eBryo SoilSkin

RESEARCH GROUP ON EXPERIMENTAL BRYOLOGY
GRUPO DE INVESTIGACIÓN EN BRIOLOGÍA EXPERIMENTAL

ACTIVITY 2

eBryoSoil: Citizen Science project

Be a scientist for a day!

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

FECYT FUNDACIÓN ESPAÑOLA PARA LA CIENCIA Y LA TECNOLOGÍA

CIBC UAM Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM)

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GOBIERNO DE ESPAÑA MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA

Fundación Biodiversidad 20 AÑOS

PIMA adapta

oecc Oficina Española de Cambio Climático

Grade

- ESO: 1º, 2º, 3º y 4 º.
- Bachillerato de Ciencias: 1º y 2º

Estimated time

- Approx. 1.5 hour

Locations

- Any green area, urban or not (e.g. schoolyard, garden, park, forest, field etc.)

Materials

- Mobile phone (1 per group of students) with the eBryoSoil app installed and user account created
- A 1€ coin per group (to be used as a reference for scale)
- **Optional:** Measuring tape (≥ 15m)
- **Optional:** Magnifying glasses to observe and identify different types of biological soil covers (BSC)

Background

Soil is a crucial ecosystem that provides a large number of ecosystem services that benefit human welfare. Just to name a few, soil is the basis for human infrastructures and provides food, fiber, fuel, building materials and pharmaceutical products. Soil is also important for the maintenance and health of ecosystems worldwide since it contributes to the global cycles that make life possible on Earth. For example, it is involved in carbon sequestration, water purification and reduction of pollutants, flood control and climate control.

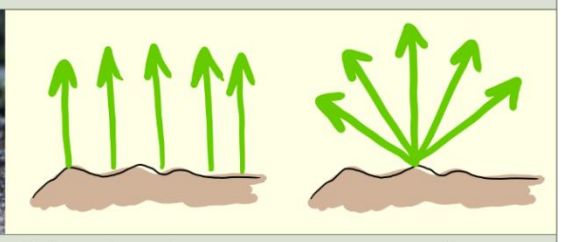
All these services and functions are tied to the structural complexity and diversity of soils. That is because soils are hyper-diverse ecosystems that host about one-quarter of the biodiversity in our planet. Imagine, just a teaspoon of soil (about one gram) typically contains millions of microorganisms including bacteria, protists (unicellular eukaryotes), fungi and nematodes. And this is without taking into account the arthropods, earthworms and mammals that live in the soil. Although we tend to overlook the soil organisms because they are small and spend their lives out of plain sight, we need to maintain their biodiversity so that we can also maintain all the services the soils provide.

Image of some soil dwellers. Source https://esdac.jrc.ec.europa.eu/themes/soil-biodiversity

An important component of soil biodiversity are the Biological Soil Covers (BSC). These are small sized topsoil communities that develop on the few upper centimeters of the soil. They cover around 12% of the terrestrial surface and are usually dominated by mosses, lichens and, to a lesser extent, algal colonies (macroscopic colonies of microscopic organisms). Mosses are tiny land plants that lack proper roots, leaves and stems, while lichens are a symbiotic association between a fungal partner (mycobiont) and one or two unicellular photosynthetic partner(s) (photobiont). We can identify different types of mosses and lichens based on their growth form. In particular, mosses and lichens growing on the soil can be classified in two and three categories, respectively, as you can see in the following scheme.

MOSSES

Acrocarpous: grow upward and are usually unbranched or with just a few branches.



Pleurocarpous: grow parallel to the substrate or creeping and have abundant branches.

