Succession and diversity

GLOBE		Associated SDG	Type of Activity
Sphere	**Protocols**		
Biosphere	Land Cover Classification Biometry Biomass	15: Life on Land	Research

Overview

Heraclitus said 2500 years ago that "the only constant is change" and it is precisely the observation of changes in ecosystems that has attracted the attention of scientists over time. With this activity, students will describe the successive changes that occur in the vegetation of an ecosystem over a period of time determined by them.

Time

Once a week for 3 months to 1 school year, depending on the teacher and the student goals

Prerequisites

None

School level

Secondary

Purpose

Students will describe the general characteristics of a process of secondary succession of soil vegetation in a square of 1 meter of side to see the changes that its composition and diversity undergo after removing all the vegetation.

Student Outcomes

- Students will recognize the main species of plants in their environment
- Students will calculate the abundance and diversity of plants in their environment
- Students will analyze the changes that occur in ecosystems over time

Background

Succession is the process through which the ecosystem undergoes a series of changes and organizes itself from an initial state, called pioneer, to an advanced state, called climax (Odum & Barret, 2006). As succession occurs, certain ecosystem characteristics increase, such as diversity, resistance to disturbances (stability), connections among elements, species specialization, the amount of organic matter accumulation and biomass (Rodríguez, 2010).

Within the succession process, some types of succession can be recognized, for example (Mazparrote and Romero, 2020):

- Primary succession: The process that involves the formation of soil and the constitution of the ecosystem as a whole.
- Secondary succession: The process that occurs when an already formed ecosystem suffers a disturbance that alters its structure and dynamics. Through a secondary succession, the structure of an ecosystem is restored.
- Autotrophic succession: It generally takes place in the early stages of succession and occurs when there is a surplus of production (plants photosynthesizing) in relation to respiration.
- Heterotrophic succession: It starts from a situation in which there is a large amount of not-respired, produced material, therefore, there is an excess of decomposing and disintegrating organisms (an excess of respiration). It is like the process of disintegration that takes place in a fallen tree trunk.

Throughout the successional process an ecosystem goes through a series of stages in a cycle, called an adaptive cycle (Figure 1). The adaptive cycle consists of phases of ecosystem development in which long periods of resource accumulation and transformation alternate with short periods that create opportunities for new elements to emerge. When studying the succession of an ecosystem, it is possible to identify in which phase of the cycle it is by considering the following:

- Exploitation phase or r: This is when the system has begun its development. It is characterized by very few species, called pioneers, which grow rapidly, taking advantage of the soil, water, nutrients and light resources available to them.

- Conservation or K phase: This is when the system has accumulated many species, several of which have established close relationships. In this phase diversity and biomass are very high.

- Release phase u Ω: This is the phase in which a system has experienced some disturbance that has caused the system to lose resources, e.g. when all existing vegetation has been removed from a space.

- Reorganization phase or α: This is when the system begins to reorganize itself after having suffered a disturbance. This will be the process of the succession that will be studied with this activity.

Knowing in which stage of succession a system is and the characteristic diversity of each phase is useful for applying management methods that guarantee the sustainability of ecosystems.

Guiding Research Questions

- What is succession?
- How does the plant community change in my environment?
- What is the biological biodiversity value of the species present in an experimental plot?
- What are the pioneer species of succession?
- What are the most common species in the ecosystem?

