LOESS INTEGRATED LEARNING SCENARIO

Introduction

In LOESS, the acquisition of soil health knowledge is facilitated using integrated STEM teaching and learning, which is carried out via the Biology Science Curriculum Study (BSCS) 5E Instructional Model by Bybee and colleagues (Bybee et al. 2006) as well as the application of innovative pedagogical approaches (PBL, IBL, etc).

Topic

Endangered soils, soil conservation, human – environment interaction, water erosion

Title

SOS! Save Our Soils!

Authors

Emma Abbate & Vittoria Buccigrossi

Summary

This learning scenario engages students in understanding soil health through interactive, hands-on activities that examine soil properties and their role in ecosystems and society. Students investigate soil types, conduct experiments in a virtual lab, and analyse soil degradation using digital tools, culminating in a presentation challenge. The plan integrates web research and practical tasks to build skills in data analysis, interpretation, and persuasive communication. Flexible and adaptable to various curricula, it emphasises ecology, biodiversity, sustainability, physical geography, and human-environment interaction. Familiarity with satellite imagery, graphs, and GIS resources is recommended to maximise learning outcomes.

Licenses

Subject (s)

Biology, Geography

Real-life questions

- How does soil vary around Europe?
- What role does soil type play in the growth of plants?
- How water balance and tree cover influence soil health?
- How do different light conditions affect plant growth and health?
- What are the most dangerous threats of soil health?

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Learning objectives

- Recognize the commonest patterns of soil types across Europe.
- Acquire knowledge that cartographic representations of soil can be employed to guide decisions regarding land stewardship.
- Develop scientific observation and data recording skills.
- Conduct experiments to observe how different light conditions affect plant growth and health and interpret the results.
- Integrate concepts from Geography and Biology to gain a holistic understanding of soil health and its environmental impact.

Link to curriculum

This lesson plan is designed to foster scientific literacy and environmental awareness, aligning with the goals of sustainable development and environmental protection found in many national curricula. It emphasises understanding the natural world, enhancing inquiry skills, and applying scientific knowledge, particularly through activities related to soil science, plant growth, and environmental sustainability. The plan addresses competencies in scientific inquiry, environmental stewardship, and sustainable development, and it is designed to be flexible and replicable, matching the proficiency levels of average high school students. Additionally, it aligns with Sustainable Development Goals (SDGs): SDG 13 (Climate Action), and SDG 15 (Life on Land), by promoting awareness and action towards soil health and environmental conservation.

Age of students

Between 15 to 18 years old.

Time

Preparation time: 2-3 hours.
Before starting the module, teachers should:

- Familiarise themselves with the lessons and gather the necessary materials and technology.
- Obtain and examine the instructional resources.
- Ensure that any required handouts are printed (see annexes).
- Consider assigning some activities as homework or offering them as optional to minimise classroom time.

Teaching time: approximately 6 hours are needed to complete the learning scenario, but each lesson can be separately implemented.

- Geography: 4.5 hours.
- Biology: 1.5 hour (lab experiment digital version) or 1 week (in- class lab)

Teaching resources (material & online tools)

Materials:
Printable materials:

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

All Annexes should be printed, if necessary, even though the assignments, instructions and the rubrics can be projected on the classroom board or shared with students digitally.

Lesson 1. Warm up. Brainstorming

- KWL chart printable
  https://www.readwritethink.org/classroom-resources/printouts/chart-0
- Activity "Think -Pair-Share" Graphic organiser
  https://ophea.net/sites/default/files/2021-12/sr_tpsorganizer_ja17.pdf
- ESDAC glossary of soil terms
  https://esdac.jrc.ec.europa.eu/ESDB_Archive/Glossary/Glossary.pdf

Lesson 1. "The best European soil" challenge

- Graphic organisers to compare and contrast
  https://www.education.com/worksheet/article/top-hat-graphic-organizer/
- Comparison template
  https://toolsforconqueringthecommoncore.com/wp-content/uploads/2015/04/Top_Hat-Comparison_Organizer.pdf
- Venn diagram
  https://www.readwritethink.org/sites/default/files/resources/lesson_images/lesson378/venn.pdf
- Annex 1 – The soil type cards

Lesson 2. Exploring soil and water erosion

- Annex 3 – Soil degradation mind map
- Computers or smartphones/tablet ("Bring Your Own Device" approach) with internet access

Lesson 3. Connection between soil health and vegetation: a web lab approach

- Plant growth setup
  - small plant pots (12–18, depending on the number of light filters and repetitions)
  - uniform potting soil
  - seeds of a fast-growing plant (e.g., radish, lettuce, or bean)
- Lighting and filters
  - adjustable desk lamps or grow lights (at least 4–6 lamps)
  - coloured transparent light filters (red, blue, green, yellow, and a control with no filter)
  - white light bulb (use for all lamps to ensure consistency in light intensity)
  - electrical power source and extension cords
- Measurement tools
  - ruler or measuring tape
  - notebook for data recording
  - graph paper or a digital graphing tool for data visualization
  - calculator for averaging measurements
- Environmental control
  - Thermometer to monitor room temperature

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

- Spray bottle for watering plants

***Online tools*:**

Lesson 1. "The best European soil" challenge

- Video on soil types - structural guide
  https://www.youtube.com/watch?v=E_Ilueioink
- Videos on soil taxonomy
  - English (option 1): https://www.youtube.com/watch?v=BArbrfmsxeQ
  - English (option 2): https://www.youtube.com/watch?v=WecFKZXAiYI
  - Italian: https://www.youtube.com/watch?v=-d0zqZN2T5I
  - French: https://www.youtube.com/watch?v=Gl9IyL0Smxs
  - German: https://www.youtube.com/watch?v=5DrggzLkCFw
  - Spanish: https://www.youtube.com/watch?v=H-vzC2mHDaM
- Soil Atlas of Europe
  https://esdac.jrc.ec.europa.eu/content/soil-atlas-europe
- Earth satellite view
  - Google Earth: https://www.google.it/intl/it/earth/index.html
  - Zoom Earth: https://zoom.earth/
  - NASA WorldView: https://worldview.earthdata.nasa.gov/
  - Bing Maps: https://www.bing.com/maps?cp=39.499206%7E-104.757192&lvl=16.0
  - OpenStreetMap (OSM): https://www.openstreetmap.org/relation/112321
  - MapQuest: https://www.mapquest.com/us/colorado/80134-co-286301801
  - ArcGisEarth: https://www.esri.com/en-us/arcgis/products/arcgis-earth/overview

Lesson 2. Exploring soil and water erosion

- Soil loss by water erosion in Europe
  https://esdac.jrc.ec.europa.eu/themes/rusle2015

Lesson 2. The Water Balance App

- The Water Balance App
  https://livingatlas.arcgis.com/waterbalance/
- Storymap - a simple guide to using the *Water Balance* App for teachers
  https://storymaps.arcgis.com/stories/9c675f92e57548b79162ecfaeeb33066
- Student workbook and practice questions
  https://arcg.is/08f4uH

Lesson 2. Global forest watch app task

- The Global Forest Watch App
  https://www.globalforestwatch.org/map/
- "How to use" tutorials
  http://www.globalforestwatch.org/howto
- Introductory videos explaining the goal of the project in multiple languages
  http://www.globalforestwatch.org/about/videos

Lesson 3. Connection between soil health and vegetation: a web lab approach

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

- Virtual lab experiment that explores how different colours of light impact plant growth, directly linking light wavelengths to photosynthesis https://nt7-mhe-complex-assets.mheducation.com/nt7-mhe-complex-assets/Upload-20190715/InspireScience6-8CA/LS12/index.html

STEM Strategy Criteria

Developing the LOESS learning scenario will help you and your school comply with the STEM School Label criteria. Please find below which STEM School Label criteria this learning scenario fulfils.

