Module 3 Lesson C: Living Soils & Ecosystem Services – Hands-On Activity C1, C2, C3,C4

Student Instructions Worksheet – Module 3 Lesson C

Grouping: Small teams (3–4 students) working at 4 stations (rotate as needed)
Time: ~50 minutes total (about 10–12 minutes per activity station)

Precautions and Hazards:

- **Hygiene:** Soil may contain microbes. Avoid touching your face and wash hands after handling soil and compost.
- **Tool Use:** Be careful when pushing metal rings or cans into soil (for infiltration). Only use gentle pressure or a rubber mallet if provided. Watch fingers and wear gloves if available.
- **Chemicals:** Vinegar will be used – avoid splashing it into eyes (wear safety glasses if needed) and wash hands if contact occurs. Baking soda and vinegar are generally safe but can fizz vigorously; perform that step slowly.
- **Cleanup:** Keep work areas tidy. Wipe any water spills immediately to prevent slips. Dispose of soil and water as instructed by your teacher.

Materials (per group):

- **Soil Samples (2 types):** Collect two different soil samples, labeled **Sample A** and **Sample B**. Ideally, choose one "healthy" soil (e.g. from a garden or under grass, with roots and dark color) and one "degraded" soil (e.g. from a trampled or bare area). Each sample should be in a tray or bucket for use in tests.
- **For Soil Glue (Aggregate Stability) test:** 2 clear cups or jars (large enough to fit a soil clod and water), water (~1–2 L to submerge clods), 2 pieces of wire mesh or screen (to support soil clods in water), **dry** soil clods from Sample A and B (golf-ball sized), tray or paper towels, stopwatch/timer, student worksheet. *(If wire mesh isn't available, use a spoon or strainer to hold the clod.)*
- **For Infiltration test:** 2 metal coffee cans or PVC rings (open at both ends) for infiltration rings, water (at least ~500 mL per soil sample), a measuring cup (or graduated cylinder) to measure water volume, stopwatch/timer, ruler (optional for water depth). **Optional:** a plastic sheet or tray to place under rings if doing this indoors.
- **For Build vs. Deplete sorting activity:** List of farming practices (provided below or as cards), pen and paper or the worksheet table to categorize them. *(Teacher may provide pre-cut cards or you can write them out.)*
- **For Soil Respiration test:** 2 clear jars with tight-fitting lids (e.g. Mason jars) for Samples A and B, baking soda (~2 tablespoons per jar), white vinegar (~¼ cup per jar), 2 small containers (film canisters or plastic cup lids) to hold baking soda inside the jars, measuring spoon, funnel (optional for adding vinegar).

Objective:

Work as a team to conduct four mini-experiments that demonstrate **soil health indicators** and the benefits of "living" soil. You will: observe how soil structure holds together with water ("Soil Glue" slake test), measure how quickly water soaks in (Infiltration test), classify farming practices as building or depleting soil health (Build vs. Deplete activity), and detect soil microbial activity by capturing CO_2 gas (Soil Respiration test). Through these activities, you'll learn how healthy soils support ecosystem services like clean water, fertility, and climate regulation, and how land management choices can either improve or degrade these soil functions.

Instructions: *(Demonstration videos for some tests are available – e.g., an NRCS "Slake Test" video and an "Infiltration Test" video – your teacher may show these for guidance at nrcs.usda.gov.)*

Activity C1: Soil Glue Test (Aggregate Stability) – *How well do soil clods stay intact in water?*

Resource*: Follow the USDA NRCS Soil Health Educators Guide* **- Soil Glue Lesson Plan***, and watch the* YouTube: **Soil Glue Overview**.

1. **Setup:** Fill a clear cup or jar about ¾ full with clean water. Gently place a piece of wire mesh or screen over the opening of the cup (it should sit flat or just inside the rim). The mesh will support the soil clod.