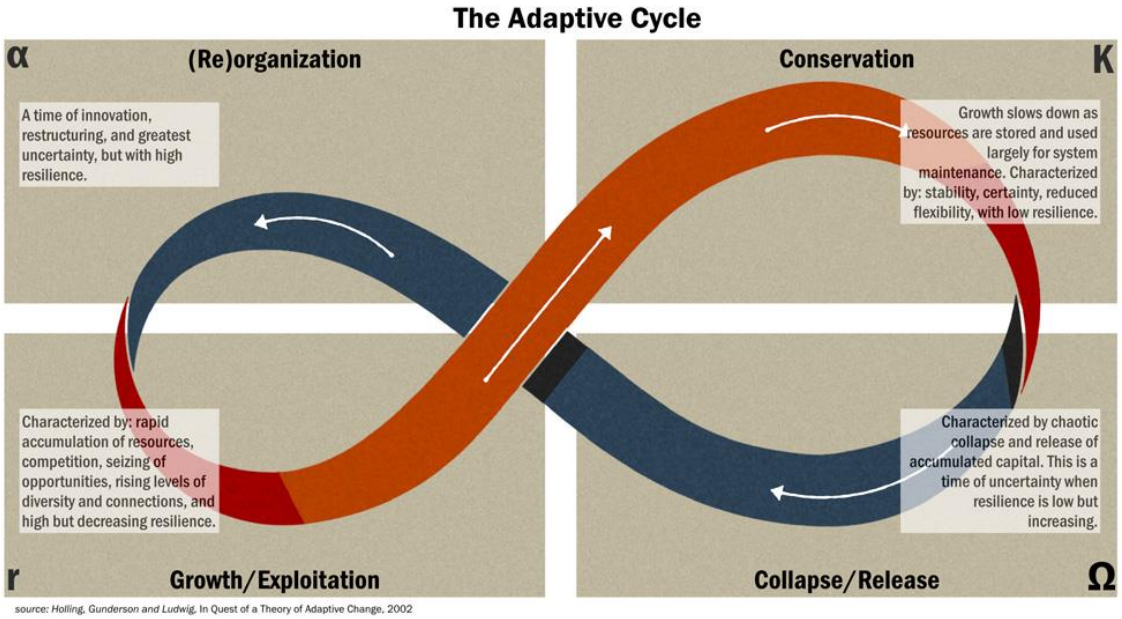


Figure 1: Adaptive cycle of ecosystems. In this image, potential can be used as a synonym for accumulated resources. Connectivity refers to the relationships among resources, and resilience is the ability of system elements to maintain their fundamental structure and functions despite disturbances.
Source: Vilchis-Mata et al., 2018.

Scientific Concepts

- Succession
- Adaptive Cycle
- Biodiversity
- Cover
- Stability
- Wealth
- Biomass
- Production
- Productivity
- Resilience
- Equity

Materials and Tools

- A roll of candle wick or thread to build a net of 1 m2 with 25 cm reticules
- 4 wooden stakes
- 1 small flag or bright color ribbon to put on a sign
- A small wooden stick or knitting stick
- Paper
- Pencils

What to Do and How to Do It

- ***Beginning***

  - The teacher asks the students to bring in photos of when they were younger and of different times when they were growing up, then he/she asks them to analyse some of the changes they have undergone over time. The teachers take this opportunity to explain to students that ecosystems also change over time and that this process of change is called succession.

  - The teacher can also show the students photographs of the same place at two different times so that they can see the similarities and differences between the two images. Perhaps they can see new buildings, plants that are no longer there, etc.

  - Then, the students are told that they will be studying the succession of a small area, of one meter on each side, near the school and that they will have to build a wick or thread net with small squares, within 25 cm, as a key tool to make their measurements (Figure 2).

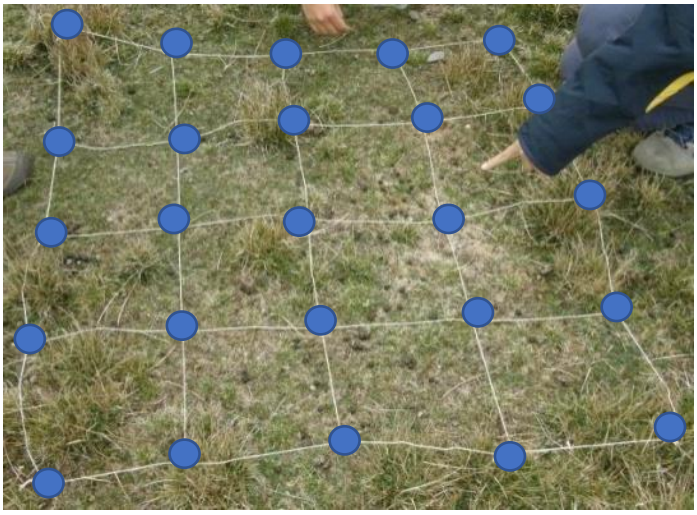


Figure 2: Wick grid constructed to assess vegetation cover. The net should measure one meter on each side (sample) and the squares in the middle are made every 25 cm so the number of points to be assessed (sample units) will be 25. This means that the sample units are composed of the intersections of the squares (blue dots).

- ***Development***

  - A location in the school is selected where to set up the net, this place should have vegetation on the ground, it would help a lot to follow the GLOBE Cover Classification protocol and determine the MUC Code of the study site.

  - Using four wooden stakes, the net is set up on the ground and should be stretched out as far as possible (Figure 2).

- Measure the plant cover in the square. To make the cover measurement it will be necessary to use a wooden stick or a knitting stick and place it perpendicularly at each point, recording the species that is touched with it (Figure 3).

- Record the species present at each given point. The number of points where the species is present with respect to the total number of points will be equivalent to the cover (C) of the species, for which this formula is used:

$$\%C = (ni/25) * 100$$

Where:

C is the percentage of cover
ni = Number of points where a species is recorded.

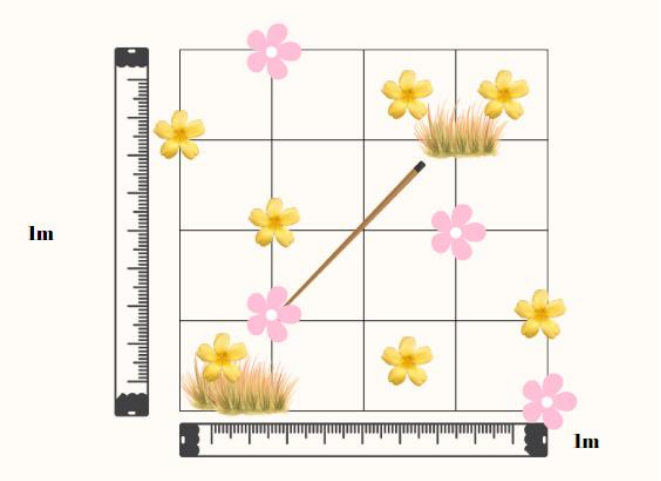


Figure 3: Measurement of the vegetation cover using the square method. It is important to remember to record species that fall only at the intersections of the squares. In this case we have pink flowers in 4 points out of 25, for example, so the cover value of pink flowers would be 16%.

