EPFL

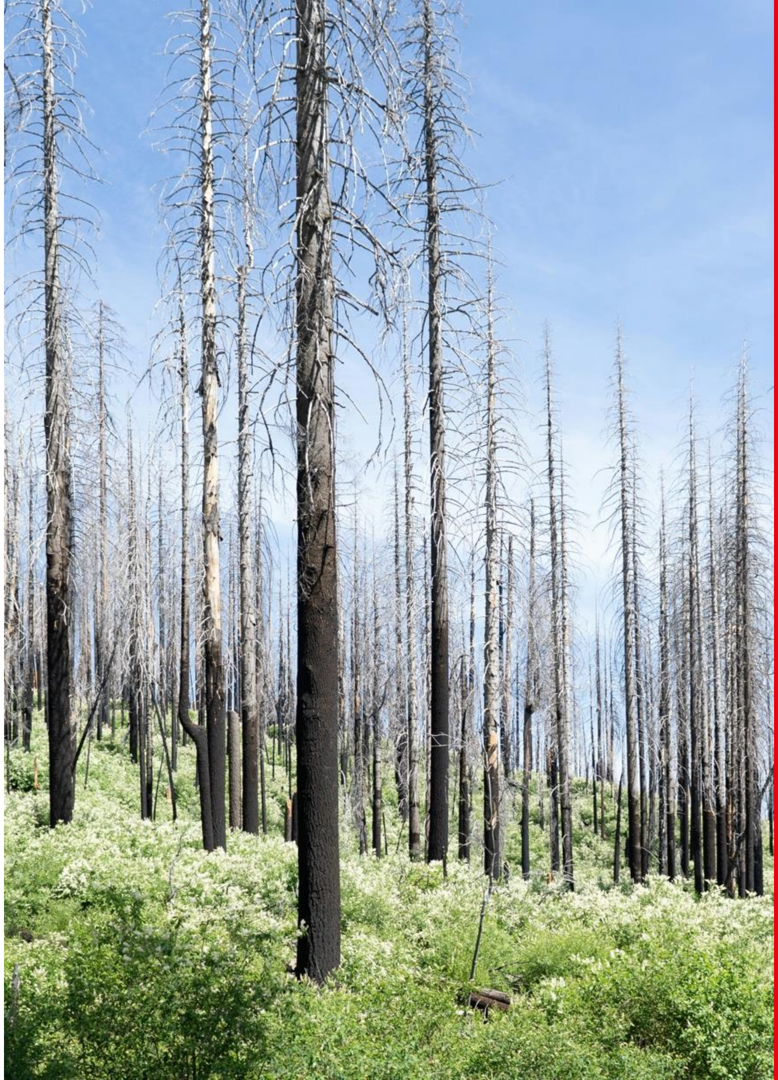
Practicals: Terrestrial Ecosystems

Week 1

Introduction

PERL group

Bachelor 2 - SIE

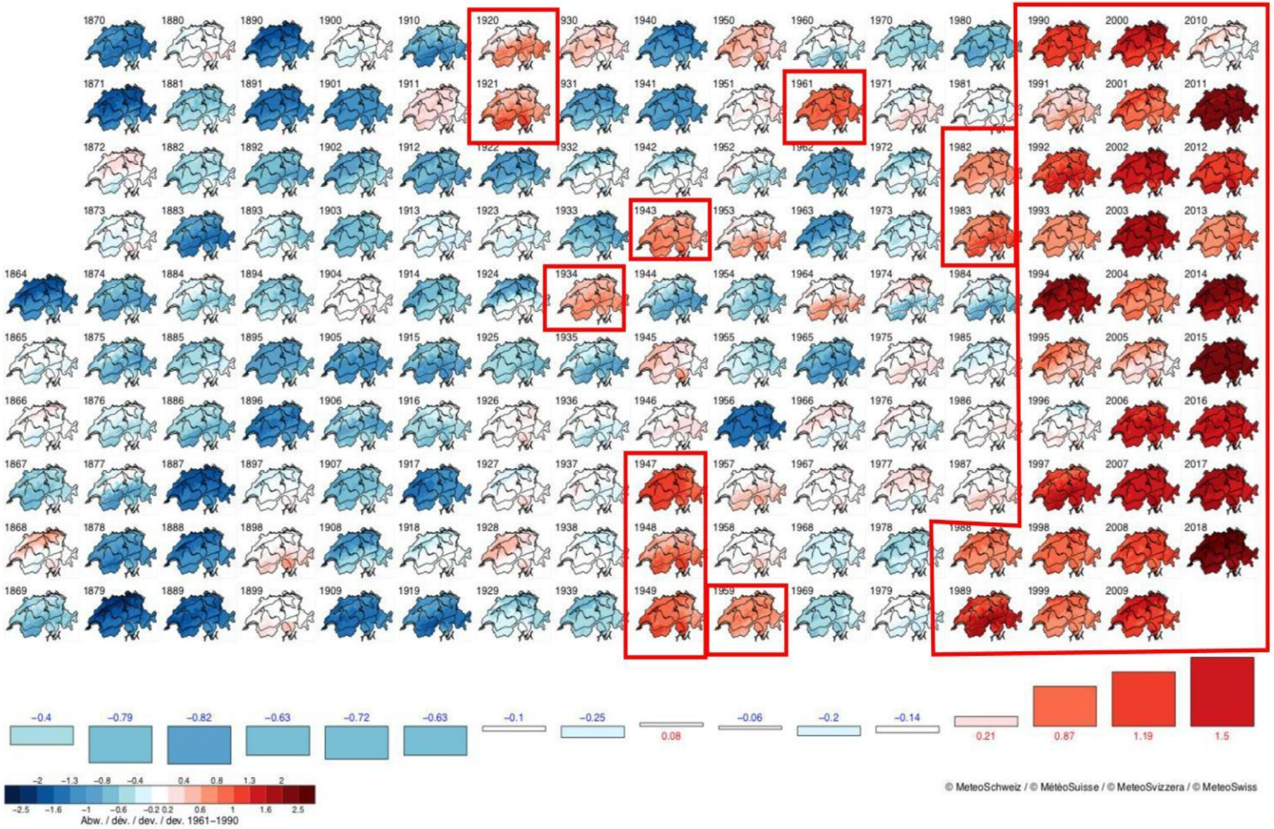


Context

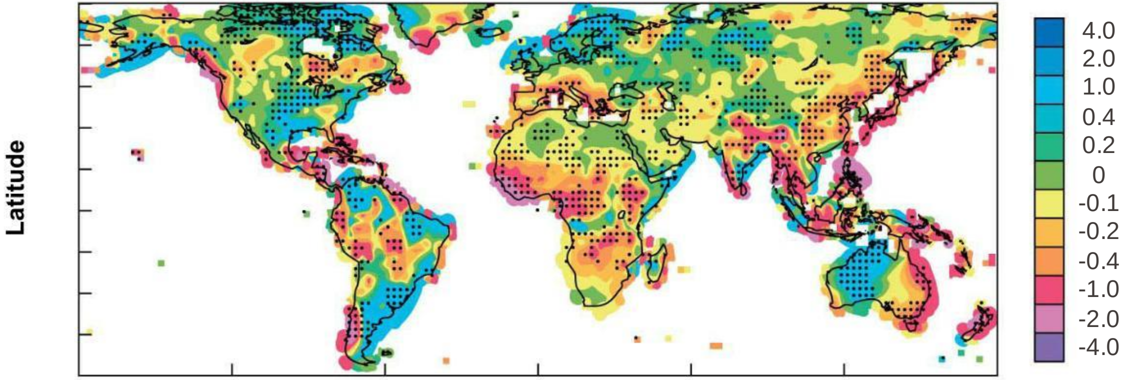
What are the major challenges faced by terrestrial ecosystems in the coming decades and what will the consequences be?

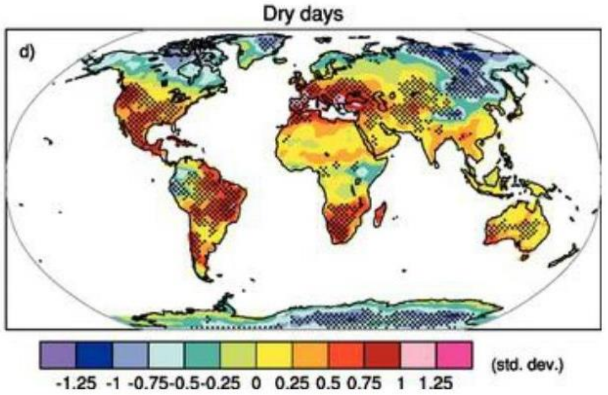
Global warming

- Temperature deviations from the 1961-1990 mean in every year since 1864
- Clear trend in the past 30 years affecting all of Switzerland



Increased drought stress



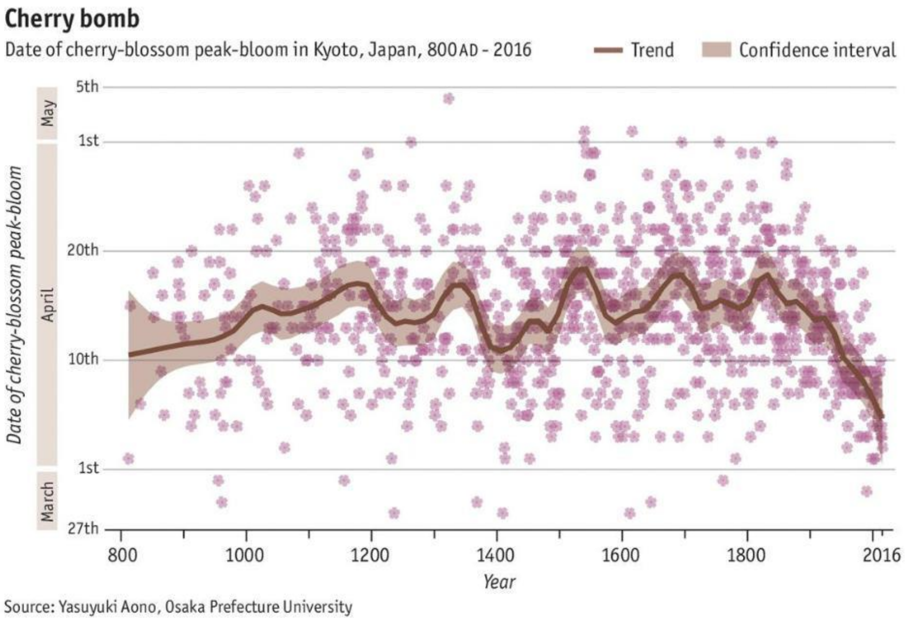


Globally averaged changes in dry days (defined as the annual maximum number of consecutive dry days, [IPCC]

