



Module 3: Soil Science and Soil Health

Hands-On Activity Lesson C: Living Soils & Ecosystem Services

Teacher Guide & Rubric – Module 3 Lesson C

Hands-On Activities (C1: Soil Glue, C2: Infiltration, C3: Build vs. Deplete, C4: Soil Respiration)

Overview: Lesson C wraps up Module 3 by giving students a hands-on investigation of soil health properties and the concept of “living soils” providing ecosystem services. This set of four mini-activities ties together topics from Lessons A and B in a practical way. In **Lesson A**, students learned about soil’s physical properties – for example, they discussed how soil texture and structure affect water movement (with a Think-Pair-Share on infiltration). They also were introduced to the idea that soil is a foundation for ecosystems (likely touching on how healthy soil prevents erosion and supports plant growth). **Lesson B** delved into biological and chemical aspects: students explored soil organic matter, decomposition (perhaps through the “compost cake” activity), and the soil food web. They learned how microbes and organic inputs (like compost) contribute to soil fertility and carbon cycling. Now, in **Lesson C: “Living Soils & Ecosystem Services,”** students actively measure key soil health indicators and directly observe differences between a healthy and a degraded soil sample. Each test highlights a dimension of soil as a living ecosystem: aggregate stability (soil structure and erosion resistance), infiltration rate (water regulation), and soil respiration (biological activity and nutrient cycling). The **Build vs. Deplete** sorting activity then challenges them to connect these soil properties to farming practices, reinforcing the idea that **human management can either regenerate or deteriorate soil health** kisstheground.com.

By the end of this lesson, students see firsthand that a “**living**” soil with organic matter and biota performs **valuable services** – it holds together in water, absorbs rainfall, and breathes out CO₂ as microbes metabolize nutrients. These are concrete examples of ecosystem services (water filtration, erosion control, carbon sequestration, nutrient cycling) that tie back to the module’s themes. This hands-on lesson serves as a capstone for Module 3, prompting students to apply systems thinking: healthy soil is a product of both nature (biology, chemistry, physics) and nurture (how we treat the land). It prepares students to discuss real-world implications, like how regenerative agriculture practices (cover cropping, no-till, compost use, managed grazing) can enhance soil’s functions, whereas conventional practices (excessive tillage, leaving soil bare, chemical dependence) often degrade those functions kisstheground.com. Emphasize that maintaining soil health is critical for achieving sustainability goals – for instance, soil is a major carbon reservoir (holding more carbon than the atmosphere and plant biomass combined kisstheground.com) and is key to clean water and food security. This practical lesson thus reinforces scientific understanding with tangible observation, and empowers students with knowledge that **the way we treat soil can either help solve or worsen global challenges**.

Implementation Notes:

- **Timing:** This entire set of activities can be done in one standard class period (~55 minutes) if organized efficiently. A **station rotation** model works well: set up 4 stations (one for each activity) and have student groups rotate every 10–12 minutes. Build in a minute for transition/cleanup between stations. Alternatively, if materials are limited, you could conduct some tests as a demonstration (e.g., do one big slake test and one infiltration demo for the class) and others as small-group activities. If Lesson C spans two days, consider doing the hands-on tests on day 1 and the analysis/discussion on day 2. Note that the **soil respiration jars** need a waiting period to collect CO₂ – if possible, set those up at the start of class (or even a class earlier) so they have ~20+ minutes before the vinegar reaction. If time is extra tight, the Build vs. Deplete sorting could be assigned as a brief group discussion or homework rather than an in-class station.
- **Preparation:** Gather two distinctly different soil samples ahead of time. For dramatic results, **Sample A** could be from a **healthy soil** – e.g., a garden bed with compost or an undisturbed grassy area (rich in

roots, organic matter), and **Sample B** from a **poor soil** – e.g., dirt from a heavily tilled field, a construction site, or any bare, compacted ground (low organic matter). **Dry** the soil clods for the slake test (air-dry for a few days, or gently in an oven at low heat) – dry clods will show the aggregate stability contrast more clearly. Prepare enough clods so each group can test one of each type (size ~4–5 cm chunks). For infiltration, if doing outdoors, identify two small plots (a few square feet each) of the respective soils (perhaps on campus: a grassy lawn vs. a trampled dirt area). Mark them as Station 2A and 2B. Have infiltration rings (metal cans with ends removed) ready – if you only have one set, you'll demonstrate or have groups go sequentially, which takes more time. Pre-measure water (e.g., a 250 mL graduated cylinder or a 1-cup measuring cup for consistency). For the respiration test, assemble jars, baking soda, and vinegar. It helps to label jars/lids "A" and "B" and to have small containers (like bottle caps or mini paper cups) pre-filled with baking soda to save time. Ensure lids seal well (leaks will ruin the CO₂ capture). Have pH strips or a CO₂ sensor as an alternative extension if available (not required, but sometimes used to quantify CO₂). For the sorting activity, prepare either printed **cards** or a clear list on the board/worksheet of the practices. If using cards, one set per group cut out from paper works; students can physically place them in two piles. If using the worksheet list, ensure each student group has it. It may be helpful to review what each practice means during prep (see below).

