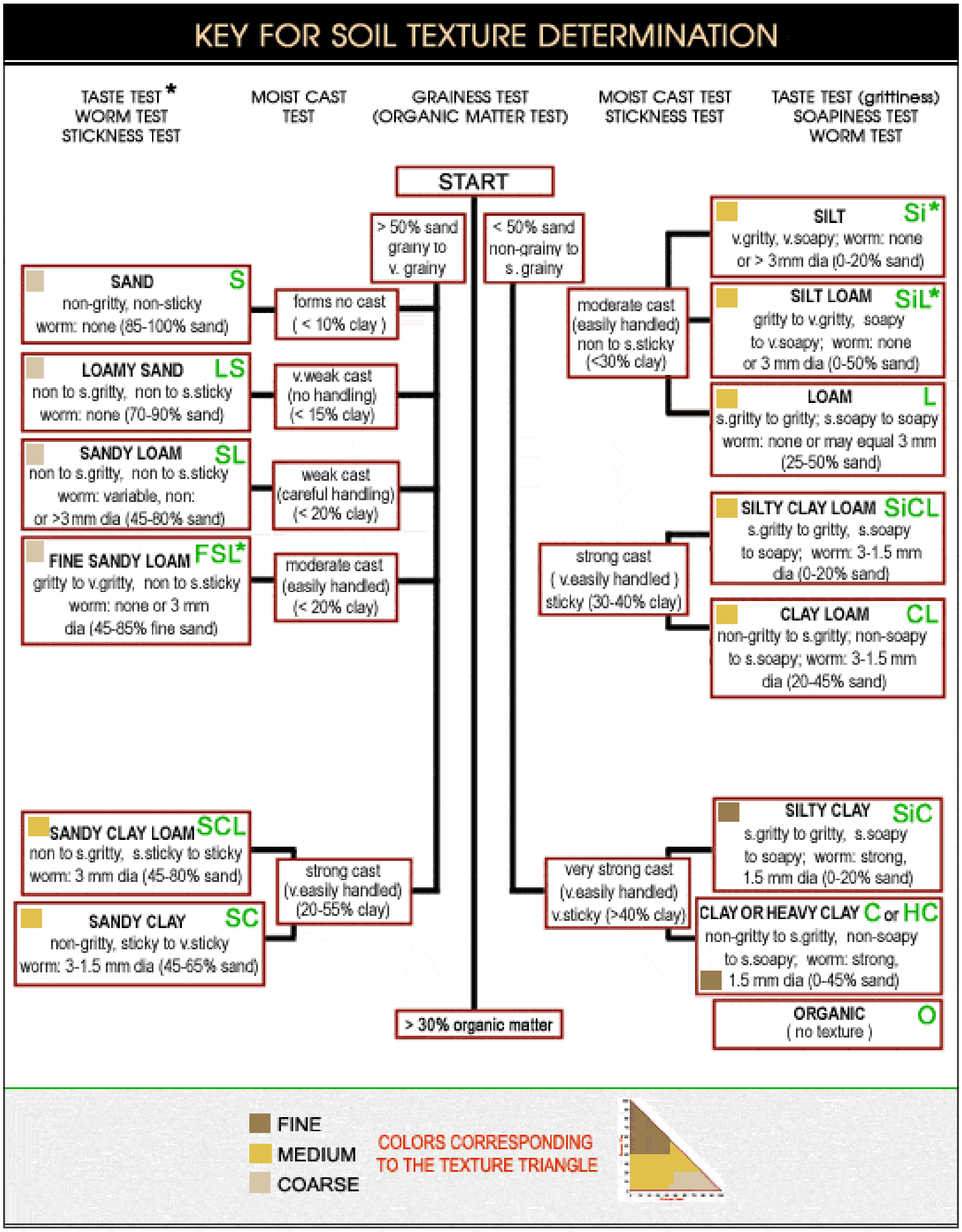
**Note: Well-decomposed organic matter (humus) imparts silt-like properties to the soil. It is generally very dark in color when moist or wet, and stains the hands brown or black. This organic matter is not used as a determinant of soil texture; estimates of the silt content of humus-rich mineral soils should be reduced accordingly. If the soil contains more than a few % of organic matter, hand texturing may become unpractical.

Reference

BC Ministry of Environments, Lands, and Parks and the BC Ministry of Forests. 1998. Field methods for describing terrestrial ecosystems. Land management handbook no. 25. Victoria, BC.

