SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Ecosystem Explorers	Grade 9 Science - Biology: Sustainable Ecosystems and Climate Change (SNC1W)

Lesson Plan

Learning Outcomes

Students will participate in hands-on ecosystem monitoring activities to investigate different environmental factors that impact ecosystem sustainability and communities.

Students will actively engage in data collection and analysis to foster a deeper understanding of the impacts of climate change and various human activities on ecosystem sustainability.

Specific Expectations

B1.1 assess impacts of climate change on the sustainability of local and global ecosystems, describe local or global initiatives for combatting climate change, and identify solutions to address some of the impacts

B2.4 investigate factors and processes, including biodiversity, air and water quality, soil health, and succession, and explain how they contribute to ecosystem sustainability

B2.5 explain the effects of various human activities on the dynamic equilibrium of ecosystems

B2.6 identify and use various indicators of climate change to describe the impacts of climate change on local and global ecosystems, and analyse how human activities contribute to climate change

Description

Students will look at essential components of a sustainable ecosystem and examine the impacts of climate change and various human activities on those important ecosystem components. Students will get the opportunity to rotate through different ecosystem monitoring stations and perform hands-on testing procedures to analyze collected samples of water and soil, neutralize acidic soil samples, and conduct biodiversity transect surveys to gather information about the environmental health of an area.

Materials

- Soil samples (collected from sports field, garden, forested area, near parking lot or other infrastructure, near water source, etc.)
- Water samples (from tap water, bottled water, sparkling water, river water, lake water, pond water, etc.)
- Vinegar 5%: 14.3g per jar
- Baking soda: 2g per jar
- pH indicator solution
- pH test strips (or pH meter)
- Water testing kits (measure parameters like pH and various nutrient levels)
- Test tubes

- Pipettes or droppers
- Paper cups or small containers
- Paper coffee filters
- Metre sticks
- Rulers, wire coat hangers, or string or rope for quadrats

Introduction

In the natural world, organisms in sustainable and healthy ecosystems are all interconnected with each other and the environment, and in a state of dynamic equilibrium. Dynamic equilibrium is a state of balance in an ecological system between the biotic (living) and abiotic (non-living) elements. In this state of equilibrium, ecosystems can maintain stability even when they face ever-changing environmental conditions. Since all organisms in an ecosystem are interconnected, when one component of an ecosystem faces an environmental challenge or impact, the other components are impacted as well, whether directly or indirectly. For example, when forested areas face deforestation and the removal of trees, plants, and other vegetation, this not only has a significant impact on the habitats and wildlife living in that forest but also changes the soil ecology and affects the water balance of the forested ecosystem.

Biotic and abiotic elements all contribute to ecosystem sustainability and healthy levels of each are needed to maintain a stable dynamic equilibrium. One of the biggest threats to ecosystem sustainability is climate change. Climate change has an impact on ecosystems and the organisms within them in many ways. Climate change has major impacts on living things and the biodiversity on Earth, such as plants and wildlife, but it also has significant effects on the non-living things that determine the type of life that lives in the ecosystem, such as the soil, water, temperature, and air. As a result, strong ecosystems, biodiversity, and healthy soil and water quality all help contribute to sustainable ecosystems. This lesson will examine some of the impacts that these essential components of ecosystems face due to climate change and various human activities.

How does climate change affect the soil?

Changes in temperature and precipitation because of climate change have impacts on many soil properties and can lead to soil erosion, declines in soil organic carbon, changes in nutrient levels, and changes in acidity or alkalinity. One major impact of climate change on soil is changes to the acidity or alkalinity (pH) of soil. Soil pH influences soil bacteria, nutrient availability, toxic chemicals, soil structure, and plant growth. All plants have ranges of pH that they find suitable to grow, and if the pH changes beyond that range, some plants will not be able to adapt. For example, if the soil in an ecosystem becomes too acidic or too basic, this will change how well a certain plant can grow.

On the pH scale, 7 is neutral – anything below 7 is acidic and anything above 7 is alkaline (basic). Most plants will thrive in a pH range from 6 to 7.5. Most vegetables and lawn grasses prefer a pH of 6.5 (a little on the acidic side).