The information from the points is very important, as both the species richness (number of different species) and diversity (a measurement that helps to know the variety of species according to their richness and equal abundance) can be calculated. As an example to make these calculations we will use the data in Figure 3, presented in Table 1. It is important to remember that only the number of intersection points where the plants are located is taken into account.

Table 1
Data for the calculation of plant diversity based on Figure 3

Species	ni
Pink flower	4
Yellow flower	3
Brown grass	2
Total	9

- The richness according to Table 1 would be 3, three different species (pink flower, yellow flower and brown grass). The richness is usually represented by the letter S, for the word species.

- The calculation of diversity is done with indexes. Indexes are numerical values that synthesize a lot of information in a single number and have a scale that helps to interpret its meaning.

- Using the data in Table 4, diversity will be calculated using the complement of an index known as Simpson's index, which is calculated on the basis of probabilities (Table 5). The probability is the chance we have of finding a certain element within a group.

Table 5
Calculation of diversity based on the data in Table 4

Species (S) It helps to determine the identity of each species	ni Number of points where the species is found	Pi The probability of finding the species within the set of species	Pi^2 Simpson's index needs the probability to be squared
Pink flower	4	4/9	$(4/9)^2$
Yellow flower	3	3/9	$(3/9)^2$
Brown grass	2	2/9	$(2/9)^2$
Total sum	9	1	**0,36**

The diversity of the site will then be 1- 0.36 = **0.64**. This is the value of Simpson's diversity index, where 0 means that all species are the same and 1 means that all species are different and each could be found in approximately the same number of points. The formula is presented below:

$$\text{Simpson's Diversity Index} = 1 - \sum_1^S \quad Pi^2$$

- After measuring richness and diversity, remove all plants from the square, leaving only the soil. This will have the effect of a disturbance on the ecosystem.

- Then, take the same measurements as the first time, once a week. This will help to identify the species that grow first and see how the community is changing over time.

- Calculate cover and wealth every time you go to the field, at least once a week.

- ***Closing***

  - Analyzing the data and the results, it is especially important to know which are the first species that appear in the square after the vegetation has been removed, how the diversity value changes and which are the plants that appear later in the succession process.

  - Teachers will assess the knowledge learned, using the target shooting technique, as shown in Figure 4.

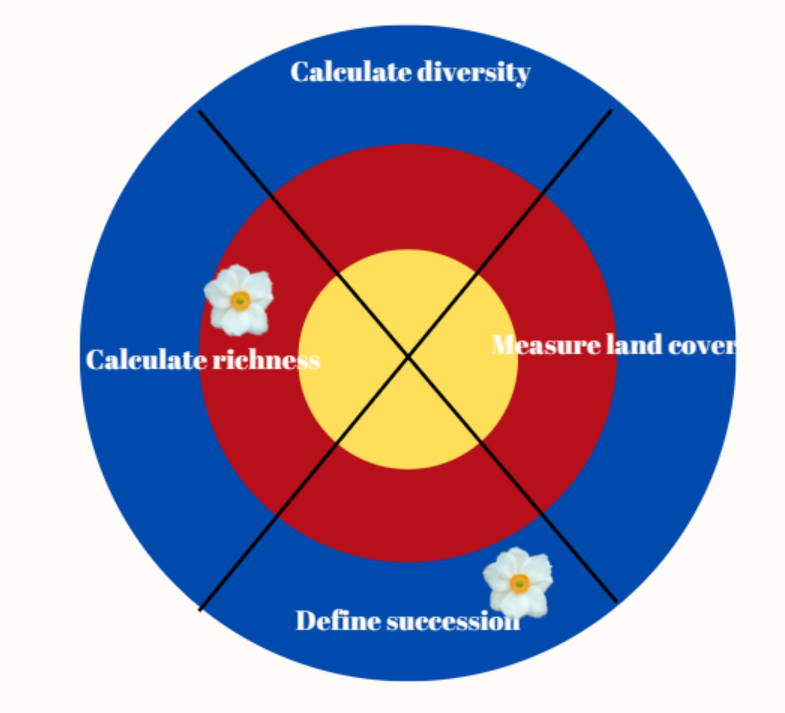


Figure: 4 Students should place a point according to how well they know some of the skills the teacher wants to assess.

Frequently Asked Questions

- What if we can't follow the succession for a long time, will one month be enough?
  Of course, the time is to be decided by the students with the teacher. It will depend on the project objectives.

- Some of the calculations seem complicated, could you limit the activity to just taking measurements in the field and recognizing species by calculating cover?
  You can adapt the activity to what you think is convenient and manageable for your group of students.

Suggested Resources

- MUC Guide to the GLOBE Program
  https://bit.ly/3wYkhMV

Bibliography

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