- Changes in precipitation have not been spatially or temporally uniform in the last century
- Increase in extremely low precipitation events: droughts
- More frequent drying events are often associated with intense precipitation or flooding

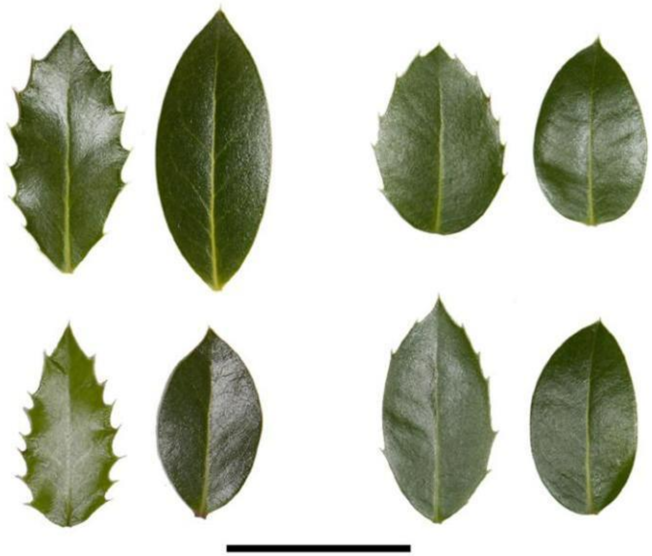
Vegetation acclimation to climate change

Reversible phenotypic changes in an individual organism in response to changing environmental conditions is referred to as **acclimation**



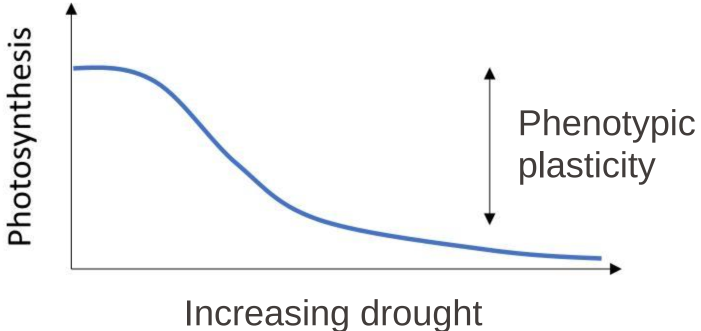
Phenotype: definition

Phenotype: outward appearance of an organism for a given characteristic (i.e., the external, observable expression of the genome)