- **Safety & Management:** Remind students of basic lab safety: no tasting or directly inhaling soil or vinegar, wash hands after. If doing infiltration outside, monitor the class's whereabouts – perhaps do it with half the class at a time or station an adult at the outdoor site. For the slake test, have towels ready for any spilled water. Vinegar and baking soda are generally safe, but the reaction can foam up – ensure the jars are not pointed at anyone's face when opened, and use safety goggles for the vinegar drop as a precaution. The fizz is usually gentle (not like a violent eruption, but enough to startle if unexpected). If any student has dust allergies or concerns handling soil, provide gloves and a dust mask (disturbing dry soil can release dust). **Disposal:** After class, discard used soil in a garden or waste bucket (do not dump it down sinks), and rinse jars and rings. The vinegar+baking soda solution can go down the drain (it's basically salt water).
- **Student Roles & Station Tips:** If running stations, assign roles within groups to keep everyone engaged. For example, at the infiltration station, one student is the "pourer," one is the "timer," one is the "recorder," and one is the "photographer/observer." Rotate roles at each station. Print out or post station instructions (you can cut apart the student instructions for each station or provide a short cue card) – this way groups can self-start at each station by reading the instructions relevant to that test. For the **Build vs. Deplete** station, encourage a quick brainstorm: perhaps have a mini whiteboard where they write their sorted lists, which you can later collect or photograph to see group thinking. Monitor this station to prompt deeper reasoning ("Why do you think cover crops improve soil? What do roots do for the soil?"). At the **respiration station**, after they set up jars, they will be in "waiting mode" – they can use that time to discuss predictions or perhaps work on the sorting activity if it's combined. It might be wise to pair the respiration and sorting at the same station (one student monitors time on the jars while others start sorting). **Note:** If students set up the respiration test early, make sure they remember to come back and do the vinegar step – perhaps have a bell or alarm when it's time.
- **Understanding the Results:** Guide students as they interpret each test's outcome:
 1. *Aggregate Stability (Soil Glue):* If Sample A remained intact and Sample B crumbled, ask students what ingredients or properties Sample A had (they might say "more roots or organic stuff acting like glue"). Connect this to real-world erosion: soil with plant roots and organic matter can resist heavy rain disintegrating it, thus preventing erosion and runoff of sediment. Soil B's behavior (disintegrating) shows why tillage or lack of roots can leave soil vulnerable – it collapses into mud that easily washes away. This is a visual confirmation of concepts like why cover crops or root networks are crucial. **Tip:** If you have a rainfall simulator or even just pour water over each sample in a tray, you could further show erosion vs no erosion. NRCS demonstrations often use exactly this comparison [nrcs.usda.gov](https://www.nrcs.usda.gov).

2. *Infiltration*: Students might observe dramatic differences here. Often, a soil from a grassy or no-till area will absorb the cup of water in, say, under a minute, whereas a compacted/bare soil might take many minutes or still have puddles after the class ends. Use their timed data: e.g., “Soil A took 45 seconds, Soil B took 300+ seconds (and still not all in).” Ask how this relates to runoff or flooding. If applicable, tie it to any local issues (e.g., “remember how the school lawn floods in heavy rain? Infiltration matters!”). This also links to water quality – slow infiltration means more runoff, which can carry pollutants. Students should realize that better soil structure (often from roots, no compaction) == faster infiltration [nrcs.usda.gov](https://www.nrcs.usda.gov). You can mention that farmers measure infiltration to gauge soil health, and NRCS has a target that a healthy soil might infiltrate an inch of water within a certain time.