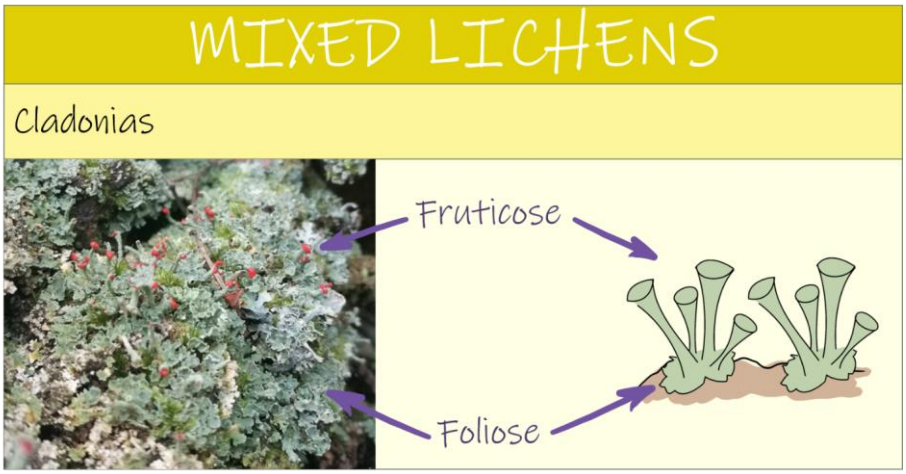
LICHENS

Foliose: grow parallel to the substrate in a leaf-like form and can be easily separated from the substrate

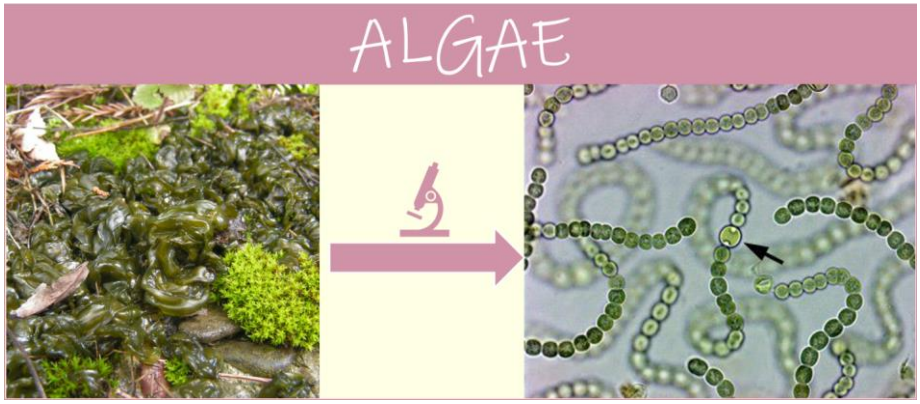
Fruticose: grow perpendicular to the substrate in a shrub-like form. Usually they are attached to the substrate by one single point.

Crustose: attach firmly to the substrate, forming rough patches. They form crusts over the soil.

Sometimes you can find mixed lichens where you can identify both foliose and fruticose growth forms. Let's see an example:



Algal cells often colonize bare soil surfaces enabling the subsequent establishment of other organisms. The presence of algae on the soil provides a carbon and nitrogen supply and minimize erosion by the stabilization of soil aggregates. These algal cells usually form colonies to protect themselves from desiccation and high light exposure. In the following picture you can see the gelatinous masses (colonies) of the cyanobacterium *Nostoc* and what we would see if we looked at these colonies under the microscope:



Biological soil covers form a "living skin" over the soil surface and play key roles on ecosystem functioning preventing soil erosion, regulating the water balance and nutrient cycling, and acting as bioindicators. The organisms that form the BSCs have a unique characteristic in common: they do not have active mechanisms to regulate their water and nutrient content. Thus, their water content depends entirely on the water available in the environment. When the air is dry they dry-out and stay dormant until there is enough humidity (rain or dew), then "wake up" and absorb the available water very quickly. This is why they are considered "the sponges" of the ecosystems.

Furthermore, they have a very important role in the nitrogen cycle. Nitrogen is a necessary nutrient for plants. It is abundant in the atmosphere but plants cannot use it directly, they need it in bio-available form. Only a few organisms can transform the nitrogen of the atmosphere to the form that plants need. Some bacteria that grow in the BSCs are capable of doing this transformation. These

bacteria are responsible for fixing about 40% all the nitrogen that is fixed by living organisms in the world!