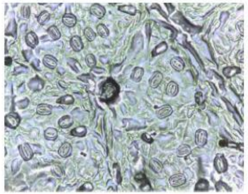


Phenotypic plasticity: ability of a genotype to give rise to different phenotypic expressions under different environmental conditions

Phenotypic plasticity can lead to an increase in fitness under changed environmental conditions (i.e., climate change)

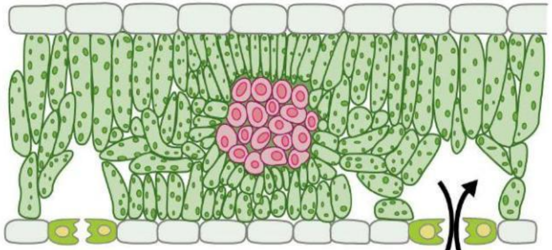


What are the expected phenotypic plasticity under warm and drought conditions?

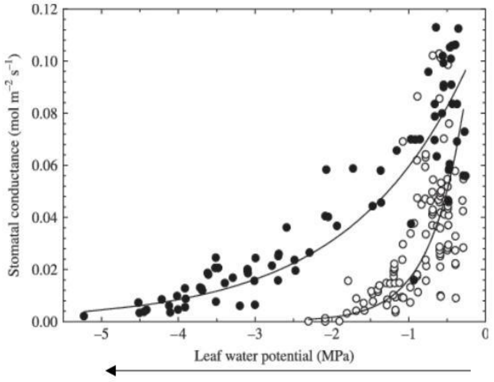


Stomata: openings on the leaf surface that allow the synthesis of CO_2

Stomatal conductance: flow rate of CO_2 or water through the stomata [$\mu molm^{-2}s^{-1}$]

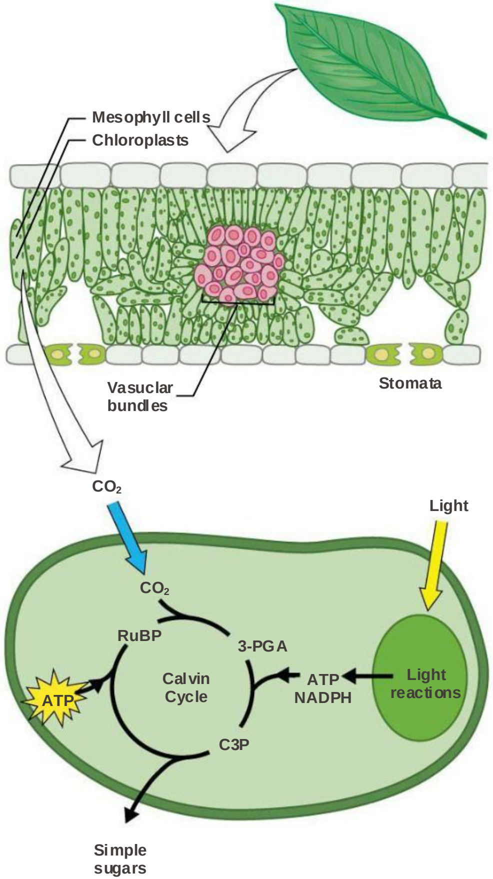


During heatwaves and droughts, plants will **close their stomata** to minimise water loss, as a consequence, **transpiration and photosynthesis decreases.**



What are the expected phenotypic plasticity under warm and drought conditions?

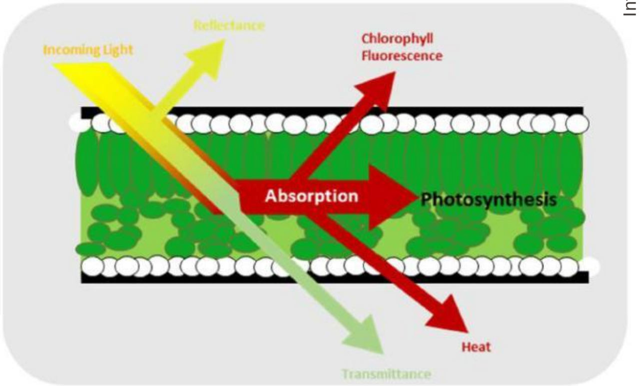
- **Photosynthesis** relies on light energy to synthesise glucose from CO_2 and transpires water. The light energy is harvested by a pigment called **chlorophyll.**
- Higher chlorophyll content in the chloroplasts (darker leaves) enables for a higher light harvesting.
- Chlorophyll content is driven by **environmental** (light, temperature, and water in the soil) and **biochemical** (protein and membrane stability) factors.
- Higher air temperature and reduced soil moisture can lead to a **destabilisation of the cell membranes** and a **denaturation of the proteins**, ultimately reducing chlorophyll content.



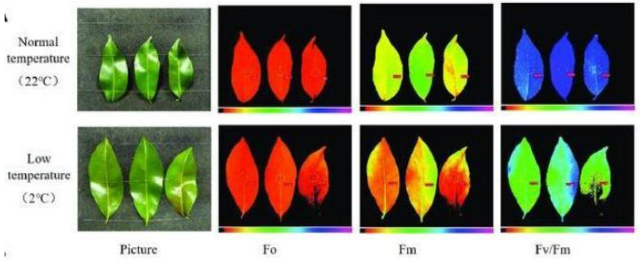
What are the expected phenotypic plasticity under warm and drought conditions?

When chlorophyll molecules absorbs light energy, they enter an **excited state**. The accumulated energy is **dissipated** in three main ways:

1. Photosynthesis pathway
2. Emitted to heat
3. Emitted as chlorophyll fluorescence



The higher the chlorophyll fluorescence, the less efficient was the light energy funnelled in photosynthesis and/or dissipated as heat, as for example under drought or heatwaves



What are the expected phenotypic plasticity under warm and drought conditions?