 3. *Respiration (CO₂ release)*: Students will likely be fascinated by the fizz. If Sample A (healthy soil) fizzed more, that indicates more CO₂ had been trapped – thus more microbial respiration occurred. Explain the science: microbes in soil respire CO₂ just like we do, especially when organic matter is available. Baking soda captured that CO₂ as carbonate; adding vinegar released it back as gas (hence the fizz). If Sample B had little fizz, it suggests fewer microbes or less food for them. Connect this to soil organic carbon – a living soil cycle. If by chance the results were opposite or inconclusive (maybe a dry soil with carbonates like caliche could fizz irrespective of microbes, or an error), troubleshoot with students: Was the soil too dry or too wet? Did the jar seal? Generally, though, a rich soil (compost, etc.) will out-fizz a poor soil. This leads to discussing why organic matter and microbes are considered the heart of a “living soil.” **Extension**: You could relate to soil temperature or moisture – microbes are more active when warm and moist [nrcs.usda.gov](https://www.nrcs.usda.gov). In a longer project, one could leave jars 24 hours and even measure CO₂ by weighing the baking soda or using pH indicators (but not necessary here).

 4. *Build vs. Deplete Sorting*: Review each practice with the class. This is where you clarify any misconceptions. For example, students might initially be unsure about “managed grazing” if they haven’t heard it – explain it involves moving livestock to avoid overgrazing and can actually improve soil via manure and hoof aeration (as opposed to CAFOs where manure isn’t returned to soil effectively and soil is absent or compacted). Ensure they got the idea that **no-till, cover crops, compost, organic farming, managed grazing, and diverse cropping** are generally soil-builders that increase soil organic matter and biota [kisstheground.com](https://www.kisstheground.com). **Tillage, bare fallow, overuse of chemicals, monoculture, overgrazing/CAFO** are typically soil-depleting (causing erosion, carbon loss, or harm to soil life). If some groups mis-sorted, have them explain their thinking and gently correct with evidence. This discussion solidifies the take-home message: the physical and biological advantages seen in the tests correlate with certain farming methods. You can explicitly connect, for example, “Soil A behaved like a no-till, cover-cropped soil; Soil B behaved like a tilled, bare soil.” This ties back to Lesson B content on regenerative vs conventional practices.
- **Connecting to Broader Context**: Step back and highlight why these soil properties matter beyond the classroom. **Healthy soils as an ecosystem service provider**: For instance:
 1. **Water regulation**: Infiltration and aggregation mean healthy soils reduce flooding and recharge groundwater (aligns with SDG 6: Clean Water). After heavy storms, fields with cover crops or good structure have less runoff; cities are even exploring “sponge soils” to manage stormwater.
 2. **Climate regulation**: Soil respiration is part of the carbon cycle. While we saw CO₂ coming out, the key is that good practices (like in Soil A) both release and store carbon dynamically. Point out that plants put carbon into soil through roots; if we farm in a way that builds soil carbon (as in Soil A’s practices), we sequester carbon long-term. In fact, globally, soils hold huge amounts of carbon [kisstheground.com](https://www.kisstheground.com), and improving soil management is considered a climate mitigation strategy (e.g., the “4 per 1000” initiative seeks a 0.4% annual increase in soil carbon

to offset global emissions). This can inspire hope: farming can be part of climate solutions.

3. **Biodiversity and food production:** Living soils support a vast soil food web (microbes, worms, etc.) which in turn aids plant growth and pest resistance. Thus, soil health connects to food security (SDG 2: Zero Hunger) and ecosystem health (SDG 15: Life on Land).
 4. Feel free to mention real-world efforts: e.g., the USDA and many states promote **Soil Health** programs encouraging farmers to adopt no-till/cover crops. Some farmers testify that after a few years of soil-building, they see better yields and resilience to drought. This shows students the practical value of what they learned.
 5. If time allows, you might compare class data with published data. For example, “In an NRCS demo, a no-till soil clod stayed intact in water for 30+ minutes, while a tilled soil clod fell apart in 30 seconds [nrcs.usda.gov](https://www.nrcs.usda.gov).” Or share that “on average, cover-cropped fields can infiltrate x more water than bare fields” – such stats can be found in soil health literature (optional: some NRCS videos illustrate this vividly). This validates their observations scientifically.
- **Debrief and Synthesis:** After all stations, conduct a debrief discussion or have groups present their findings. Encourage students to answer the Reflection questions in the worksheet with depth. Go over each question:
 1. For aggregates, they should mention organic matter/glomalin, etc., and erosion implications.
 2. For infiltration, mention porosity, compaction, and the benefits of water availability and reduced runoff.
 3. For practices, ensure each example given is correct and tie it to what it would do to soil (e.g., compost adds nutrients and food for microbes, vs. chemical fertilizer adds nutrients but no carbon, possibly leaving soil biota starving).
 4. For respiration – highlight the idea of soil as alive (microbial community size).
 5. Ecosystem service – collect a variety: some might say “prevents dust storms/erosion,” others “stores carbon to fight climate change,” others “provides nutrients naturally so we need fewer chemicals,” etc. Celebrate all these answers and connect them to previous lessons or upcoming ones.