Healthy soil is important in maintaining a sustainable ecosystem because soil can sequester carbon and help reverse the effects of climate change. Soil can also better absorb and retain water to create resilience to drought and extreme weather events, increase soil fertility, support greater biodiversity, and ensure the stability of an ecosystem's dynamic equilibrium.

How does climate change affect water?
Water quality in lakes, rivers, or ponds is affected by many different factors, such as the water chemistry, contaminants and nutrients added by human activities, and substances that runoff into water from neighbouring watersheds and terrestrial areas.

Temperature is also a key driver of water quality for lakes and freshwater. Changes in temperature because of climate change have a big impact on the water chemistry because temperature determines which chemical reactions can take place and affects certain properties of the water, such as algal growth, increased nutrient levels, and pH levels. pH is an important measure of water quality because varying pH levels can affect the organisms living in water and change the behaviour of water chemistry. Pollution from human activities can significantly change water's pH, which in turn can harm the animals and plants living in the water.

The pH range of lakes and rivers usually falls between 6 (slightly acidic) and 9 (slightly basic), but the optimum pH level is 7.4. Water below a pH of 5 may result in stunted, reduced, or even absent fish populations. Algae blooms occur when the pH is between 8.2 and 8.7, and all fish die above a pH of 10.

Maximum acceptable concentrations or levels of other water elements/qualities:

Nitrate	Nitrite	Phosphate	Chlorine	Hardness
Less than 4 parts per million (ppm)	0-0.5 ppm (should be as low as possible)	Less than 0.03 ppm	Less than 0.01 ppm	70-140 ppm

How does climate change affect biodiversity?
Biodiversity is the variety of all living things found on Earth, from bacteria and plants to animals and humans. Life depends on biodiversity. In a healthy and biodiverse ecosystem, every organism has a role, no matter how small, and all these organisms are connected and working together to help their environment thrive. Climate change is causing temperatures to increase and the Earth to heat up, which has an impact on natural habitats and ecosystems. Because of these changes, many species are being forced to find new habitats, but some of the animal or plant species that are not able to relocate to new areas will struggle with these changes and may even become endangered.

Humans also affect biodiversity in many ways, such as by destroying natural habitats like forests, converting diverse ecosystems into monocultures of just one plant or one crop species, extracting fossil fuels, overconsuming Earth's natural resources, polluting the environment, and more. With biodiversity loss, nature loses its ability to manage greenhouse gases and to protect or restore itself against climate impacts like flooding, wildfires, and droughts, which then accelerates climate change. Biodiversity is an essential component of ecosystem sustainability and is needed to maintain equilibrium.

Action

Monitoring Station 1: Soil Sampling

Students will test the pH of various soil samples from around the schoolyard or local natural areas to determine the soil's acidity, and which soil samples are better suited to support plant vegetation.

1. *For the teacher:* Prepare soil samples ahead of time or have students collect soil samples from different locations around the schoolyard (sports field, garden, forested area, near parking lot or other infrastructure, near water source, etc.). Be sure to remove any grass, stones, or other large debris from the soil sample.
2. Using one of the soil samples collected (ex. soil from the garden), add less than a handful of the collected soil sample to a small container or test tube.
3. Add distilled water to the soil sample in the test tube until the soil is completely covered with water.
4. Mix the soil sample and water using a stir stick or another instrument. Let the soil and water mixture sit for roughly 5 minutes.
5. After 5 minutes, filter the soil from the water using a paper coffee filter. To do this, place a paper coffee filter over a small container and pour the sample of the soil and water mixture into the small container, passing through the filter.
6. After the solution has been filtered, test the pH of the soil sample by dipping the end of a pH test strip into the soil and water solution. Leave the end of the strip in the solution for 5 minutes to get an accurate pH reading.
7. After 5 minutes, remove the test strip from the solution and examine the colour. Compare the colour of the test strip to the pH colour chart to determine the pH of the soil sample. Record the pH level of the collected soil in the activity worksheet.
8. Repeat this same procedure for the other collected soil samples and record their pH levels in the worksheet as well until all soil samples are tested.
9. Answer the discussion questions from the activity worksheet.

