



# SOIL FRAMEWORK FIELD MANUAL

2024

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# SUMMARY

This field manual provides an extensive guide for environmental practitioners and restoration projects aiming to restore and monitor ecosystem health effectively. It encompasses a broad range of techniques and methods tailored to assess soil conditions, biodiversity, and climate factors crucial for successful ecosystem restoration.

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## BROAD CONTEXT

This section highlights key elements to map out the context of restoration projects. Our advice is to document these as part of a baseline inventory and/or restoration plan, which can be shared with relevant stakeholders and through the project's communication channels.

### Before and after photos

One of the easiest and most appealing ways to demonstrate changes in ecosystems is to take before and after photos of the areas undergoing restoration. The best before and after images are taken with drones. If you do not have access to a drone<sup>1</sup>, use the 'Fixed Point Photography Method' described below, where you take photographs of the site from the same point(s) over time.

#### Method:

1. Mark out specific points on your zone(s) with labelled sticks or flags. (If possible, mark as well the height at which you will take a photo with your smartphone camera)
2. From those points, take a photo of the zone(s) OR if you have a drone, use the marker as a reference as you take aerial photo(s)
3. Keep the markers in place and take again a photo from the same location(s) and angle one year later.
4. Store these photographs in ERC's database (and digital cloud/drive folder) by sending them to [hello@erc.earth](mailto:hello@erc.earth)

### Extent of restoration

Given that gains from ecosystem restoration are highest at large scale, the extent of restoration is an important element of ecosystem restoration. (Note that ERC welcomes and supports projects of any size).

#### Method

1. Draw polygon(s) of the area undergoing restoration (within your own restoration site or beyond-the-fence where you contribute to the restoration of other sites), and the potential restoration area (that is, area where you know restoration might happen even if no formal plans or property agreements exist; for example, think of neighbouring public or private lands you think may be allocated to restoration in a collaborative effort to establish wildlife corridors, replicate what you are doing at your site, or perhaps where you may be doing restoration consultancy work).
2. Some platforms (e.g. Restor, MyMaps) may auto-generate the extent or area (m<sup>2</sup> or ha) you are interested in analysing.
3. Record the extent of the area undergoing restoration and the potential restoration area (m<sup>2</sup> or ha) and the date.

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<sup>1</sup> You can reach out to [hello@erc.earth](mailto:hello@erc.earth) for affordable drone imagery of your site(s).

## Habitat connectivity

In ecosystem restoration, natural recovery processes play an important role and should be facilitated. Often, recovery processes and ecosystem resilience depend on habitat connectivity (e.g. for seed dispersal, providing shelter for fauna, etc.).

### Method

1. Identify and describe the particular type(s) of habitat you wish to see recovering in/around your restoration site(s) (this may include complex agroforestry systems based on principles of ecological succession and whereby future human intervention is minimized; it should not include agricultural areas, human settlements, where human intervention is high.)
2. Using regional maps and/or satellite imagery, measure distance between patches of the particular habitat within the project area and/or between the project and broader landscape or aquatic environment
3. Calculate and record the average distance between habitat patches

## Land cover change

Effective ecosystem restoration goes hand in hand with an understanding of pressures on ecosystem function and associated biodiversity. As detrimental changes in land cover contribute to terrestrial ecosystem degradation and biodiversity loss, tracking land cover is of crucial importance. It helps you understand what preceded your interventions as well as what the trends are in the landscape surrounding you.

### Method

Land cover detection is a complex process that involves sensing reflectance of different wavelengths of the electromagnetic spectrum with satellite-mounted sensors, which in turn need 'trained' algorithms and ground data for calibration. Today, open-source satellite imagery (e.g. from satellites like Sentinel II) makes it easy to do a quick assessment of land cover change. Some platforms may autogenerate the land cover classes of the area you wish to monitor. Typically, free satellite imagery has a spatial resolution ranging between 10m-60m (pixels equal to or larger than 100m<sup>2</sup>). Depending on this resolution, you may be able to identify the specific pre-degradation or pre- pre-restoration land cover classes of the area(s) you are interested in. Through satellite imagery from different points in time, you can see changes in the extent of these land cover classes. Considering the polygons of your restoration site(s), record changes in land cover classes (% increase/decrease) yearly on your record sheet.

**Free digital tools and platforms** to help monitoring land cover change:

- <https://restor.eco/>
- <https://openlandmap.org/>
- <http://earthmonitor.org/>
- [www.globalforestwatch.org/map/](http://www.globalforestwatch.org/map/)
- <http://maps.elie.ucl.ac.be/CCI/viewer/index.php>
- <http://earthenginepartners.appspot.com/science-2013-global-forest>
- <https://www.oneearth.org/navigator/>