By the end, students should be able to articulate that **soil health is a linchpin for sustainability** – it intersects water, climate, food, and ecological well-being. This lesson not only reinforces scientific understanding but also frames a positive narrative: through certain practices, we can regenerate soil and thus reap multiple benefits (whereas neglect or mismanagement of soil has cascading negative effects).

- **Next Steps:** Encourage actionable follow-ups. For instance, challenge students to test soil from their **own backyard or local park** using these methods and report back. Or have them design an experiment: e.g., take some Soil B, add compost to part of it, keep part as is, and in a few weeks test again – does the “treated” soil improve in structure or infiltration? Another extension: if Module 3 has an extended project, they could create a “Soil Health poster” connecting their data to recommending a regenerative practice for a farming scenario. This bridges to Module 4 or others where soil health impacts plant growth. Finally, prompt them to share knowledge – maybe start a school compost program (connects to Module 2 and 3), or a demonstration for younger students (“soil magic” tricks showing how soil with plants versus without reacts to water). This empowers students to see themselves as stewards of soil and advocates for sustainable practices.

Credit: This lesson integrates multiple sources and inspirations. The **aggregate stability** (“soil glue”) and **infiltration** demonstrations are core soil health tests developed by the USDA NRCS and soil scientists (adapted here from NRCS field demos and the Soil Quality Test Kit protocols) nrcs.usda.gov/nrcs.usda.gov. The **Build vs. Deplete sorting activity** is adapted from *The Soil Story Curriculum* by Kiss the Ground (2018), Lesson 4, which uses agricultural practice cards to distinguish regenerative vs. conventional techniques kisstheground.com. The **soil respiration (CO₂) test** was designed as a simplified version of lab soil respiration assays (drawing on NRCS educator guides) nrcs.usda.gov, using common materials to visualize microbial activity. All together, these adaptations were made to fit our module’s learning goals and timeframe, while preserving the essence of those excellent educational resources.

Grading Rubric: Living Soils & Ecosystem Services Activities (Module 3C)

Use the following rubric (see detailed descriptors below) to evaluate student performance on the set of soil health activities and the associated worksheet. The rubric covers each key aspect: how well students carried out the hands-on tests and recorded data, the insightfulness and accuracy of their answers about the results, their understanding of sustainable vs. unsustainable soil practices, their ability to connect to broader ecosystem services, and overall communication and teamwork. Each criterion can be rated on a 4-point scale: **4 (Exemplary), 3 (Proficient), 2 (Developing), 1 (Beginning)**.

| Criteria | Exemplary (4 pts) | Proficient (3 pts) | Developing (2 pts) | Beginning (1 pt) |
|---|--|--|--|---|
| Hands-on Investigation (<i>Data Collection & Execution</i>) – Properly conducts experiments (C1, C2, C4) and records observations. | All data carefully and accurately recorded; followed procedures for all tests correctly and completely. | Most data recorded with minor omissions; followed procedures with only minor errors. | Some data missing or inaccurate; some procedural steps missed or done incorrectly. | Little or no useful data recorded; instructions not followed (experiments incomplete or incorrect). |
| Soil Health Understanding (<i>Concept Interpretation & Answers</i>) – Demonstrates understanding of results (aggregate stability, infiltration, respiration) in answers. | Answers show thorough understanding of each soil test and what results mean; explanations are accurate and insightful. | Answers show good understanding of most concepts; may have minor confusion on one aspect, but overall correct. | Answers show partial understanding; some misconceptions or weak explanations of results. | Answers demonstrate little to no understanding; multiple incorrect explanations or missing responses. |