Finally, BSCs are also valuable bioindicators, which can be defined as living organisms that help us screen the health of an ecosystem. In particular, BSCs play an important role as indicators of soil health allowing us to monitor multiple ecosystem functions such as nitrogen and carbon fixation, soil building and retention, and hydrological processes. They are powerful bioindicators because some of their characteristics can be easily measured and they are considered early-warning indicators since they are more sensitive to degradation than other organisms present in the soil. Thus, by studying BSCs we can assess soil health by focusing on those functions that are relatively easily lost.

Earth's climate has been getting warmer in the past 50 to 100 years due to human activities. On average global air temperatures have risen up more than 1ºC since 1950, and scientists expect similar or even larger increases in the future. In some parts of the Mediterranean region, climate change is expected to cause a sharp increase in temperature and decrease in precipitation. For this reason, assessing the consequences of climate change in the area is an urgent task. These changes will affect all ecosystems including soils and the BSCs that live on it.

To be able to evaluate the impact of climate change on ecological communities we urgently need information on their current distribution, conservation and health status. However, we do not know enough about the distribution and health of the BSCs to make a fair assessment of the effects of climate change on them. This is a complex task that requires the collection of a large amount of data, but the economic and human resources available are limited. To overcome these limitations, citizen science projects offer a unique tool to obtain data effectively and at relatively low cost, while disseminating scientific content and creating a collective feeling of citizen responsibility for environmental protection.

We have developed the citizen project "SoilSkin" and the mobile app "eBryoSoil" to disseminate the existing knowledge about BSCs, and their value in mitigating the impact of global change on soil functions such as nutrient cycling and water balance. The following experience uses these resources to introduce students into citizen science, seeking to integrate new survey methodologies with engaging them into observing commonly unnoticed components of the ecosystems.

Description

In this activity you will learn to identify the different types of BSC communities and their role as bioindicators for monitoring the state of soil ecosystems. Within this context, you will participate in the citizen science project SoilSkin, which seeks mapping the state of BSC communities all over the Iberian Peninsula. Specifically, you will use the mobile app eBryoSoil to collect data over the distribution, abundance and health of BSC communities.

SoilSkin is a project lead by researchers of the *Universidad Autónoma de Madrid* (UAM) and the *Museo Nacional de Ciencias Naturales* (MNCN-CSIC), developed in collaboration with the *Fundación Española para la Ciencia y la Tecnología* (FECYT). The project aims to evaluate the vulnerability of soil ecosystems of the Iberian Peninsula in the face of global change, by making use of BSC communities as bioindicators, as well as to disseminate scientific knowledge and raise awareness about the value of these tiny organisms.

The app eBryoSoil was developed as a tool that enables students, teachers, nature lovers and anyone who is interested in expanding scientific knowledge, to contribute in the very important process of data collection. By following a simple method which includes taking photos of the soil along a transect and filling out short data forms, citizens can help in mapping the state of BSC communities around the Iberian Peninsula. The app can be downloaded for free and it requires a simple registration process in order to begin sampling. Users can find all the entries they and their peers have made on a map and follow the evolution of the project as more data are being collected in the project webpage.

You can find more information about SoilSkin at https://ebryo.com/soilskin/

Objectives

- Understanding the importance of soil and its functions.
- Comprehending what bioindicators are and how they can be useful in the context of global change.
- Understanding the role of BSC as bioindicators.
- Demonstrating how citizens can contribute to expanding scientific knowledge.
- Participating in a citizen science project aiming to map the state of BSC communities all over the Iberian Peninsula.

Key concepts students need to know before the experiment

- Main characteristics of BSC
- Citizen science
- Climate change basic facts
- Familiarization with the eBryoSoil app

Directions for teachers

Planning the activity

- It is recommended that prior to conducting the activity the teachers have introduced to the students the key concepts that are addressed in it.
- **Sampling location:** Choose a location that is as less disturbed as possible in order to have a higher chance of finding more developed BSC communities (e.g. avoid areas where human presence is very high and the soil is being stepped on or removed constantly). Note that there may be well-developed BSC communities in some urban parks, in areas that are not subject to recurrent trampling (i.e., walkways, paths, playing field grounds, etc.).
- If possible, the students can split in groups, where each group can be in charge of carrying out one transect. **Each group should have one mobile phone**. Try to make a **maximum of 3 linear transects** within the **same ecosystem type** with a 15 meter distance between them.
- The groups can be formed in a way that each student takes charge of a separate task e.g. identify BSC types, take photo, estimate BSC cover, fill out data form, measure distance etc.
- Students under 14 should use the application under the supervision of/with permission from their parents or legal guardians.
- It is highly recommended that teachers familiarize themselves with the app before using it with students.
- Teachers and students can download the eBryoSoil app for free from the Google Play App Store for Android devices.