# SOIL HEALTH

## Indicator 1: Soil texture

### Materials needed

- Glass jar
- Timer
- Water
- Ruler/tape measure
- Fine-tip marker

### Method

1. Mark your glass jar(s) at the halfway point of the total volume, and then split it each half further in two (you should end up 4 marks)
2. Remove a vertical slice of soil approx. 30 cm deep from each sampling spot
3. Remove any large rocks or organic matter, then break up all the lumps
4. Fill half of the jar(s) with soil
5. Using your fingers, press the soil down as much as possible
6. Mark level of the soil
7. Fill jar(s) with water to the  $\frac{3}{4}$  mark with water, then shake vigorously for 3 minutes until soil is suspended in water
8. Set the jar(s) on a level surface where it can be left undisturbed for at least a day
9. **Start the timer**
10. After 1 minute mark on the side of the jar the level of settled particles at the bottom = V<sub>sand</sub> (volume of sand)
11. After 2 hours mark the level of settled particles = V<sub>silt</sub> (volume of silt)
12. After water has cleared (may need >24 hours) mark top level of particles = V<sub>clay</sub>
13. Using a tape measure, use distances on the jar to calculate relative proportions of sand, silt and clay
14. Using the soil texture triangle below, determine the type(s) of soil you are working with

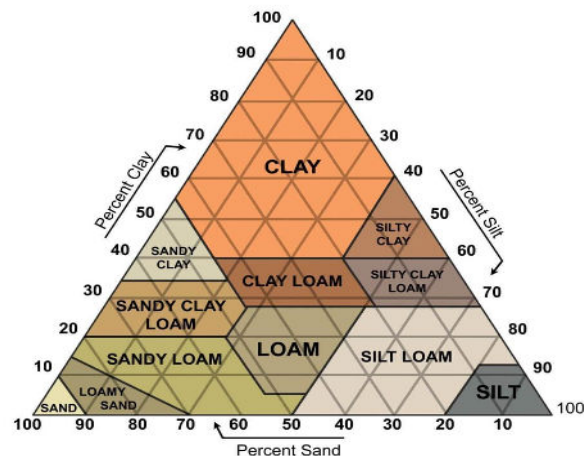


Figure 2: Triangle to classify soil by texture

## Indicator 2: Soil structure and aggregate stability

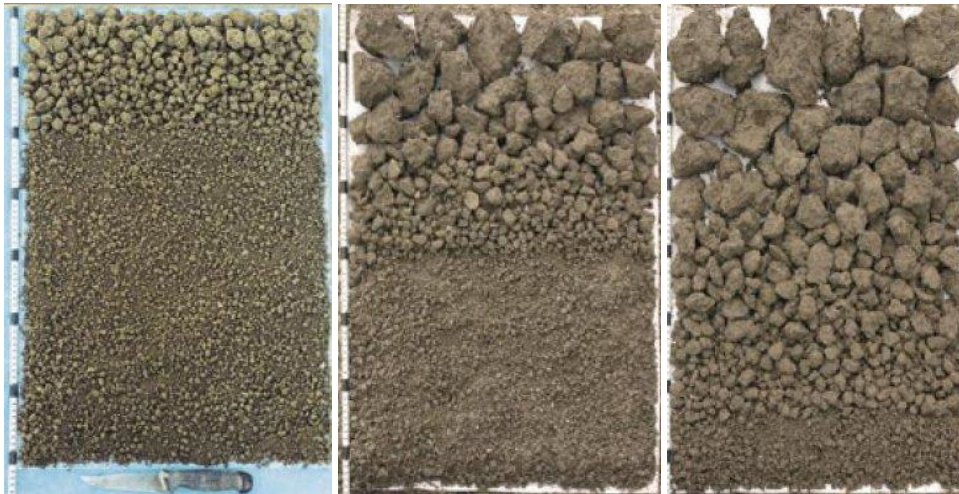
### Means of Verification (1): Drop and Shatter

#### Materials needed

- Firm container (can be a bucket/plastic box)
- Garden spade
- Wheelbarrow or Large transparent plastic bag

#### Method

1. At each sampling point, remove the 0-5 cm topsoil containing dense root systems, without disturbing the soil underneath
2. Remove a 20x20x20cm cube of soil with a spade
3. Drop the soil sample a maximum of three times from a height of one metre (waist height) onto the firm base of your container. If large clods break away after the first or second drop, drop them individually again once or twice. If a clod shatters into small units after the first or second drop, it does not need dropping again. Do not drop any piece of soil more than three times
4. Part each clod by hand along any exposed fracture planes or fissures.
5. Transfer soil onto wheelbarrow or large plastic bag
6. Move the coarsest parts to one end and the finest to the other end to obtain a measure of the aggregate-size distribution. Compare your distribution of aggregates with the three photographs below.



2 = GOOD

1 = MODERATE

0 = POOR

**Good condition (2):** Good distribution of finer aggregates with no significant clodding.

**Moderate condition (1):** Soil contains significant proportions of both coarse firm clods and friable, fine aggregates.

**Poor condition (0):** Soil dominated by extremely coarse, very firm clods with very few finer aggregate

## Means of Verification (2): Soil Slaking Test

Note: the slaking test is not very effective in soils with a high content of clay.