Elements and criteria	How is this criterion addressed in the learning scenario?
Instruction	
Personalisation of learning	The learning scenario includes a variety of activities, such as brainstorming, think-pair-share, and hands-on experiments, which cater to different learning preferences and abilities. This variety allows teachers to differentiate instruction based on individual student needs.
Problem and project-based learning (PBL)	The learning scenario incorporates PBL by having students work on open-ended, well-defined questions that require them to collaboratively devise solutions to preserve soils' health.
Inquiry-Based Science Education (IBSE)	IBSE is integrated by having students go through asking questions, developing hypotheses, planning experiments, collecting data, analysing results, and sharing findings with peers on the topic of endangered soils.
Curriculum implementation	The learning scenario is designed to be easily implemented within most of the national curricula with activities that align with the educational standards and objectives commonly set in schools all over Europe. It involves the integration of various pedagogical approaches, including the BSCs 5E Instructional Model, to ensure effective learning.
Emphasis on STEM topics and competencies	
Interdisciplinary instruction	The scenario emphasises interdisciplinary instruction by uniting Biology and Geography to provide a holistic understanding of soil health and its real-life challenges.
Contextualisation of STEM teaching	Contextualization of STEM teaching is obtained by linking soil health to real-life challenges. Teachers are encouraged to connect the activities with local case studies and field experiences.
Assessment	
Continuous assessment	The scenario includes continuous assessment, such as formative evaluation during the BSCs 5E Instructional Model phases, to monitor student learning and make necessary adjustments.
Personalised assessment	Personalised assessment is addressed by using a variety of assessment methods adapted to individual student needs and learning styles.
Professionalization of staff	
Highly qualified professionals	The scenario assumes the involvement of highly qualified professionals who can facilitate the complex pedagogical approaches required for the proposed learning activities.
Existence of supporting (pedagogical) staff	The presence of supporting staff is recommended to assist in the implementation of the learning activities, ensuring that students receive the necessary support. Scaffolding tools and approaches (guiding questions) are also suggested.
School leadership and culture	
School leadership	School leadership is necessary to foster a culture that supports the implementation of the pedagogical approaches on which the Learning scenario is based, and the necessary resources for their success.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Elements and criteria	How is this criterion addressed in the learning scenario?
High level of cooperation among staff	The scenario encourages cooperation among staff to ensure the interdisciplinary nature of the planned activities is well-executed and that all necessary support is provided.
Inclusive culture	Engaging all students in the learning process and providing personalised assessment to accommodate diverse learning needs, make this lesson plan inclusive.
School infrastructure	
Access to technology and equipment	The request to collect and analyse data for completing activities such as the Water Balance and the Global Forest Apps tasks, calls for a computer Lab access or a BYOD (Bring Your Own Device) approach.
High quality instruction classroom materials	The detailed annexes included in this learning scenario are important material to convey a high-quality instruction.

Description of activities

Name of activity	Procedure	Time
	1st lesson	
5E Phase	Engage, Explore, Explain, Elaborate and Evaluate	
Warm up. Brainstorming	Students are divided into small groups and asked to brainstorm everything they already know about soil and what they would like to know. The activity can be facilitated using a K-W-L chart graphic organiser that will be re-examined at the end of the module to recap the whole pathway, as a wrap-up reflection. Biology/Geography teacher encourages pupils to think broadly, including topics like soil composition, the role of soil in food production, and the impact of human activities on soil health. To ignite reflection, teacher can ask the following guiding questions: 1. *What are the key components of soil, and how do they contribute to soil health?* 2. *How does soil play a crucial role in food production?* 3. *In what ways do human activities affect soil health, both positively and negatively?* 4. *What are some examples of sustainable practices that can help maintain or improve soil health?* 5. *How does soil health impact biodiversity and ecosystem stability?* 6. *What are the consequences of soil degradation, and how can it be prevented or mitigated?* 7. *How can the study of soil health contribute to addressing global challenges such as climate change and food security?* 8. *What are some innovative technologies or methods being used to study and manage soil health?* 9. *How can local communities and individuals contribute to soil conservation efforts?* 10. *What are the economic and social benefits of maintaining healthy soil?*	15 min.
Subject 1	Geography	
"The best European soil" challenge	This activity follows the challenge-based approach: it is aimed at familiarising students with some of the major 23 soil types of Europe (pp. 28-32, Soil Atlas of Europe). Material for the competition must be prepared before class. In connection with the warming up phase, the activity begins with a brief (15 min) overview of the European types of soil: the teachers mustn't present all the 23 types of European soil	90 min.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Name of activity	Procedure	Time
	depicted in the Atlas, but only 5-10 of them, possibly the most diffused ones in their country. These will be prepared for the subsequent challenge. Then students, divided into teams (the size of the groups is up to the teacher; 4 or 5 students is recommended), randomly select a soil type card (see Annex 1 – The soil type cards). Each card includes general information about the soil: students are tasked with creating a presentation to argue why their soil type is the "best" in Europe. To accomplish this, they are encouraged to use online resources, such as the Soil Types. Structural Guide, a video which shows the main soil types and their features, and other information on the web to support their claims and create a slogan to promote their soil, so each group should have a tablet/laptop/computer with internet access available. The promotional presentations should highlight the unique features, usefulness, and distinctiveness of each soil type. *Annex 2 – The best European soil challenge* includes evaluation criteria and instructions for judges as well as a customizable challenge participation certificate. At the end, the teacher can explain to the students how their is no "best" soil type as the ideal soil depends on a specific location and plants you want to grow.	
Learning products	Presentation of a specific type of soil.	
2nd lesson		
5E Phase	Engage, Explore and Evaluate	
Subject 2	Geography	
Exploring soil and water erosion	This activity is aimed at showing the impactful effects of water erosion on soils. Firstly, students are introduced to the ESDAC (European Soil Data Centre) "soil degradation processes" mind map projected on the interactive board (the map can be also shown on students' laptops, if possible, or printed). You find it in *Annex 3 – Soil degradation mind map*. In particular, their attention must be grasped on the *water erosion process* by highlighting the beneficial and detrimental interactions between soils and water (e.g., the contribution of water to soil formation, the harm caused by water in soil erosion, the reliance of agricultural lands in river valleys on sediment for nutrient replenishment, the effect of sediment on aquatic and estuarine environments, the movement of pollutants from soil into water bodies). Teacher can make some thought-provoking questions on the effects of water erosion on soil that can engage students and stimulate critical thinking, such as the following: 1. *How does the force of rainwater impact different soil types, and why do some soils erode more quickly than others?* 2. *What long-term effects does water erosion have on the fertility and structure of soil in agricultural areas?* 3. *Can water erosion ever benefit the landscape, or is it always harmful? If so, how?* 4. *How do human activities, such as deforestation and urbanisation, accelerate the process of water erosion?* 5. *In what ways do water erosion and soil compaction interact, and how can these combined effects impact plant growth?* 6. *What roles do vegetation and root systems play in preventing or reducing water erosion?* 7. *How do the effects of water erosion in coastal areas differ from those in inland areas?* 8. *What are the economic and environmental impacts of soil erosion caused by water in farming communities?*	30 min.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Name of activity	Procedure	Time
	9. *How do different landscape designs, like terracing or contour farming, reduce water erosion, and why are these strategies effective?* 10. *How might climate change influence the severity and frequency of water erosion events in the future?* The teacher could also display or distribute the "continental average" and "cropland average" erosion figures (the dataset for year 2024 can be requested to the Joint Research Centre ESDA by filling the form available here) to identify the erosion rates associated with different soil locations to make students aware of how rapidly soil fertility will diminish under current erosion rates. To further explore the soil loss by water erosion in Europe, the teacher presents a photo which shows the estimation of soil loss factors for Europe in the RUSLE2015 model (Fig 1.). Simple and short definitions of the 5 factors which cause soil loss (rainfall erosivity factor, soil erodibility, cover-management, topographic factors and support practices) are given to students. The teacher then shows a map which indicates soil loss by water erosion in Europe, available here (Fig. 2), and learners autonomously detect two or more areas on the map where soil erosion is prevalent. It would be better if students concentrate their attention on places situated in a different European climatic region to reflect on how climate jeopardises water balance and, consequently, soil's health.	
Water balance app task	This activity allows students to explore soil health through the Water Balance App that makes it easier to interrogate data like temperature, humidity, and rainfall, all important factors which influence soil aspect. After a short slideshow presentation necessary to introduce the water balance concept (if they do not have material to create the presentation teachers can take inspiration from here). The teacher demonstrates the functionality of the Water Balance app showing how the water balance is changing over time on Earth (this can be also anticipated in a previous class). Students then conduct research in groups of 4 -5 on how hydrologic patterns have changed in a specific location to investigate the link between these changes and soil features. Clicking on the map makes it possible to see how a chosen variable has changed over time, and clicking anywhere on the graph allows you to switch the map to that month – time slot of interest. For detailed instructions on how to accomplish this task, see *Annex 4 – Instructions for the Water Balance App and The Global Forest Watch Activity.*	60 min.
Global forest watch app task	To highlight the close connection among water balance, tree cover and soil health, the same locations' changes in the given time frames are examined using the *Global Forest Watch* App. The activity proceeds as follows: Students, divided in the same groups formed for the previous activity, open the Global Forest Watch Interactive Map (the tool consents to select the language, apart from English 5 languages are available) and use the search bar to find on the map the same locations explored with Water Balance. Teacher asks students what they initially observed about the patterns of *tree cover loss and gain* in each area. The students must uncover the story behind these patterns. The following questions can be made to stimulate the observation in the initial phase: 1. *Do you note any tree cover loss is in large geometric shapes? If yes, what might this signify?* 2. *Do you note if certain areas exhibit minimal Tree Cover Loss?* Clicking on "Analysis", students can explore interactive charts and maps that summarise key statistics about forests in a specific region/city. Statistics – including rates of forest change and forest extent – can be customised, easily shared and downloaded for offline use. Selecting the "dashboard" option is possible to have a clear full screen view.	60 min.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Name of activity	Procedure	Time
	Students analyse the App's several sections for the chosen location: "land cover", "forest change", "fires" and "climate"; and jot down their reflections. The teacher ensures that they understand the nature of the data and provides guidance and feedback to help students refine their observations. A list of questions is included in *Annex 4 – Instructions for the Water Balance App and The Global Forest Watch Activity* to help students delve deeper into the information found and to highlight connections between tree cover changes, human activities, and impacts on soil health. The analysis guiding questions have been designed according to the Pattern, Quantify, Exceptions (PQE) tool that asks students to: • examine general spatial patterns on maps • observe maps closely for specific details of patterns • recognize and illustrate exceptions • draw on prior knowledge to explain the observed patterns and irregularities. The procedure for using the PQE tool is adapted from Easton et al. (2013).	
Learning products	ESSAY (60 min) 250-400 words (can be given as homework): Based on the two previous activities and as a wrap up task, students are asked to produce a well-structured and insightful essay that compares and combines the observations from the two Apps providing a comprehensive analysis of soil health in the investigated locations. This can be a group task (collaborative writing), if assigned in class students are advised to use the ESDAC glossary of soil terms as a linguistic and conceptual scaffold for completing the task. Detailed instructions to complete the given assignments are collected in *Annex 5 – Instructions for the essay assignment.*	
3rd lesson		
5E Phase	Engage, Explore	
Subject 3	Biology	
Connection between soil health and vegetation: a web lab approach	In this virtual lab experiment on *Plant Growth and Light Spectrum*, students explore how different colours of light impact plant growth, directly linking light wavelengths to photosynthesis. Students hypothesise which colours (red, blue, green, etc.) will promote the most growth, then test this by placing identical plant seeds under various light filters. Using an interactive setup, they observe, measure, and record plant height changes under each colour. To engage with the experiment: 1. Hypothesize: Students predict which light colours will maximise and minimise plant growth. 2. Select & Test: They choose a seed type, apply coloured light filters, and turn on the light to observe plant growth. 3. Measure & Analyse: Using a virtual ruler, students measure plant heights, average the results, and record them. They then switch filters to test other colours. 4. Graph Results: The data is plotted to help visualise and confirm which colours most enhance photosynthesis.	60 min.
Connection between soil health and	For a hands-on approach to this activity and for a practical application of the main concepts, this virtual lab experiment can be transformed into an activity for the classroom that's both practical and fun for students. This experiment will help them observe how different colours of light influence plant growth, creating a tangible connection to photosynthesis and the light spectrum.	60 min for preparation. 1 week for