Scan QR code to get the app!

Registering in the app

- Before carrying out the activity in the field, users (one for the whole class or one per group) should **register** in the app via the section “Registrarse”.
- Each user creates their own username and password and provides an email address. In addition, they need to provide the name of the Institution/Association they are affiliated with and choose their “user type” (“tipo de usuario”) between: Researcher (“Investigador”), Technician (“Técnico”), Amateur (“Aficionado”), Student (“Estudiante”) and Other (“Otro”). **Make sure this field is filled out correctly**.
- It is recommended that the registration process is realized prior to the activity, in the classroom or in any area where you have a stable internet connection.

- Ideally, the teacher should register an email for the whole class, or use his/her institutional one, or one s/he uses for educational purposes.

After the activity

- We would really appreciate if you could share with us photos of the activity you carried out. You can send them to lapielvivadelsuelo@gmail.com. You should attach an authorization to publish the images on the web page and twitter accounts of the projects as well as in the reports of the SoilSkin project. Note that for children under the age of 14 the authorizations should be signed by one of the parents or legal guardians while, for those between 14 and 17, the authorization needs to be signed by the parents or legal guardians and by the teenager himself. You can find a draft for the authorization on the web page of the project www.ebryo.com/soilskin/

Data protection

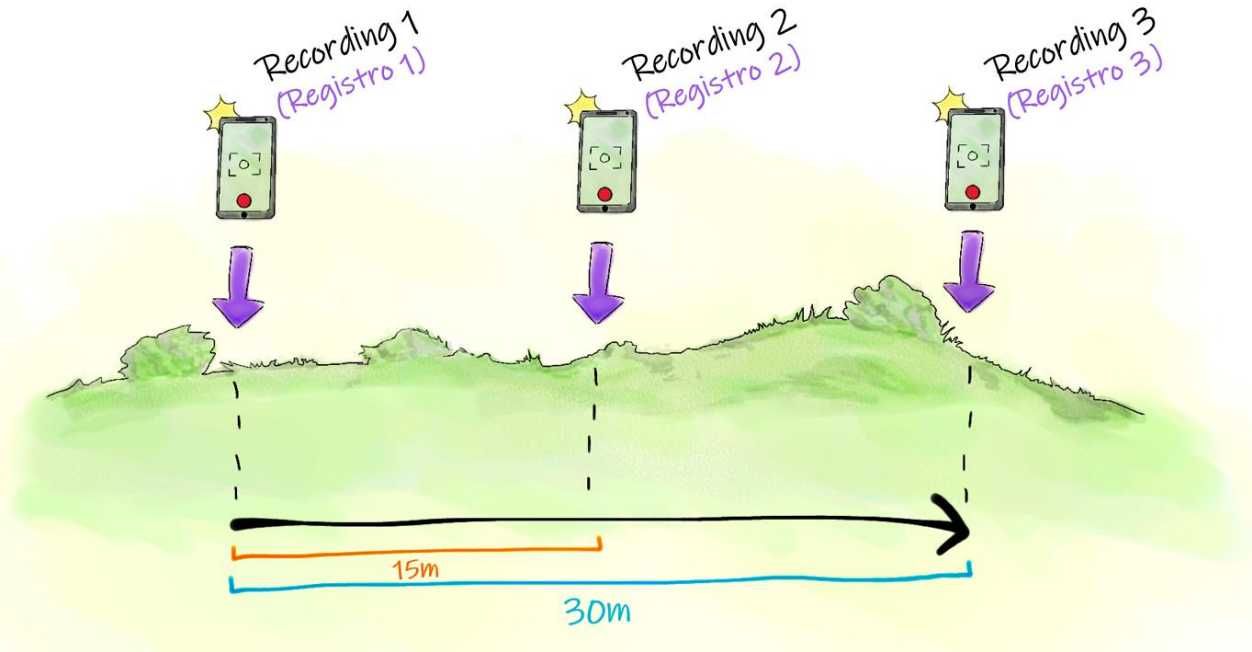
- We do not save any personal information, but be aware that the location of the sites will be saved. We will use the information exclusively for scientific and educational purposes related with this project, and will never show your personal information attached to the data.