- Plants will invest **more carbon** in their roots, to increase the capture water more effectively

- Plants can **reduce their leaf area** to limit transpiration, thus holding water longer

These adjustments will lead to different aboveground (leaves/shoot) vs. below-ground (roots) biomass allocation reflecting the plant's strategy

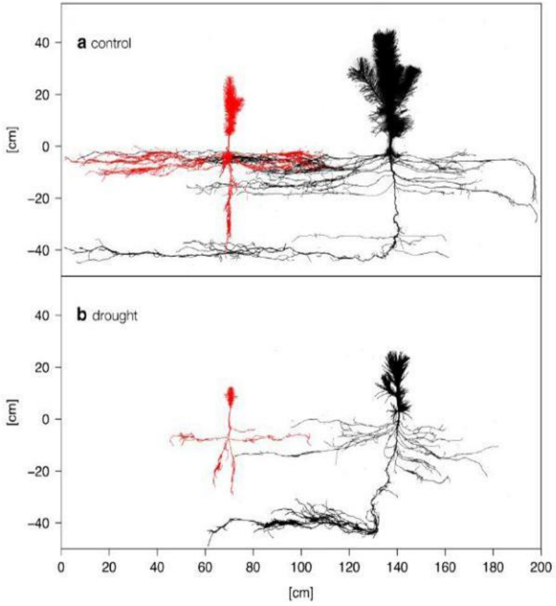


Fig. 3 *Pseudotsuga menziesii* (*red*) and *Pinus sylvestris* (*black*) seedlings grown under contrasting water conditions in a common garden in the Rhone valley, Switzerland. The seedlings were excavated from mesocosms (200 cm × 80 cm × 50 cm) at the end of the third growing season. Original photograph in Online Resource 5

More details on vegetation responses to climate change will be provided in the lectures #3 and #10

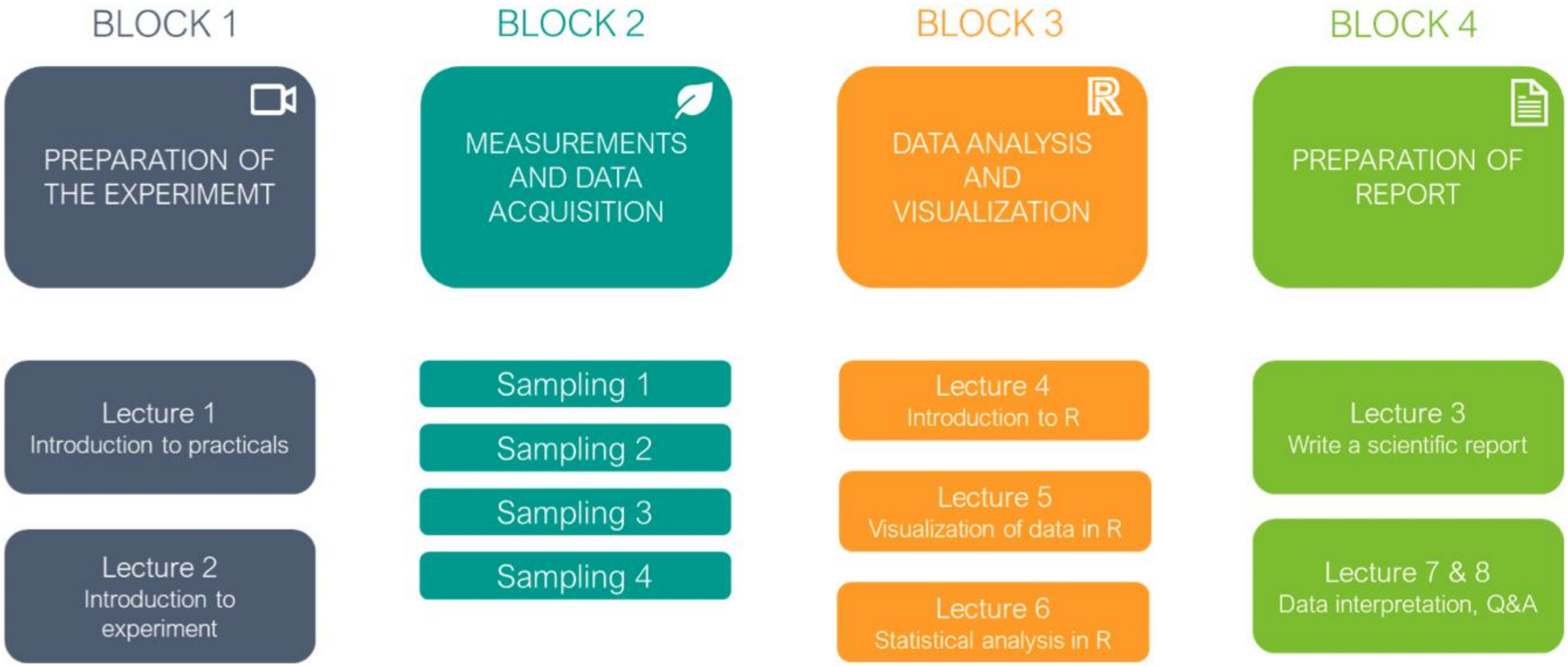
WEDNESDAY - LECTURES - ENV 220			Week	Teacher
19/2/2025	10h15-12h	The nature of ecology (introduction)	1	T. Battin
26/2/2025	10h15-12h	The physical environment	2	T. Battin
5/3/25	10h15-12h	Adaptations to the environment/Physiological ecology	3	C. Grossiord
12/3/25	10h15-12h	Population structure, dynamics, and regulation	4	C. Grossiord
19/3/25	10h15-12h	Community Ecology I	5	C. Bachofen
26/3/2026	10h15-12h	Community Ecology II	6	C. Grossiord
2/4/26	10h15-12h	Ecosystem ecology I	7	T. Battin
9/4/26	10h15-12h	Ecosystem ecology II	8	T. Battin
16/4/2026	10h15-12h	Biodiversity and conservation ecology	9	C. Grossiord
23/4/2025		Easter Holiday		
30/4/2025		ENAC Week		
7/5/24	10h15-12h	Climate Change impacts on terrestrial ecosystems	10	C. Grossiord
14/5/2024	10h15-12h	Climate Change impacts on aquatic ecosystems	11	T. Battin
21/5/2025	10h15-12h	Restoration ecology. Principles of ecosystem restoration, case studies	12	T. Battin
28/5/2025	10h15-12h	Applied ecology. Review and course wrap-up	13	C. Grossiord

Design your experiments

What will you be testing ?