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Name of activity	Procedure	Time
vegetation: a classroom/ lab approach	To get started, you'll need a few materials. First, gather some small pots and fill them with uniform soil. Each pot will house one seed, so choose something that grows quickly, like radishes, beans, or lettuce. You'll also need adjustable desk lamps or grow lights for each group of plants, along with coloured transparent filters in red, blue, green, yellow, and a control setup with no filter. It's important to use identical white light bulbs to maintain consistent light intensity. Once the materials are ready, prepare the classroom by organizing the pots into groups, with each group assigned a specific light colour. Place them under their respective lamps, attaching the coloured filters to the lights. For the control group, use unfiltered light. Make sure all the plants are exposed to the same conditions: they should receive equal amounts of light (about 8–10 hours a day), the same amount of water (around 10 mL daily), and be kept in a stable temperature environment. A thermometer can help monitor this. Begin by asking the students to form a hypothesis. Which colour of light do they think will make the plants grow the tallest? Which might have little or no effect? Encourage them to jot down their thoughts in their notebooks. This is a great way to set the stage for scientific inquiry. Once everything is set up, the students can observe the plants as they grow. Every two days, they'll measure the height of each plant using a ruler and record their findings. For each colour group, they'll calculate the average height of the plants and keep these results in a table. After two weeks, or once noticeable differences appear, it's time to analyse the data. Students can graph the average heights for each light colour, either by hand on graph paper or using a digital tool. At this stage, bring the class together to discuss the results. Which colour of light led to the tallest plants? Did any colour seem to hinder growth? Encourage them to think about why this might be, linking back to what they've learned about chlorophyll and how it absorbs certain colours of light while reflecting others. To wrap up, revisit their initial hypotheses. Did the results match their predictions? If not, explore why their expectations might not have been met. This is a perfect opportunity for students to reflect on the experiment and ask further questions. For example, how could these findings be applied in real-world agriculture or gardening? What other variables might affect plant growth, such as soil type or water levels? For students to see light manipulation techniques in action, incorporate a local field trip to a greenhouse or garden. This real-world experience allows students to see how professional growers use various methods to optimize plant growth, such as altering light intensity, spectrum, or duration. Alternatively, the experiment can be extended by testing other variables alongside light colour.	implementation.

Initial assessment

The initial assessment includes a pre-test, a survey, and open-ended discussion (all deliverable also online) to understand students' baseline understanding. See *Annex 6 – Initial assessment.*

Formative evaluation

The teacher can monitor students' progress, employing Socratic questioning techniques to help them achieve the objectives of examining specific soil characteristics fostering a deeper comprehension of soil properties. The guided questions are provided to teachers all along the learning scenario for each activity. Informal assessment of students' knowledge can be applied

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

during class discussions. For each activity of this learning scenario a type of formative evaluation is suggested:

Lesson 1. Introduction to Soil Health

- Ask students to share their initial thoughts on soil health by using the THINK-PAIR-SHARE approach.

Lesson 1. The Best European Soil Challenge

- Interactive Poll: Use a live poll to ask students which soil type they think is the best and why (an online poll tool can be employed).

Lesson 2. Water Balance & Global Forest Watch App Task

- Practical Skills Assessment: Evaluate students' ability to use the apps Water Balance and Global Forest Watch and interpret the data.

Lesson 3. A Vital Connection between Soil Health and Vegetation: a web approach

- A lab report allows students to demonstrate their understanding of the entire experimental process.

Final assessment

Students will synthesise their knowledge of soil health (including its importance, the factors that affect it, and strategies for conservation) acquired through this learning scenario into a final output: a comprehensive project presentation. See Annex 7 – Final assessment.

Student feedback

Students will give feedback on the learning scenario following a questionnaire which can be adapted online or printed. See Annex 8 – Student feedback.

Teacher feedback

The teachers can provide feedback on how the learning scenario was received and implemented by using a self-assessment table. See Annex 9 – Teacher feedback.

Reflection on the development process

Add here your personal reflection on the creation of your learning scenario (max 200 words). Here below are a few questions that can help you brainstorm.

1. *Describe where your initial ideas for the LS came from. What inspired you to choose the particular focus you have chosen?*
2. *Summarise the research you have conducted and resources you have found to inform your plan. How did those influence your thinking and creation process?*
3. *What did you learn about your own planning and development process?*

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Add your reflection below:

Our initial inspiration for this learning scenario came from a deep interest in the intersection between environmental science and geography, particularly soil health's role in ecosystems. Recognizing soil as a critical yet often overlooked resource, we wanted students to understand its importance for both environmental sustainability and human activity. We began by reviewing resources on soil science, including the *Soil Atlas of Europe* and tools like the *Water Balance* and *Global Forest Watch* Apps. These resources allowed us to design hands-on activities that empower students to analyse real-world data and make connections between soil health and broader environmental issues.

Throughout the planning process, we focused on using the 5E Instructional Model, which encouraged a structured, inquiry-based approach. This model and the integration of interactive apps enabled us to create a dynamic, student-centred learning environment that promotes critical thinking and problem-solving skills. Reflecting on our process, we learned the value of blending digital resources with hands-on tasks to create a rich, interdisciplinary learning experience. This journey has deepened our appreciation for well-planned, inquiry-based learning and the impact it can have on students' environmental awareness.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Annex 1 – The soil type cards

The soil of Europe

The major soil types of Europe

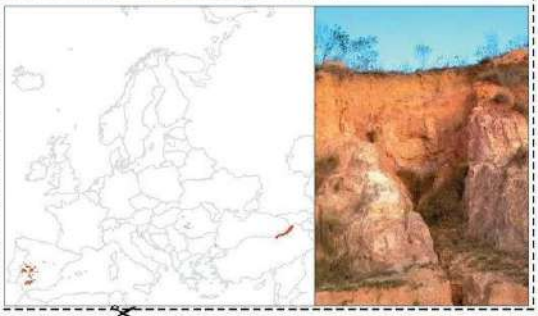
ACRISOLS

Soil with subsurface accumulation of low activity clay minerals and low base saturation (from the Latin, *acris*, meaning very acid).

An Acrisol is a highly weathered soil occurring in warm temperate regions and the wetter parts of the tropics and subtropics. Acrisols have poor chemical properties, low levels of plant nutrients, high levels of aluminium and high susceptibility to erosion. These conditions are strong limitations for agricultural use. Acrisols are similar to the Red-Yellow Podzolic soil of Indonesia, Red and Yellow Earths and are related to several subgroups of Alfisols and Ultisols (Soil Taxonomy).

Left: Sheet and rill erosion on Acrisols;
Below: a natural Acrisol profile exposed by deep gully erosion;
The map shows the location of areas in Europe where Acrisols are the dominant soil type.

Cover less than 1 % of Europe.