For any questions or doubts contacts us at lapielvivadelsuelo@gmail.com

Activity

Outline

Data are collected along transects. You are asked to take a photo of the ground and complete a data form for three equally spaced points across a linear transect of approximately 30 meters, as seen in the figure.



1. Locate your starting point. Search for the most developed BSC community you can find in the area you have visited.
2. Start the eBryoSoil app*, begin new entry (+) and complete “Registro 1” by taking a photo and completing the data form provided (**find detailed instructions in section “Using the app”**). Consult schemes “Ecosystem Types” and “How to estimate cover” for help with completing the data forms.
3. Walk in a straight line in any direction for approximately 15 meters** and complete “Registro 2”. **Absence of BSC is not a problem, you should take a photo regardless! *****
4. Walk another 15 meters continuing in the same direction you did for the 2nd point and complete “Registro 3”.
5. Complete your sampling by uploading the data.

***Attention:** Make sure GPS localization is on before you begin!

****Tip:** If you do not have a long field measuring tape, an intuitive way to count 15 meters is walking 15 broad steps. Check first how broad should each step with a 1-m ruler or toolkit measuring tape.

*****Tip:** Try to direct your transects towards areas that may have BSCs, rather than pathways, degraded or constructed areas.

Choose location and plan your transect

Biological soil covers can be found practically everywhere, in a field, in a forest, an urban park, etc. For the needs of this activity, you will need to find any area where you can find some BSCs growing. Ideally, especially if you are working in several groups, you should choose an area where BSCs grow with relative abundance so you can make multiple transects.

1. **Go to** the nearest park, forest or any green area that is relatively undisturbed. Walk around and observe the soil closely. Look at the openings between the areas where grass grows. You will soon start noticing mosses and lichens growing all around. Aim for areas that are relatively protected from the wind and sun and try to find the communities that are better developed in that area. These are going to be the starting point of your transect(s).
2. **Identify** the ecosystem type of the area you are in. You will need to fill in this information in the eBryoSoil data form. Ideally, the whole transect should be within a homogeneous ecosystem but if your area is very patchy it might happen that you cannot place a transect in a homogeneous landscape. If so, don't worry! Remember to specify the ecosystem type for each picture in the app. See scheme "Ecosystem Types" for more information.
3. **Plan** your transects in advance. Choose **how many** transects you are going to make in the area and **where**. We recommend a **maximum of 3 transects** within the same ecosystem type. Each transect should be at least **15 meters apart** from the other. In case you visit an area with more than one ecosystem type (e.g. open forest + grassland), make **the same number** of transects in both ecosystems.

Optionally: If possible, you can visit more than one area so you can collect data from different ecosystem types, see how communities differ among them and consider the potential causes and consequences of that.

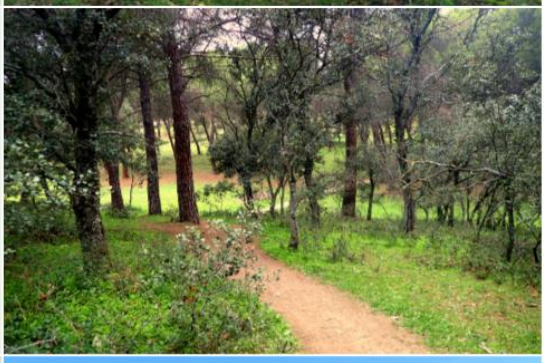
Ecosystem Types

Closed Forest (Bosque Cerrado)

Ecosystem dominated by trees of more than 2 meters tall and where trees have a percent canopy cover above 60%.