Monitoring Station 2: Soil Restoration

Students will neutralize acidic soil samples and discuss how once degraded land can be restored to support healthy soil and plant life.

1. *For the teacher:* Provide students with already prepared acidic soil samples in paper cups or small containers (containing Vinegar 5%, 14.3 grams per jar). Also, in a separate container, prepare the correct amount of baking soda (2 grams per jar).
2. Half-fill a test tube with distilled water and add soil from the prepared acidic soil sample. Mix the water and soil well, and then add a few drops of the pH indicator to observe a colour change.
3. Now, we aim to neutralize the soil sample. To do so, add the prepared amount of baking soda (a base) to the original acidic soil sample. Mix the baking soda well into the soil sample to initiate a reaction between the vinegar and baking soda.
4. Once the reaction subsides, repeat the pH test to assess the neutralization. To do this, use a fresh test tube half filled with distilled water and add the neutralized soil into the test tube. Mix the samples well and then add a few more drops of the pH indicator into the test tube. As the soil is expected to be neutral, we anticipate minimal colour change.
5. After both pH tests, students should end up with a test tube indicating acidic soil (purple/blue), one representing neutralized soil (yellow/green), and their neutralized soil sample which is now ready for potential plant growth.

6. Answer the discussion questions from the activity worksheet.

Monitoring Station 3: Water Quality Testing

Students will test different water samples and analyze them to assess the health of the ecosystem and identify any pollution or contamination exacerbated by climate change or human activities.

1. *For the teacher:* Ahead of the activity, collect water samples from various sources including tap water, bottled water, sparkling water, river water, lake water, pond water, etc., and have each water source in its own labelled container. Provide students with labelled samples of each collected water source in separate containers or have students come to collect their samples from the labelled containers.
2. Pour each water sample into separate test tubes and label each sample indicating its source (ex. tap water). Then, test each water sample for the following parameters (depending on testing materials/kits available) and record the results in the activity worksheet:
    a. pH: using test strips or pH meter. Record the colour of the test strip or read the pH value from the meter and record the results.
    b. Any of the following: nitrite, nitrate, phosphate, chlorine, carbonate levels, or total hardness: observe the colour on the test strip and record the results.
3. Repeat the above procedure for the other collected water samples until all samples are tested and record the results in the activity worksheet.
4. Answer the discussion questions from the activity worksheet.

Monitoring Station 4: Biodiversity Survey

Students will perform field work using transect surveys and quadrats to measure and record the biodiversity of a local ecosystem and investigate how human-made landscapes can affect ecosystem health.

1. *For the teacher:* Take the students outside to a greenspace located on the school grounds (this activity is best performed in the early fall or spring to observe the best results). Have students work in groups of 3 or 4. Each group will need a metre stick and a quadrat. A quadrat can be made by either taping four rulers together to create a square, bending a wire coat hanger to create a square, or tying a piece of string or rope into a circle.
2. Find a natural area on school grounds that is near a non-natural or paved area (sidewalk, parking lot, gravel, etc.).
3. Place the metre stick at the edge of the non-natural/paved surface, so that the stick is lying perpendicular to it and extending into a natural (grassy) area.
4. Place the quadrat adjacent to the metre stick. To start, have the quadrat at the beginning of the metre stick, so it is also adjacent to the paved surface. The area inside the quadrat is the observation area.
5. Observe the variety of species found within the quadrat area by looking at the following and record the results in the activity worksheet:
    a. Plants: Count the number of plants found fully inside the quadrat as well as the plants that are 50% within the quadrat. To determine how many different plants there are look at the shape of the leaves, any fruit, flowers, or seeds on the plant.
    b. Invertebrates: Count the number of invertebrates (centipedes, spiders, worms, etc.) found inside the quadrat.

c. Vertebrates: Look for signs of vertebrate activity within the quadrat, including animal tracks, animal bites on plants, scat or pellets, fur, feathers, or nests.
d. Other: Look for abiotic elements present within the quadrat area such as rocks and signs of human activity (garbage, concrete, etc.)