2. **Position Soil Clod:** Take a dry clod (crumbly chunk) of **Soil Sample A** and gently place it on the mesh so that the clod is just at the water surface (not submerged yet). Now slowly lower the mesh or push the clod into the water until it's fully submerged on the mesh. **Do not stir or shake** – just let it sit. *(The mesh keeps the clod suspended so you can see what happens to it in water.)*

3. **Observe:** Watch the soil clod for about 1–2 minutes. Note any **bubbles** rising (air escaping), any **cracks or pieces breaking off**, and whether the water becomes **cloudy** or stays clear. A "stable" aggregate (healthy soil) will hold its form and the water will remain clearer, whereas a weakly aggregated soil will **disintegrate** and muddy the water nrcs.usda.gov.

4. **Repeat for Sample B:** Set up a second cup of water and mesh, and repeat the procedure with a dry clod of **Soil Sample B**. Again, observe the differences. Does one sample's clod hold together much better than the other? Record your observations for each sample on the data sheet (Part A).

5. **Think:** What might cause one soil to have better "glue" holding it together? Consider the role of organic matter and roots producing natural glues (like plant exudates and microbial slime) that bind soil. Be ready to discuss why stability matters (hint: think about erosion when heavy rain hits the soil). *(You will answer a question about this in the Reflection section.)*

Activity C2: Soil Infiltration Test (if not used in Lesson A) – *How fast can water penetrate into soil?*

Procedure Summary (refer to NRCS *Soil Infiltration* Guide and and YouTube Soil Infiltration Overview Video and Soil Infiltration Test Video)

1. **Prepare Soil Surface:** Go to the container or area for **Soil Sample A**. If you're outdoors on a soil patch, clear any surface debris without disturbing the soil structure. If using a tray of soil, gently level the surface.

2. **Insert Infiltration Ring:** Take the metal ring (open-ended can) and **insert it into Soil A** about 5 cm (2 inches) deep. Press straight down evenly – you can twist gently or tap with a mallet/wood block if needed, but avoid cracking the soil inside the ring. The goal is a snug, vertical ring that will hold water above the soil. Make sure there are no big gaps at the edges (press soil against the inside edges if needed to seal).

3. **Add Water:** Measure a set volume of water (e.g., **250 mL** or 1 cup). **Slowly** pour the water into the ring on Soil A. Start timing **as soon as** you begin pouring. Pour steadily but not faster than the soil can absorb – avoid overflowing or eroding the soil. If the soil is very dry, you might see it absorb slowly at first; keep pouring until you've added the full 250 mL.

4. **Measure Infiltration Time:** Observe the water as it infiltrates. Stop the timer when **no standing water** remains on the soil surface inside the ring (i.e., it has all soaked in). Record the time in seconds on the data sheet (Part B). If water is still standing after a set maximum time (e.g., 5 minutes = 300 seconds), note the amount infiltrated or remaining.

5. **Repeat for Sample B:** Now perform the same steps with Soil Sample B. Insert the second ring into Soil B (or rinse and reuse the ring in a different location/soil tray for Sample B). Pour the same volume of water and time the infiltration. Record the time for Sample B.

6. **Compare:** Which soil absorbed water faster? A soil with better structure (more pores from roots and soil life) will typically have a faster infiltration rate nrcs.usda.gov. If one soil had water pooling or very slow absorption, it may be compacted or lacking those pores. Note any differences in how the water behaved (Did one soil form puddles or run-off? Did the other soak it up like a sponge?).

7. **Think:** Discuss why having a higher infiltration rate is beneficial. (Hint: fast infiltration means less runoff and erosion, and more water stored for plants. Slow infiltration or runoff can cause flooding, nutrient loss, and carry soil away.) You will reflect on this in the questions later.