Open Forest (Bosque Abierto)

Ecosystem dominated by trees of more than 2 meters tall and where trees have a percent canopy cover below 60%.



Shrubland (Matorral)

Ecosystem dominated by woody vegetation less than 2 meters tall.

Grasslands (Herbazales y Pastizales)

Ecosystem dominated by herbaceous plants.

Agricultural land (Cultivo)

Ecosystem dominated by temporary or woody crops.

Urban Green Spaces (Espacios Verdes Urbanos)

Landscape in which buildings or other man made structures are dominant.

Coastal Ecosystems (Ecosistemas Litorales)

Ecosystems where land and sea join to create a landscape that is visibly different from the inner terrestrial vegetation (i.e. sand dunes, salt marshes, wetlands, estuaries etc.).

Using the app

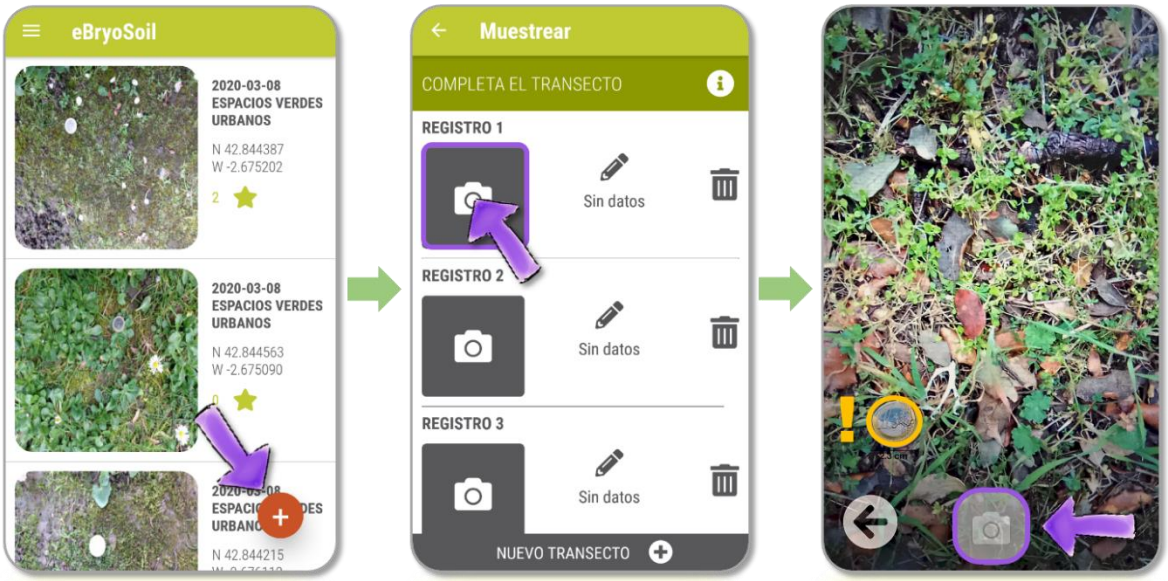
1.

Before you begin, make sure you are registered and logged in!

Your username should appear on the screen.

Remember to turn on your device's GPS!

2.



Tap on + to begin your data collection!

Start by collecting data for the first stop of your transect ("Registro 1")

First, take a photo!

a) Place the euro coin inside the frame of the photo.

b) Make sure both your coin and the one that you see on your screen, appear to have about the same size.

c) Capture your photo!

3.

