Green Foundation Ireland

Educational Module for Transition Year Students

Soils and Soil Stewardship

Lesson Plan

March 2022

TABLE OF CONTENTS

PAGES

INTRODUCTION

Value of educating transition year students on soils

Soil is a complex, living ecosystem which, when properly cared for, has innumerable benefits, has enormous potential to avoid climate crisis, and on which all terrestrial life depends, via the food chain, for continued survival.

The importance of soil stewardship cannot be overstated: a 2014 study estimated that farm soils in the UK may only have 100 harvests remaining, after which soils would be unfit to produce food, due to nutrient removal. In order to avoid crises of scarcity, and encourage sustainable living, a generation of students not only with an understanding of the importance of soil, but also knowledge on soil stewardship, and an active interest in soil remediation, is essential. As explored in this module, soils, when managed and functioning properly, perform a range of essential ecosystem services, such as food provision, carbon storage and flood prevention and, as such, informed, empowered students will be critical in maintaining sustainable lifestyles in the future.

In the completion of this module, other important sustainability concepts will be reinforced, such as importance of biodiversity, waste management, climate conscience, and other topics.

Learning outcomes

Through completion of this module, students will develop their knowledge on the following topics:

1. Understand soil structure, formation and soil types.
2. Appreciate the value of soils, and their ecosystem services.
3. Understand the value of soil biodiversity.
4. Identify threats to soil sustainability and biodiversity.
5. Become familiar with soil stewardship practices.
6. Understand in detail the risk of soil erosion.
7. Understand in detail the role of soil in carbon storage.
8. Understand in detail the effects of fertiliser and pesticide use.
9. Develop an appreciation for the local soils and biodiversity of their area.
10. Develop communication and teamwork via delivery of a project.

Transition Year (TY) is intended to be a period wherein students develop a range of skills, including critical thinking, observational, opinion forming, research, communication, and others. As such, the delivery of this module is designed to encourage these skills through a mixture of class discussion, practical experiments, and research project delivery.

Module structure

The following module is intended as a resource for teachers for delivery to transition year students on a weekly basis. Experiments throughout the module are often performed in one class, with results being explored in another class, creating a continuity between sessions.

To allow for flexibility within delivery, six lesson plan outlines are provided, each featuring **core information**, as well as **extra information**, should material need to be extended or contracted to fit lesson time. Core versus extra information is clearly labelled within each lesson plan, with extra information being *italicised and underlined*, meaning this information can be omitted or included depending on time available.

The last two weeks of the module are an optional research project for students, developing and presenting their own presentation individually or in groups, based on a topic of their choice and their own research. This project is designed to encourage teamwork, research skills, and presentation skills. This project will require students to have some access to a projector in class, as well as computer access to create a PowerPoint presentation or similar.

PRE-SESSION 1

A number of weeks before the module begins, collect two identical flat trays, two to three inches deep, made of plastic or metal. Place the same quantity of soil into each tray. Then, place grass seed into one tray, and leave the other tray unseeded. Over the intervening weeks, lightly water the seeded tray to ensure grass grows healthily.

SESSION 1: Soil composition, formation

Class question: What are soils made of?

- 5 constituent parts (mineral matter, air, water, organisms, humus).

Demonstration: How soils form.

- Weathering of bedrock, creation of mineral matter component.
- Infiltration of microorganisms, generation of organic matter.
- Decay and generation of humus.

Demonstration: Main soil types in Ireland.

- *What is the main soil type in your school's area?*

Class question: How does soil type impact human activity in an area? Raising points of:

- Local flora and fauna.
  - *How do flora and fauna in an area impact human activity?*
- Crops and agricultural practices.
  - Impact on food culture and economy.
  - ***Class question:*** *Do you typically eat local foods?*

Experiment: Identifying soil types.

You will need:

- Several sealable glass jars with all packaging removed (between 3 and 5).
- Soil samples from different locations (same number as jars).

If possible, collect soil samples in glass jars prior to the class. The more diverse locations, the better. For example, lawn soil, soil from a near a river or beach, soil from a forest. If necessary, and time allows, soil samples can be collected by student groups from nearby locations during the class. Place the soil samples into the jars, filling to approximately two-thirds full.