DATA COLLECTION SHEET FOR HAND TEXTURING

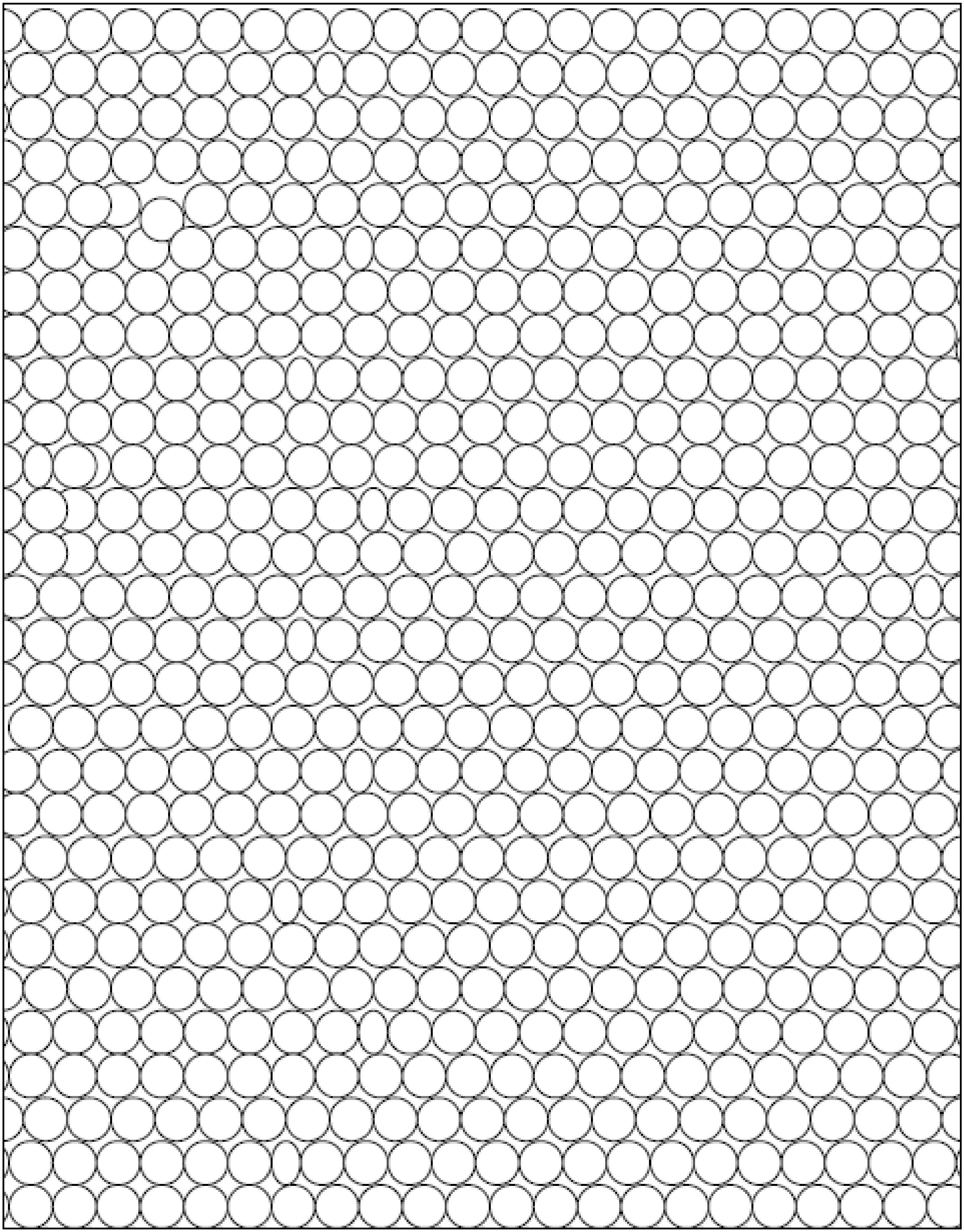
	Mystery sample A	**Mystery sample B**
Graininess test		
Moist cast test		
Stickiness test		
Worm test		
Soapiness test		
Soil texture		
Justification (why you chose that texture)		