Experimental design

Goal: measure the response (phenotypic plasticity) of plants in response to heat or to drought



Preparation of the experiment

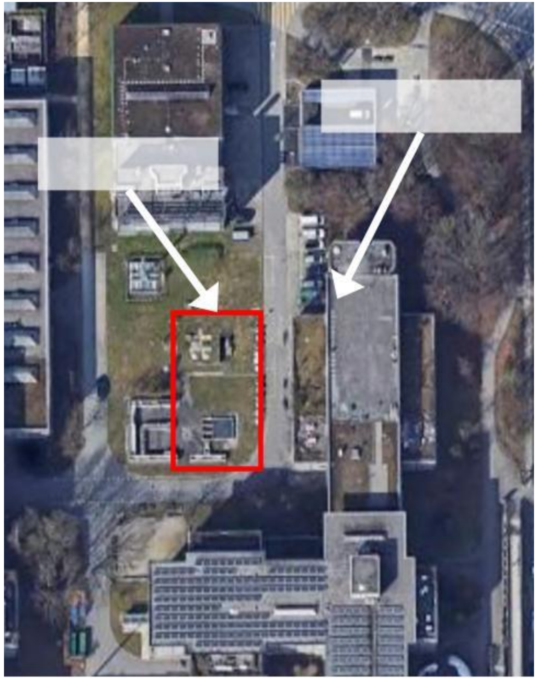
Small individuals of **ivy plants** (*Hedera Helix* L.) are selected as they are an **evergreen** species, **easy to manipulate**, and **respond fast to treatments**.

What you must do

1) Select your individuals
2) Plant them in the experimental pot
3) Label them in a unique way for your measurements

Summary of materials

Experimental unit: one pot
Replication: 3 pots per treatment
Pseudo-replication: 3 individuals per pot



All experiment will be conducted on the EPFL campus, next to the polytunnels. We will provide all the material you need. **We will always meet in the GRC001 classroom and go together outside**

Treatment selection

- **Drought**: reduce the water availability by reducing watering. You can choose the frequency of drought (continuous *vs.* intermitted)

➔ Place half your replicates (3 pots in treatment) under the rain shelter and half outside (3 pots in control). Irrigate the control pots at saturation but do not irrigate the treatment pots!

- **Warming**: increase air temperature by placing pots in a plastic shelter (simulating a greenhouse).

➔ Place half your replicates (3 pots in treatment) under the shelter and half outside (3 pots in control). All pots must be irrigated.


Drought treatment


Warming treatment

Only choose one treatment (heat or drought)

Treatment selection

You are welcome to propose your own treatment but inform us in advance (see calendar in next slides)

Measurements

What will you measure to estimate the impact of your treatments?

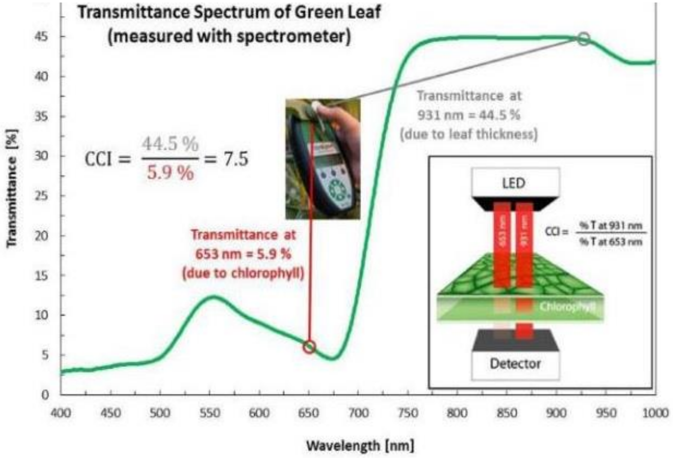
Measurements – Chlorophyll Content

- Material: **MC-100 Chlorophyll meter** (Apogee Instruments, US)

- How it works: Device emits two light sources, one at 653 nm (photosynthetically active, can be absorbed by chlorophyll) and one at 931 nm (reference, can not be absorbed). The light passes through leaf and is then measured by a detector ➔ ration between 931 nm and 653 nm provides an estimation of the relative chlorophyll content.

- Values are between 1 and 100 CCI (chlorophyll content index)

- Information provided: chlorophyll content is directly related to the plant's capacity to harvest light energy for photosynthesis. Under extreme heat or drought, we could expect it to drop



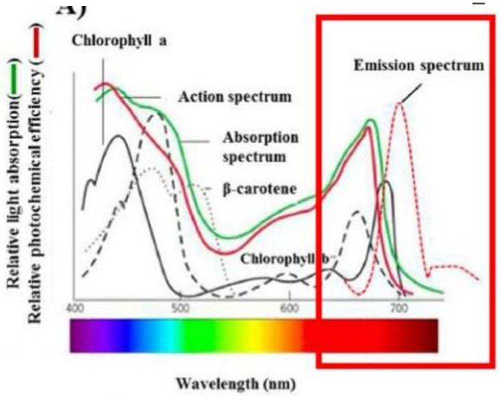
Measurements – Chlorophyll Fluorescence

- Material: **FluoroPen FP-100** (Photon Systems Instruments, CZ)

- How it works: Leaf requires to be dark-adapted for 20 minutes before measurement to ensure maximal light absorption. The device emits a red to far-red light that is absorbed by the chlorophyll. Some of the light is used for photosynthesis whilst the rest is re-emitted as fluorescence. The device computes the photosynthetic activity of the leaf (= quantum yield, QY), i.e., how much of the light energy was used for photosynthesis

- Values are between 0.1 and 0.85 (ratio Fv/Fm, unitless)

- Information provided: higher values imply higher efficiency (i.e., plants are in good condition), low values imply lower efficiency (i.e., plants are stressed or sick)

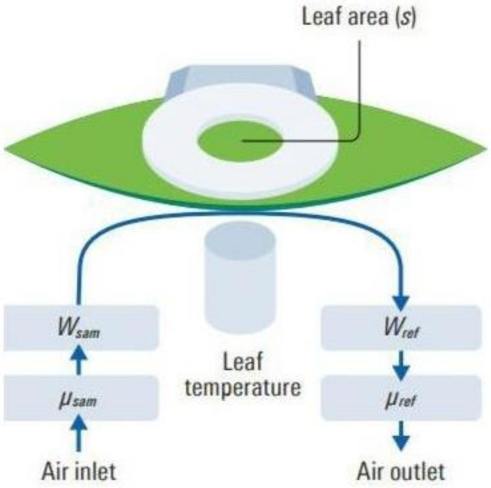


Measurements – Stomatal Conductance

- Material: **Porometer** (LI-600, Li-Cor Biosciences, US)

- How it works: Device has a small chamber that measures the flow rate and the amount of water vapour between the reference (air in the chamber) and the sample (flow coming out of the leaves). From this difference, it quantifies transpiration and stomata conductance

- Values are between 0-0.6 $molm^{-2}s^{-1}$
- Information provided: stomatal conductance reflects the flow rate of water through the stomata. The higher the stomatal conductance, the higher the water exchange between the leaf and the atmosphere. Low or almost zero stomatal conductance suggests that plants closed their stomata.