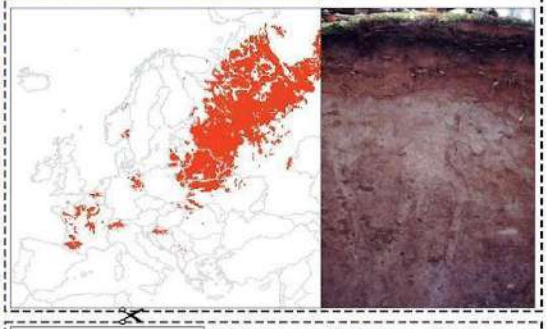
ALBELUVISOLS

Acid soil with a bleached horizon penetrating a clay accumulation horizon (from the Latin, *albus*, meaning white and *eluere*, meaning to wash out).

Albeluvisols have an accumulation of clay in the subsoil with an irregular or broken upper boundary and deep penetrations or 'tonguing' of bleached soil material into the illuviation horizon. The typical "albeluvic tongues" are generally the result of freeze-thaw processes in periglacial conditions and often show a polygonal network in horizontal cuts. Albeluvisols occur mainly in the moist and cool temperate regions. Also known as Podzoluvisols (FAO), Orthopodzolic soil (Russia) and several suborders of the Alfisols (Soil Taxonomy).

Left: Albeluvisols develop mostly under forest vegetation;
Below: Albeluvic tongues are clearly visible penetrating the bleached illuvial horizon; The map shows the location of areas in Europe where Albeluvisols are the dominant soil type.

Cover 15 % of Europe, the most common soil.



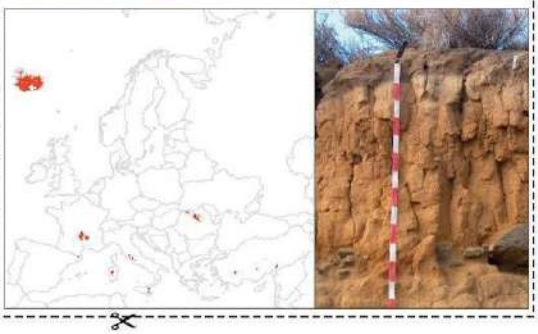
ANDOSOLS

Young soil developed from highly weatherable volcanic deposits (from the Japanese, *an*, meaning black, and *do*, meaning soil).

Most Andosols are formed from volcanic ejecta (ash, pumice, cinder) and related parent materials. The rapid chemical weathering of porous, permeable, fine-grained mineral material, in the presence of organic matter, generally results in the rapid development of soil profiles. The dark topsoil is generally different in colour from subsoil. Andosols occur throughout the world where volcanic activity is common. Other international names are Andisols (Soil Taxonomy), Vitrisols (France) and volcanic ash soil.

Left: Fertile pasture land developed on old volcanic ash deposits – note the cinder cones in the distance;
Below: An Andosol develops in unconsolidated volcanic deposits – note the contrast in colour of the horizon; The map shows the location of areas in Europe where Andosols are the dominant soil type.

Cover around 1 % of Europe.



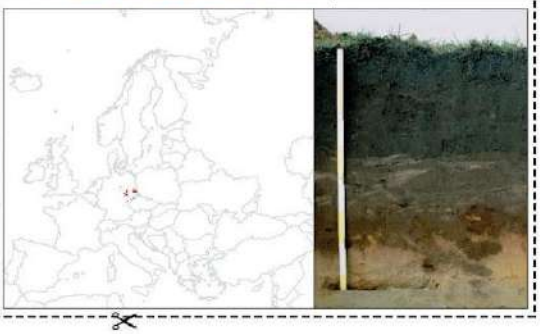
ANTHROSOLS

Soil formed or modified by human activity that caused profound changes in soil properties (from the Greek, *anthropos*, meaning man).

An Anthrosol is a soil that was formed or significantly modified through human activities ranging from long-term deep cultivation (e.g. terraces), substantial additions of mineral and organic fertilizers, continuous application of earth (e.g. sods, shells), irrigation and substantial additions of sediment to wet cultivation involving *puddling* of the surface soil. The morphological and chemical characteristics of this soil vary depending on the specific human activity. Anthrosols are also known as Plaggen soil, Paddy soil, Oasis soil and Terra Preta do Indio.

Left: "Plaggen" fertilization over time has resulted in a raised land surface. Farm houses often lie deeper than their surroundings. (R.); Below: Thick, black Anthrosol in Belgium, overlying remnants of a Podzol developed by long-term fertilization of sods or "Plaggen" mixed with animal manure. Spade marks are clearly visible at the boundary between the Anthrosol and the buried Podzol; The map shows the location of areas in Europe where Anthrosols are the dominant soil type.

On a continental scale, it is the dominant soil in less than 0.3 % of Europe but locally can be very important.



28

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

The major soil types of Europe

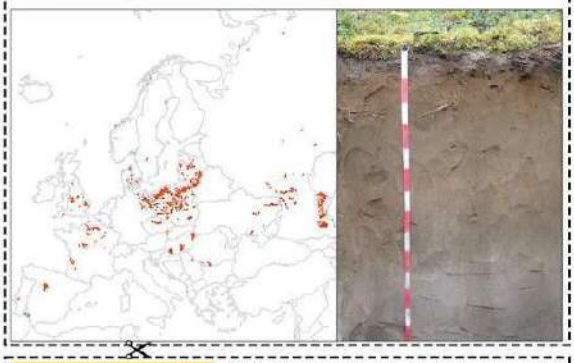
ARENOSOLS

Easily erodable sandy soil with slow weathering rate, low water and nutrient holding capacity and low base saturation (from the Latin, *arena*, meaning sand).

Arenosols have a coarse texture to a depth of one metre or to a hard layer. Soil formation is limited by low weathering rate and frequent erosion of the surface. If vegetation has not developed, shifting sands dominate. Accumulation of organic matter in the top horizon and/or lamellae of clay, and/or humus and iron complexes, mark periods of stability. Arenosols are amongst the most extensive soil types in the world.

Left: the surface of Arenosols are often unstable in the absence of continuous vegetation cover;
Below: stabilized Arenosol with organic matter accumulation at the surface and lamellae in the subsurface; The map shows the location of areas in Europe where Arenosols are the dominant soil type.

Cover 1 % of Europe.



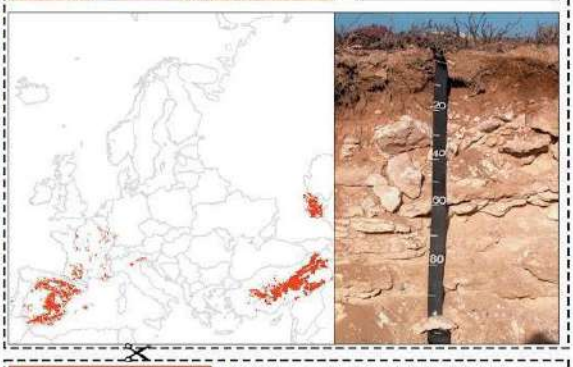
CALCISOLS

Soil with significant accumulation of secondary calcium carbonates, generally developed in dry areas (from the Latin, *calcarius*, meaning calcareous or lime-rich).

Calcisols have substantial movement and accumulation of calcium carbonate within the soil profile. The precipitation may occur as *pseudomycelium* (root channels filled with fine calcite), nodules or even in continuous layers of soft or hard lime (*calcrete*). Calcisols are common on calcareous parent material in regions with distinct dry seasons, as well as in dry areas where carbonate-rich groundwater comes near the surface. Formerly Calcisols were internationally known as Desert soil and Tekyrs.

Left: a typical Calcisol landscape showing a hard calcrete layer;
Below: the deposition and accumulation of calcium carbonate ($CaCO_3$) may form a continuous hard pan layer; The map shows the location of areas in Europe where Calcisols are the dominant soil type.

Cover 5 % of Europe.



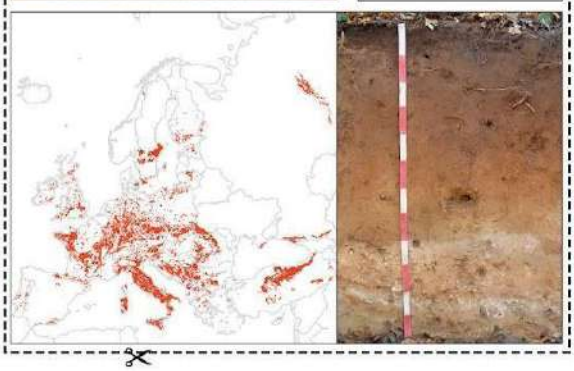
CAMBISOLS

Soil that is only moderately developed on account of limited age or rejuvenation of the soil material (from the Latin *cambiare* meaning to change).

A Cambisol is a young soil. Pedogenic processes are evident from colour development and/or structure formation below the surface horizon. Cambisols occur in a wide variety of environments around the world and under all many kinds of vegetation. Commonly referred to as brown soil, Braunerde (Germany), Sols bruns (France) or Brunizems (Russia). The USDA Soil Taxonomy classifies Cambisols as Inceptisols.

Left: Cambisols are common in Europe and can be very productive agriculturally, especially in loess areas;
Below: Pedogenic processes are evident in colour development or structure formation below the surface horizon; The map shows the location of areas in Europe where Cambisols are the dominant soil type.