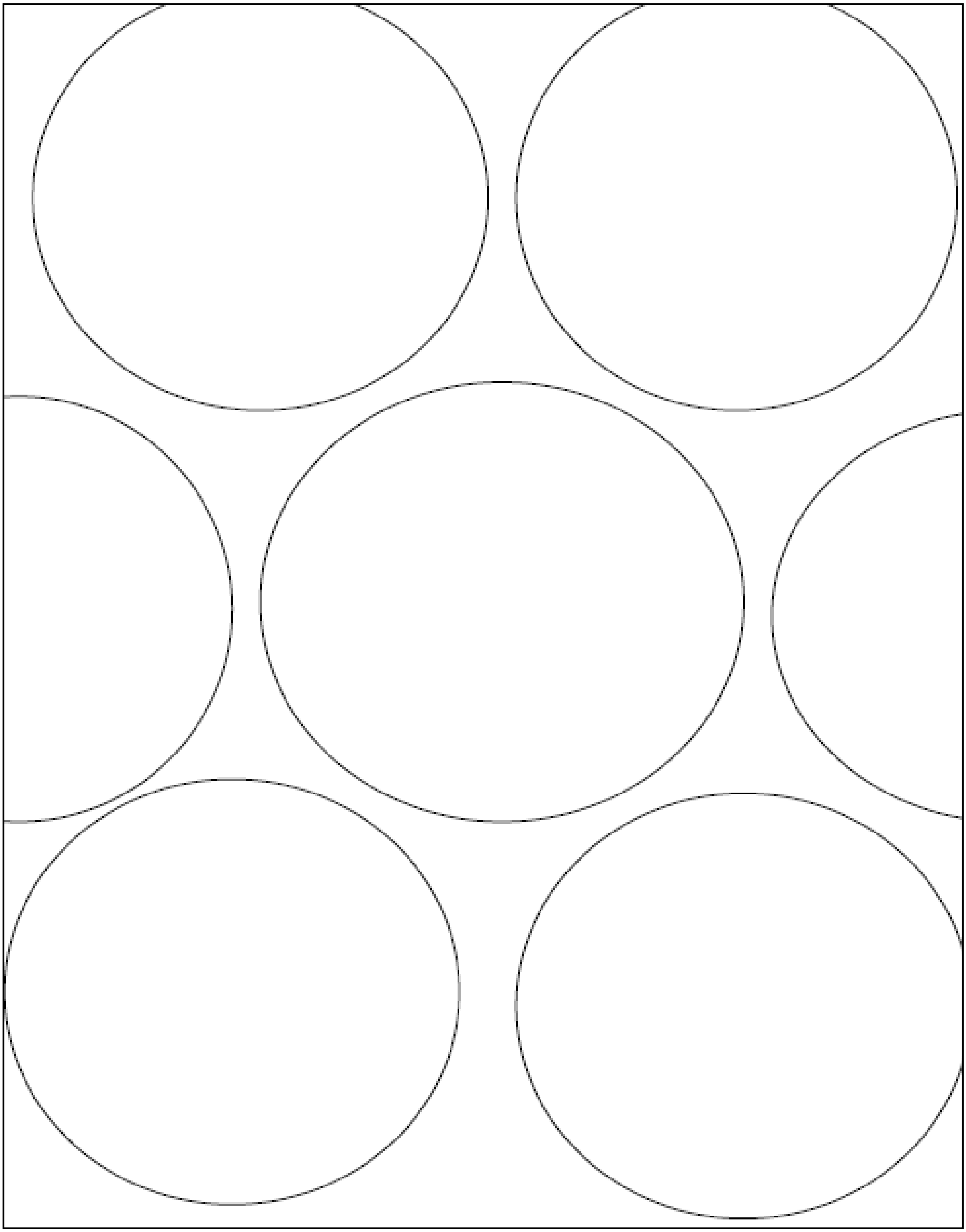


* Silt feels slippery or soapy when wet; fine sand feels stiffer, like grinding compound or fine sandpaper.

Key to Abbreviations	**Measurement Conversions**
s = slightly	3.0 mm = 1/8"
v = very	1.5 mm = 1/16"
dia = diameter	

Fine Fraction		**(particle diameter)**
SAND -------------	(S)	2 - .05 mm
SILT ---------------	(Si)	.05 - .002 mm
CLAY -------------	(C)	<.002 mm





2. Find Your Soil (using soil maps)

Learning Objectives:

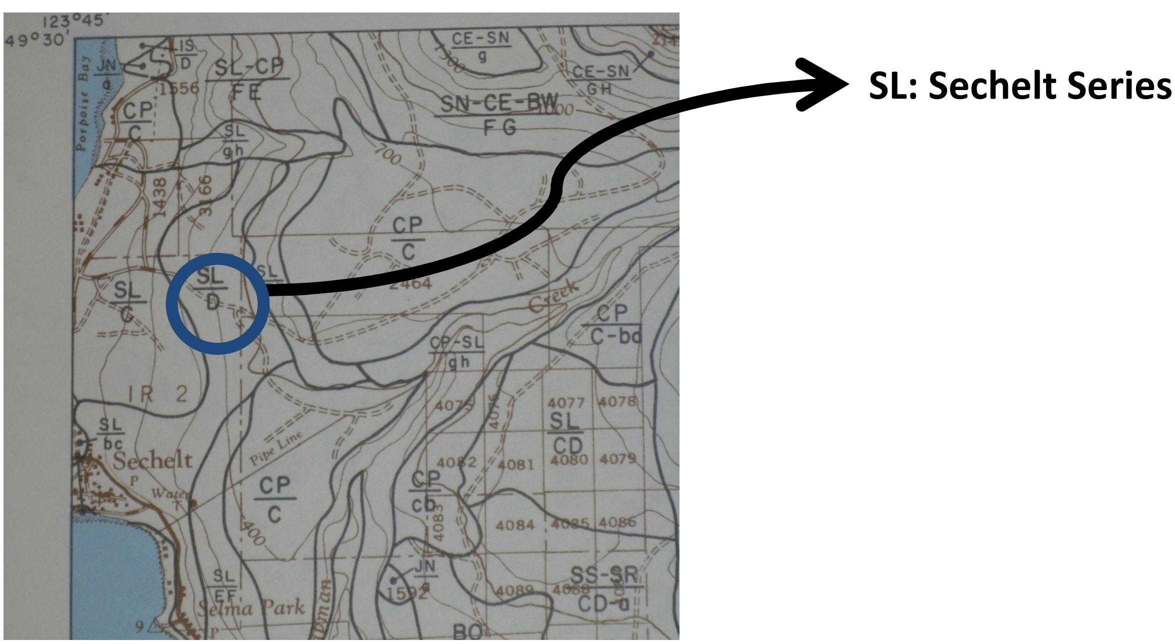
- Be aware that there are many different types of soils in a given community, and that the different soils have their own names
- Recognize that soil maps can be used to make land management decisions

Materials:

- Soils maps → in British Columbia, the main mapping books in print come in 3 Volumes: Soils of the Langley-Vancouver Map Area Volumes 1, 2, and 3. Volume 1 contains maps of the Langley-Vancouver area and Volume 3 provides a legend of information for the different soil series in Volume 1. Volume 2 contains maps and legend for the Southern Sunshine Coast and Southern Coast Mountains
- To access maps online, go to: http://sis.agr.gc.ca/cansis/publications/surveys/bc/bc15/index.html (Note: these documents take quite a bit of time to upload, so give ample time to access these online maps!)

Activity Description:

As a class, identify a certain landmark – the location of a popular local park (or ski hill) is a simple place to start (ie. Cypress Mountain) – on a photocopied map of your choice. Photocopy the map on to an overhead transparency so that the class can work together to find the school. Point out the surrounding landmarks that might help the students identify where the school is on the map. Once the school is found, bring up a transparency of a photocopied soil map for a similar area; point out the surrounding landmarks as before and find the school on the soil map. Match the two-lettered symbol on the soil map to the soil series names in the soil map Volume 3.



<u>Figure 2.</u> Above (left) is an image taken from a soil map for the Sechelt, BC area. The excerpt to the right is an example of the soil series legend information for map code SL: Sechelt Series.