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|---|--|--|---|--|
| <p>Practices Classification & Reasoning – Categorizes farming practices correctly and justifies choices (C3 sorting).</p> | <p>All or nearly all practices correctly identified as building or depleting soil; provides clear, logical reasons for classifications.</p> | <p>Most practices correctly categorized; reasoning given for each is mostly solid (a few thin explanations).</p> | <p>Some practices misclassified or uncertain; reasoning is vague or not provided for several items.</p> | <p>Many practices incorrectly classified; little to no reasoning or rationale shown for choices.</p> |
| <p>Connections to Ecosystem Services – Connects soil health to broader environmental benefits (water, climate, etc.).</p> | <p>Makes insightful connections between soil properties and ecosystem services (e.g. erosion control, water quality, climate); can articulate at least two clear benefits of healthy soil.</p> | <p>At least one clear connection made between soil health and an ecosystem benefit; shows awareness of why soil health matters beyond the test (may not cover all facets).</p> | <p>Connections to broader context are limited or unclear; might mention one benefit vaguely (e.g. “soil is good for plants”) but misses others.</p> | <p>No meaningful connection made to wider ecosystem or societal importance; seems unaware of why soil health is important outside the activity itself.</p> |
| <p>Communication & Collaboration (<i>Clarity, Organization, Effort</i>) – Quality of worksheet, group work, and participation.</p> | <p>Data and answers are very well-organized, neat, and clear. The student (and group) showed strong collaboration and engagement at each station; all tasks completed with high effort.</p> | <p>Work is generally neat and organized; minor lapses in clarity. Participated actively in group and contributed to completing all tasks; good effort overall.</p> | <p>Work is somewhat disorganized or hard to follow in places; some answers or data may be incomplete. Engagement in group was moderate (perhaps passive at times); effort was uneven.</p> | <p>Work is sloppy, incomplete, or very disorganized. Little to no meaningful participation in group activities; low effort evident in the outcome.</p> |

Detailed Rubric Descriptions:

1. Hands-on Investigation (Data Collection & Execution):

- **Exemplary (4 pts):** The student conducted all experiments carefully and exactly as instructed. All required data (times, observations, notes) are recorded **accurately** for Soil A and B in each test. For example, they timed infiltration precisely and noted it in seconds, described the slake test observations in detail, and recorded clear differences in the CO₂ fizz test. The student’s procedure followed safety and directions: they properly set up the clod on the mesh without breaking it, inserted rings correctly, measured water volumes, waited the appropriate time for the CO₂ test, etc. There is evidence of thoroughness, such as additional notes or sketches of what was observed. Essentially, the student treated the activity like a real lab: careful measurements, keen observations, and complete recording of results.

- **Proficient (3 pts):** The student carried out the experiments with only minor slip-ups. Most data points are recorded, though there might be one small omission or estimate (e.g., they wrote “~5 minutes” instead of exact seconds for infiltration, or forgot to label a sample but context makes it clear). The procedures were generally followed – maybe a slight mistake like not fully drying a clod (affecting slake test a bit) or starting the timer a tad late – but nothing that invalidated the results. Observations are noted, though perhaps with a little less detail. Overall, the student’s execution shows competence and a good faith effort to get the data.
- **Developing (2 pts):** The student attempted the experiments but had some issues with data collection. Some observations or measurements are missing or incorrect. For instance, they might have only noted “Soil A infiltrated faster” without any quantitative time, or left the CO₂ observation blank. There might be signs of not following instructions precisely: perhaps the student submerged the whole clod without the mesh and lost pieces, or didn’t wait long enough before adding vinegar, leading to ambiguous results. The data that is there might be inconsistent (e.g., claiming both soils infiltrated “fast” with no differentiation, or unrealistic times). This suggests confusion or lack of care in execution. They might have needed more teacher prompting.
- **Beginning (1 pt):** Little or no reliable data was collected. The student’s worksheet might be largely blank or have only one-word observations like “good/bad” without clarification. It could be that they did not actually perform parts of the lab (e.g., skipped timing, or didn’t do the second soil test). Procedural errors significantly affected results – e.g., they might have mixed up which soil was which, or spilled the vinegar before sealing the jar (invalidating the respiration test). There may be evidence of misunderstanding the activity itself (recording irrelevant data, like writing down the water temperature instead of infiltration time). Overall, it shows minimal effort or serious confusion in carrying out the tasks.

2. Soil Health Understanding (Concept Interpretation & Answers):

- **Exemplary (4 pts):** The student’s answers to questions and explanations demonstrate a deep and accurate understanding of what each test revealed about soil health. For example, when explaining the aggregate stability results, they correctly identify why Soil A stayed intact (mentioning factors like organic matter or root binding) and explicitly connect that to less erosion. They use appropriate terminology (e.g., “Soil B lacked structure and dispersed, indicating low aggregate stability”). For infiltration, they not only note which was faster but can say “Soil A had better porosity and allowed water to percolate, likely due to its root channels, whereas Soil B was compacted.” In discussing respiration, they clearly state that more fizz = more CO₂ from microbial respiration, showing Soil A has a more active microbial ecosystem due to more organic material. Their explanations are logical and scientifically sound with no significant misconceptions. They might even integrate knowledge from class, like referencing the soil food web or previous lessons (“Soil A functions more like an agroecological system with compost we learned about in Lesson B”). Overall, their work shows they truly grasp why the “living” aspects of soil matter in each test.
- **Proficient (3 pts):** The student’s interpretations are mostly correct and complete, with only minor gaps. They correctly identify which soil performed better in each test and give a reasonable cause. For instance, they know Soil A didn’t break because it had “plant roots or more organic material” (even if not using the word aggregate, the idea is there). They know faster infiltration is good and likely due to Soil A being less compact (“looser soil,” they might say). They understand that fizz meant more microbes, though they might describe it simply (“Soil A had more organisms or nutrients”). Minor issues could be slight vagueness or not connecting all the dots. For example, they might not explicitly mention erosion when talking