Cover 12 % of Europe.



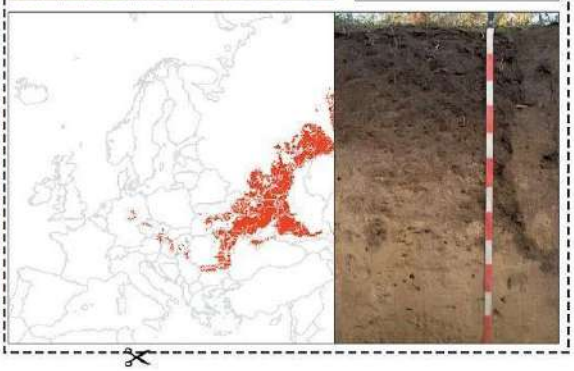
CHERNOZEMS

Soil with a deep, dark surface horizon that is rich in organic matter and secondary calcium carbonate concentrations in the deeper horizons (from the Russian for *chern*, black, and *zemlja*, earth).

Soil having a very dark brown or blackish surface horizon with a significant accumulation of organic matter, a high pH and having calcium carbonate deposits within 50 cm of the lower limit of the humus rich horizon. Chernozems show high biological activity and are typically found in the long-grass steppe regions of the world, especially in Eastern Europe, Ukraine, Russia, Canada and the USA. Chernozems are amongst the most productive soil types in the world.

Left: The main source of the high organic content of Chernozems is the annual decay of grass;
Below: the dark surface soil material is generally mixed to significant depths by the high biological activity; The map shows the location of areas in Europe where Chernozems are the dominant soil type.

Cover 9 % of Europe.



Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

The soil of Europe

The major soil types of Europe

CRYSOLS

Soil of cold areas with permafrost within a depth of 1m from the surface (from the Greek *krios*, meaning cold or ice).

Cryosols develop in arctic and mountainous regions where permanently frozen subsoil or "permafrost" is found. In this type of soil, water occurs primarily in the form of ice and cryogenic processes - such as 'freeze-thaw' sequences, 'cryo-turbation', 'frost heave', 'cryogenic sorting', 'thermal cracking' and 'ice segregation' are the dominant soil forming processes. These processes result in distorted horizons and patterned ground. These soils are widely known as Permafrost soil, Gelisols, Cryozems, Cryomorphic soils and Polar Desert soil.

Left: patterned ground in the permafrost region of Russia, the result of sorting of soil due to freezing and thawing; Below: cryoturbed or distorted horizons above the permafrost; The map shows the location of areas in Europe where Cryosols are the dominant soil type.

Cover 2 % of Europe.

FLUVISOLS

Young soil in alluvial (floodplain), lacustrine (lake) and marine deposits (from the Latin, *fluvius*, meaning river).

Fluvisols are common in periodically flooded areas such as alluvial plains, river fans, valleys and tidal marshes, on all continents and in all climate zones. Fluvisols show layering of the sediments rather than pedogenic horizons. Their characteristics and fertility depend on the nature and sequence of the sediments and length of periods of soil formation after or between flood events. Common international names are Alluvial soil, Fluvents (Soil Taxonomy) and Auenböden (Germany).

Left: Fluvisols develop due to the deposition of sediments following flood events - the picture shows a typical flood event where the river has overflowed its banks; Below: the profiles of Fluvisols show a layering of the sediments indicating deposition by water; The map shows the location of areas in Europe where Fluvisols are the dominant soil type.

Cover 5 % of Europe.

GLEYSOLS

Soil saturated by groundwater near the surface for long periods (from the Russian, *gley*, meaning 'mucky mass')

Gleysols occur mainly in lowland areas where the groundwater comes close to the surface and the soil is saturated with groundwater for long periods of time. Conditioned by excessive wetness at shallow depth, this type of soil develops gleyic colour patterns made up of reddish, brownish or yellowish colours on ped surfaces or in the upper soil layers, in combination with greyish/bluish colours inside the peds or deeper in the soil profile. Common international names are Gleyzems (Russia), Gley (Germany), meadow soil, groundwater soil and hydro-morphic soil.

Left: Gleysols are generally not well drained and need intensive management before they can be used; Below: note the characteristic red and bluish /grey mottling and the presence of water in the profile pit; The map shows the location of areas in Europe where Gleysols are the dominant soil type.

Cover 5 % of Europe.

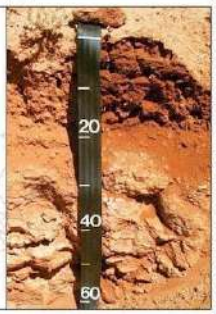
GYPSISOLS

Soil of dry areas with secondary accumulation of gypsum (from the Latin, *gypsum*, meaning the evaporite calcium sulphate).

Gypsisols have substantial secondary accumulation of gypsum in the subsurface. Most areas of Gypsisols are in use for low volume extensive grazing. They occur in the driest parts of the arid climate zone, which explains why leading soil classification systems label them Desert soil (USSR), Aridisols (Soil Taxonomy), Yermosols or Xerosols (FAO).

Left: Arid "bush" vegetation so typical of many gypsisol regions; Below: The high amount of gypsum may form a petrogypsic horizon - a hardpan that further limits the use of this soil; The map shows the location of areas in Europe where Gypsisols are the dominant soil type.

Dominant in only very small part of Europe (less than 0.1 %)



30

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

The major soil types of Europe

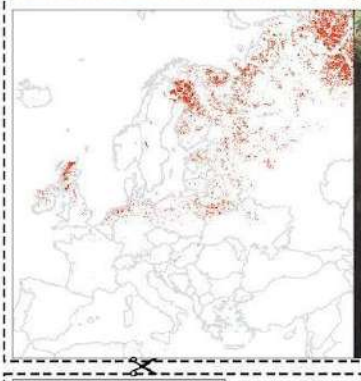
HISTOSOLS

Dark soil with high accumulation of partially decomposed organic matter generally developed in wet or cold conditions (from the Greek, *histos*, meaning tissue).

Histosols are composed mainly of organic soil material. During development, the organic matter production exceeds the rate of decomposition. The decomposition is retarded mainly by low temperatures or anerobic (low oxygen) conditions which result in high accumulations of partially decomposed organic matter. Histosols occur mainly in the boreal and sub arctic regions and are also known as peat, muck, bog and organic soil.

Left: a typical Histosol landscape from northern Europe;
Below: Histosols are usually black or very dark brown and contain recognizable remains of plants; The map shows the location of areas in Europe where Histosols are the dominant soil type.

Cover 5 % of Europe.



KASTANOZEMS

Soil with surface horizon rich in organic matter and with calcium carbonate or gypsum accumulation in subsurface horizons (from the Latin *castanea*, chestnut, and the Russian, *zemlja*, meaning earth or land).

Kastanozems have a deep, dark coloured surface horizon with a significant accumulation of organic matter, high pH and an accumulation of calcium carbonate within 100 cm of the soil surface. Kastanozems occur mainly in the dry parts of the steppe regions of the world and are shallower and lighter in colour than Chernozems.

Left: Kastanozems being "observed" in the field;
Below: Secondary calcium carbonate accumulation occurs close to the surface; The map shows the location of areas in Europe where Kastanozems are the dominant soil type.

Cover 2 % of Europe.

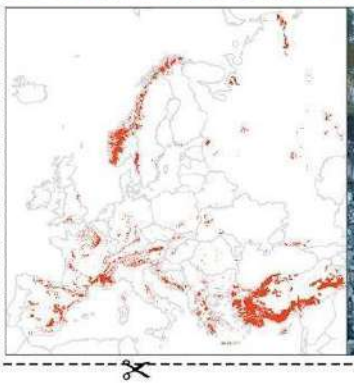
LEPTOSOLS

Shallow soil over hard rock or gravelly material (from the Greek, *leptos*, meaning thin).

Leptosols are shallow over hard rock and comprise of very gravelly or highly calcareous material. They are found mainly in mountainous regions and in areas where the soil has been eroded to the extent that hard rock comes near to the surface. Because of limited pedogenic development, Leptosols do not have much structure. On a global scale, Leptosols are very extensive. Leptosols on limestone are called *Rendzinas* while those on acid rocks, such as granite, are called *Rankers*.

Left: in Leptosols, rocks are often close to the surface and many outcrops are visible;
Below: a Leptosol on highly calcareous material, known as a Rendzina; The map shows the location of areas in Europe where Leptsols are the dominant soil type.

Cover 9 % of Europe.



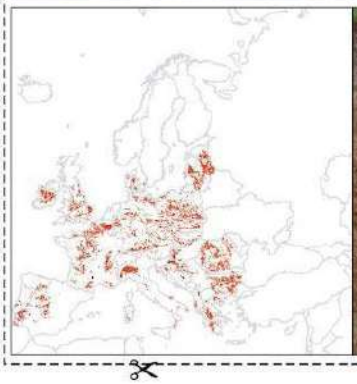
LUVISOLS

Soil with a subsurface horizon of high activity clay accumulation and high base saturation (from the Latin, *luere*, meaning to wash).