Proceed to complete the data form for "Registro 1"

a)

Select the ecosystem type of the area

b)

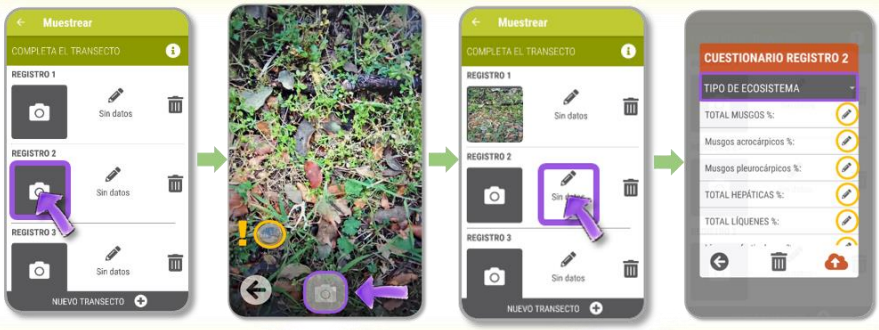
Fill out the approximate percentages of BSC and bare soil cover

Consult "How to Estimate Cover" for directions!

Upload your data!

4.

Walk 15 m to the next stop of your transect and repeat the same process for "Registro 2" and, finally, "Registro 3"

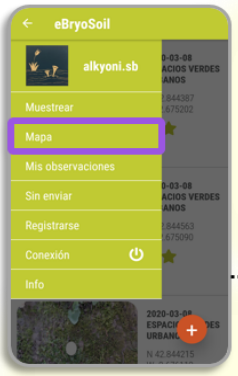


Capture photo! → Fill data form! → Upload data!

Finalize the process by tapping on

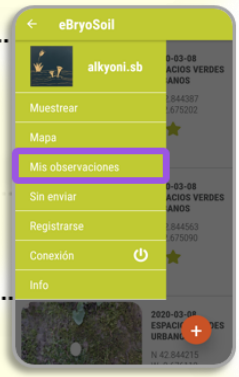
NUEVO TRANSECTO

Extra Features



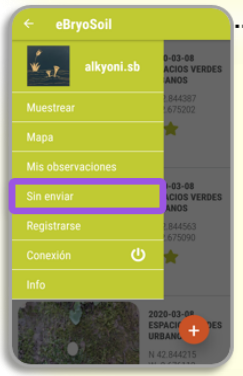
"Mapa"

You can explore all the data that have been collected all over the Iberian Peninsula



"Mis observaciones"

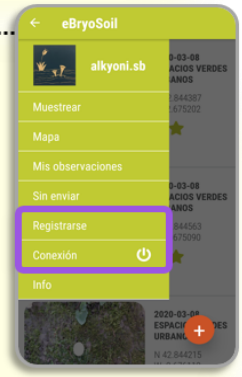
Here you can find all the data you have collected in chronological order.



"Sin enviar"

Don't worry if you are not connected to the internet during the data collection process!

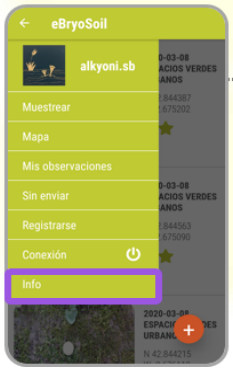
Find your transects in **Sin enviar** and upload the data whenever you are connected.



"Registrarse" & "Conexión"

Before you start collecting data for the first time you should create your account. Just tap on **Registrarse**

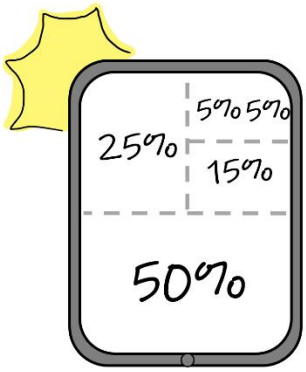
You can log in to your account anytime by tapping on **Conexión**

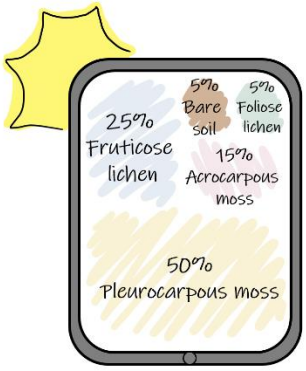


"Info"

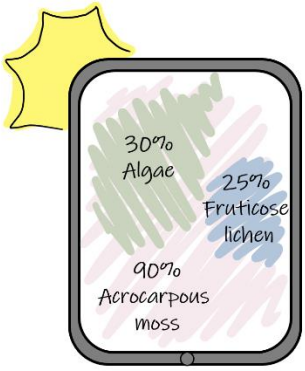
Find more information about eBryoSoil here!