- **Class question:** Compare how dark the soils are. Darker soils have more organic matter. Can you explain why the darker soils have more humus, based on their location?

Label the jars with the location these soils came from. Then, fill the jars almost to the brim with water, and shake the jars containing soil and water as vigorously as possible for a minute, until the soil is completely suspended in water.

Place the jars somewhere they will not be disturbed. They will be examined in the next session.

SESSION 2: Value of soils and ecosystem services

Experiment: Identifying soil types (continued).

Without disturbing the jars from the previous week too much, examine how the soil has settled within the jars. You should observe that the larger particles of sand have formed a layer on the bottom, silt, the next heaviest component, will form a layer above this. Clay, the lightest and finest particles, will form a layer above that. The layers should be visibly different. Ignore the water above and anything suspended in it.

Mark using a permanent marker the divisions between the layers. Do the different soil samples have different proportions of these layers? Using the ratios of the depth of each soil layer, of the total settled material, what percentage of sand, silt and clay make up the soil from each location?

Using a soil texture triangle, classify each of the soil types.

Class question: What direct value to humans do soils provide? Raising points of:

- Provision of food.
    - *Impact of global events on food supply, importance of food sovereignty*.
- Provision of building materials, biomass.
- Cultural value (gardening).

Demonstration: The definition of an "ecosystem service".

- *Discuss examples of non-soil ecosystem services (pollination, etc)*.
- *Discuss the four categories of ecosystem services*.

Class question: What ecosystem services do you think that soils provide? Raising points of:

- Role of healthy soil in sustaining animal and plant biodiversity.
    - *Biodiversity loss: Has soil degradation had an influence? Can you give an example?*
    - *Case study: Bees are reliant on plant biodiversity, therefore human treatment of soils*.
- Role of soil in breakdown of organic matter.
    - *Returning of organic matter to the ecosystem*.
- Role of soil in carbon storage.
- Role of soil in protecting against flooding.
    - *Increased importance of flooding resistance with climate change*.
- Role of soil in water filtration.

***Class question:** Can you name one of each of the first three types of ecosystem service that is provided by soils?*

SESSION 3: Soil biodiversity

Class discussion: Roles that animals play in the soil functions discussed? Raising points of:

- Nutrient cycling.
- Bioturbation.
- Rhizobia that fix nitrogen.

Experiment: Biodiversity examination using a Berlese trap.

- Access to local green site.
- Plastic bottles.
- Light microscopes.
- Metallic mesh (steel wool or any sort of wire gauze can be used).
- Multiple lamps.

If one is accessible, the class can engage with a walk to a local green site, noting the diversity of plants growing on the way. Once the green site is reached, soil cores should be collected, for an investigation into the microorganisms present in the soil.

Soil cores can be collected by pressing any round hollow surface into the soil surface, such as a pipe. Alternatively, soil cores can be collected simply by cutting into the soil surface with any sharp object.

When collecting soil cores, pay attention to the number of worms seen within the soil. Healthy soils are associated with a higher density of worms.

If possible, collect soil cores from different areas or soil types, so that the class can compare the biodiversity of different soils. This can be done either by collecting from different soils along the path to the local green site, or by getting several students to bring soil cores from their home gardens. However, if possible, minimise the time that the soil core is collected before the experiment.

Remove the lids and cut the bottoms from plastic bottles, and then invert them, creating a downward funnel. Place the metallic mesh or gauze into the funnel, to stop large pieces of soil from falling through the funnel. Place the soil samples onto the metallic mesh. Place each funnel containing a soil core beneath a heated lamp bulb and a collection dish beneath the bottom of the funnel.

Demonstration: Over time, heat from the lamp causes organisms to move deeper into the soil core, and fall through the mesh into the collection plate below.

In the following session, we will examine the microorganisms that are captured in the trap.

SESSION 4: Threats to soils

Experiment: Soil biodiversity (continued).

Examine, using a light microscope, the microorganisms present in the collection plates beneath the Berlese trap from the previous session. Take a few minutes to count the number of different species that can be identified. Return the animals to the site at which they were found.