6. Once all the elements in the quadrat have been observed and recorded, move the quadrat 40 centimetres down the metre stick to a new location. Repeat step 5 for this new location and record the observations in the worksheet.
7. Continue to move the quadrat 40 centimetres down the metre stick until it reaches the end of the stick. Record all observations in the worksheet.
8. Once the quadrat has reached the end of the metre stick, find a new natural area that is distant from any non-natural or paved area. Repeat step 5 for this new location and record the observations in the worksheet.
9. Answer the discussion questions from the activity worksheet.

Consolidation/Extension

To build on the Soil Sampling and Water Quality Testing stations, students can also analyze samples of collected soil and water under microscopes to investigate microbial ecosystems from various environments. Students can use microscopes to identify microorganisms in soil and water samples and explore their roles in nutrient cycling, decomposition, and overall ecosystem health. Discuss the importance of the critical roles of microbes in maintaining ecological balance.

Other Monitoring Station Options:

Carbon Sequestration

Students can further explore topics like photosynthesis and cellular respiration, and how plants store carbon dioxide by performing an activity related to carbon sequestration. This monitoring station looks at how increased levels of carbon dioxide can affect plant growth and how plants function as a natural carbon sink, sequestering carbon from the atmosphere through photosynthesis.
Discuss the importance of preserving and restoring natural carbon sinks like forests, wetlands, and peatlands for climate change mitigation.

Action: Students will measure carbon dioxide uptake by plants through photosynthesis.

1. Students should work in groups of 2 or 3 at this station. Provide each group with a small potted plant, a plastic cup or container, and soil.
2. Instruct each group to fill their plastic cup or container with soil and plant the potted plant in the soil.
3. Have the students tightly seal their cup or container with plastic wrap or a plastic bag, sealing it around the edges leaving no gaps for air exchange and simulating a closed system.
4. In a separate container, have the students prepare a carbon dioxide source by mixing baking soda and vinegar to generate carbon dioxide gas.
5. When the students are ready, unseal the cup with the plant and add a small amount of carbon dioxide gas into the closed system around the plant. Immediately seal the container again after adding the carbon dioxide gas.

6. Have students leave the sealed cup undisturbed for 30 minutes to one hour (or even longer if possible). Place the cups in a well-lit area or an area with access to natural light.
7. After the allotted time, remove the plastic wrap or bag from the cup and observe any changes in the plant.
8. Encourage students to record their observations and any changes in the plant, such as increased growth or colour changes.

Plant Identification

Have students identify local plants found on the school grounds using identification applications such as Seek, PlantNet, or PlantSnap. Once students have identified a plant species, have them read about the species information, including where it's usually found, if it is native or non-native to Canada and its preferred growing conditions. Discuss native species of plants versus non-native or invasive ones, and the importance of native species to maintain ecosystem sustainability.

Biodiversity Blitz

Using the app iNaturalist, have students perform a "Biodiversity Blitz" to find and identify as many living species as possible in a specific natural area (schoolyard, local park, forest, etc.). Discuss the importance of biodiversity and the ability of students to participate in citizen science to engage in actual scientific research and discoveries. Make this activity a competition where the student or group with the most observations at the end of the blitz receives a prize.

Additional Resources

EN:

Soil pH protocol: https://www.globe.gov/web/soil/protocols/soil-ph

Testing water quality: https://www.otffeo.on.ca/en/resources/lesson-plans/testing-water-quality/

Important Water Quality Factors: https://h2ou.com/h2wtrqual/#_3)_Nitrites_and

Biodiversity in your backyard: https://practicalbiology.org/environment/fieldwork-techniques/biodiversity-in-your-backyard

FR:

Analyser la qualité de l'eau: https://cdn.we.org/wp-content/uploads/sites/7/2016/10/Trousse-dactivite%CC%81s-pe%CC%81dagogiques-Secondaire-.pdf