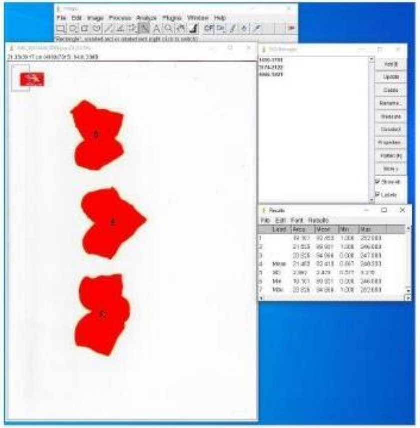


Measurements – Stem Length + Number of Leaves

- Material: regular meter
- How it works: we will estimate plant growth measuring the stem length (from the soil level to the tip of one selected stem) and the number of leaves on the stem
- Information provided: growth rates vary depending on environmental conditions. Plants under stressful conditions will tend to demonstrate lower growth (lower stem length and lower number of leaves) than plants under favourable conditions. This measurement also reflects the investment of photosynthesis to different plant tissues

Measurements – Mean leaf area

- Material: phone, reference sheet, ImageJ program
- How it works: at the end of the experiment, we detach 10 leaves (of various size and shape) of each stem and place them on the reference sheet. The reference sheet has a scale of known size. We then take a picture with the phone (name them with the the pot label) including the 10 leaves and the reference. Using ImageJ, we can select the leaves and compute their surface.
- Information provided: higher leaf area indicates higher growth and/or metabolic activity. Lower leaf area might be related to lower growth in more stressful conditions or phenotypic plasticity to reduce transpiration.
- Only measured during the last field measurement day



Measurements – Above vs. Belowground biomass

- Material: labelled paper bags, oven, scale
- How it works: at the end of the experiment, we separate the above-ground biomass (leaves and stem) from the below-ground biomass (roots), clean them to remove the dirt, place them in pre-labelled paper bags, and dry them for at least 48h. Their dry weight is then measured using a scale.
- Information provided: ratio between above- vs. below-ground biomass informs us on the plant strategy to cope with its environmental conditions (investing in specific organs)
- Only measured during the last field measurement day

Measurements – Soil temperature and moisture

- Material: **soil moisture meter** (TDR 100, Spectrum Technologies Inc., US) and **digital soil thermometer** (Checktemp, HANNA Instruments, UK)
- How it works: for the soil moisture meter, two rods are fully inserted in the soil. The device sends a signal that travels through the soil and returns to the sensor. The time it takes to return determines the soil water content (faster signal with more water).
- Values are between 0-100% VWC (Volumetric Water Content)
- Information provided: soil conditions experienced by the plants, degree of drought or heat stress. **This is not a direct consequence on the plants (like the other measurements), but it provides the environmental conditions the plants experience throughout your study**

Measurements – Climatic conditions

- Material: meteo stations outside and inside the shelters
- How it works: specific sensors continuously record air relative humidity (RH, %), air temperature (Tair, °C), and rainfall (mm) at 30 mins intervals
- Sensors: air temperature and humidity: HOBO (OnSet, US), rainfall: ECRN-100 rain gauge (MeterGroup, US)
- Information provided: climatic conditions experienced by the plants during the experiment (including extreme temperatures, low vs. high light conditions, etc) that can help us interpret our results
- Data will be provided by us through moodle

Measurements – Important Information

- The groups will organise themselves to take all measurements
- All measurements must be included in the final report
- Measurements will be carried out outside (bring warm clothes and right shoes if weather is unfavourable). We will meet in this classroom before.
- The devices used for the measurements are stored in our lab and we will provide them to you,
- Material must be shared between groups, so try to be efficient with time and bring them back when you are finished with it ➔ **collaboration is key!**
- The material is expensive, please handle them with care

Planning

When are the measurements taking place?

Schedule

General practicals schedule

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REPORT SUBMITTED on MOODLE BY 06/06/25				

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Come prepared for fieldwork

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Inform us before next week your experimental design (in the case you wish to no carry out heat or drought treatment)

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Learn about scientific writing

Schedule

Introduction to programming in R

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EPFL

Schedule

1st field measurement: come prepared

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Learn about plotting data in R

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REPORT SUBMITTED on MOODLE BY 06/06/25				

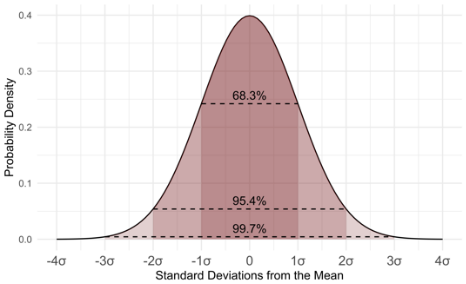
Schedule

2nd field measurement: come prepared!

THURSDAY - PRACTICALS - ENV 220			Week	Important deadlines
20/02/25	11h15-13h	Introduction to practicals	1	
27/02/25	11h15-13h	Setting up experiments	2	**Inform the experimental setup to TAs by email by 26/02/25**
6/3/25	11h15-13h	How to write a report	3	
13/03/25	11h15-13h	Introduction to R	4	
20/03/25	11h15-13h	Field measurements 1	5	
27/03/25	11h15-13h	Data visualization in R	6	
3/4/25	11h15-13h	Field measurements 2	7	
10/4/25	11h15-13h	How to do statistical analyses	8	
17/04/25	11h15-13h	Field measurements 3	9	
24/04/25	**Easter Holiday**			
1/5/25	**ENAC Week**			
8/5/25	11h15-13h	Field measurements 4	10	
15/05/25	11h15-13h	Data Analysis/Interpretation	11	**Weighting of plant material in GR B2 423 before 15/05/25**
22/05/25	11h15-13h	Questions / Discussion	12	
REPORT SUBMITTED on MOODLE BY 06/06/25				