Luvisols show marked textural differences within the profile. The surface horizon is depleted in clay while the subsurface 'argic' horizon has accumulated clay. A wide range of parent materials and environmental conditions lead to a great diversity of soils in this Reference Soil Group. Other names used for this soil type include Pseudo-podzolic soil (Russia), sols lessivés (France), Parabraunerde (Germany) and Alfisols (Soil Taxonomy).

Left: Luvisols generally occur on well drained landscapes;
Below: note the marked textural differentiation within the soil profile between the surface and subsurface horizons; The map shows the location of areas in Europe where Luvisols are the dominant soil type.

Cover 6 % of Europe.



Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

The soil of Europe

The major soil types of Europe

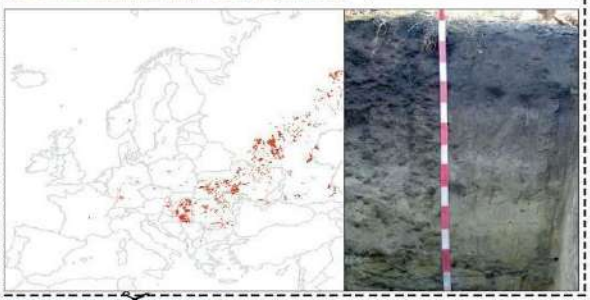
PHAEOZEMS

Soil with a deep, dark surface horizon that is rich in organic matter without secondary calcium carbonate concentrations within 1m (from the Greek, *phaios*, meaning dusk and the Russian, *zemlja*, meaning earth or land).

Phaeozems are found in wet steppe (prairie) regions and are much like Chernozems and Kastanozems but more intensively leached in wet seasons. Consequently, they have a dark, humus-rich surface horizon and have no secondary carbonates in the upper metre of soil. Commonly used international names are Brunizems (Argentina, France), Parabraunerde-Tschernozems (Germany) and Aquolls in the order of the Mollisols (Soil Taxonomy).

Left: Chernozems and Phaeozems are highly productive soil types and are used mainly for cereal crop production; Below: Phaeozems are more intensively leached than other steppe (prairie) soils and do not have secondary carbonates in the upper horizons; The map shows the location of areas in Europe where Phaeozems are the dominant soil type.

Cover 3 % of Europe.



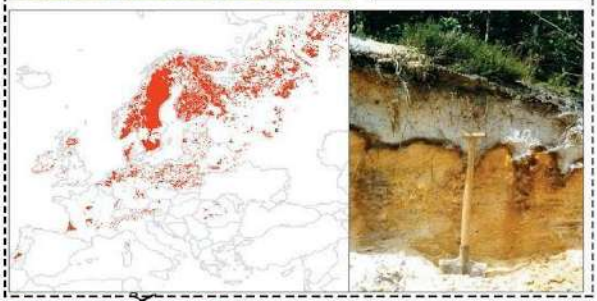
PODZOLS

Acid soil with a bleached horizon underlain by an accumulation of organic matter, aluminium and iron (from the Russian, *pod*, meaning under, and *zola*, meaning ash).

Under acidic conditions aluminium, iron and organic compounds migrate from the surface soil down to the B-horizon with percolating rainwater. The humus complexes deposit in an accumulation (spodic) horizon while the overlying soil is left behind as a strongly bleached *albic* horizon. Most Podzols develop in humid, well drained areas, particularly, in the Boreal and Temperate Zones.

Left: Podzols are common under vegetation with acidic litter (e.g. conifer trees); Below: the typical contrasting leached and accumulation horizons of a Podzol - note the formation of an 'iron pan'; The map shows the location of areas in Europe where Podzols are the dominant soil type.

Cover 14 % of Europe, the dominant soil of the northern latitudes.



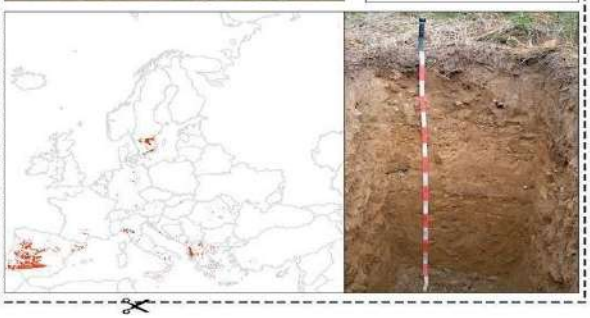
REGOSOLS

Soils with limited development (from Greek, *rhegos*, meaning blanket).

A Regosol is a very weakly developed mineral soil in unconsolidated materials with only a limited surface horizon having formed. Limiting factors for soil development range from low soil temperatures, prolonged dryness, characteristics of the parent material or erosion. Regosols form a taxonomic rest group containing all soil types that cannot be accommodated in any of the other WRB Reference Groups. Regosols are extensive in eroding lands, in particular, in arid and semi-arid areas and in mountainous regions. Internationally, Regosols are similar to Entisols (USA), skeletal soil (Australia), Rohböden (Germany) and Sols peu évolués régosoliques d'érosion(France).

Left: Regosol is a shallow blanket-like soil - rock outcrops are often common; Below: Regosol profiles show thin surface horizons overlaying generally unstructured deposits; The map shows the location of areas in Europe where Regosols are the dominant soil type..

Cover 2 % of Europe.



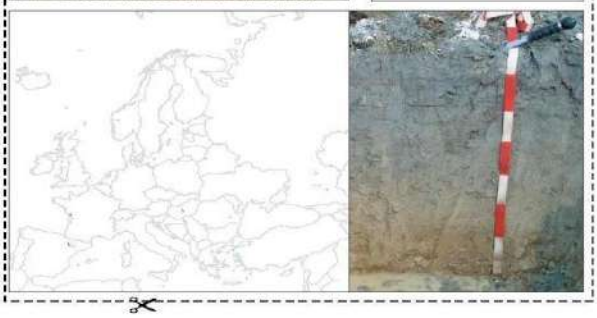
SOLONCHAKS

Strongly saline soil (from the Russian, *sol*, meaning salt and *chak*, meaning salty area).

Solonchaks are a strongly saline soil type with high concentration of soluble salts. They occur where saline groundwater comes near to the surface or where the evapo-transpiration is considerably higher than precipitation, at least during a large part of the year. Salts dissolved in the soil moisture remain behind after evaporation of the water and accumulate at or near the surface. Their morphology, characteristics and limitations to plant growth depend on the amount, depth and composition of the salts. Common international names for Solonchaks are saline soil and salt-affected soil.

Left: after evaporation of water salts accumulate at or near the surface of Solonchaks - note the surface salt crusts and crystals; Below: a Solonchak with shallow saline groundwater; The map shows the location of areas in Europe where Solonchaks are the dominant soil type.

Dominant in very small areas but can be very important locally.



32

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

The major soil types of Europe

SOLONETZ

Soil with subsurface horizon of clay accumulation and high sodium content (from the Russian, *sol*, meaning salt and *etz*, meaning strongly expressed).

Strongly alkaline soil with a subsurface horizon of clay minerals, strong columnar structure and high proportion of adsorbed sodium and/or magnesium ions. Solonetz are normally associated with flat lands in a climate with hot, dry summers or with former coastal deposits that contain a high proportion of salt. Solonetz soil occurs mainly in the Ukraine, Russia, Kazakhstan, Hungary, Bulgaria and Romania. Internationally, Solonetz are referred to as alkali soil and sodic soil, Sols sodiques à horizon B et Solonetz solodisés (France), Natrustalfs, Natrustolls, Natrixeralfs, Natrargids or Nadurargids (Soil Taxonomy).

Left: Typical landscape of Solonetz with salt crystals on the surface and salt tolerant vegetation;
Below: Columnar structure close to the surface of a Solonetz; The map shows the location of areas in Europe where Solonetz are the dominant soil type.

Cover 0.5 % of Europe.

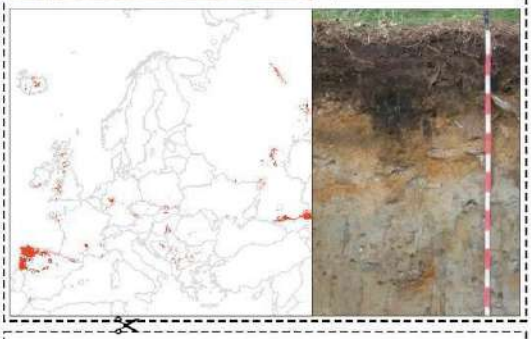
UMBRISOLS

Soil with dark, acid, surface horizon rich in organic matter (from the Latin, *umbra*, meaning shade).

Umbrisols generally develop in cool and humid climates, where precipitation considerably exceeds evapotranspiration. They are usually associated with acid parent materials. In other mapping systems, these soils are classified as Umbrepts and Humitropepts (Soil Taxonomy), Humic Cambisols and Umbric Regosols (FAO), Sombric Brunisols and Humic Regosols (France).