Class question: Which soil cores had the most diversity?

- What areas were these soil cores from?
- If we know those areas, can we think of any reasons why those areas might have lower soil biodiversity?

Class question: What results of human activities can damage soils? Raising points of:

- Monoculture (why does monoculture occur?, how does it damage soils?).
- Soil compaction (what causes this?, what impact does it have?).
- Vegetation removal (subsequent drying/erosion).
- Sealing (what causes sealing?, what does it do to soils?).
- Fertilisers and pesticide use (why are these used?, how do they impact soils long-term?).

Class question: What activities can lead to soil erosion? Raising points of:

- Tilling of soil.
- Deforestation.
    - *Land-use and farming practices leading to deforestation*.
- Overgrazing.
- Removal of topsoil for construction, etc.

Demonstration: Effects of soil erosion:

- Infertility.
- Carbon emission.
- Entry of soil to water bodies.
    - *Subsequent risk of eutrophication*.

Experiment: **Soil erosion, requiring:**

- Two flat trays from pre-session 1: one seeded and one unseeded.
- Watering can or other water vessel.
- Slanted surface.
- Two buckets.

Demonstrate to the class the two trays from pre-session 1. Ideally, the seeded tray will have thick, one-to-two inch long grass on top of the soil. Emphasise to the students that these trays contain soil from the same source, and that the only difference between the two is that one was seeded with grass seed.

Place the two trays on an inclined surface of approximately 45 degrees. Beneath the lower end of each tray, place a bucket.

Slowly, using the watering can, simulate rainfall onto the two trays for the same amount of time. Then, demonstrate to the students the water collected in the bucket from each tray. The water running off the unseeded tray should visibly contain a lot more soil. This demonstrates the importance of vegetation in protecting soil from erosion.

Class question: How does vegetation protect soil from erosion? Raising points of:

- The root system of vegetation creates structure, anchoring soil particles.
- Vegetation absorbs the impact energy of rainfall, reducing the erosion power.
- Vegetation slows rainwater moving across the soil, causing it to drop suspended soil particles.

SESSION 5: Soil stewardship

This session will familiarise students with gardening practices they can partake in that benefit soils. This learning can be reinforced if a teacher has access to a community or school garden, in which one or more of these activities can be engaged with, or demonstrated in a practical setting. In the absence of such a site, demonstrations of gardening practices using internet resources is another method.

Class question: What are some ways to make a garden climate friendly? Raising points of:

- Reducing the use of fertilisers and pesticides reduces their impact on soils and microorganisms.
- Planting native grass species in lawns.
- Reducing the intensity and frequency of grass cutting, which encourages biodiversity.
- Replacing lawns with more biodiverse cover, such as mixed cover crops or wildflowers.
- Planting native flowers/plants, encouraging native animal species.
- Replacing fences with hedges.
- Using a water butt to capture water for plants, rather than using mains water.
- Composting.
- Soils can also be used to create vertical walls, such as the Bosco Verticale in Milan, and green roofs.
- Planting red clover and legumes is a natural way to enhance soil fertility and biodiversity.

Demonstration: Composting.

- Composting is a sustainable way to add humus to soils.
- As well as being good for soils, composting also reduces food waste, reducing landfill.
- Compost should not just include food and plant matter or "green materials".
    - Compost should also include a mixture of "brown materials", including shredded cardboard or paper, sawdust, straw or wood chips.
    - Best compost is made by layering brown, green, brown, green…

Demonstration: Buying organic food, or food that is farmed using sustainable methods, is another way to promote soil health.

Demonstration: Gardening projects that encourage soil health, climate consciousness, and biodiversity.

- Benjes hedge.
- Jerusalem artichokes.
- Worm composter.
- Hügel bed.

SESSION 6: Carbon sequestration, pesticides and fertilisers

Demonstration: Explanation of carbon sequestration.

- The potential for soil carbon sequestration to combat climate change.