Once the soils series name has been identified, have students write the name on a blank page. Go through the notable climate, vegetation, and soil information for that soil series (in very basic terms), and get students to write those characteristics down. Then, go through another location, one with very different in soil characteristics. Once you have drawn that soil, talk about how Soil #2 and Soil #3 are different (this can also be done in small groups). Is one more gravelly? Does one have more trees of a certain type (evergreen vs. deciduous)? Is one darker (more organic matter and nutrients) or more salty? How might these characteristics impact a farmer trying to grow a crop there, or a construction company trying to build a road there? This part of the conversation will help to demonstrate that soils can be quite different from one another, and can affect the types of land use in the area. Inclusion of locally relevant land use examples will make this particularly powerful.

The selected spots to locate on the soil maps can be whatever you choose, according to what is of interest to students and possible for students to identify. For example, individual house locations can be fun to do if students are able to find their houses on a map; the trick here is that no Canadian cities have their own online soil maps of the urban area, and so this is more easily done for rural communities. Any nearby farms or parks can also be interesting. You may then get the students to identify a given location (either assigned or of their own selection) on their own, and match the map information to the soil series name.

3. Earthworm Farm

Learning Objectives:

- Describe why earthworms are the "mixers and shredders" of the soil
- Identify earthworm biopores and casts in the soil
- Explain how biopores improve water movement, and how casts improve nutrient availability
- Identify that earthworms are indicative of a healthy soil

Materials:

- Shovel and trowel
- Earthworm farm structure (Plexiglas and grooved two-by-fours), or clear plastic/glass jars
- Towel

Activity Description:

The earthworm farm may be constructed of two sheets of Plexiglas slotted between two grooved pieces of wood (see photo below). This most effectively shows the biopore channels formed by the worms. However, it is possible to use clear plastic or glass jars instead – the biopores don't show up as well, but you can still generally see them! Once the earthworm farm structure is ready, collect the earthworms and soil to fill the earthworm farm. This can be done in one of two ways:

1) Go outside as a class and dig the upper 10-15 cm of a productive looking soil. Sort through as you dig to collect the earthworms, and bring the soil back to class.
2) Dig the upper 10-15 cm of soil on your own, and bring the soil back to the classroom where you can sort through as a class inside.

Gradually put the soil in the earthworm farm(s), and place the earthworms in at varying depths (around 20 worms were put in the earthworm farm pictured below, Figure 3). Place a layer of fresh organic matter, such as grass, and a layer of dry organic matter, such as hay, on the soil surface. Keep the earthworm farm moistened and covered with a towel – earthworms don't like much light! You should see biopore formation the following day; cast formation (at the soil surface) will take longer.

Earthworm activity dramatically changes the soil in two main ways: through biopore and cast formation. Biopores are the tube-shaped, slimy paths that form as the earthworms burrow through the soil. The biopores create channels that water can flow and drain through easily. This channeling also helps to **mix** the soil.

Earthworms also "eat" the soil to get nutrients from organic matter and microorganisms. As the soil is passed through their intestines, bits of organic matter are **shredded** up and some microorganisms are added to the soil. Their excrement, or casts, contains a lot of microorganisms and microorganism food. This enables the decomposition of organic matter into nutrients that are available for uptake by plants.

To complete this activity, you may require students to write a paragraph or short essay explaining the role of the earthworms in the ecosystem...or a simple class discussion may suffice. What is important in this activity is that students are able to both discuss and how earthworms affect the soil.

Photo: Dru Yates

Photo: Novak Rogic

Figure 3. Completed Earthworm Farm shown above, with towel to keep out light.

Some fun earthworm facts:

- There are over 7000 species of earthworms in the world
- A single earthworm can ingest soil up to 30 times its own weight
- "It would be difficult to deny the probability that every particle of earth...has passed through the intestines of worms." – Charles Darwin

A great complementary activity:

...is to make "dirt cupcakes"! Following a basic cupcake recipe of your choice, make enough cupcakes for everyone in the class. In class, have students decorate their cupcake(s) with the extra toppings of green/brown icing, oreo/chocolate pieces, shredded coconut, gummy worms, etc. (Figure 4).

This cupcake activity is light, enjoyable, and short, and may help to more directly engage some of the students who were reluctant to get involved in the Earthworm Farm creation.

Photo: Vegan Feast Catering

Figure 4. Dirt cupcakes, complete with worms!

4. Soil Erosion

Learning Objectives:

- Describe the negative impacts to water and soil quality by water erosion
- Describe how vegetation helps in the prevention of erosion

Materials:

- 3 large water jugs (as used with water coolers)
- Moist soil with grass/vegetation growing on it (for 1 jug)
- Moist soil without vegetation (enough to fill 2 jugs about halfway)
- Leaf litter (to cover 1 jug)
- 3 clear containers to collect water (suggestion: small plastic water bottles cut in half)

Activity Description:

Lay the 3 jugs side by side, and cut out one side on each of the jugs (see photo below). Fill all jugs with the same soil (obtained from the same location) and plant some grass seeds in one of them. In the second jug cover the soil surface with leaf litter, while in the third jug leave the soil uncovered and do not plant anything. Prop up the non-spout ends of the jugs by a few centimeters. Place the small water collection containers at the spout end of the jugs; hanging the containers at the end of the jugs with string works well (see Figure 5 below). Once the grass has germinated and gown several centimeters in height to completely cover the soil surface, carefully and slowly pour the same quantity of water into the raised part of each jug, and let it flow down through the jugs and into the collection containers.

Photo: Google+ Earth

Figure 5. Three jugs of the same soil, but different vegetative cover to test differences in runoff.