stability, but they do say “stayed together better which is good.” Or they say “Soil B had less life” without elaborating. They might not use all the scientific terms but the concept is right. Essentially, they understand the results and can explain the main idea of each, albeit not as detailed or flawlessly.

- **Developing (2 pts):** The student shows some understanding but also confusion or missing reasoning. They might correctly state observations but struggle to explain the “why.” For example, they might note “Soil A clod didn’t break, Soil B did” but then attribute it to something incorrect, like “Soil A might be more clay so it stuck” (a misconception, since clay alone doesn’t necessarily stick when wet). Or for infiltration, they might identify the faster soil but give a shallow reason like “because it had holes” without explaining what caused those holes. They might recognize fizz means more CO₂ but not link it to microbes clearly (“Soil A fizzed more maybe because the baking soda mixed more?” – focusing on procedure rather than biology). In answers, some parts might be left blank or answered with uncertainty. They might only partially answer a question (e.g., they say which soil was stable but not *why*). These responses indicate they observed differences but aren’t fully comfortable with the underlying soil science, or they have misconceptions (like thinking sand vs clay was the reason, rather than organic content, if that wasn’t relevant here). With some guidance, they could likely correct these, but as is, the understanding is incomplete.
- **Beginning (1 pt):** The answers demonstrate little to no conceptual understanding. The student might have guessed or written something that doesn’t connect to the activity. For instance, they might say “Both soils broke because water is strong” – not distinguishing samples or missing the point of structure. Or for infiltration, “Soil B was slower because we poured slower” – misunderstanding the controlled variables. They may confuse which sample was which in explanations or say “I don’t know” for rationale. Perhaps they give irrelevant answers (talking about things like pH or color when that wasn’t part of the test). If they did the Build vs. Deplete reasoning, it might be extremely off (like “I put composting as depleting because you remove waste” – a sign they misunderstood the concept entirely). Overall, the student’s work shows no clear link between what they did and what it meant; they have not internalized the lesson’s concepts of soil structure, water movement, or soil biology.

3. Practices Classification & Reasoning (Build vs. Deplete Activity):

- **Exemplary (4 pts):** The student (and their group) accurately categorized every or nearly every practice correctly, and provided reasoning that reflects understanding of how each practice impacts soil. For example, their worksheet might list cover crops, compost, no-till, managed grazing under Soil-Building, and tillage, bare soil, chemical fertilizer reliance, CAFO under Soil-Depleting – all correctly. More importantly, when asked to explain one of each, their explanation is spot-on: e.g., “I chose *cover cropping* as building because it protects soil from erosion, adds organic matter, and feeds soil organisms when it decomposes” and “I chose *frequent plowing* as depleting because it breaks soil aggregates, causes organic matter to be lost quickly, and can lead to erosion and loss of topsoil.” This level of detail shows they not only memorized that something is good or bad, but truly understand the mechanism or rationale behind it. Even if not every single practice was 100% sorted (maybe they weren’t sure about one subtle point), an Exemplary student would typically indicate uncertainty and seek clarification. Overall, their reasoning demonstrates an integrated understanding of farming practices’ effects on soil health, reflecting lessons from class and perhaps external examples.
- **Proficient (3 pts):** The student correctly classifies most of the practices, with at most one mix-up. They show a solid general understanding: e.g., they know compost, cover crops, no-till are beneficial; they know tillage, leaving soil bare, etc., are harmful. Their reasoning, when

explaining, is generally good but maybe not as detailed. For example, they might say “No-till is building because it doesn’t destroy the soil structure” – which is correct, just not mentioning as many factors. Or “Adding chemical fertilizer is depleting because it’s not natural” – a somewhat simplistic reason (the more precise reasoning would be about not adding carbon or harming soil biota), but they grasp that it’s not improving soil health. Perhaps one practice they were unsure about: e.g., they could incorrectly place “managed grazing” if they haven’t heard of it, but they might mark it with a question. Their explanation might also lean on class phrases (“compost is good because it’s part of regenerative agriculture” – true, though not specific). In sum, they mostly get it right and show understanding, just missing some nuance or clarity in explanation.