Activity C3: "Build vs. Deplete" – Soil Practices Sorting – *Which farming practices help build healthy soil, and which deplete it?*

1. **Understand the Task:** You have learned about various agricultural practices in class. Now you will categorize them into two groups: **Soil-Building Practices** (those that **improve or maintain** soil health) vs. **Soil-Depleting Practices** (those that **harm or reduce** soil health over time) kisstheground.com. This activity is based on a lesson from the *Soil Story* curriculum, Handout 4.2: Agricultural Practice Cards, Pages 61 to 64.

2. **Review Practices List:** Look at the list of farming practices below (your teacher may also have physical cards for each). Make sure everyone in your group understands what each practice means – ask for definitions if needed. For example, "cover cropping" means planting crops like clover or rye in the off-season to cover and enrich the soil, whereas "leaving soil bare" means nothing is grown and soil is exposed.

   - **Frequent plowing or tillage** (turning over soil with machines)
   - **No-till or reduced till farming** (minimizing soil disturbance)
   - **Leaving fields bare between crops** (no cover, fallow soil)
   - **Planting cover crops** (growing plants primarily to protect/boost soil)
   - **Using synthetic chemical fertilizers only** (no organic inputs)
   - **Adding compost or organic manure** (returning organic matter to soil)
   - **Confined Animal Feeding (CAFO)** – animals kept on small feedlots or barns (manure often concentrated as waste)
   - **Managed rotational grazing** – livestock graze on pasture and are moved regularly (manure naturally fertilizes soil)

3. **Sort the Practices:** As a team, discuss each practice and decide if it belongs in **"Soil-Building"** or **"Soil-Depleting."** One way to think about it: Does the practice add life/organic matter to the soil and enhance structure, or does it remove nutrients and disturb soil structure? For each practice, try to articulate **why** it builds or depletes soil. (For example, "Adding compost is soil-building because it increases organic matter and feeds microbes, improving structure and nutrients. Frequent plowing is soil-depleting because it breaks up soil structure and can reduce organic matter over time.")

4. **Record Your Categories:** Write down the practices under the two category headings on your data worksheet (Part C). Make sure all practices are sorted. If your group is unsure about one, make your best guess and mark it with a "?" to revisit later.

5. **Class Discussion:** After sorting, be prepared to share one example of each and explain your reasoning. Your teacher or classmates might have different opinions – that's okay, it's important to discuss and use evidence. (The goal is to realize, for instance, that practices like cover cropping, no-till, composting, and managed grazing are generally **regenerative** or soil-building, while things like leaving soil bare, intensive tillage, overuse of chemicals, and CAFOs can degrade soil health kisstheground.com)

Activity C4: Soil Respiration Test (if not used in Lesson B) – *Is your soil "breathing"? Measuring CO_2 from soil life. This activity detects **carbon dioxide (CO_2)** released by microbes in the soil as they respire (breathe and break down organic matter). We will trap the CO_2 using baking soda, then reveal it with vinegar. It's a fast way to compare microbial activity between two soils.*

*Resource: Follow the NRCS Soil Respiration test guide [**Soil Respiration**] and see the demonstration videos for this activity [YouTube: **Overview** and **Test**. 10–15 min setup; read the next day].*

👉 **Pro-tip: Start this test at the beginning of your station rotations, so the jars have time (20+ minutes) to accumulate CO_2 while you do other steps. Then do the vinegar step at the end of the rotations.**

1. **Set Up Jars (Beginning of Lesson):** For **Sample A**, take a clean empty jar and add about **1 cup of Soil A** (if the soil is very dry, mix in a few drops of water to make it slightly moist – microbes are more active when moist). Place a small, open container (such as a bottle cap or a paper cup piece) on top of the soil in the jar. Into that container, add **2 tablespoons of baking soda ($NaHCO_3$)**. **Do not spill the baking soda onto the soil** (it should stay separate). Now quickly but carefully seal the jar with its lid, making sure it's tight. Trap as little outside air as possible. Label the jar "A."

