



## Module 3: Soil Science & Soil Health Lesson

### Lesson Overview and Standards Alignment

#### Soil Science & Soil Health Lesson

Soil is more than dirt—it is a living, dynamic foundation of food systems and ecosystems. In this module, students explore soil as both a productive medium for crops and a provider of ecosystem services like clean water, climate regulation, nutrient cycling, and biodiversity. Healthy soils are framed as essential to achieving multiple UN Sustainable Development Goals, including Zero Hunger (SDG 2), Clean Water (SDG 6), Climate Action (SDG 13), Responsible Production (SDG 12), and Life on Land (SDG 15).

Across three core lessons and optional lab extensions, students investigate soil from physical, chemical, and biological perspectives. They measure soil health indicators (texture, structure, pH, nutrient levels, organic matter, biological activity), analyze soil carbon flows using the Build–Maintain–Consume framework, and uncover the hidden life of soils through the soil food web. Students connect soil functions to sustainable agriculture, climate resilience, and circular systems, building directly on Modules 1 and 2 (systems thinking and agroecology).

The module emphasizes hope and solutions—students see how practices such as composting, cover cropping, and reduced tillage can regenerate soil and support productive, climate-resilient farming.

#### Standards Alignment

##### Next Generation Science Standards (NGSS)

*Disciplinary Core Ideas (DCIs)* – This module ties into several DCIs by contextualizing science concepts within soil systems:

- **Performance Expectations**
  - **HS-LS2-3:** Construct explanations of matter cycling/energy flow in ecosystems (soil food web, carbon cycling).
  - **HS-ESS3-6:** Analyze human impacts and mitigation (soil conservation, carbon sequestration).
  - **HS-ETS1-3:** Evaluate solutions to complex problems (soil improvement practices, feasibility).
- **Disciplinary Core Ideas**
  - **LS2.B:** Cycles of Matter and Energy Transfer (soil carbon, nutrient cycling).
  - **LS2.C:** Ecosystem Dynamics, Functioning, and Resilience (soil biodiversity, resilience).
  - **ESS3.A:** Natural Resources (soil as foundational resource for food).
  - **ESS3.C:** Human Impacts on Earth Systems (agricultural practices affecting soil/climate).
- **Science & Engineering Practices**
  - Planning & Carrying Out Investigations (soil pH, infiltration, respiration).
  - Analyzing & Interpreting Data (lab results, carbon balance scenarios).
  - Constructing Explanations/Designing Solutions (soil health improvement plans).
  - Engaging in Argument from Evidence (debating management trade-offs).
- **Crosscutting Concepts**
  - Energy & Matter (flows of carbon/nutrients).
  - Stability & Change (soil aggregates, SOM persistence).
  - Cause & Effect (tillage → compaction, compost → structure).
  - Systems & System Models (soil as a living system within larger cycles).

##### Science and Engineering Practices (SEPs)

- **Asking Questions and Defining Problems:**
  - Students ask questions like “Is this soil healthy?” or “How can we improve water retention and nutrient cycling in this soil?”
  - They define problems for investigation, such as identifying limiting soil properties in a school garden or farm plot.
- **Planning and Carrying Out Investigations:**
  - Students measure soil properties including texture, structure, pH, nutrient content, organic matter, and biological activity.
  - They design simple investigations, such as comparing infiltration in different soil samples or monitoring decomposition in compost.

- **Analyzing and Interpreting Data:**
  - Students interpret soil test results, infiltration rates, CO<sub>2</sub> release from soils, or observed biological activity to draw conclusions about soil health.
  - They compare outcomes across treatments (e.g., amended vs. non-amended soils) to understand management effects.
- **Constructing Explanations and Designing Solutions:**
  - Students explain how soil properties influence ecosystem services (e.g., nutrient cycling, carbon storage, erosion control).
  - They design soil improvement plans using practices such as compost addition, cover cropping, reduced tillage, or crop rotation.
- **Engaging in Argument from Evidence:**
  - Students use lab data to defend recommendations for soil management, evaluate trade-offs (cost, labor, climate benefits), and critique peers' proposed interventions.
- **Using Mathematics and Computational Thinking:**
  - Students quantify soil health indicators (e.g., % organic matter, C:N ratios, infiltration rates, CO<sub>2</sub> emissions).
  - They calculate trends, make predictions, and interpret graphs to connect numbers to sustainability outcomes.
- **Developing and Using Models:**
  - Students model soil as a system with inputs, outputs, and feedbacks (e.g., Build–Maintain–Consume carbon triad).
  - They use diagrams or flow charts to show interactions between soil organisms, nutrients, water, and plant growth.