This very simple experiment can be used to show the importance of vegetation in preventing erosion of a productive soil. The water that runs through soil with vegetation comes out clear, while water that run through soil in the other containers without vegetation came out muddy. The aboveground parts and roots of plants help to keep the soil in place. This observation can be relevant in situations when people are deciding how to manage land uses (e.g., logging and agriculture) around waterways. What could happen if we cut too many trees in a forest near a river or creek? Or on farmer's field that is left completely bare over the winter? What sorts of water quality problems might this cause? What happens to the nutrients during water erosion?

5. Six Ecosystem Functions of Soil (group skits)

Learning Objectives:

- Interpret and identify the six main categories of functions performed by the soil

Materials:

- Cue cards outlining the six ecosystem functions of soil

Activity Description:

To begin, introduce students to the idea that the soil is involved in many parts of Earth's ecosystems, beyond being important for plant growth. Perhaps challenge the class to brainstorm all of the different soil functions that they can think of. Displaying a photo (such as the one in Figure 6) and asking students to identify all of the roles the soil is playing can be a helpful prompt. Then, focus on explanation of the 6 ecosystem functions (outlined below). Emphasize any functions that were omitted during the brainstorming.

Photo: Sam Beebe, Ecotrust

Figure 6. A photo of the urban/rural interface; a photo like this can provide a helpful prompt to students to brainstorm the difference functions served by the soil.

Split students into groups, assign them a function (ie. each group gets a certain cue card with the function outlined on it), and let them plan a short (ie. 2 minute) skit that represents that ecosystem function in some way. The students then present back to the class. This is an interactive (and entertaining) way to help students see that soil is necessary in a lot of important processes and services in the world.

The 6 Ecosystem Functions of Soil are:

1. Medium for plant growth.

In the soil, plant roots obtain: Physical support to anchor them, air, water, temperature moderation, protection from toxins, nutrients.

2. Regulator of water supply.

Soil affects water supply by storing water for use by plants, or allowing water to seep down into the groundwater. Contaminated water may also be purified as it passes through the soil and removes impurities. Wetlands are a good example of this!

3. Nutrient cycling.

Soil is nature's recycling system. Waste and dead matter are decomposed and their nutrients made available for new life.

4. Habitat for many organisms.

Many living things, from small mammals and reptiles to tiny insects and microorganisms, find their homes in the soil.

5. Atmospheric modification.

Soils breathe! Gases are exchanged between the soil surface and the air. Gases like oxygen and methane are absorbed, while, while gases like carbon dioxide and nitrous oxide are released. The soil provides a valuable carbon sink. The evaporation of soil moisture also affects air temperature and weather patterns.

6. Foundation for construction.

Soil provides building material such as bricks and gravel. It also provides the solid foundation for all our roads and buildings.

6. Soil Order Competition

Learning Objectives:

- Know that there are multiple levels of soil classification in the Canadian Soil Classification System, with soil Order being the largest scale.
- Name all 10 Canadian soil Orders.
- Become familiar with at least one soil order in detail.

Materials:

- Computers with internet access to the online videos at: http://soilweb.landfood.ubc.ca/classification/
- Scrap paper and hat or bucket

Activity Description:

The Canadian Soil Classification System classifies soil at 5 main categorical levels: Order, Great group, Subgroup, Family, and Series. The soil Order is the most general grouping (ie. largest scale category), and there are a total of 10 Orders in the Canadian Soil Classification System. Each Order is distinct from one another due to differences in soil formation processes, and each has an interesting set of characteristics that distinguish it. A compilation of videos describing the different Orders can be found online at http://soilweb.landfood.ubc.ca/classification/. This activity uses these videos as a teaching tool for students to explore and extract information from in order to learn about a given soil Order. Students will then practice using their persuasion skills as they try to convince the class that their soil Order is "the best".

Figure 7. Homepage for the Canadian Soil Orders online video compilation.

Begin by outlining the 10 Orders very briefly (a basic outline can be found here: http://www.soilsofcanada.ca/orders/index.php) and providing some examples of where these Orders can be generally found around Canada. Introduce students to the online "Canadian Soil Orders" videos (the homepage is shown in Figure 7). Have them come up and blindly select the name of a soil Order from a hat. Get students with the same Order to group together, and then tell them that you are going to hold a mock competition for "The Best Soil Order in Canada". As a group, they must come up with a presentation for their soil Order to try to make a case for why it is "the best" soil in Canada. They should use the online "Canadian Soil Orders" videos, as well as any other information they can find about the Orders, to inform their arguments. They should hit the following points in their description (feel free to use your own ideas here, too):

- Appearance – what does the soil look like, how is it "stylish"
- Value – notable ecosystem services or land use
- Uniqueness – something else interesting, bizarre, or somehow notable that is specific to that Order

In a future class, students will come back with their presentations and make the case for their soils. At the end of the presentations, have everyone cast a vote as to what their favourite Order was, specifying that they cannot vote for their own Order! The winning Order may receive some sort of fun prize.

Having the students present in front of each other helps the students to gain more exposure to all of the Orders. To have students learn about more than just one Order in detail, follow up the Soil Order Competition by getting them to select two more Orders (either by random selection or by choice) as well as a land use (again, either random or by choice). Some land use ideas include: park, forestry, wildlife reserve, agriculture, highway construction, etc. Then, have the students individually prepare a short write-up comparing the suitability of their two soil Orders for that particular land use. Which Order is better suited to that land use and why? This will get students to think about the characteristics of 3 soil Orders in detail, with some exposure to the 7 others through the class presentations.

7. Macro- and Meso-fauna Extraction

Learning Objectives:

- Become familiar with the various ecosystem roles played by soil fauna.
- Define, extract, and quantify soil macro- and meso-fauna.
- Calculate richness and species diversity to compare the soil biology of different soil types, and then speculate as to why the different soil environments could cause these observations.