HOW TO ESTIMATE COVER?





TOTAL MOSSES=65%
TOTAL LICHENS=30%
BARE SOIL=5%



TOTAL MOSSES=90%
TOTAL LICHENS=25%
TOTAL ALGAE=30%

Overall cover (%) doesn't need to sum up to 100%!!

CUESTIONARIO REGISTRO 1	
BOSQUE CERRADO	
TOTAL MUSGOS %:	80
Musgos acrocárpicos %:	10
Musgos pleurocárpicos %:	70
TOTAL HEPÁTICAS %:	10
TOTAL LÍQUENES %:	0

CUESTIONARIO REGISTRO 1	
TOTAL LÍQUENES %:	0
Líquenes fruticulosos %:	0
Líquenes foliáceos %:	0
Líquenes crustáceos %:	0
TOTAL ALGAS %:	0
TOTAL SUELO %:	10

CUESTIONARIO REGISTRO 1	
MATORRAL	
TOTAL MUSGOS %:	40
Musgos acrocárpicos %:	40
Musgos pleurocárpicos %:	0
TOTAL HEPÁTICAS %:	0
TOTAL LÍQUENES %:	60

CUESTIONARIO REGISTRO 1	
TOTAL LÍQUENES %:	60
Líquenes fruticulosos %:	60
Líquenes foliáceos %:	0
Líquenes crustáceos %:	0
TOTAL ALGAS %:	0
TOTAL SUELO %:	50

Discussion

1. Analyze the communities you have found and compare the abundance and diversity of growth forms.
    a. How many life forms did you find? Which ones were more common and where?
    b. Which type of community was dominant in each area? Can you identify the factors that affect BSC types?
2. Do you think BSC are good bioindicators?
3. Were there any areas without cover? What are the potential causes? Can you identify the most important threats to the BSC in your area?
4. How do you think climate change can impact BSCs?
5. **Optional:** In case you were able to visit more than one location compare the observations you made in each one. Which type of community was dominant in each case? Which factors that may affect BSC differ between the different locations?

Your contribution doesn't end here!

You can keep on collecting data with eBryoSoil at any point

Follow news and updates about the project at

@PielSuelo La Piel Viva del Suelo and www.ebryo.com/soilskin

Fun facts

- Did you know that what we know as 'wet soil's smell', or 'earthly aroma' is produced by BSC organisms? This distinctive odor is due to geosmin, a volatile organic compound produced by some soil fungi and bacteria (cyanobacteria among them). You knew the smell of BSCs before you were aware they existed!
- Did you know that BSCs are more easily seen when wet? In humid conditions, bryophytes and lichens brighten their colors, the leaves of mosses spread, and some slimy organisms, such as gelatinous lichens and cyanobacterial colonies, swell and become apparent.
- Did you know that research on BSCs is now cutting-edge science? They are featuring more than 25 000 research papers in the last 5 years, and many scientific projects, governmental policies for soil restoration and agriculture, and even military plans, are now targeting BSCs.
- Did you know that your cell phone is a first-class research tool? Search for applications to know your environment! You will find lots of interesting developments, from identification of plants, insects and birds to earthquake monitoring!
- Did you know that citizen science and social networks are a wonderful help for scientists around the world? For example, a new species of carnivorous plant, *Drosera magnifica*, was discovered through a picture published in Facebook. From neuroscience to documenting wildlife, citizen collaboration is invaluable. In Ecology, where we need to collect lots and lots of data, even more so. Thank you all, dear participants!

Photo Attributions

- **Shrubland:** Krzysztof Ziarnek, Kenraiz / CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)
- **Grasslands:** Mike Green / CC BY-SA 2.0 (https://creativecommons.org/licenses/by-sa/2.0)
- **Urban Green Spaces:** Kolforn (Wikimedia) / CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)

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Con la colaboración de:

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CIBC UAM
Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM)

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