### Materials needed

- Sheet of 1cm mesh
- Glass bottles/jars (one for each zone you will be surveying)
- Water

### Method

1. Fill the jar(s) with water
2. 'Hang' a piece of the mesh inside-/at the top of each jar (to prevent the soil sinking to the bottom directly)
3. Take an air-dry soil aggregate (4-6 cm diameter) from each zone (if you have conducted the visual inspection test, select three pea-sized lumps of soil from each soil slice/zone)
4. Place different soil fragments in different meshes/jars
5. Observe soil fragment for 10 minutes
6. Give a score for each zone:

1 = Complete slaking/poor condition (aggregate breaks down completely into sand grains)

2 = Partial slaking/moderate condition (aggregate breaks but some remain intact on top)

3 = No slaking/good condition (no change, water is clean)

## Indicator 3: Topsoil depth

### Materials needed

- Shovel
- Tape measure

### Method

1. At each sampling point, dig a hole at least 50cm deep if possible (or until soil changes colour, from darker tones to lighter subsoil with little/no root mass)
2. If you cannot easily reach this depth, make a note in datasheet
3. Measure thickness of topsoil layer (cm) from the surface until subsoil edge
4. Calculate the average topsoil depth for each zone
5. Record these values (in cm) and score according to the bands it falls into: **very shallow (VS) = <15 cm; shallow (S) = 15-30cm; moderately deep (MD) = 30-50cm; deep (D) = > 50cm)**
6. Repeat the process every year, avoid digging in the same spot

## Indicator 4: Teabag decomposition rate

### Means of Verification: 'TeaComposition'

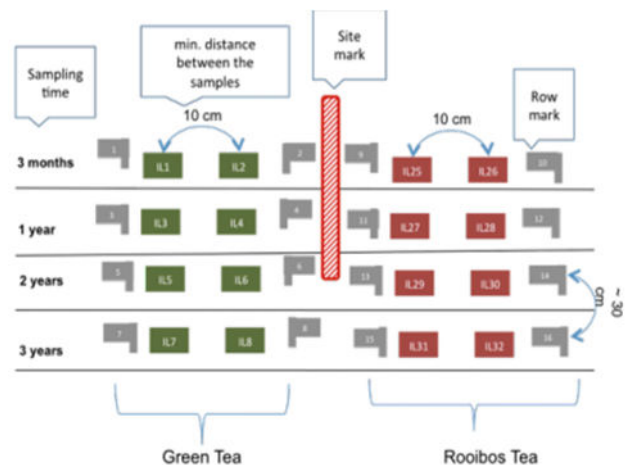
Note: contact [hello@erc.earth](mailto:hello@erc.earth) if you would like to request teabags for this test

### Materials needed

- 8 rebars/metal poles per zone
- 16x Lipton Green tea bags (EAN no.: 8 722700 188438) per zone
- 16x Lipton Rooibos tea bags (EAN no.: 8 722700 188438) per zone
- Water-proof pen to label tea bags
- Zip lock bags, Tupperware or any other water-proof recipient(s) with lid
- Weighing scale
- Little spade
- Tape measure

### Method

1. Select two representative sampling areas of at least 1m<sup>2</sup>, with gentle slope (avoiding very steep/flat sites along slope)
2. Physically mark these areas using so you can find them easily
3. Record altitude & GPS coordinates of these areas and if possible, the soil type
4. Label tea bags with a unique identifier code that represents the number of the tea bags (1-16), the type of tea, the zones you are studying and the sampling area you are studying (i.e. 1 or 2); for example: 2GRCOM1 = second green tea bag buried in 'area treated with compost' in sampling area 1.
5. Record weight of tea bags before burial (preferably on 4 decimal places)
6. Place tea bags in Ziplock bag or (Tupperware) box until burial
7. Note the starting date of incubation/tea burial
8. Using string and sticks/rebars, mark 4 lines in each sampling area (each 40-cm long, with 10 cm between lines)
9. Gently dig 4 slots (approx. every 10 cm, at least 5cm deep) along each line, creating a pocket for the tea bags
10. In each line, bury 2 green + 2 rooibos tea bags roughly 5cm deep, ensure the identifier codes on the tags are visible on the surface
11. Plan retrieval dates or sampling points in your calendar (3, 12, 24 and 36 months after burial)



### *Retrieval of tea bags:*

12. Collect 2 bags of Green tea and 2 bags of Rooibos tea (avoiding pulling the rope and lift the soil to retrieve tea bags instead) from each plot
13. Clean tea bags from roots, soil etc (careful not to damage the bag/lose any tea!) and note if bag was damaged or found at surface
14. Place every tea bag in zip lock bag/box, checking the label (if missing, reconstruct based on previous/following bag number in the line)
15. Dry tea bags at 70° C for 48 hours
16. Determine weight of empty tea bag and note the weight
17. Record results in datasheet
18. Repeat procedure after 12, 24 and 36 months.