- **Developing (2 pts):** The student’s sorting has several errors or shows uncertainty, and their justifications are weak. They might have half the list mixed up or hedged (maybe they thought “chemical fertilizer helps plants grow so that’s building” – which indicates misunderstanding the difference between short-term yield vs long-term soil health). They could also mis-categorize something like managed grazing (perhaps thinking any kind of grazing is bad for soil because animals eat plants, not recognizing the managed aspect). Their reasons might be one-liners without depth: “I put composting as building because compost is good.” That doesn’t explain *why* it’s good. Or they might say “tilling is building because it prepares the soil for planting” – showing they recall a conventional rationale but not the soil health perspective, indicating a gap in absorbing the lesson content. In the written explanation for one practice each, they might only address one and not both, or give an incorrect explanation. For instance, “I said leaving soil bare is depleting because it looks dry” – a very surface-level observation without hitting the real issue (erosion, no organic input). These responses show the student hasn’t fully connected management actions to soil outcomes, or they have misunderstandings about what is beneficial. More instruction or examples are needed for them.
- **Beginning (1 pt):** The classification is largely incorrect or not done. The student may have been very confused about the practices, possibly due to lack of prior knowledge or not paying attention. They could have placed items almost randomly or all in one category. For example, maybe they thought “plowing, chemical fertilizer, and pesticides are good because that’s what modern farming uses” (missing the soil health perspective entirely), putting those in Soil-Building, and things like cover crops or compost in Soil-Depleting because they might think “leaves covering soil could be bad for insects” or some misconceived reason. If they did fill the categories correctly, it might have been by chance or copying others, because their reasoning (if any given) doesn’t align. They perhaps did not even attempt to explain choices on the worksheet. This level indicates either a serious misunderstanding or minimal effort/engagement with the activity. The student doesn’t demonstrate recognition of the core idea that some farming methods regenerate soil while others degrade it.

4. Connections to Ecosystem Services (Broader Environmental Connections):

- **Exemplary (4 pts):** The student clearly articulates multiple ways that healthy soil contributes to environmental or societal benefits. In discussion or their reflection answer, they might say something like: “Healthy soil improves water quality by filtering runoff and reduces flooding because it can absorb more rain. It also stores carbon (as we learned, soil has a huge carbon pool) which helps mitigate climate change. Plus, it supports more biodiversity (like worms, microbes) which can lead to more productive crops.” They might only be required to mention one in writing, but an exemplary student often can’t help but mention a couple because they see the interconnected benefits. They tie it directly to what they observed: e.g., “Our infiltration test showed soil with roots absorbed water fast – that would mean less surface runoff in a real field, preventing erosion and downstream flooding.” This shows a transfer of knowledge from the small scale experiment to a big picture context. Their answer is specific and accurate – no

confusion between concepts. They understand soil health as foundational to things like the water cycle, climate system, and agriculture's sustainability.

- **Proficient (3 pts):** The student makes at least one clear connection to an ecosystem service or benefit of soil health, and it's accurate. For instance, they might write, "Healthy soil prevents erosion, which keeps the nutrient-rich topsoil in place for plants and also keeps rivers from getting polluted with sediment." That's a good connection. Or they say, "Soil with more organic matter can store more water, helping in droughts." They might not mention multiple services, but the one they do mention is on point. Alternatively, they might generalize, "It's important because without healthy soil we can't grow good crops" – which is true (agricultural productivity is a service to humans). That's a valid point though maybe doesn't explicitly say "ecosystem service" in those words. As long as they identified a real benefit like water retention, carbon storage, supporting plant growth, or biodiversity habitat, and linked it to soil being healthy, they meet this level. They show awareness that this was more than just a lab – it matters in real life.
- **Developing (2 pts):** The student's connection is weak, vague, or only partially correct. They might say something like "Healthy soil is good for the environment" but not elaborate how. Or they might latch onto something tangential: "It smells better" or "It looks nicer" – not really an ecosystem service in the intended sense. They could also confuse cause and effect: "If the soil infiltrates water, then you don't need irrigation" – not exactly a broad benefit unless clearly phrased (maybe they meant groundwater recharge but didn't know the term). Or "Soil breathing means the air is cleaner" – a misconception (soil respiration actually releases CO₂; maybe they confused it with plants providing oxygen). These answers indicate the student didn't fully grasp or recall the bigger significance. They might know one simple fact like "plants need healthy soil to grow," which is true but might be the only thing they mention, lacking depth (and they might not tie it to what they observed in the lab). Essentially, they need prompting to articulate clear benefits; they have some idea that healthy soil is positive but can't say why in meaningful detail.
- **Beginning (1 pt):** No connection to ecosystem services or broader impacts is evident. The student may have left the question about benefits blank or wrote something completely off-base. For example, they might say "Healthy soil gives us more soil" – which doesn't communicate an environmental benefit, or "It doesn't matter if soil is healthy" – which shows they missed the key takeaway. They demonstrate no awareness that soil health ties into water, climate, food, or any larger issues. Perhaps they view the activities as isolated experiments with no relevance beyond. This could be due to not paying attention during the wrap-up discussion or just not understanding those concepts in class. It might also manifest as a very confused statement like "If soil is alive, it could be bad because of germs" – focusing negatively or missing the context that those microbes are beneficial for ecosystem function. In any case, a student at this level did not connect the lesson to any real-world importance in their responses.