EPFL

Schedule



Learn to apply statistics to a dataset

THURSDAY - PRACTICALS - ENV 220			Week	Important deadlines
20/02/25	11h15-13h	Introduction to practicals	1	
27/02/25	11h15-13h	Setting up experiments	2	Inform the experimental setup to TAs by email by 26/02/25
6/3/25	11h15-13h	How to write a report	3	
13/03/25	11h15-13h	Introduction to R	4	
20/03/25	11h15-13h	Field measurements 1	5	
27/03/25	11h15-13h	Data visualization in R	6	
3/4/25	11h15-13h	Field measurements 2	7	
10/4/25	11h15-13h	How to do statistical analyses	8	
17/04/25	11h15-13h	Field measurements 3	9	
24/04/25	Easter Holiday			
1/5/25	ENAC Week			
8/5/25	11h15-13h	Field measurements 4	10	
15/05/25	11h15-13h	Data Analysis/Interpretation	11	Weighting of plant material in GR B2 423 before 15/05/25
22/05/25	11h15-13h	Questions / Discussion	12	
REPORT SUBMITTED on MOODLE BY 06/06/25				

Schedule

3rd field measurement: come prepared!

THURSDAY - PRACTICALS - ENV 220			Week	Important deadlines
20/02/25	11h15-13h	Introduction to practicals	1	
27/02/25	11h15-13h	Setting up experiments	2	**Inform the experimental setup to TAs by email by 26/02/25**
6/3/25	11h15-13h	How to write a report	3	
13/03/25	11h15-13h	Introduction to R	4	
20/03/25	11h15-13h	Field measurements 1	5	
27/03/25	11h15-13h	Data visualization in R	6	
3/4/25	11h15-13h	Field measurements 2	7	
10/4/25	11h15-13h	How to do statistical analyses	8	
17/04/25	11h15-13h	Field measurements 3	9	
24/04/25	**Easter Holiday**			
1/5/25	**ENAC Week**			
8/5/25	11h15-13h	Field measurements 4	10	
15/05/25	11h15-13h	Data Analysis/Interpretation	11	**Weighting of plant material in GR B2 423 before 15/05/25**
22/05/25	11h15-13h	Questions / Discussion	12	
REPORT SUBMITTED on MOODLE BY 06/06/25				

EPFL

Schedule

4th field measurement: come prepared!

THURSDAY - PRACTICALS - ENV 220			Week	Important deadlines
20/02/25	11h15-13h	Introduction to practicals	1	
27/02/25	11h15-13h	Setting up experiments	2	**Inform the experimental setup to TAs by email by 26/02/25**
6/3/25	11h15-13h	How to write a report	3	
13/03/25	11h15-13h	Introduction to R	4	
20/03/25	11h15-13h	Field measurements 1	5	
27/03/25	11h15-13h	Data visualization in R	6	
3/4/25	11h15-13h	Field measurements 2	7	
10/4/25	11h15-13h	How to do statistical analyses	8	
17/04/25	11h15-13h	Field measurements 3	9	
24/04/25	**Easter Holiday**			
1/5/25	**ENAC Week**			
8/5/25	11h15-13h	Field measurements 4	10	
15/05/25	11h15-13h	Data Analysis/Interpretation	11	**Weighting of plant material in GR B2 423 before 15/05/25**
22/05/25	11h15-13h	Questions / Discussion	12	
REPORT SUBMITTED on MOODLE BY 06/06/25				

Schedule

Analysis of your dataset

THURSDAY - PRACTICALS - ENV 220			Week	Important deadlines
20/02/25	11h15-13h	Introduction to practicals	1	
27/02/25	11h15-13h	Setting up experiments	2	**Inform the experimental setup to TAs by email by 26/02/25**
6/3/25	11h15-13h	How to write a report	3	
13/03/25	11h15-13h	Introduction to R	4	
20/03/25	11h15-13h	Field measurements 1	5	
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17/04/25	11h15-13h	Field measurements 3	9	
24/04/25	**Easter Holiday**			
1/5/25	**ENAC Week**			
8/5/25	11h15-13h	Field measurements 4	10	
15/05/25	11h15-13h	Data Analysis/Interpretation	11	**Weighting of plant material in GR B2 423 before 15/05/25**
22/05/25	11h15-13h	Questions / Discussion	12	
REPORT SUBMITTED on MOODLE BY 06/06/25				

Schedule

Deadline to weigh all the plants (for biomass measurements) **by 15/05/25**

THURSDAY - PRACTICALS - ENV 220			Week	Important deadlines
20/02/25	11h15-13h	Introduction to practicals	1	
27/02/25	11h15-13h	Setting up experiments	2	**Inform the experimental setup to TAs by email by 26/02/25**
6/3/25	11h15-13h	How to write a report	3	
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22/05/25	11h15-13h	Questions / Discussion	12	
REPORT SUBMITTED on MOODLE BY 06/06/25				

Schedule

Session dedicated to your questions on the report

THURSDAY - PRACTICALS - ENV 220			Week	Important deadlines
20/02/25	11h15-13h	Introduction to practicals	1	
27/02/25	11h15-13h	Setting up experiments	2	**Inform the experimental setup to TAs by email by 26/02/25**
6/3/25	11h15-13h	How to write a report	3	
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22/05/25	11h15-13h	Questions / Discussion	12	
REPORT SUBMITTED on MOODLE BY 06/06/25				

Schedule

Deadline to submit report: 06/06/25

- Max 5 pages
- 40% of final grade

THURSDAY - PRACTICALS - ENV 220			Week	Important deadlines
20/02/25	11h15-13h	Introduction to practicals	1	
27/02/25	11h15-13h	Setting up experiments	2	**Inform the experimental setup to TAs by email by 26/02/25**
6/3/25	11h15-13h	How to write a report	3	
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22/05/25	11h15-13h	Questions / Discussion	12	
REPORT SUBMITTED on MOODLE BY 06/06/25				

Communication

All information you will need will be on the moodle:

Course: Fundementals in Ecology

Please check it before coming to the practical session!

In particular you will find:

- **Slides** presented both in theoretical and practical parts
- **Protocols and bibliography**: documents and files for your scientific report
- **Forum for terrestrial students**: forum in which we will provide information and in which you can ask questions regarding the terrestrial practical part

You can also reach us by email: maxwell.bergstrom@epfl.ch or cross.heintzelman@epfl.ch

Environmental Sciences and Engineering (SIE) / SIE - Bachelor

Fundamentals in ecology

Course | Settings | Participants | Grades | Reports | More

This course is currently **hidden**. Only enrolled teachers can access this course when hidden.
You can change the visibility in the **course settings**.