## Indicator 5: Soil sediment levels

### Means of Verification: Soil Accumulation Test

#### **Materials needed**

- 1 metre threaded rods (picked up from your local hardware store)
- Spray paint

#### **Method**

1. At each sampling point, fix the pole halfway into the soil so it won't move
2. Spray paint the level at which the pole goes into the ground
3. Return to the poles one year later and mark current soil level
4. Record coordinates of each spot where threaded rods have been installed

## Indicator 6: Soil compaction

### Means of Verification: (a) Penetrometer Test

#### **Materials needed:** penetrometer

#### **Method**

1. At each sampling point, push down penetrometer until 300 psi is reached
2. Record the depth (at >300 psi) as the "top level" of your compaction layer
3. Decrease the pressure but continue pressing down into the penetrometer until psi values below 300 psi are found
4. Record the second depth/level (at <300psi) (i.e. bottom of "compaction layer")
5. Repeat this several times within each zone/monitoring unit

## Results

% sampling points whereby >300 psi in top 40 cm	compaction rating	subsoil recommended
<30	Little to none	No
30–50	Slight	No
50–75	Moderate	Yes
>75	Severe	Yes

### (b) Bulk Density Test (and soil moisture content)

#### Materials needed

- Garden trowel
- Flat bladed knife
- Sealable bag & marker
- Scale (0.01g precise)
- Sturdy tube/ring (or soil corer)
- Ruler or tape measure
- A hammer/mallet and wood block to drive in the ring
- Microwave oven

#### Method

1. Push the tube firmly into the soil (with a piece of wood/hammer) until it is  $\frac{2}{3}$  in
2. Measure the diameter of the ring and then half it to obtain the radius
3. To determine the exact depth that the tin has gone into the soil, measure the height from the top of the tin to the soil surface four times evenly spaced and record the average, subtract this from the total height of the tin
4. Record the values from steps 5 and 6 on the app/[datasheet](#)
5. Dig around- and remove ring with trowel underneath it, preventing loss of soil
6. Place entire sample in bag and label
7. Repeat this for each zone you wish to study
8. Record the weight of your wet soil sample(s) (subtract the bag or container that goes on top of the scale)
9. To dry, place the soil sample(s) in a [microwave](#) and for 2 or more 4-min cycles at full power. Open the microwave door for 1 min between cycles to allow venting. (To determine if the soil is dry, weigh the sample and record its weight after each 4-minute cycle. When the weight no longer changes, it is dry.)
10. Measure & record the weight of your dry soil sample
11. Obtain the bulk density using the app or [datasheet](#) (using the formulas below); you could also work out the water content and porosity of your soil!

$$\text{Soil water content (g/g)} = \frac{\text{weight of moist soil} - \text{weight of oven dry soil}}{\text{weight of oven dry soil}}$$

$$\text{Soil bulk density (g/cm}^3\text{)} = \frac{\text{oven dry weight of soil (g)}}{\text{volume of soil (cm}^3\text{)}}$$

$$\text{Soil porosity (\%)} = 1 - \left(\frac{\text{soil bulk density}}{2,65}\right)$$

## Indicator 7: Water percolation and retention

### 7a) Water Holding Capacity (WHC) Test

#### Materials needed

- Coffee Filter
- Rubber Band
- Open can/cylinder (both ends removed)
- 50 grams oven dried soil samples (labelled accordingly - including zone, date)
- Kitchen/microwave oven that reaches 105° C

#### Method:

1. Take a composite soil sample from each zone and label accordingly
2. Using the oven: Bake the soil in an oven at 105° C for 24 hours until the water has evaporated, let it cool  
Using the microwave: Place the soil sample(s) in a microwave for 2 or more 4-min cycles at full power. Open the microwave door for 1 min between cycles to allow venting. (To determine if the soil is dry, weigh the sample and record its weight after each 4-minute cycle. When its weight does not change after a drying cycle, then it is dry)
3. Place the filter paper on the end of the can with a rubber band.
4. Slightly moisten the filter paper on the end of the can and weigh; (record weight R)
5. Place the (105° C) oven-dried soil in the can and reweigh it. (again, record this weight, S)
6. Set the can (filter paper down) in water, so that the lower half is immersed
7. Leave it for 14-16 hours (or overnight).
8. After this time, remove from the water, transferring to a rack where it can drain for approximately 30 minutes.
9. Wipe surface of can dry, blot once (5 sec) and weigh (record "WS")

10. Calculate the water holding capacity (WHC) of the soil sample using the equation  $WHC = 100 \times (WS-S)/S$ , whereby

- WHC: Water holding capacity (mass of water retained by 100g of dried soil (mL))
- S: Dry soil weight (g)
- WS: Soil + water added (g)

### 7b) Soil Water Infiltration test

#### Materials needed

- Hand sledge and wood block
- sturdy tube (e.g. from steel or pvc)
- Marker
- Plastic wrap
- 500 mL bottle
- Water
- Stopwatch or timer

#### Method

1. Free a 1x1 m area of soil from vegetation (if the soil isn't wet already, soak it slowly until saturated)
2. Drive the tube in the soil it is half-way in
3. Start the timer as you pour 500 mL water as gently as possible into the tin
4. Stop time when water is infiltrated (when surface is just glistening rather than submerged). If soil is uneven, count time until half of the surface is exposed and just shining.
5. Record time counts for each of the sample sites/management areas in datasheet