### Crosscutting Concepts (CCCs)

- **Systems and System Models**
  - Soil is presented as a living system with interacting components: minerals, water, air, organic matter, and organisms.
  - Students map inputs, outputs, and feedbacks (e.g., carbon flow, nutrient cycling, and water movement) and connect soil to the larger farm ecosystem.
- **Energy and Matter**
  - Students trace carbon and nutrient flows through soil, linking plant inputs, microbial decomposition, and soil organic matter formation.
  - Hands-on labs (respiration tests, decomposition observations) illustrate energy transformation and matter cycling.
- **Cause and Effect**
  - Students examine how soil management practices affect soil properties and ecosystem services (e.g., tillage → compaction → reduced water retention; compost addition → increased organic matter → better fertility).
- **Stability and Change**
  - Students explore how soil structure, organic matter, and biodiversity contribute to resilience versus how degradation leads to instability (erosion, nutrient loss, reduced fertility).
- **Patterns**
  - Students observe patterns in soil properties across different management practices or locations (e.g., organic vs. conventional plots, covered vs. bare soils).
- **Influence of Science, Engineering, and Technology on Society and the Natural World**
  - Students see how soil science innovations (composting, biochar, cover crops, microbial inoculants) influence farm productivity, climate mitigation, and ecosystem services.

### California CTE Standards (Agriculture & Natural Resources Pathway)

- **Foundation Standard 5: Problem Solving and Critical Thinking** – Students investigate soil health challenges such as erosion, nutrient depletion, and poor structure, then evaluate and design solutions to improve soil function (e.g., Build–Maintain–Consume soil carbon management, compost application, cover cropping, soil scorecard projects).

- **Foundation Standard 9: Leadership and Teamwork** – Collaborative labs and projects (soil testing, infiltration and slake tests, compost monitoring, soil health scorecard) strengthen teamwork, peer dialogue, and applied problem-solving as students collectively interpret results and propose soil improvement strategies.
- **Foundation Standard 11: Demonstration and Application** – Learners apply environmental science concepts (soil texture, structure, pH, nutrient cycling, microbial activity, carbon storage) to practical challenges like analyzing soil test data, interpreting infiltration results, and designing interventions to enhance soil health and ecosystem services.
- **Sustainable Agriculture Pathway Standard** – Module 3 cultivates student capacity to “understand the environmental, social, and economic impacts of decisions” in farming systems by linking soil management practices (tillage, compost, crop rotation, cover crops) to productivity, climate resilience, and sustainable resource use.
- **Innovation & Resource Management** – By testing and comparing soil improvement practices and analyzing their co-benefits and trade-offs (e.g., carbon sequestration vs. labor input, nutrient retention vs. erosion control), students evaluate innovations in agriculture and practice evidence-based resource management.

### UC A–G “D” Lab Science Alignment:

This module is designed to meet UC/CSU A–G “D” Laboratory Science requirements as part of an approved science course.

- **Inquiry & Hands-On Activities:** At least 20% of instructional time is teacher-supervised lab-style work, including soil texture and structure tests, infiltration tests, compost monitoring, and soil health scorecard projects.
- **Scientific Practices:** Students pose scientific questions (e.g., “How does soil organic matter affect water retention?”), design investigations, collect and analyze quantitative data (soil pH, nutrient levels, C:N ratios, infiltration rates, microbial activity), and draw evidence-based conclusions, consistent with UC’s emphasis on inquiry and NGSS practices.
- **Interdisciplinary Science:** Module 3 integrates biology (soil organisms, nutrient cycling, biodiversity), earth science (soil as part of Earth systems, carbon storage, erosion), and chemistry (pH, nutrient availability, decomposition), ensuring breadth and depth of scientific foundations.
- **Rigor & Depth:** Reflection exercises, peer assessments, and group soil improvement projects emphasize higher-order thinking and science communication skills, aligning with the requirement for rigorous, college-prep laboratory science.

Content supports NGSS disciplinary core ideas LS2 (Ecosystem Dynamics, Interactions, and Biodiversity) and ESS3 (Human Impacts on Earth Systems), while engaging students in cross-cutting science and engineering practices such as modeling, data analysis, and designing solutions.