Materials:

- Berlese funnel (see notes for construction of these funnels on page 23)
- Petri dishes
- Dissecting forceps
- Dissecting microscope

Activity Description:

A Berlese funnel is used in soil biology to extract insects from a soil sample. It uses a light source (a light bulb) to repel insects in the sample to the bottom of the funnel, until they fall through a screen and into a jar of preserving alcohol.

In this activity, students will work in groups to extract both macro- and meso-fauna, using Berlese funnels, from three different soil types: potting soil, soil from a lawn, and soil from a forested site. Logistically, it typically works best to assign a group (of 2-4 people) to each soil type. There may be multiple groups for each soil type, depending on class size.

Macro-fauna extraction:

1. Collect samples by extracting a 20 cm x 20 cm block of soil, to a depth of 3 cm. In the lawn and forest soils, remove as much of the plant matter and forest floor as possible to make sure you are sampling the top of the mineral soil.
2. Place sample in a labelled plastic container.
3. Hand-sort the samples, removing any visible macro-fauna (>1 cm in body size) with dissecting forceps.
4. Place the macro-fauna in petri dishes and identify using the “ID Info” provided on page 22. May choose to use a dissecting microscope here.
5. Count and record the number of individuals of each group present in each sample.

Meso-fauna extraction:

1. Using a trowel, remove a 5 cm x 5 cm square of soil to a depth of 3 cm. In the lawn and forest soil, be sure to include the plant matter and or forest floor as well as 3 cm of the mineral soil.
2. Set-up Berlese funnels, placing an empty jar below the funnel to start.
3. Place the litter sample on top of the screen. Gently shake and tap funnel so that any loose soil falls through. Place any fallen soil back into the funnel.
4. Replace the empty jar with jar of alcohol. Turn on light over top of funnel and let sit for 7 days in a place where it will not be disturbed.
5. Etch a 1 cm x 1 cm grid onto the bottom of 4 petri dishes. Transfer an equal portion of the extraction liquid (the alcohol solution) to each petri dish (be sure to rinse the jar to ensure everything is transferred).

6. Using a dissecting microscope, observe the contents of each dish, using the grid on the dish to systematically work through the entire space.
7. Record any observations and add to the tally of individuals from the macro-fauna extraction.

Once all the organisms have been identified and counted, have students enter their data into a table set up in the following way:

Sample: Forest	**Organism Group**	**Abundance**	**Proportion (p_i)**	**$-p_i*\ln(p_i)$**
	Mites	50		
	Springtails	30		
	Isopods	10		
	Millipedes	9		
	Ants	1		
Totals				

In this table, students will calculate the following:

- Richness of organism groups:
  - equal to the sum of all organism groups

- Organism group diversity (H’), using the Shannon Index:

  Let p_i = the proportion of all observed organism groups

  $H' = -\sum [p_i*\ln(p_i)]$ ***Note: Higher index value = more diverse community*

Following calculations, the table should look like this:

Sample: Forest	**Organism Group**	**Abundance**	**Proportion (p_i)**	**$-p_i*\ln(p_i)$**
	Mites	50	0.5	0.347
	Springtails	30	0.3	0.361
	Isopods	10	0.1	0.230
	Millipedes	9	0.09	0.217
	Ants	1	0.01	0.046
Totals	5 (richness)	100	1.00	1.201 (H’)

At this point, have the entire class share their final results with each other and then compare the results for each of the soil types analyzed. Either as an in-class discussion or as a written lab report, have students discuss the following:

- What important roles do invertebrate macro- and meso-fauna play in the soil ecosystem?
- Why would we be interested in the a) richness and b) diversity of organism groups in the soil?
- Which of the three soil types had the most richness/abundance/diversity? Which soil had the least? Based on your own critical thinking, what are some possible reasons for these observations?

Background on Soil Macro- and Meso-fauna:

Soil macrofauna are typically classified as the invertebrates in the soil with a body length >1 cm. Their main functions involve burrowing and mixing the soil. Some of them also play a large role in the breakdown of organic matter at the surface (a.k.a. surface litter). Examples: earthworms, millipedes, centipedes, ants, Coleoptera (adults and larvae), Isopoda, spiders, slugs, snails, termites, Dermaptera, Lepidoptera larvae, and Diptera larvae.

Soil mesofauna are of a body length between 1 cm and 1 pm; anything smaller is microfauna! They are largely responsible for fragmenting debris and contributing to good soil structure. Examples: mites, springtails, tardigrades, Enchytraeidae, and Pauropods.

Macro- and meso-faunal mostly live in the litter or in the upper few centimeters of the soil because this is where most of the food is. Food comes to these organisms as organic matter and/or other organisms. Some of the many functions affected by soil organisms include: decomposition, nutrient availability/cycling, carbon sequestration, degradation of pollutants, plant protection (through predation of pests), and soil aeration. Biodiversity of soil organisms is essential for maintaining these ecosystem functions. Low biodiversity can leave an ecosystem susceptible to extreme events in the environment; high biodiversity in a community can make an ecosystem more resilient in the face of disturbance.

There are more living individual organisms in a tablespoon of soil than there are people on the earth!