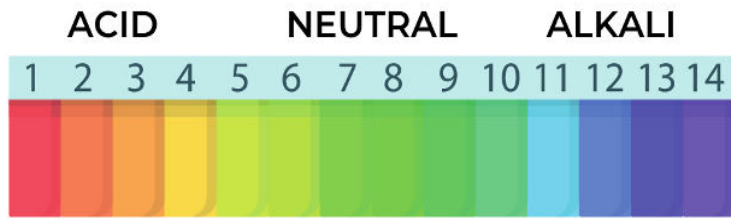
### Indicator 8: pH colour test (or probe)

#### Materials needed

- Bag or box to mix soil
- pH paper & chart
- Cup
- Water

#### Method (colour strip)

1. Mix soil from at least 3 different spots in each zone/area of interest
2. Fill the cup with 2/3 soil and 1/3 water (such that the soil is covered)
3. Stir well for 1 minute
4. Completely immerse pH strip in soil solution for 3 seconds
5. Remove strip & rinse quickly (with same water as used for the solution)
6. Hold pH paper up to the light and compare colour to colour table below



7. Identify and record pH value in datasheet

## Indicator 9: Biological activity in soil

### 9a) Earthworm test (Temperate/Subtropical region)

#### Materials needed

- 2 L tap water
- Hand trowel or shovel
- Large jar/container for worm collection & cleaning
- Mustard solution (2 tablespoons mustard powder in 2 liters of water)

#### Method

1. Measure 30x30 cm square plot (NOTE: avoid sampling where earthworm populations might be affected i.e. mulch or compost piles).
2. Dig down 30 cm with a hand trowel/shovel, minimizing damage to the earthworms...
3. Count number of earthworms (against pale-coloured background to help locate them)
4. Add mustard solution to the hole and wait for deep-burrowing earthworms to appear (usually within 5 mins).
5. Count the number of deep-burrowing earthworms and add to amount of 3 to obtain total # earthworms
6. Record yearly counts for each of the zones/sample sites in datasheet
7. Rinse earthworms in water and return them to the soil.

### 9b) Termite activity (Tropical/Subtropical region)

#### Materials Needed

- Termite identification guide (simplified for volunteers)
- Camera or smartphone for photographing termite activity
- Protective gloves (optional)
- Data recording sheet or app

## Method

1. Measure 30x30 cm square plot (NOTE: avoid sampling where termite populations might be affected i.e. mulch or compost piles).
2. Inspect each sampling point for signs of termite activity, such as termite mounds, mud tubes, foraging trails, or discarded wings.
3. Use a termite identification guide to distinguish termites from other insects
4. Record the number of active termite nests or structures within each 30x30 cm plot
5. Take photographs of significant termite activity for verification and further analysis.
6. Note the size, height, and condition of termite mounds, as well as the presence of foraging trails or other behaviours indicative of active colonies.
7. Enter all observations, including counts and mound characteristics, into your datasheet or app.

## Indicator 10: Soil fauna (DIY Tullgren funnel)

### Materials needed

- Zip lock backs for soil samples
- 1 funnel
- Sheet of 1-cm mesh (could be the same one as used for the soil slaking test)
- 1 jam jar/collecting vessel with slippery sides
- Moist tissue (to place at the bottom of the jar)
- Desk light (incandescent, one that produces heat)

### DIY Tullgren Funnel assembly:

1. place the mesh halfway through the funnel
2. place a moist tissue at the bottom of your jar/insect collecting vessel
3. place the funnel with mesh above your jar/insect collecting vessel

## Method

1. Label bags for monitoring area(s) & collect 1kg soil sample(s) (0-20cm depth)
2. Take a handful of your soil sample and place inside the funnel
3. Position the light so that it shines on the soil within the funnel

*Over a period of 16-22 hours, insects, mites and other invertebrates present in the soil gradually work their way down away from the light and heat, falling into your vessel. Maximum extraction of soil microfauna can be recorded after a duration of 16 to 22 hours of continuous heating at temperature ranges between 35.1° C to 35.2° C (Bano and Roy, 2016).*

4. Record the number of organism and classify them according to their size (microfauna = 20-200 µm; mesofauna = 200 µm-2mm; macrofauna = 2-20mm; megauna = >200 mm)
5. Return the insects to their habitat & repeat procedure for each soil sample

# BIODIVERSITY

## Indicator 11a: Biodiversity quadrats

### Materials needed

- Smartphones with the iNaturalist, Observation.org, Merlin Bird ID, and/or eBird apps installed
- Marking sticks (with flags)
- Measuring tape or rope for marking quadrats
- GPS device or smartphone with GPS capability
- Notepad and pen for additional notes
- Magnifying glass or portable microscope (optional for close observations)
- Binoculars (for bird observations)

### Method

1. **Duration per quadrat:** A commonly used duration for quadrat surveys is approximately 15-30 minutes per person per quadrat, based on peer-reviewed literature suggesting this range provides a balance between thoroughness and practicality for diverse taxa (source: "Methods in Ecology and Evolution," British Ecological Society).
2. **Quadrat setup and team coordination (if applicable):**
  - 2.1. Outline the 10x10 meter quadrat in the selected study area, using sticks (with flags), measuring tape or rope to visually define the area.
  - 2.2. Capture the GPS coordinates of the corner's quadrat.
  - 2.3. If applicable, divide tasks among team members to cover broader taxa efficiently (e.g. one focuses on flora and fauna using iNaturalist/Observation.org, and another focuses on birds with Merlin Bird ID/eBird).
3. **Survey procedure:**
  - 3.1. Note the start and end time of the survey to adhere to the recommended duration, ensuring consistent effort across quadrats.
  - 3.2. Within the quadrat, survey for plants, insects, and other life-forms. Ensure the entire area is covered.
  - 3.3. Document observations using designated apps, ensuring accurate tagging for each entry.
  - 3.4. Adhere to ethical observation practices, prioritise safety, and ensure minimal environmental impact.