Class question: What are some negative impacts of chemical pesticide use? Raising points of:

- Killing of non-target animals essential to soil function.
- Movement of pesticides to rivers or lakes with rain can be toxic to aquatic life.
- Altering microbial communities (which can interfere with nitrogen fixing and other essential soil processes).
- Bioaccumulation.
- Exposure to pesticides can cause health issues to humans and pets.

Class question: What are some ways to reduce pesticide use? Raising points of:

- Use physical barriers, such as a fine net, to protect vegetables from insects.
- Companion planting.
- Biological control.
    - **Class question:** *Are pesticides used frequently in your home garden*?

Class question: What are some negative impacts of chemical fertiliser use? Raising points of:

- Increased risk of eutrophication.
- Can alter pH of soil.
- Can cause chemical scorch to plant tissues.

Class question: What are some ways to reduce fertiliser use? Raising points of:

- Planting native species, which are better adapted to our climate.
- Composting, using natural fertilisers.
    - **Class question:** *Are fertilisers used frequently in your home garden?*

OPTIONAL SESSION 7: Project/presentation week 1

A teacher may wish to encourage students in groups to complete a project on the topics explored within this module, in order to encourage self-directed learning, as well as research, teamwork and presentation skills.

The teacher can assign groups, or allow students to select their own groups.

To this end, the following are suggestions of headings for projects, under which students can create and deliver a slideshow presentation on a specific topic of their choice. The following are examples of project headings, although a teacher may choose to pick their own theme, choose a mixture of the below themes, or allow students to decide on and research any theme relating to soils of their choice.

Examples:

- **Poor stewardship** – A project detailing the causes, effect, fallout of examples of lack of soil stewardship leading to negative outcomes. **Examples:** Acidification, compaction, eutrophication, etc. Students may also wish to explore specific soil-related crises case studies in history. **Examples:** American Dust Bowl, Nigerian Gully Crisis, Desertification in Sahel region, etc. Due to the complexity of these specific crises, this may necessitate larger project groups.
- **Soil organisms** – A project detailing the life cycle, ecology, and role in soil function of a selected organism within the soil from Ireland, or the wider world. **Examples:** Earthworms, woodlice, ants, etc. A teacher may choose to limit species explored here to Irish examples, or encourage students to examine species from any location. **Examples:** Moles, termites, dung beetles, etc.
- **Soil and culture** – A project detailing how the soil type in a specific region or country impacts the culture, farming practices, and economy of that country or region.
- **Sustainable farming practices** – A project detailing the rationale for, implementation of, and positive outcomes of, a sustainable farming practice.
- **Ecosystem services** – A project detailing an ecosystem service that soils provide, as well as how different soil types perform at that ecosystem service **Examples:** Flooding prevention, water filtration, etc.

The purpose of this session should be for students to decide on, and create an outline for, their presentation, and should discuss this within their groups.

If the class has access to a computer room, this may aid groups in picking their topic.

By the end of this session, groups should be able to give a **short summary** (4 or 5 sentences) of their chosen topic, discuss **two subheadings** of that topic that they will examine, and detail to the teacher what the responsibilities of each group member will be.

OPTIONAL SESSION 8: Project/presentation week 2

Groups should be allotted equal time to present on their topic (between 5 and 10 minutes, depending on the number of groups, and other time constraints).

Students should be encouraged to ask questions of the presenting group about their topic, and to give feedback on presentations, including both aspects of the presentation that they liked, as well as aspects of the presentation they would like to know more about.

About Green Foundation Ireland

Green Foundation Ireland aims, through education, to inspire the public to work towards a sustainable society for Ireland.

Green Foundation Ireland (GFI) is an independent registered charity which promotes education for sustainability in Ireland. It is affiliated to the Green European Foundation (GEF).

GFI aims, through education, to create public support for a sustainable society and economy in Ireland and elsewhere. We aim to engage with both the arts and sciences to create a new environmental narrative that promotes action to conserve and protect life on earth.

For more information about what Green Foundation Ireland does, or if you would like to contribute to our work in any way, please contact us at:

email: **info@greenfoundationireland.ie**
web: **www.greenfoundationireland.ie**

GREEN FOUNDATION IRELAND