ID Info:

If students have access to laptops or computers, it can be very effective for them to look up images for organism ID on their own. Compiling photos and brief descriptions of these organisms can actually be assigned to students, in groups, as part of the preparation for this activity. Here is a list of commonly found invertebrate fauna in B.C.'s forest soils, which can be given to students as a minimum list of organisms that require photos and brief descriptions:

- Diploda (millipedes)
- Chilopoda (centipedes)
- Isopoda (woodlice)
- Psocoptera (bark lice)
- Pauropoda
- Symphyla
- Diplura
- Collembolan (springtails)
- Tardigrada (water bears)
- Rotifera
- Protura
- Insect larvae
- Araneida (spiders)
- Pseudoscorpionida
- Acari (mites)
- Nematoda (roundworms)
- Enchytraeids (pot worms)
- Annelida: Lumbricidae (earthworms)
- Coleoptera (beetles)
- Hemiptera (true bugs)
- Homoptera (aphids, psyllids)
- Diptera (flies)
- Isoptera (termites)
- Hymenoptera (bees, wasps, ants)
- Gastropoda (slugs, snails)
- Thysanura (bristletails)


Photo: Silversyrpher

-Insecta
-3 pair legs, 10-15 mm long
-no wings
-usually elongate and flattened
-long antennae
-has a long central tail that is longer than two shorter tails

Example above: Thysanura

Some very basic sketches for a more limited list of the major types of soil fauna in B.C. can also be found here (see Fig. 2.3): http://www.ilmb.gov.bc.ca/risc/pubs/teecolo/fmdte/soilohl.htm

How to make your own Berlese Funnel:

Photo: Brian Gratwicke

Figure 8. A home-made Berlese funnel.

Materials:

- a one-Liter plastic milk container
- an empty glass jar or clear plastic container
- a mesh hardware cloth or aluminum window screen
- masking tape or duct tape
- rubbing alcohol (ethyl alcohol)
- 25 Watt light bulb (suggest a gooseneck lamp)

Instructions:

Cut the bottom out of the milk jug and turn it upside down over the Mason jar to make a funnel. Bend down the corners of the hardware cloth/window screen so it fits snugly inside the wide end of the funnel. Layering with two levels of the mesh/screen, one at the wide end and one at the spout, is most ideal. Collect several handfuls of humus or leaf litter and put them on top of the wire mesh. Pour 50-60 mL of alcohol into the jar. Place the funnel on top of the jar and tape the funnel to the jar to secure it. Set the light directly over the funnel.

8. Mini Soil Monoliths

Learning Objectives:

- Become aware that the soil is composed of multiple layers called "horizons"

Materials:

- dark coloured dry soil labelled "A", lighter coloured soil labelled "B", coarse (and light) coloured soil labelled "C"
  **Note: the soils used must be pre-dried and also ground up so that it is less clumpy and will stick to the tape/glue better. Soil can be ground using a rolling pin.
- paper with a strip of double-sided tape on it (can use glue as an alternative)

Activity Description:

Stick a length of double-sided tape (~8 cm long) on to a piece of paper. The paper can be labelled with horizons A B and C as a guide. Tear down the tape 1/3 of the way, exposing the sticky part of the tape. Pour the dark A horizon soil on to the tape, and brush off the excess. Tear down the tape another 1/3, and pour the light B horizon soil on to the tape. Tear all of the tape off, and pour on the coarse C horizon soil. And voila! A mini soil monolith!

Photo: Dru Yates

Figure 9. A mini soil monolith, composed of 3 main horizons.

The top A horizon is dark because of the organic matter inputs from plants and roots. Some students might have fun drawing trees/flowers/grass on the surface of their mini monolith – this can help demonstrate the concept of vegetation decomposing at the soil's surface. The B horizon is lighter in colour because it doesn't have as much organic matter as at the surface. The C horizon is coarse and rough because it is the farthest underground. Soil is developed from bedrock below the Earth's surface. The C horizon is the closest to the bedrock and is protected from weathering below many layers of minerals above, so it is the least developed horizon.

Soil scientists make larger versions of these monoliths using a glue-like hardening compound. Some examples of real soil monoliths can be found here: http://soilweb.landfood.ubc.ca/monoliths/.

9. Cinematic Soils

Learning Objectives:

- Become engaged in the many ways soil health applies to human society

Materials:

- Dirt! The Movie (2009): http://www.thedirtmovie.org/
- Symphony of the Soil (2012): http://www.symphonyofthesoil.com/

Activity Description:

These are simply two soil-related documentary suggestions, both with the overriding message that soil is an important (and often underrated) resource in our society. The idea behind presenting these films to a class would be to create a jumping off point from which future environment-related lessons could be based, or to generate ideas for in-class discussions about the environment. Many land use applications are touched on in these films, and the importance of soil is shown in various real life settings. For example: Students could be asked to complete a simple worksheet while watching the film, and then this worksheet would provide a set of notes for students to refer to in a discussion later on.

Dirt! The Movie is a film that outlines the historical and current relationship between humans and the soil. It provides some humor to otherwise very serious issues about land management and the need to shift attention to the health of our soil.

Symphony of the Soil focuses a lot on the connection between healthy soil and healthy people, touching on a lot of the same themes as in Dirt! The Movie.

Photo: o5com

Figure 10. Soil-themed movies often touch on broad-sweeping environmental topics, and can be a great starting point to generate an environmentally focused discussion in class.

**Extra Challenge Activity: Organic Acid Leaching Demo

This is a more advanced soil science lab that involves a greater level of detail in soil chemistry. Due to the complexity and detail, it may not be suited for many high school science classroom settings; however, it may provide an interesting chemistry lab for an advanced science course!