## Indicator 11b: Vegetation Survey

### Materials needed

- A one 1m<sup>2</sup> frame/quadrat (this can be made of wood, or nails connected with string, any other material that you think would be suitable to use; this could also be a hula hoop, as long as you know its area and always use the same instrument!)
- A camera/smartphone
- A plant identification guide for your region
- Marking sticks (could be small, coloured stones, small flags etc)
- (Tape measure if doing the square method along a transect)

### Method

1. Explore plant encyclopaedias/local botany resources for flora surveying
2. Place the 1m<sup>2</sup> within the different monitoring areas (avoiding crop production areas where weeding or even ploughing is likely to happen); if applicable, do this within the quadrat used for the Flora & Fauna Survey
3. Mark the corners of each quadrat physically (e.g. using marking sticks) and take the GPS coordinates of its corners; take a picture of each quadrat
4. Identify the names of species you find in each quadrat and attribute unique labels to those you cannot identify (use therefore local plant ID guides or phone app such as observation.org, plantnet, or iNaturalist); if possible, classify each species as “native”, “introduced” and/or “unknown/other”)
5. Count the number of distinct plant species you can see inside the quadrat (this is the “**species richness** per m<sup>2</sup>”)
6. In each quadrat, make a visual estimate of the % quadrat area covered by the 3-5 most dominant species, the remaining area vegetated for “other species”, and the % naked soil (this is how you assess “**species abundance**”)
7. Record the values in the datasheet
8. (*Optional*) If you would like to study the relationship between other ecological variables (e.g. moisture), survey your flora quadrat along transects with a (moisture or elevation) gradient

## Indicator 12: Moth trapping

### Materials

- UV light LED strip
- White plastic funnel
- Clear Plexiglas sheets
- Plastic bucket with a lid
- Wooden board and a stick or small pipe for mounting the LED strip
- Zip ties
- Recycled egg boxes
- Portable power bank ( $\geq 10,000$  mAh)
- Camera or smartphone
- Insect identification guide or app (e.g. iNaturalist)

### Method

#### 1. DIY Robinson trap assembly:

- 1.1. Attach the UV LED strip around the interior of the bucket lid using zip ties.
- 1.2. Cut the Plexiglas sheets to fit as vanes around the bucket's circumference and secure them above the lid level with zip ties.
- 1.3. Place the funnel inside the bucket lid opening, ensuring it leads into the bucket.
- 1.4. Set the LED strip's power source to the power bank and mount the entire assembly on a wooden board for stability.

#### 2. Site selection and setup:

- 2.1. Choose a location away from artificial lights and preferably within varied habitats for a representative sample.
- 2.2. Place the trap on an elevated platform to avoid ground predators and set it to operate from dusk till dawn.

#### 3. Data collection:

- 3.1. After the night of operation, photograph the trapped moths for species identification at sunrise. Use an app like iNaturalist for preliminary IDs and record the species and number of individuals.
- 3.2. Gently release the moths back into their habitat.
- 3.3. Compile the photographs and data into a report, including observations on moth diversity and abundance.
- 3.4. Submit the report to the ERC database, adhering to the required format for data integration and analysis.

## (MICRO)CLIMATE

### Indicator 13: Temperature differentials

**Materials needed:** Data loggers or thermometers

#### **Method**

1. Identify locations to install data loggers in the zone(s) you wish to study (preferably including at least one control site)
2. Install data logger(s)
3. Ensure continuous recording of min/max temperatures, as well as the recording date/time, geo coordinates, zone, and height

### Indicator 14: Evapotranspiration rates

#### Means of Verification: DIY Atmometer

#### **Materials needed**

- 1 liter bottle with cap
- 1 Unwanted CD/DVD
- Absorbent fabric (e.g. old underwear or jeans)
- 3 paper clips
- Glue
- Rubber band
- Ruler or tape measure

#### **DIY Atmometer Assembly**

1. Drill a 15mm hole in center of the bottle cap
2. Glue the disk to the top of the cap aligning the center hole of the CD/DVD over the hole in the cap
3. Cut a circular piece of cloth to just cover the disk
4. Cut three narrow (~15mm) strips of cloth about 6.5cm to 7.5cm longer than the height of the bottle
5. When the glue is dry screw the cap with the attached disk onto the bottle
6. Feed the three cloth strips through the hole in the bottle cap until they just reach the bottom of the bottle
7. Lay the exposed portions of the strips out flat on the disk and trim them to the edge of the disk
8. Arrange the cloth strips so that they are evenly distributed on the disk
9. Place the cloth circle on the disk and fasten it and the strips in place using the paper clips
10. Carefully unscrew the cap from the bottle and fill the bottle with water until the water is near the top of the straight side of the bottle. It is a good idea to also moisten the cloth on the top
11. Replace the cap on the bottle and you're done