Left: Umbrisols generally develop under woodland;
Below: Umbrisols have dark organic matter rich surface horizons; The map shows the location of areas in Europe where Umbrisols are the dominant soil type.

Cover 2.5 % of Europe.



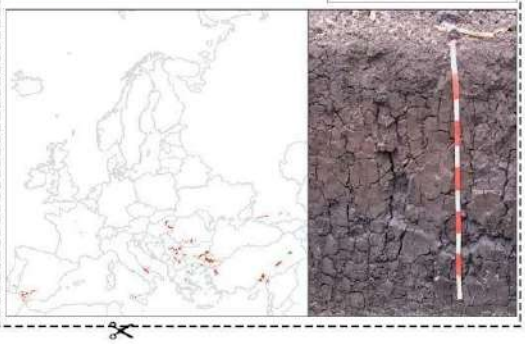
VERTISOLS

Seasonally cracking soil, rich in swelling clays (from the Latin, *vertere*, to turn).

Vertisols are rich in swelling clay minerals and occur primarily in level landscapes under climates with pronounced dry and wet seasons. Vertisols shrink and swell upon drying and wetting. Deep wide cracks form when the soil dries out and swelling in the wet season and creates polished and grooved ped surfaces (*slickensides*) or wedge-shaped or parallel-sided aggregates in the subsurface vertic horizon. The landscapes of a Vertisol may have a complex micro-topography of micro-knolls and micro-basins called "*gilgai*". Vertisols are also known as black cotton soil (USA), regur (India), vlei soil (South Africa) and margalites (Indonesia).

Far left: Vertisols open wide cracks in the dry season;
Left: Wedge-shaped aggregates and grooved ped surfaces called slickensides are common in Vertisols;
Below: a highly cracked Vertisol profile showing compaction of the surface horizons due to agricultural machinery; The map shows the location of areas in Europe where Vertisols are the dominant soil type.

Cover 0.5 % of Europe.



Reader's Tip!

This section of the Atlas has introduced you to the 23 major soil types of Europe[1].

The colour used in the box surrounding the soil group name is the same colour that is used for that soil type in all the maps in the next sections of the Atlas.

In this way, when you see a red area (i.e. an Andosol) on a map then you can refer to this section find the same colour to see the basic characteristics of the soil, what it generally looks like and the type of landscape associated with it.

The colours used in the maps of the Atlas are based on the soil maps produced by the UN Food and Agriculture Organization (FAO) with slight modifications to clarify certain issues.

1. In this exercise, the soils of Turkey and Russia as far as the Ural Mountains were included.

All photographs in this section were provided by (EM) unless otherwise stated.

33

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Annex 2 – The best European soil challenge

Criteria for Evaluation

Content Knowledge (20 points)

- Accuracy (10 points): The presentation contains accurate information about the selected soil type.
- Depth (10 points): The presentation demonstrates a deep understanding of the soil type's characteristics, usefulness, and distinctiveness.

Presentation Skills (20 points)

- Clarity (10 points): The presentation is clear and easy to understand.
- Engagement (10 points): The presenters engage the audience effectively, using appropriate language and maintaining their interest.

Use of Resources (20 points)

- Relevance (10 points): The resources used (e.g., online materials, images, data) are relevant and support the arguments presented.
- Quality (10 points): The resources are of high quality and credibility.

Persuasiveness (20 points)

- Argument Strength (10 points): The arguments presented are strong and well-supported.
- Convincing (10 points): The presentation is convincing and effectively persuades the audience that the selected soil type is the "best."

Creativity and Originality (20 points)

- Unique Insights (10 points): The presentation offers unique insights or perspectives on the soil type.
- Innovative Presentation (10 points): The presentation is creative and uses innovative methods to convey information (e.g., videos, interactive elements, storytelling).

Total Points: 100

Instructions for Students:

Ensure your presentation includes accurate information; is engaging, uses high-quality resources, presents strong arguments, and incorporates creative elements.

Practise your presentation to ensure clarity and engagement.

Instructions for Judges (Teachers or Peers):

Carefully review each presentation based on the criteria in the rubric.

Assign points for each criterion based on the performance of the presentation.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Add up the points for each criterion to get the total score for each presentation.

The presentation with the highest total score wins the "Best European Soil Challenge."

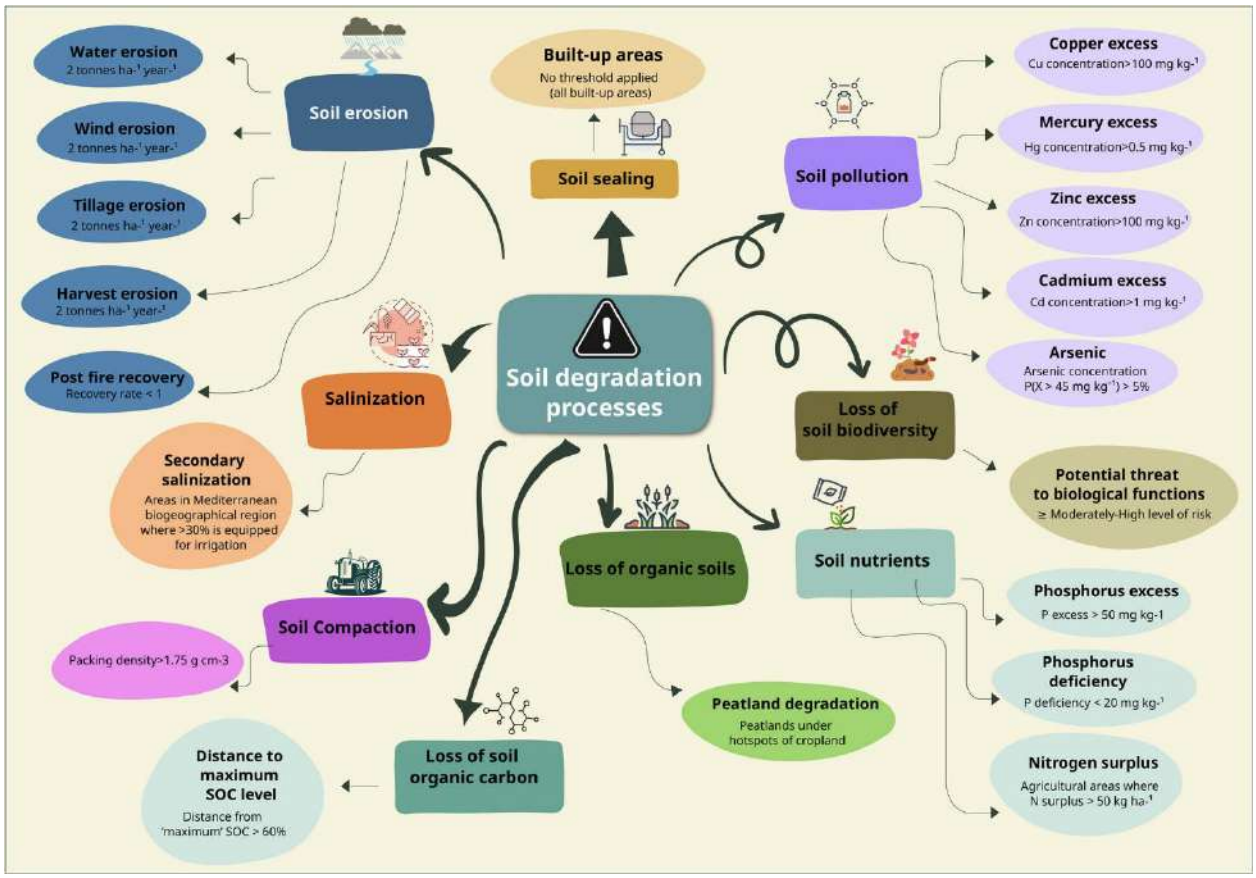
Customizable challenge participation certificate realised with Canva.

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Annex 3 – Soil degradation mind map

Retrieved from:
https://esdac.jrc.ec.europa.eu/public_path//shared_folder/dataset/102/Soil%20degradation%20process.jpg



Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Annex 4 – Instructions for the Water Balance App and The Global Forest Watch Activity

Instructions for the use of the Water Balance App

Group Formation

- Form groups of 4-5 students.

Select Locations and Parameters

- Open the Water Balance App.
- Select the locations of interest by clicking on the map or typing them into the search box in the top right-hand corner.
- Choose the parameter to be displayed from the following options: Soil Moisture, Snowpack, Precipitation, Evapotranspiration, Runoff, Change in Storage. You can select the parameter from the menu at the top left and display the relevant legend at the bottom left.

Observation and Analysis

- Observe the 'Trend Analyser' graph on the bottom right, which shows the monthly average of the chosen parameter over several years (2002-2024).
- To the left of the centre graph, consult the parameter list, which shows the values of all parameters in the selected month in mm.
- To the left of the parameter list, examine the water balance panel. Here, a horizontal black line shows the change in mm, compared to the average ('Normal'), of the water reserves ('Change in Storage').

Describe Alterations

- Describe the alterations you noted for each simulation.
- Discuss with your partners how these changes varied among the different sites.