2. **Repeat for Sample B:** Set up a second jar the same way: add 1 cup of Soil B (with a bit of water if dry), place a cap or small cup of **2 tbsp baking soda** on the soil, and seal the jar. Label it "B." Now you have two closed jars: any CO_2 produced by soil organisms will be absorbed by the baking soda over the next several minutes.

3. **Wait (~20–30 minutes):** Leave the jars undisturbed while you continue with other activities (slake, infiltration, sorting). This gives time for the soil microbes to respire CO_2 which the baking soda can capture (as bicarbonate). **Do not** shake or open the jars during this period. (If you have more time, letting it sit longer – even 24 hours – would allow more CO_2 to accumulate. But 20–30 min should show a noticeable difference if one soil is very active.)

4. **The Vinegar Test (End of Lesson):** After the waiting period, bring your timer and be ready to observe closely. **Carefully open jar A** and immediately pour about **2 tablespoons of vinegar** directly into the little cup of baking soda inside. (You may tilt the jar so the vinegar reaches the baking soda without spilling soil.) The vinegar will react with the baking soda **if** the baking soda has absorbed CO_2. Look for **fizzing/bubbles** as the vinegar hits the powder – this fizz is CO_2 gas rapidly being released. Quickly do the same for jar B: open it and pour ~2 tbsp vinegar onto the baking soda. **Compare** the intensity of fizz between jar A and jar B. One might foam up more vigorously than the other.

5. **Observe & Record:** On your data sheet (Part D), jot down how much fizz each sample produced (e.g. "A: lots of bubbling over 10 seconds; B: only mild fizz for a few seconds"). A stronger fizz indicates that more CO_2 was trapped – meaning **more respiration** happened in that soil sample. More respiration suggests more microbial activity and/or more organic matter for them to consume nrcs.usda.gov.

6. **Think:** Which soil had more "breathing"? What does that tell you about the life in that soil? Relate this to what you know: healthy soil teems with microbes breaking down organic matter (releasing CO_2). Poor soil might be lacking in microbes or food (organic matter), so it releases less CO_2. Consider also if any chemical carbonates in the soil (like limestone) could produce CO_2 – but in most cases for topsoil, the difference is biological. You'll answer a reflection question about this.

7. **Dispose Properly:** After observing, you can dispose of the vinegar and baking soda mixture (which is now just a neutral solution of sodium acetate) and the soil. **Rinse out** the jars and wash your hands. Ensure any remaining vinegar or baking soda is cleaned up.

📋 **After finishing all four activities, make sure you have recorded your data and observations for each part on the Data Collection Worksheet. Then, answer the Reflection questions in Part E of the worksheet.** Discuss your answers with your group and be prepared to share highlights with the class.

Skills You'll Use:

- *Observation & Measurement:* Carefully observing physical changes (soil clod disintegration, water levels, fizzing bubbles) and measuring time/quantity (infiltration seconds, water volume).
- *Scientific Reasoning:* Inferring soil qualities (like stability, porosity, microbial activity) from your experimental results, and understanding cause-and-effect (e.g. "because Soil B lacked organic matter, it fell apart in water").
- *Critical Thinking & Categorization:* Evaluating farming practices and categorizing them based on their long-term impact on soil, using evidence and concepts from lessons to justify your grouping.
- *Data Recording & Documentation:* Accurately recording data and notes in tables, which is an important scientific skill, and organizing information clearly.
- *Systems Connection:* Connecting the dots between what you observe in a small soil sample and larger ecosystem processes (water cycling, carbon cycling) and human agricultural practices.

Remember: Soil is not "just dirt" – it's a **living system**. The tiny differences you observed (clods holding together, faster water absorption, fizzing from microbial breath) demonstrate huge services that healthy soils provide: they **hold onto water** (preventing floods and droughts), **resist erosion** (keeping fertile land in place), and **cycle nutrients & carbon** (helping plants grow and even pulling CO_2 from the air). By building healthy soil, we work *with* nature to create a more sustainable, resilient world. 🌱