Course description

Collapse all

In this class, students will explore the fundamentals of ecology, aiming to understand the environment beyond its physical and chemical characteristics. They will gain a broad overview of the different disciplines of ecology, spanning scales from individual organisms to the entire globe. Beginning with core concepts, students will develop a mechanistic understanding of how individuals adapt to their environment, the structure and function of populations and communities, the role of ecosystems in global carbon, water, and nutrient cycles, the drivers of biodiversity patterns, and the impacts of global change. This course will combine both theoretical and practical parts.

Keywords: Ecology, ecosystems, theory and concepts, environment, populations, communities, biodiversity, global change

Evaluation:

- Theoretical part: **60%** of the final grade: Final written exam - *Individual*
- Practical part: **40 %** of final grade - *Group of 5 students*

Deadline for submission of the final report (practicals): 06.06.2025 at 23:59

Date of the final exam: will be added once known

Schedule of the lectures:

19/2/2025	The nature of ecology (introduction)
26/2/2025	The physical environment
5/3/2025	Adaptations to the environment/Physiological ecology
12/3/2025	Population structure, dynamics, and regulation
19/3/2025	Community Ecology I
26/3/2025	Community Ecology II
2/4/2025	Ecosystem ecology I
9/4/2025	Ecosystem ecology II
16/4/2025	Biodiversity and conservation ecology
7/5/2025	Climate Change impacts on terrestrial ecosystems
14/5/2025	Climate Change impacts on aquatic ecosystems
21/5/2025	Restoration ecology. Principles of ecosystem restoration, case studies
28/5/2025	Applied ecology. Review and course wrap-up

Expected deliverable

What are we expecting from the scientific report?

Requirements and assessment

- Each group must write a scientific report about their experiment.
- The format will be the same as a scientific article: title, abstract, introduction, materials and methods, results, discussion, references
- Report must be written in English, clearly structured and organised in paragraphs
- Max 5 pages (Times New Roman, 12-point)
- Final report to include **group number, names of all group members, date**. It must be **submitted through moodle**.
- Introduction and discussion: should include **at least 5 references from scientific literature** (i.e., papers from scientific journals, books, or relatable websites (InfoFlora, MeteoSuisse, etc – NOT Wikipedia). The information should be paraphrased and not copy-pasted!
- Grade: the grade of the practical part will be per group and not individual

Scientific report

The format will be the same as a scientific paper:

1. Title: title of your scientific report, referring to the experiment carried out
2. Abstract: short description of what's in the scientific report (short version of all parts)
3. Introduction: scientific background introducing the topic, providing the basic knowledge necessary to understand the rest of the report and stating the hypotheses, including references (for example: Grossiord et al., 2017)
4. Materials and methods: description of the experimental design, measurements and statistical analyses performed, with details!
5. Results: summary of the results of the experiment (objective description), with plots!
6. Discussion: interpretation of the results and description of their implication in a wider scientific context (building on what your learned in the theoretical part of Fundamentals in Ecology), linked to what was written in the introduction, including references.
7. References: full references, scientific format

More information during the scientific writing lecture

Learning outcomes

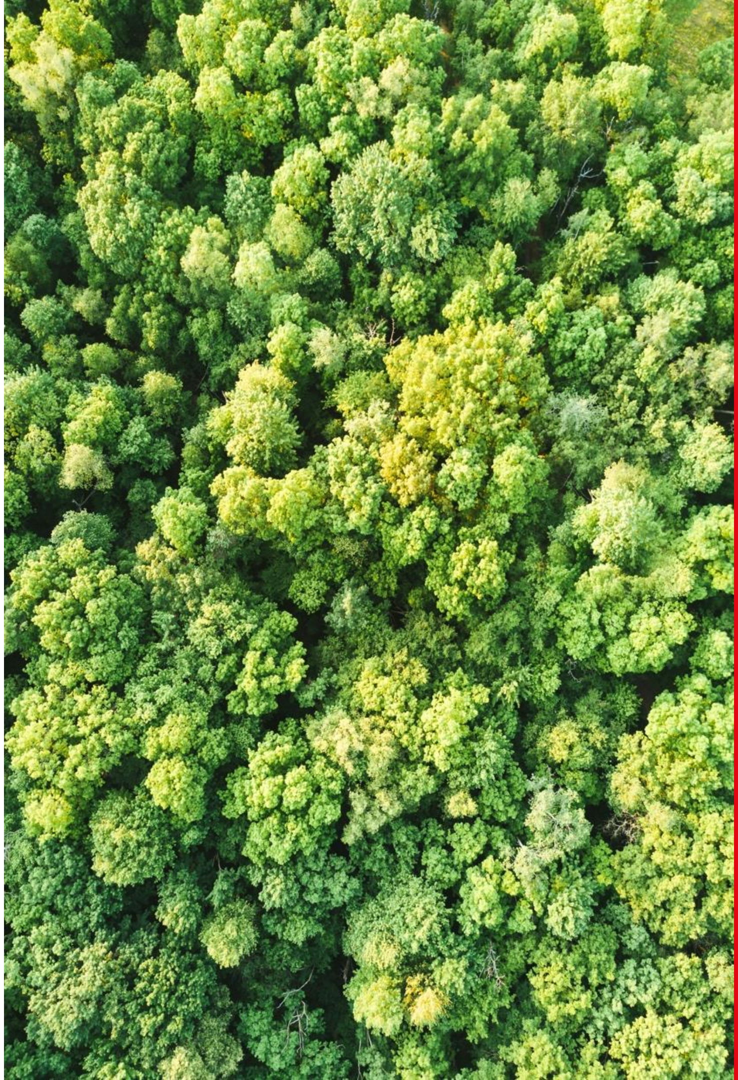
What will you learn from the practicals?

Learning outcomes

- Learn how to design an experiment in terrestrial ecology
- Learn how to carry out plant physiological measurements
- Learn how to conduct basic statistics and plot your results
- Learn how to write a scientific report
- Learn to work in a group

Terrestrial teaching group

Who is involved in the terrestrial practicals and lectures?



Terrestrial teaching group

Charlotte Grossiord
Professor

Maxwell Bergström
Teaching assistant

Cross Heintzelman
Teaching assistant

Christoph Bachofen
Teaching assistant

Janisse Deluigi
Teaching assistant