Substantiate Explanations

- Incorporate graphs into your report to substantiate your explanations.
- You may either copy and paste graphs directly from the web application (screenshots) or export data by selecting the 'Download water balance data as CSV' option to create your own graphs.
- Jot down your observations, discussions, and graphs, they will help you for the final assignment (the essay).

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Stimulus questions for promoting observation and analysis skills for The Global Forest Watch Activity

Tree cover loss and gain

- What are the primary causes of tree cover loss in the areas you are observing? (Hint: Look for indicators like “fire” and “land cover”.)
- Are there any areas that show significant tree cover gain? What might be contributing to this positive trend?

Geometric shapes and patterns

- If you notice tree cover loss in large geometric shapes, what human activities might be responsible for these patterns? (Hint: Consider activities like logging, mining, or construction.)
- How do these geometric patterns of tree cover loss compare with natural patterns of tree cover change?

Minimal tree cover loss

- In areas with minimal tree cover loss, what protective measures or natural factors might be contributing to the preservation of the forest?
- How do these areas with minimal loss compare in terms of biodiversity and ecosystem health?

Analysis and data interpretation

- What trends do you observe in the "land cover" section? How do these trends relate to tree cover loss and gain?
- In the "forest change" section, what significant events or changes can you identify? How do these events impact the overall forest health?

Fires and climate

- How do the "fires" and "climate" sections provide context to the patterns of tree cover loss and gain?
- Can you identify any correlations between climate conditions (e.g., drought, temperature changes) and tree cover loss?

Impact on water balance and soil health

- How might the observed patterns of tree cover loss and gain affect the local water balance (answer this question using data you collected with the previous activity, the Water Balance Task)?
- What implications do these changes have for soil health and fertility in the area?

Future projections

- Based on the current trends, what might the future look like for these areas in terms of tree cover and forest health?
- What potential interventions or conservation strategies could help mitigate tree cover loss?

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Annex 5 – Instructions for the essay assignment

Access the Apps

- Open again both the Global Forest Watch App and the Water Balance App on your device.
- Use the search function to locate the same areas you investigated in the previous activities.

Gather Data and Observations

- Take 2-4 screenshots from each app that capture relevant information such as the area, graphs, and pictures. Ensure that these screenshots highlight key data points and patterns.
- Make detailed notes on your observations from each app, focusing on patterns of tree cover loss/gain and water balance indicators.

Compare Data

- Analyse the data and information gathered from both apps to identify similarities, connections, and discrepancies.
- Consider how the data from each app relates to soil health in the investigated locations.

Write the Essay

- Begin with an introduction that outlines the purpose of your essay and the locations you are comparing.
- In the body of the essay, present your observations and comparisons. Use the screenshots as visual aids to support your narrative.
- Discuss what the data from both apps tells us about the soil health in the investigated locations. Highlight any significant findings or patterns.
- Ensure that your essay is concise and well-organised, adhering to the 400-word limit.

Integrate Screenshots

- Insert the screenshots into your essay at appropriate points to illustrate your observations and findings.
- Label each screenshot clearly and provide a brief explanation of what it shows.

Reflect on the Data

- Discuss the implications of your findings for soil health and the environment.

Conclusion

- Summarise your main observations and the key insights gained from comparing the data from both apps.
- Offer any recommendations or further questions that arise from your analysis.

Review and Edit

- Review your essay for clarity, coherence, and adherence to the word limit.
- Ensure that your narrative flows logically and that your screenshots are well-integrated.
- Make any necessary edits to improve the overall quality of your essay. Use the ESDAC glossary of soil terms and an English Dictionary for any conceptual or linguistic doubt.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Annex 6 – Initial assessment

Pre-Test

The pre-test is designed to assess students' prior knowledge about soil health. It will be useful to test students' knowledge of the basic topic- specific terminology in English. It includes multiple-choice questions and short-answer questions.

Multiple-Choice Questions

1. What is soil erosion?

A) The process of soil formation
B) The removal of the top layer of soil by wind or water
C) The addition of nutrients to the soil
D) The compaction of soil particles

2. What is the main cause of soil erosion?

A) Wind
B) Water
C) Human Activities
D) All of the above

3. Which soil type is best for plant growth?

A) Sandy Soil
B) Clayey Soil
C) Loamy Soil
D) Peaty Soil

4. What is the primary role of organic matter in soil?

A) To increase soil acidity
B) To provide nutrients and improve soil structure
C) To reduce water retention
D) To promote soil erosion

5. Which of the following practices can help prevent soil erosion?

A) Deforestation
B) Crop rotation
C) Overgrazing
D) Urbanization

6. Which soil type is known for its high-water retention capacity?

A) Sandy Soil
B) Clayey Soil

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

C) Loamy Soil
D) Silt Soil

7. Which of the following is NOT a property of soil?

A) Texture
B) pH
C) Colour
D) Moisture Content

Answers: 1: B; 2: D; 3: C; 4: B; 5: B; 6: B; 7: B

Short-Answer Questions

What is soil sustainability (1-2 lines)?

Name two land management practices that can lead to soil erosion.

Survey

The survey is aimed at understanding students' attitudes and misconceptions about soil health. It includes both closed-ended and open-ended questions and can be administered online or offline before or during the 1st Lesson.

Closed-Ended Questions

How important do you think soil health is for environmental sustainability?

A) Very Important
B) Somewhat Important
C) Not Very Important
D) Not Important at All

Do you believe that climate change can affect soil erosion rates?

A) Yes
B) No
C) Unsure

Open-Ended Questions

What do you think are the main factors contributing to soil erosion?

How do you think soil health can be improved?

Open-Ended Discussion

The open-ended discussion can be conducted online on a debate platform (such as Kialo) to allow students to share their thoughts and ideas about soil health. It helps in identifying any misconceptions and gauging students' interest in the topic.

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Discussion Prompts

- What comes to mind when you think about soil health?
- Have you ever observed soil erosion in your local area? If yes, describe the situation.
- What do you think are the consequences of poor soil health?
- How do you think farmers can contribute to soil sustainability?

Annex 7 – Final assessment

Instructions for students:
Synthesise what you have learned throughout this module and organise your thoughts before you begin designing your presentation. Much of the information you need can be found in your notes, readings, and previous assignments. Feel free to incorporate material you have written for other units into your presentation. Remember to cite all sources in your final assignment.

Materials Needed:

- Presentation software (e.g., PowerPoint, Google Slides)
- Access to the internet for research
- Any additional materials or data collected throughout the lesson activities

Students will conduct further research on a specific aspect of soil health that interests them (e.g., a case study of soil degradation in a particular region, the impact of climate change on soil health, innovative soil conservation techniques). They will compile their findings, including data, images, and references. The presentation must include:

- An introduction to soil health and its importance
- A detailed exploration of their chosen topic
- Analysis of data and information gathered
- Conclusions and recommendations for soil conservation

The following evaluation criteria will be applied:

- Understanding of soil health concepts (scores from 0 to 2)
- Quality and relevance of research (scores from 0 to 2)
- Clarity and organisation of the presentation (scores from 0 to 2)
- Ability to analyse and interpret data (scores from 0 to 2)
- Engagement and participation in the presentation and discussion (scores from 0 to 2)

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Annex 8 – Student feedback

1. Understanding of Concepts

- What were the key concepts about soil health that you learned during this lesson?
- How well do you feel you understand the differences between sandy and clay soils?

2. Engagement and Participation

- Did you feel engaged during the activities? Why or why not?
- Which part of the lesson did you find most interesting or enjoyable?

3. Application of Knowledge

- How do you think the knowledge gained from this lesson can be applied in real-life situations?
- Can you think of any ways to improve soil health in your local community based on what you learned?

4. Feedback on Activities

- How effective were the hands-on activities (like the plant growth experiment) in helping you understand soil properties?
- Were there any activities that you found confusing or difficult to follow?

5. Suggestions for Improvement

- What suggestions do you have for improving this lesson in the future?
- Are there any additional topics related to soil health that you would like to explore further?

Overall Experience

- On a scale of 1 to 5, how would you rate your overall experience in this lesson? Please explain your rating.
- What is one takeaway from this lesson that you will remember?

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Annex 9 – Teacher feedback

Instructions for Use

- **Self-Assessment**: Teachers rate themselves on a scale of 1 to 5 for each criterion, with 1 being "poor" and 5 being "excellent
- **Comments/Observations**: Teachers can jot down specific observations or experiences related to each criterion.
- **Action Steps for Improvement**: Based on their self-assessment and comments, teachers can outline specific steps they will take to enhance their teaching practices in future lessons.

Reflection criteria	Self-assessment (1-5)	Comments/observations	Actions steps for improvement
Clarity of Instruction			
Effectiveness of formative assessment techniques			
Use of technology (Apps) and resources			
Ability to facilitate group works			
Responsiveness to students needs			
Encouragement of critical thinking			
Reflection on student feedback			
Overall lessons effectiveness			

Funded by the European Union
Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Annex 10 – Photos from implementation

Figure 1 Students experience the Global Forest Watch App

Figure 2 Students working on the Apps using their laptops

Funded by the European Union

Funded by the European Union under Grant Agreement 101112707. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.