Learning Objectives:

- Name and compare the 3 different forms of organic acids in soil organic matter in terms of their solubility
- Experiment with the solubility of soil organic matter components in varying acidities, using rainwater (slightly acidic, pH 5.6), acid rain (acidic, pH 1.5-3.0), and over-liming (alkaline, pH 7.5-8.0) as examples of real world leaching situations
- See the connections between the different organic acids, nutrient availability, and carbon sequestration

Materials:

- 3 funnels/tubes (clear)
- Filter paper
- 3 collection beakers (clear)
- Funnel/tube rack
- 1 cup of moist, dark soil (with high organic matter)
- Solutions of pH 3.0, 5.6, and 7.5

Activity Description:

Place the filters in the funnels (with collection beakers below the funnels), and put a couple tablespoons of moist soil into each filter. Make sure the soil used is quite dark in colour; soil rich in organic matter will give clearer results. Moisten soil with extractant solutions of different pH values, so that one soil is treated with a pH of 3.0, one with pH 5.6, and one with pH 7.0. Leave for at least 1 min. Then add enough of the extractant solutions for some to drip through the filter paper. Leave for another 5 min. Compare colour of the extracts in the collection beakers; the colours should get darker with increasing pH of extractants.

The solutions of various pH represent different real-world solvents:

pH 3.0 = acid rain
pH 5.6 = rain
pH 7.5 = excess of lime applications in agricultural soil

Humic substances are compounds produced through the decomposition of organic matter. They are complex substances of high molecular weight, which are resistant to further decomposition (due to their complexity). They tend to be dark in colour and are chemically characterized by ring-type (a.k.a. "aromatic") structures. Humic substances make up 60-80% of total soil organic matter (SOM), and are where carbon can be sequestered in the soil. There are three general groups of humic substances with varying degrees of complexity of chemical structure:

1) Humins → particles with large molecular weight, relatively small specific surface area, a relatively low number of carboxyl groups, and are inactive. Insoluble in both acid and alkali.

2) Humic acids → smaller in size then humins and have more carboxyl groups than humins. Soluble in alkali, but insoluble in acid.

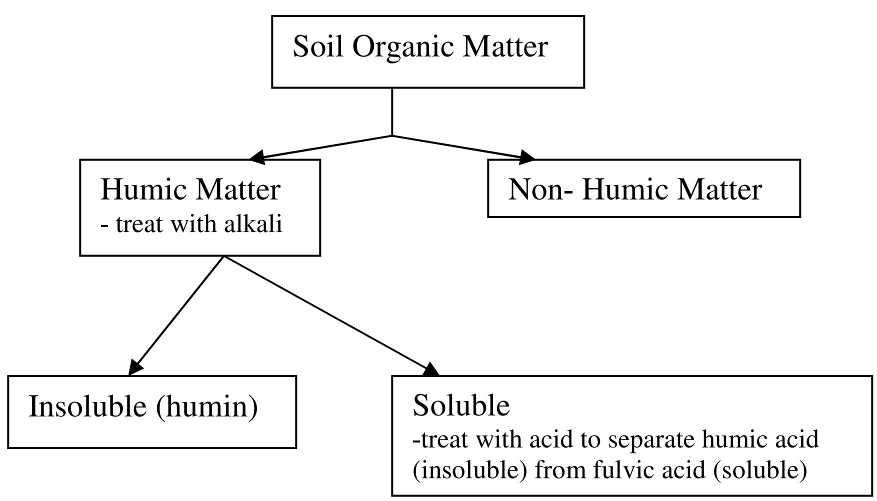
3) Fulvic acids → the smallest in size among humic substances, and have a large number of carboxyl groups per unit mass (which means they contain more functional groups of an acidic nature). For this reason they are the most active among humic substances. Soluble in both acid and alkali. Good chelators of metals.

A useful graphic outlining the differences in humic substances can be found here:
http://karnet.up.wroc.pl/~weber/kwasy2.htm

Fulvic acids have a smaller molecular size and are the least complex in structure compared to humic acid and humin. Because they are less complex, it is easier for extractants to interact with and alter the chemical structure of the fulvic acid (through protonation of aromatic rings to form water-soluble ions). These alterations create water-soluble ions from the fulvic acid, which allows fulvic acids to leach into solution. Fulvic acids are lighter in colour than their humic acid and humin counterparts.

Humic acids and humin are more complex in structure, and are both resistant to extraction by acids. ***Humic acids*** can be leached by alkaline extractants because neutralization of the acid by the extractant converts acidic components into neutral, water-soluble ions. ***Humin***, however, is the most complex and is insoluble in both alkaline and acidic conditions.

The flowchart below outlines the susceptibility of the three different humic substances to different extractants:



The colours of the extractants in this lab should get darker with increasing pH, as the alkaline solutions draw out more humic acid which is darker in colour. Acidic solutions, however, only increase solubility of fulvic acid, resulting in lighter colouration of the extract (as fulvic acid is lighter in colour). (Recall: humin is not extracted in this demo, as it is insoluble.)

Photo: Dru Yates

Figure 11. The funnels set up, with increasing pH of extractant from left to right.

In nature, acidic conditions are better suited to fungal activity than bacterial activity. This results in the solution of fulvic acid, and a decrease in the production of humic substances (resulting in lower C storage). Under excess lime, the alkalinity typically favours bacterial activity. Bacterial decomposition in the soil is typically more rapid than fungal activity, and so it results in the production of more humic acid and humin. This increases C retention and largely decreases nutrient availability. However, the alkalinity also increases the susceptibility of humic acid to break down and release C, because alkalinity makes the humic acid more soluble.

The complex nature of humic acids and humin make them more resistant to microbial activity and extraction. They provide longer term storage of carbon (C), nutrients, and metals. This improves the capacity of the soil to store C, but limits nutrient availability in the short-term.

Fulvic acids, on the other hand, are less complex and, therefore, less resistant to microbial activity and extraction. With more microbial activity, more CO_2 is released, but nutrients become available. In particular, more metals are chelated and made available in the soil as the fulvic acids in solution interact with the metals in the soil.