## Method

1. Record the date, time and coordinates of each measurement
2. Mark the starting level of water by place rubber band around bottle at that level
3. Adjust the rubber band if you refill the bottle or start new measurements
4. Take a reading at each zone – including an uncultivated/undisturbed 'reference area' - you wish to study by measuring the distance from the rubber band to the new water level
5. To compare evapotranspiration rates between different forms of land-use, repeat the process across different zones
6. To assess how your interventions are affecting evapotranspiration rate over time, repeat the test every year or every other year on the same date/time and georeferenced locations

# CARBON CAPTURE & OTHER ECOSYSTEM SERVICES

## Indicator 15: Soil Organic- Matter (SOM) & Carbon (SOC) content

### Means of Verification (1): Loss on Ignition (LOI) Lab Test

#### Materials needed

- 1 spade/auger
- 1 clean bucket
- 1 clean zip lock bag to hold the sample

#### Method

*(if you have lab-specific protocols, neglect the method/procedures below)*

1. Determine and prepare locations of subsamples you will take: At least five to ten locations should be chosen that represent the zone you want to study, for example from the top, middle, and bottom of a slope; or scattered locations in a field, pasture, or garden bed. Avoid sampling in irregular and border areas.
2. At each of the selected zones, take two soil subsamples 5m apart, and mix the subsamples together into one sample in a zip lock bag.
3. Remove any residue or plant material above the soil surface.
4. Use the spade to dig a small hole in the center of the prepared area, about 8 inches deep. From the side of the hole take a vertical, rectangular slice of soil, aim for 6 inches deep and 2 inches thick. Remove any extra soil so that you have a more or less uniform "slice of soil" that is 6 inches deep, 2 inches thick and the width of the spade. Try to ensure that the slice represents the top 6 inches with equal representation across the depth of the sample. Place the slice of soil into the clean bucket.
5. Repeat the sampling procedure at each location that you chose for this area and combine the soil in the bucket. Break up the soil and thoroughly mix the subsamples in the bucket.
6. Once the soil is sufficiently mixed, take an amount needed by the lab for analysis (specify that you want to measure Soil Organic Matter (SOM) using the Loss on Ignition (LOI) test, and transfer into the clean zip lock bag to transfer to the lab (0.7 liters of soil should be sufficient).

#### Lab procedures

1. Baking of soil samples: 24 hours at 105° C
2. Weigh the crucible.
3. Weigh approximately 15 to 20 g of each baked sample and place it in the crucible. Ensure proper labelling
4. Place the crucible in the oven after weighing.
5. Burn at ~ 550° C for 3 hours.
6. Once cooled to ~ 150° C, place the crucible in the desiccator, cool for 30 minutes and then weigh.
7.  $SOM (\%) = \frac{[(\text{dry mass } 105^\circ \text{ C}) - (\text{dry mass } 550^\circ \text{ C})]}{(\text{dry mass } 105^\circ \text{ C})} * 100$

## Means of Verification (2): Soil Colour Test

### Materials needed

- 1 spade/auger and Zip lock bags to carry soil samples

### Method

1. Take a moist soil sample from an uncultivated/undisturbed area, place it in a bag and label it as 'reference sample'
2. Take a moist soil sample from monitoring area of interest, place it in a bag and label it
3. Using the three photographs below, compare relative change in soil colour between a handful of soil from the 'reference sample' and another handful of soil from the zone you are monitoring
4. Record the scores in your datasheet & repeat process in all areas of interest

### Results



2 = GOOD

1 = MODERATE

0 = POOR

- **Good condition (2):** Dark coloured topsoil that is not too dissimilar to that from reference.
- **Moderate condition (1):** The colour of the topsoil is somewhat paler than reference
- **Poor condition (0):** Soil colour has become significantly paler compared with reference

## Indicator 16: Above ground carbon capture

This is the indicator that shows how much carbon is being stored in the living biomass of restoration sites. We are not (yet) able to recommend a specific 'citizen science-friendly' method that can be used in different types of ecosystems, to quantify above ground carbon. However, there are a number of organisations that can help individual projects quantify and verify their carbon stocks (see [this webpage](#) for more information on carbon credit certification).