5. Communication & Collaboration (Clarity, Organization, Effort):

- **Exemplary (4 pts):** The student's submitted worksheet or write-up is **neatly presented** and logically organized. Data tables are filled out completely, labels (like Soil A vs B) are clear, and the handwriting or formatting is easy to read. Their answers in the reflection are articulated in full sentences that make sense, possibly even with examples or key vocabulary. The overall quality shows time and thought were invested – e.g., they didn't rush through; they used the provided lines fully to explain ideas. In terms of collaboration, an exemplary student was highly engaged in the group. From teacher observation, they took on a leadership or active role (like ensuring everyone got a turn, or asking peers "what did you see?" to compare notes). The group completed all stations on time largely due to combined effort. If any conflict or confusion arose, this student helped resolve it constructively. Essentially, their effort and attitude

significantly contributed to the success of the activity. Even if the group struggled initially, an engaged student would communicate with the teacher or others to solve issues. The exemplary level reflects both an excellent written product and commendable participation.

- **Proficient (3 pts):** The student's work is well-organized with only minor issues. Maybe one section of the data sheet has a slight lapse – e.g., they forgot to title a column, or a couple of spelling mistakes in answers – but nothing that hampers understanding. The data and answers are mostly complete. Perhaps one answer could be a bit more clear, but you can tell what they mean. They clearly put effort into the assignment. In group work, the student participated and fulfilled their role. They might not have been the primary leader, but they were attentive and contributed (for instance, they timed the infiltration correctly, or they wrote down the group's ideas for sorting). They collaborated without issue and helped get things done. If anything, a proficient collaborator might be a tad quiet but still engaged, or conversely a bit over-eager but still respectful. Overall, they did their fair share and their communication in writing and speaking was good.
- **Developing (2 pts):** The student's worksheet has some organizational problems or missing pieces. The flow of their answers might be hard to follow – maybe they wrote in a very fragmented way, or scribbled notes that are hard to read. Some sections might be blank that shouldn't be, suggesting they lost track of a question or station. The data might be jumbled (e.g., writing Soil A's data in Soil B's space by accident) or not labeled, causing confusion about which observation belongs to which sample. In terms of effort, it might seem a bit rushed – short one- or two-word answers for questions that asked for explanation, indicating they didn't fully invest time to articulate their thoughts. For collaboration, the teacher may have noticed this student was somewhat passive or needed reminders to stay on task. Perhaps they let others in the group do most of the interacting with the materials and just copied data. Or they were engaged in one activity but lost focus in another (e.g., got distracted on their phone during the sorting discussion until prompted). They may have contributed unevenly. It's not that they refused to work, but the effort and communication were moderate. Maybe they were confused and didn't ask for help, which hampered group progress until the teacher intervened. In summary, the work and participation were acceptable but could have been much better with more focus and clarity.
- **Beginning (1 pt):** The student's work is very disorganized, incomplete, or barely legible. It might appear they answered only the first question and then gave up, or filled things in haphazardly (e.g., writing answers in random places, crossing out a lot, or entire tables empty). The lack of effort is evident – perhaps one-word answers like “good” / “bad” for complex questions, or every answer mirrors a group mate's work exactly (suggesting they didn't think for themselves at all). In terms of collaboration, the student may have been disengaged – possibly not participating, letting the group carry on without them. The teacher might have noted they were off-task (chatting about unrelated things, or idle). They could have also been disruptive or unwilling to cooperate, which affected the group's ability to finish (e.g., refusing to handle soil or arguing without contributing solutions). If working alone, it's someone who clearly rushed at the last minute to scribble something. In essence, the student showed minimal effort in both doing the work and in communicating their ideas (if any), resulting in a product that is hard to understand or very incomplete.