## Indicator 17: Ecosystem services quantification

**Method** (e.g. to quantify food production as 'provisioning service')

1. Determine what 'products' you want to monitor over time and classify them accordingly (e.g. as 'annual crops', 'perennials crops/herbs', 'animal products', 'timber', etc.)  
*(Although we hope to see diverse (agro)ecosystems, you might only be able to/interested in monitoring one or two products, which play a key role as a 'provisioning' ecosystem service.)*
2. Determine the surface area that is used to produce each of these 'products' in hectares
3. Log date and weight of each harvest of the respective products in 'harvest notebook'
4. Sum the weight values to obtain the total harvest at the end of each year for annual crops or at the end of your growing-harvesting cycles (e.g. timber)
5. Calculate the crop yield in kg/ha
6. Upload the data into your record sheet

Product	Product type	Occupied surface area (ha)	Total Harvest (kg/year) or Volume (m <sup>3</sup> /year)	Yield (kg/ha/year or m <sup>3</sup> /ha/year or \$/year)	Average share of final price (%)

## GLOSSARY OF KEY CONCEPTS

**Adaptive management:** 'an intentional approach to making decisions and adjustments in response to new information and changes in context' (USAID 2018)

**Baseline:** the documented starting point of your restoration project, acting as control against which progress or impact is measured; albeit less reliable, '**control sites**' may also function as baseline references/points of departure

**ERC initiative:** refers to a (semi)permanent restoration project involving public participation.

**Conceptual models:** as with any model, conceptual models help us to simplify complex (eco)systems. They are not statistical or predictive and do not attempt to explain all possible processes and relationships. Good conceptual models contain just the relevant information. In the context of ecosystem restoration, they illustrate assumed and/or hypothesized impacts of management and other factors on the state of ecosystems. For example, if your question is "how to increase water retention?", one hypothesis included in your conceptual model could be "mulch application increases water retention". You would then choose indicators/method(s) to help you verify your hypothesis (e.g. water holding capacity test). Based on the results of your experiments, you start to understand what practices restore water systems. For more information and practical applications of conceptual models, we recommend consulting the work of Bestelmayer et al (2017)

**Datasheet:** refers to the place where you can log the data you are collecting.

**Ecosystem:** a geographic area where a community or group of living organisms (e.g. plants, animals) interact between themselves and their physical/chemical environment (e.g. landscapes and weather) to form a microcosmos of life.

**Ecological Restoration:** is 'a practical management strategy that restores ecological processes to maintain ecosystem composition, structure and function.' (Apfelbaum & Chapman 1997).

**Ecosystem Restoration:** 'The process of halting and reversing degradation, resulting in improved ecosystem services and recovered biodiversity. Ecosystem restoration encompasses a wide continuum of practices, depending on local conditions and societal choice' (UN, 2019)

**Ecosystem Restoration Communities (ERCs):** are locations for people around the world to participate in ecosystem restoration; living laboratories where effective ecosystem restoration techniques are developed and spread through hands-on experiences and education.

**Evaluation:** the analysis of data collected during the monitoring period in relation to the established goals/outcomes

**Feedback loops** are key in systems thinking and help us to understand complexities. A negative feedback loop is 'stabilizing', one that tends to balance or slow down a process, whereas a positive feedback is 'reinforcing', encouraging the system to continue in one direction. Negative feedback loops include predator-prey interactions (as prey populations go up (+), the predator population eats well and grows, until there are too many predators and the prey population decreases (-)). Positive feedback loops are often described as 'vicious or virtuous cycles' as two processes reinforce each other, such as when water availability supports plant growth (+) and more plants (through greater water infiltration and decreasing evapotranspiration rates) increase water available to support plant growth. Positive feedback could also have 2 'minuses' such as when deforestation leads to decrease in biomass, more naked soils and nutrient runoff and smaller amounts of biomass that can grow on such soils.

Multiple feedbacks may interact at once. That is what is implied in the idea that human disturbances may push the Earth system past critical thresholds or ‘tipping points’ into qualitatively different states (e.g. irreversible climate change) such that a certain moment in time, a tiny perturbation can have long-term or even irreversible consequences for a system, i.e. “when little things can make a big difference”. Through ecosystem restoration, we believe we can promote positive feedback that is life-affirming and increase the resilience of our global ecosystem.

**Indicators:** are clues or signs that tell us whether the outcomes are being met.

**Land use or land management:** refers to the human arrangements, activities and inputs producing, changing or maintaining certain land-cover types (UNCCD 2016).

**Means of verification:** are the different tests used to measure the outcomes

**Monitoring:** is the systematic process of collecting data within a given time frame

**Outcomes:** are the goals we hope to reach and enhance through restoration

**Remote Sensing:** Is the collection of Earth observation data from satellites, aircraft or other remote sources

**Reference ecosystem/sites:** represent the (approximate) condition of the ecosystem where restoration is targeted, had degradation been less significant or not occurred at all (Gann et al, 2019)

**Restoration:** ‘(...) a process that aims to regain ecological functionality and enhance human well-being across degraded landscapes’ (Buckingham et al, 2019).’

**Sample site or sampling location:** herein broadly defined as the specific sites where the collection of ecological data takes place over time; should be representative of a given zone.

**Standardisation:** in our context, is the process of implementing/developing standards based on wide (scientific) consensus. Standardized methodologies contribute to inter-operability of data and help to ensure the repeatability and quality of measurements.

**Zone(s):** refer to the different areas/locations within the overall project site, as defined in the design of the site. The criteria used to designate each zone will vary per restoration project - could be based on the different forms of management (e.g. grazing, mulch), ecosystem types (e.g. forests, wetlands), altitudes, distance from communal area, etc.